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New perspectives in the study of group dynamics

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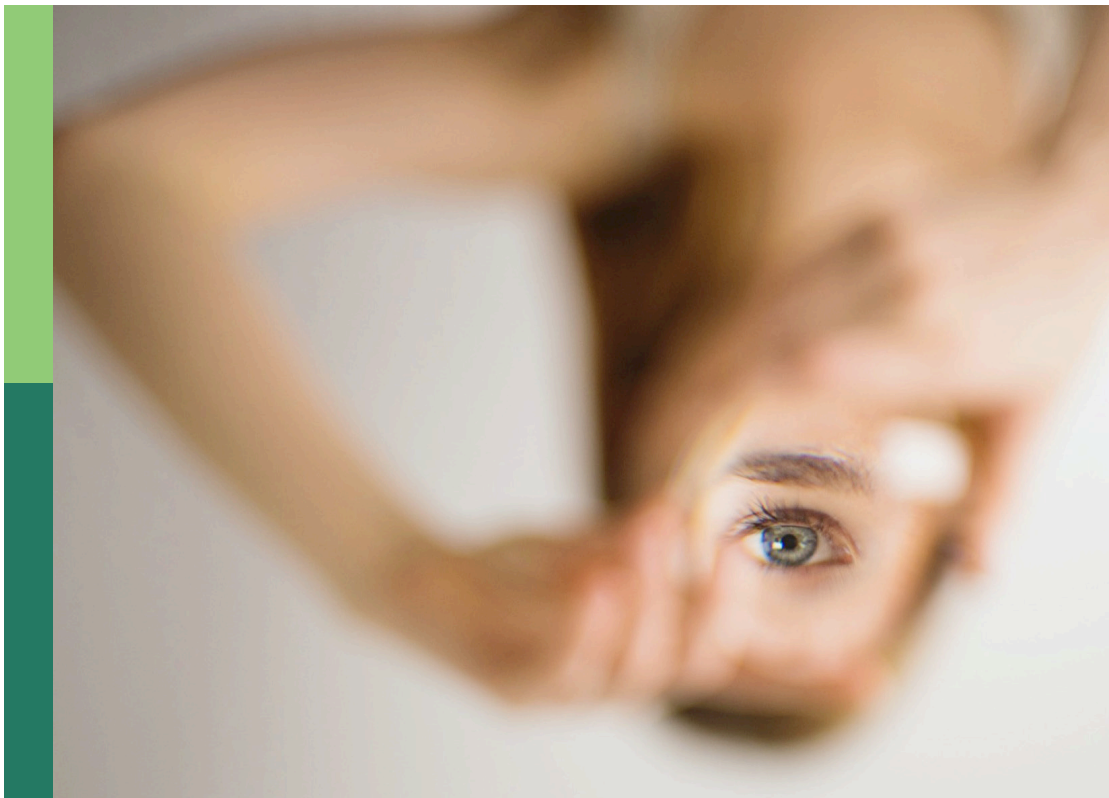

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New perspectives in the study of group dynamics

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How Team Structure Can Enhance Performance: Team Longevity's Moderating Effect and Team Coordination's Mediating Effect

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Teams are more or less structured in function. Whether team structure is beneficial or harmful for the teams entail debates in current literature. Past studies mainly investigate the effects of team structure through learning or creativity. In this study, we tend to examine the effect of team structure on team performance through team coordination. We conducted two independent field studies with samples of 56 and 67 work teams to test our hypotheses. In both two substudies, we found team structure positively affect team performance by improving team coordination. Moreover, we found team longevity was able to moderate the relationship between team structure and team performance through team coordination, such that the positive relationship between team structure and team coordination were more significant when team longevity was high rather than low.

Keywords: team structure, team coordination, team longevity, team performance, team learning

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INTRODUCTION

Teams have been considered as fundamental units in today's organizations (Mathieu et al., 2014). As a substitution for highly structured departments, teams have been traditionally considered to function without a structure (e.g., Mintzberg, 1979). However, recent studies suggest that teams usually employ structural elements to guide or coordinate their work. For instance, they are likely to elect a leader to monitor individual team member work, divide collective work among team members, and set rules or procedures for teamwork, including deadlines for tasks (e.g., Langfred, 2007; Bunderson and Boumgarden, 2010; Conaldi and Lomi, 2013; Meyer et al., 2017). These structural elements have been defined as team structure, which refers to the extent to which specialization, hierarchy and routines and/or rules are clearly defined within the team (Bunderson and Boumgarden, 2010). Given this phenomenon, the question arises: Why do teams employ structure?

The literature argues team structure is able to help teams by improving learning (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013) and coordination (e.g., transactive memory systems, Austin, 2003; Ren and Argote, 2011). However, other studies suggest that team structure may hurt performance by reducing creativity or team learning (e.g., Edmondson, 2003; Hirst et al., 2011). It is noted that a more basic task for teams is to integrate individual members' work into the team's goals (Olson, 1965; Gruenfeld and Tiedens, 2010), so we propose that team structure is more likely to play a coordinated role in teams rather than a promotor or an interrupter of creativity or learning. This study directly tested and proposed that team structure helps with

teamwork coordination mechanism, which improves team performance. We also proposed the positive effects of team structure on team coordination and performance are stronger in the stage with a higher need of coordination (i.e., a high level of team longevity). In addition, we also compared the effect of team coordination and team learning the relationship between team structure and team performance. Our theoretical model is described in **Figure 1**.

This study advances relevant research in two ways. First, we contribute to team structure research by identifying the effect of team structure on team coordination. Most studies on team structure unpack the association between team structure and team learning (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013). Our work extends the research by examining the effect of team structure on team coordination, and finds that structure can also improve coordination at team level. Secondly, this study highlights the importance of temporal factor on the effect of team structure. The results of this study show that the effect of team structure varies across the teams with different level of team longevity, such that team structure promotes team coordination when team longevity is high rather than low. This finding extends conditional context research on team structure.

THEORY AND HYPOTHESIS

Team structure refers to the extent to which the division of labor (specialization), leadership roles within the team (hierarchy), work routines, priorities and procedures (formalization) are clearly defined and understood by the team members (Bunderson and Boumgarden, 2010). Team structure is defined as a single-dimension construct comprised of these three elements. More specifically, a highly structured team has a clear division of labor, hierarchical role differentiation, and rules or procedures to guide the team's work (Bunderson and Boumgarden, 2010).

In addition, team structure can be designed and shaped by outside superiors (e.g., organizational leaders, managers) (Stewart, 2006) and also by team members (Bresman and Zellmer-Bruhn, 2013). Normally, organizations provide structural frameworks for teams or team subunits, and the teams can develop and adjust their structures based on these frameworks (Birkinshaw, 2008). Thus, team structure is more informal than organizational structure and operates at a team level. Following the concept of organization structure, the concept of team structure describe the degree to which task related activities are structured within team (Bunderson and Boumgarden, 2010). Therefore team structure differs from the concepts that emphasize cognitive or knowledge structure within team (e.g., shared mental model, transactive memory system).

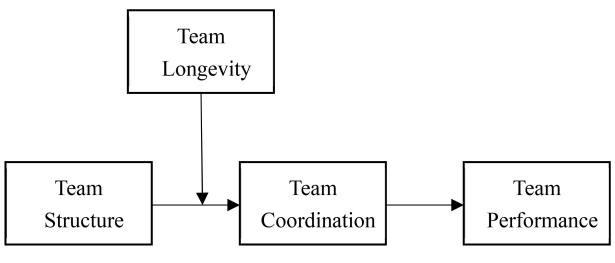

FIGURE 1 | Theoretical model.

As previously noted, the literature on team structure generally investigates its effect on learning (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013) and creativity (e.g., Edmondson, 2003; Hirst et al., 2011). However, the findings are inconsistent and paradoxical. Some studies suggest that team structure provides psychological safety, providing a safe and predicable environment for team members, which in turn benefits team learning (e.g., Bresman and Zellmer-Bruhn, 2013). However, other studies suggest that team structure may constrain team members' creativity because of low participation and lack of team member autonomy (Hirst et al., 2011). This dispute derives in part from the heated discussion among organizational structure scholars on whether organizational structure benefits or harms innovation (e.g., Thompson, 1965; Pierce and Delbecq, 1977; Yang et al., 2015; Keum and See, 2017).

However, there is scant research explores the effect of team structure on coordination. Studies have investigated the association between organizational structure and organizational coordination (e.g., Thompson, 1965; Carzo and Yanouzas, 1969; Martinez and Jarillo, 1989; Adler and Borys, 1996). Studies on transactive memory system (TMS) suggests that coordination is an element of team cognitive or knowledge structure (e.g., Lewis, 2003; Lewis et al., 2005), however this definition of structure differs with the traditional definition of structure that emphasizes task and order structure (e.g., Thompson, 1965; Pierce and Delbecq, 1977). Therefore, this study explores the effect of team structure on team coordination and team performance.

Team Structure, Team Coordination, and Team Performance

A basic problem with teamwork is how to integrate individual work into collective goals (Espinosa et al., 2007; Gruenfeld and Tiedens, 2010). Coordination refers to the process that temporally integrates individual team member work into collective goals (e.g., Faraj and Xiao, 2006). Okhuysen and Bechky (2009) review relevant studies on coordination and contend that coordination functions by creating three conditions: accountability, predictability, and common understanding. We suggest that team structure supports all three conditions, so team structure can benefit team coordination.

First, team structure clearly defines each team member's role and tasks using specialization, hierarchy and formalization (Bunderson and Boumgarden, 2010). Just how these roles and tasks are fulfilled can be tracked and adjusted by members of the hierarchy (Tarakci et al., 2016). A body of studies suggests that hierarchy in a team tends to decrease uncertainty in interpersonal interactions by establishing order and rank differentiation (e.g., Magee and Galinsky, 2008; Halevy et al., 2011). Moreover, team hierarchy has been found to benefit intrateam coordination (e.g., Halevy et al., 2012). Second,

when roles, tasks, task sequences, and schedules have been clearly specified by a team's structure, team members are likely to know others' tasks and plans. Therefore team members can predict what their teammates are doing and which activities they will respond to in certain situations and in what sequence (Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013). Therefore, teamwork becomes a more predictable process under a high level of team structure. Third, studies suggest that routines and rules can provide team members with information cues about what individual tasks should be done in certain situations so as to accomplish the team's collective tasks (e.g., Cohen et al., 2014; Pentland and Hærem, 2015). Studies also indicate that formalization helps team members to establish a shared understanding about how to organize individual work to achieve collective goals (e.g., Feldman and Rafaeli, 2002). Moreover, hierarchy may also facilitate shared understanding; this occurs because hierarchy helps to establish shared behavioral expectations for members of different ranks in the hierarchy (Halevy et al., 2011). Empirical studies have shown that hierarchy is positively related to team member schema agreement (e.g., Rentsch and Klimoski, 2001). In sum, we propose the following hypothesis:

Hypothesis 1: Team structure will positively relate to team coordination.

Team coordination is defined as the activities that temporally manage discrete tasks and coordinate these tasks into team work flow (e.g., Marks et al., 2001; Kozlowski and Bell, 2013; Li and Liao, 2014). Studies find that team coordination is an important team process as it enables teams to function effectively (e.g., Marks et al., 2001; Kozlowski and Bell, 2013). Teams are able to integrate various individual teammate tasks with team goals through coordination of efforts so that team members can contribute to collective goals rather than individual interests and purposes (Kozlowski and Bell, 2013). Under a high level of coordination, the team's information, resources and individual members' skills and abilities can more readily be integrated into an efficient temporal workflow pace and task sequence, and ultimately enhance performance (Li and Liao, 2014). Indeed, empirical studies have shown that team coordination has a positive effect on team performance (e.g., Li and Liao, 2014; Reagans et al., 2016; Sui et al., 2016). Based on this, we propose our second hypothesis.

Hypothesis 2: Team coordination will mediate the relationship between team structure and team performance.

Team Longevity: A Moderating Effect

Some studies suggest that a team's focus often changes over time, and that teams are likely to explore and experiment with teamwork approaches and procedures when teams are initially set up, whereas teams tend to complete their team tasks more effectively when they are familiar with their teammates (i.e., due to longer time working together) and each other's tasks (Gersick, 1988; Chang et al., 2003; Koopmann et al., 2016). Small group development model also support that the requirement for structure varies across the teams with different stages of development (Tuckman, 1965; Tuckman and Jensen, 1977). That is, teams only need a ground or loose structure to keep freedom to explore or test how to complete tasks and how to work with peers in early stages of development (i.e., forming and storming), but they embrace structure to effectively complete group task and coordinate team members in late stage of development (i.e., norming and performing) (Tuckman, 1965; Worchel, 1996; Bonebright, 2010). Team longevity refers to the length of time and shared experience that team members have been working together (Katz, 1982). Therefore, the relationship between team structure and team coordination is likely be moderated by team longevity.

The positive effect of team structure on team coordination may be stronger for teams with greater longevity vs. a low longevity level (young teams). As noted above, team structure provides clear and defined roles, routines and ranks for team members, and thus helps to improve team coordination. Under a low level of team longevity, teams tend to understand new situations (e.g., new tasks, changes in schedule, new goals), and test the way of groupwork and interpersonal relationship (Worchel, 1996; Bonebright, 2010). In other words, when a team is in the initial stage, team members focus on exploring and finding the best method to perform their tasks and work together as a team (Tuckman and Jensen, 1977; Chang et al., 2003). This initial activity is filled with uncertainty and complexity, therefore routines, responsibilities and rank differentiation are not able to effectively organize this exploration process (Gersick and Hackman, 1990; Sieweke and Zhao, 2015). In this stage, team members even try to resist team structure, because team structure constrains their exploration and forces them behave in a new way (Tuckman and Jensen, 1977; Bonebright, 2010). In support of this view, many studies have suggested that a tight structure may stifle members' creativity (e.g., Hirst et al., 2011; Yuan and Zhou, 2015). Thus, the positive effect of team structure on team coordination may be limited in young (low-longevity) teams. The research on development of small group also found that team members tend to resist structure in initial stage but prefer structure in late development stage (Maples, 1988).

Conversely, teams with high longevity (e.g., mature teams) face less complexity and uncertainty because team members are familiar with their own and others' tasks and their teammates in general (Gersick, 1988; McGrath, 1991). When team longevity is high, teams focus on how to compete tasks most effectively, such that team members are task orientated and seek high productivity (e.g., Tuckman and Jensen, 1977; Gersick, 1988; Maples, 1988). Under this condition, the effect of team structure is likely to be greater. A high level of team structure is likely to help teams define team members' roles and ranks, divide the labor, and establish routines and plans for effective, collective work (Bunderson and Boumgarden, 2010). In such cases, team members have a clear understanding of their responsibilities, team goals and the team's work schedule. Therefore, teams can effectively integrate individual work and improve efficiency in the implementation process. Based on these findings, we pose our third hypothesis.

Hypothesis 3: Team longevity will moderate the relationship between team structure and team coordination such that this relationship will be stronger when team longevity is high.

OVERVIEW OF OUR FIELD STUDIES

We carried out two field studies to test our three hypotheses. We first investigated 57 engineering teams to test all three hypotheses. Next, we replicated the results of field study 1 in field study 2 using a larger sample of 67 work teams.

STUDY 1

Sample

The study 1 investigated 72 engineering teams in 20 manufacturing company located in Hangzhou, China. We sent questionnaires to participants and collected questionnaires face to face. Of these, 65 teams with 63 supervisors returned questionnaires to us (response rate = 87.5%) and 286 team members returned questionnaires to us (response rate = 79.01%). To address common method bias concerns (Podsakoff et al., 2003), the dependent variable (i.e., team performance) was assessed by team supervisors and other variables – team structure, team coordination and team longevity – were assessed by the team members. The teams included in the data analysis if more than half of the team members completed questionnaires. Nine teams were excluded because less than half of the team members completed the questionnaires. Ultimately, 56 teams with 56 team supervisors and 242 team members were included in further analysis. The average age of team members was 30.95 (*SD* = 6.07), 68% were male, and 73% had a bachelor's degree or above.

Measures

Established scales were employed to measure our variables. Because the scales were originally developed in English, the transition/back-transition procedure (Brislin, 1980) was employed to translate scales from English to Chinese. The specific measures are described next.

Team Structure

A 5-item Likert scale adopted from Bunderson and Boumgarden (2010) was employed to measure team structure. This scale contains three elements of team structure – specification, hierarchy and formalization. One example item for specification is "Each team member has their particular area of specialty in the team"; an example of a hierarchy question is "There is a clear leader who directs what we do in the team"; and an example item for formalization is "We follow a very structured work schedule in the team." Team members were required to rate these five items on 7-point Likert scales (1 = totally disagree to 7 = totally agree). Cronbach's α for this scale was 0.89.

Team Coordination

A 5-item Likert scale adopted from Lewis (2003) was used to measure team coordination. Two example questionnaire items: "The team worked together in a well-coordinated fashion" and "The team had very few misunderstandings about what to do." Team members were asked to evaluate these five items on 5-point Likert scales (1 = totally disagree to 5 = totally agree). Cronbach's α for this scale was 0.81.

Team Performance

Team performance was measured by 3-item Likert scale adapted from Ancona and Caldwell (1992). Examples of these items: "The work efficiency in our team is satisfying" and "The work quality in our team is satisfying." Team supervisors were required to rate these three items on 7-point Likert scales (1 = totally disagree to 7 = totally agree). Cronbach's α for this scale was 0.86.

Team Longevity

Team longevity is calculated by averaging team members' team tenure (Katz, 1982). Team members were required to report the date that they started working on their current teams. Then team tenure was calculated for each team member. Finally, we averaged team tenure as team longevity for each team.

Control Variables

Several variables likely to affect team performance were controlled in study 1. First, team size has been found to affect the relationship between team processes and team performance (e.g., Lepine et al., 2008), so we controlled for team size. Second, given that many studies suggest that information-based diversity has a critical influence on team processes and performance (e.g., Pelled et al., 1999; van Knippenberg et al., 2004), we controlled for education level diversity and education background (i.e., study majors). Third, as a body of research shows, leaders play important roles in team functions (e.g., Giessner et al., 2013; Tost et al., 2013), and team leaders' competences and experiences can affect team performance (e.g., Sieweke and Zhao, 2015), so team leaders' education level and organizational tenure were controlled.

Data Aggregation

The justification of data aggregation needed verification. First, we examined interrater reliability using r_{wg}, as recommended by James et al. (1984). The mean r_{wg} was 0.88 for team structure, and 0.90 for team coordination. Both values were above 0.7, which is a common acceptable cutoff value (George, 1990). We also calculated the intraclass correlation coefficients as suggested by Bliese (2000). The results show that ICC(1) was 0.12, and ICC(2) was 0.36 for team structure. Regarding team coordination, ICC(1) was 0.13, and ICC(2) was 0.40. The values of ICC(1) for both team structure and team coordination were over 0.12, which is considered the median value of ICC(1) for most team research (James, 1982). However, even though our results of ICC(2) were similar to team research with small samples (e.g., Koopmann et al., 2016; Mitchell et al., 2012), these values of ICC(2) were rather low in study 1.

Results

Table 1 shows the results of descriptive statistics for all variables. In hypothesis 1, we proposed that team structure will positively

TABLE 1 | Means, standard deviation and correlates between variables (study 1).

Variable	Mean	*SD*	1	2	3	4	5	6	7	8	9
1 Team size	6.88	2.62	–								
2 Education background Diversity	0.33	0.28	0.24	–							
3 Education level diversity	0.31	0.25	0.17	0.37**	–						
4 Leader education level	3.07	0.76	0.15	−0.31*	−0.19	–					
5 Leader organizational tenure	8.79	6.17	−0.08	0.15	0.07	−0.28*	–				
6 Team structure	5.55	0.64	−0.15	0.20	0.05	0.01	−0.03	–			
7 Team longevity	3.36	2.74	−0.01	0.03	−0.01	−0.32*	0.50**	0.08	–		
8 Team coordination	3.78	0.40	−0.14	−0.06	−0.23	0.21	−0.06	0.62**	0.07	–	
9 Team performance	4.97	0.82	−0.01	−0.05	−0.11	−0.06	−0.06	0.28*	0.09	0.39**	–

n = 56. *$p < 0.05$; **$p < 0.01$.

relate to team coordination, and in hypothesis 2, we proposed that team coordination will mediate this relationship. We further tested our hypotheses using hierarchical regression. Note that all predictors in the regressions were mean-centered to eliminate the likelihood of multicollinearity.

As shown in **Table 2**, the positive regression coefficient of team structure on team coordination was significant after we controlled all control variables ($b = 0.40$, $p < 0.01$). Hence, hypothesis 1 was supported. We employed Baron and Kenny's method (Baron and Kenny, 1986) to test the mediation effect of team coordination between a team's structure and its performance. First, as model 2 represents, we found a positive and significant relationship between team structure and team performance in the regression analysis ($b = 0.43$, $p < 0.05$). Second, as explained above, the relationship between team structure and coordination was also positive and significant. Third, when team coordination was entered in model 3, team coordination was positively associated with team performance ($b = 0.77$, $p < 0.05$), but the coefficient of team structure on team performance became non-significant ($b = 0.12$, *ns.*). As a result, hypothesis 2 was supported.

We assumed that team longevity moderates the relationship between team structure and team coordination in hypothesis 3. As shown in **Table 2**, the interactive term between team structure and longevity is significant ($b = 0.08$, $p < 0.05$) as shown in model 5. We further tested this moderated effect with sample slope tests (Dawson, 2014). **Figure 2** represents the relationship between team structure and performance across different levels of team longevity. Though the relationship between team structure and team performance was positive and significant for both high longevity (1 SD above mean) and low longevity (1 SD below mean), this relationship was stronger when team longevity was high ($b = 0.63$, $p < 0.01$) vs. low ($b = 0.22$, $p < 0.05$).

Finally, we tested the moderated mediation effects using the bootstrapping method suggested by Edwards and Lambert (2007). The results, summarized in **Table 3** show that although the indirect effect of team structure on team performance via team coordination is positive and significant (at a 95% confidence interval that does not include 0) at all levels of team longevity, the effect size is greater for a high longevity level (1 SD above mean) than a low level of longevity (1 SD below mean). We further tested this difference of effect size using bootstrapping; the results suggested that the indirect effect of team structure on team

TABLE 2 | The hierarchical regression results for team structure, team coordination, and team performance (study 1).

Variables	Team performance			Team coordination			
	M1	M2	M3	M4	M5	M6	M7
Team size	0.01	0.03	0.04	−0.03	−0.00	−0.01	−0.01
Education background diversity	−0.10	−0.39	−0.33	0.19	−0.08	−0.06	−0.08
Education level diversity	−0.38	−0.39	−0.13	−0.34	−0.34	−0.33	−0.30
Team leader education level	−0.12	−0.17	−0.23	0.12	0.08	0.09	0.14
Team leader organizational tenure	−0.10	−0.01	−0.01	−0.00	0.00	−0.00	−0.00
Team structure		0.43*	0.12		0.40**	0.39**	0.42**
Team longevity						0.02	0.02
Team structure × Team longevity							0.08*
Team coordination			0.77*				
F	0.43	1.46	1.90^{+}	1.20	7.60**	6.43**	6.64**
R^2	0.02	0.12	0.20	0.12	0.48	0.48	0.53
ΔR^2		0.10*	0.08*		0.36**	0.01	0.05*

n = 56. $^{+}p < 0.10$; *$p < 0.05$; **$p < 0.01$.

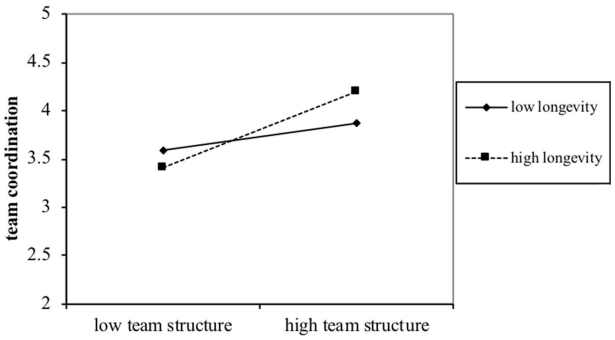

FIGURE 2 | The moderation effect of team longeivty on the relationship between team strcture and team performance (study 1).

TABLE 3 | The bootstrap results for moderated mediation effects – team coordination as mediator and team longevity as moderator (study 1).

Team longevity	Indirect effect	BCaL95	BCaU95
Low	0.17	0.00	0.50
Average	0.33	0.02	0.66
High	0.49	0.04	0.98
Diff (high vs. low)		0.02	0.81

Bootstrapping sample = 5,000.

performance is stronger when team longevity is high vs. low (at a 95% confidence interval that does not include 0). Taken together, hypothesis 3 was supported in study 1.

STUDY 2

Studies have found that team structure enhances team performance through the process of team learning (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013). In a similar vein, we suggest that team structure affects team performance mainly through the team coordination process. Team learning enables team members to reflect, experiment and explore (Edmondson, 1999), whereas team coordination stimulates team members to integrate dispersed work (Kozlowski and Bell, 2013). Therefore, it is useful to compare the mediating effect of team coordination between team structure and team performance on team learning. In study 1, we only tested the coordination mechanism between team structure and team performance. To compare the mediated effect of team coordination and team learning on the relationship between team structure and team performance, we investigated both the coordination and learning mechanism in study 2.

Sample

We investigated 450 employees with 80 team supervisors. Of these, 413 employees returned questionnaires to us (response rate = 91.8%) as did 75 supervisors (response rate = 93.8%). As in study 1, teams of which team supervisors and more than 50% of employees returned valid questionnaires were included in the data analysis; so six teams were excluded in study 2. In addition, two team were also excluded because of its small team size (i.e., team size = 2). Finally, 67 teams with 348 team members were used in further analysis in study 2. These teams included 8 RandD teams (12%), 11 financial management teams (16%), 9 marketing teams (13%), 25 human resource management teams (37%), 9 project teams (13%), and 5 others (8%). Of the 348 team members, the average age was 29.71 (*SD* = 5.63); 42% were male, 82% had a bachelor's degree or above.

Measures

We employed similar procedures and measurements that we used in study 1 to measure variables in study 2. That is, in study 2, we adopted the same scales and calculations as in study 1 to measure team structure, team coordination, team performance and team longevity. First, team members were required to assess team structure in a 5-item Likert scale adopted from Bunderson and Boumgarden (2010) (Cronbach's α = 0.86), and to assess team coordination in a 5-item Likert scale adopted from Lewis (2003) (Cronbach's α = 0.89). Second, team supervisors rated team performance in a three-item scale adapted from Ancona and Caldwell (1992) (Cronbach's α = 0.84). Team longevity was calculated by averaging team tenure (Katz, 1982). Additionally, team learning was measured using a 7-item Likert scale adopted from Edmondson (1999) (Cronbach's α = 0.84). Example items: "Our team regularly takes time to figure out ways to improve our team's work processes" and "Team members in this team often speak out to test assumptions about issues under discussion."

Data Aggregation

To check the justification of data aggregation, interrater reliability (James et al., 1984), and intraclass correlation coefficients (Bliese, 2000) were calculated in study 2. The results showed that mean r_{wg} is 0.88 for team structure, 0.88 for team learning, and 0.84 for team coordination. With respect to intraclass correlation coefficients, ICC(1) was 0.16, and ICC(2) was 0.47 for team structure; ICC(1) was 0.20, and ICC(2) was 0.54 for team learning; and ICC(1) was 0.12, and ICC(2) was 0.39 for team coordination. Though the values of ICC were relatively low for team coordination, the high value of r_{wg} indicates strong within-group agreement.

Control Variables

Consistent with study 1, in study 2, we controlled for team size, team education (subject area) diversity, education level diversity, team leader's education level and organizational tenure.

Results

Table 4 shows the results of descriptive statistics and correlations between both variables. Next, we employed a hierarchical regression analysis to test our hypotheses. To deal with multicollinearity concerns, all predictors were mean-centered before entered into the regressions.

We proposed that team structure will positively correlate to team coordination in hypothesis 1. **Table 5** shows the results of our hierarchical regression. After controlling for team size, education background diversity, education level diversity, team leader's education level and organizational tenure, we found a

TABLE 4 | Means, standard deviation and correlates between variables (study 2).

Variable	Mean	*SD*	1	2	3	4	5	6	7	8	9
1. Team size	6.60	3.84	–								
2. Education background diversity	0.51	0.29	0.03	–							
3. Education level diversity	0.34	0.25	0.08	0.11	–						
4. Leader education level	3.28	0.63	0.08	−0.24	−0.11	–					
5. Leader organizational tenure	4.08	3.07	0.19	0.00	0.02	0.15	–				
6. Team structure	4.25	0.40	0.20	0.19	−0.17	0.24	0.20	–			
7. Team longevity	2.03	1.56	0.19	0.15	−0.13	0.20	0.45**	0.13	–		
8. Team coordination	3.99	0.38	0.02	0.18	0.05	0.20	0.23	0.73**	0.17	–	
9. Team learning	3.87	0.40	0.05	0.18	0.01	0.16	−0.00	0.50**	0.07	0.48**	–
10. Team performance	3.89	0.48	−0.10	0.05	−0.11	−0.19	0.02	0.18	−0.04	0.35**	0.16

*n = 67 for most of variables, n = 65 for variable 10 because of missing data. *p < 0.05; **p < 0.01.*

TABLE 5 | Hierarchical regression results between team structure, team coordination and team performance (study 2).

Variables	Team performance[a]				Team coordination[b]			
	M1	M2	M3	M4	M5	M6	M7	M8
Team size	−0.01	−0.02	−0.01	−0.01	−0.00	−0.02	−0.02*	−0.02*
Education background diversity	0.02	−0.15	−0.12	−0.12	0.34	−0.03	−0.05	−0.04
Education level diversity	−0.24	−0.15	−0.32	−0.33	0.09	0.28*	0.30*	0.29*
Leader education level	−0.16	−0.23*	−0.24*	−0.24*	0.15	0.02	0.00	0.02
Leader organizational tenure	0.01	0.01	−0.00	−0.00	0.02	0.01	0.01	0.01
Team structure		0.36*	−0.17	−0.19		0.77**	0.78**	0.84**
Team longevity							0.03	0.01
Team structure × Team longevity								0.15*
Team coordination			0.69**	0.68**				
Team learning				0.04				
F	0.74	1.37	2.55*	2.20*	1.87	15.23**	13.33**	12.90**
R^2	0.06	0.13	0.25	0.25	0.14	0.62	0.63	0.65
ΔR^2	0.74	0.07*	0.12**	0.001	0.14	0.48**	0.01	0.03*

*[a]n = 65. [b]n = 67. *p < 0.05; **p < 0.01.*

positive and significant coefficient for team structure when it was added in model 6 (M6) ($b = 0.77$, $p < 0.01$). Therefore hypothesis 1 was supported.

Next, we used the procedures recommended by Baron and Kenny (1986) to examine hypothesis 2, which proposed that team coordination will mediate the relationship between team structure and performance. As shown in models 2 and 5, team structure had a positive and significant relationship with team performance ($b = 0.36$, $p < 0.05$) and team coordination. However, the relationship between team structure and team performance became insignificant ($b = -0.17$, *ns*) when team coordination was added in model 3 (M3). And the relationship between team coordination and team performance remained positive and significant ($b = 0.69$, $p < 0.01$) after controlling for team structure and control variables. As such, hypothesis 2 was supported.

In addition, we also compared the indirect effect of team learning and team coordination. When we entered team coordination and team learning into model 4 (M4), the effect of team coordination remained significant ($b = 0.68$, $p < 0.01$), whereas the effect of team learning was nonsignificant ($b = 0.04$, *n.s.*). The result of bootstrapping (bootstrapping sample = 20,000) also showed that the indirect effect of team coordination (effect = 0.48, 95% CI [0.10, 0.95]) was stronger than team learning (effect = 0.02, 95% CI [-0.26, 0.26]). Even the indirect effect of team learning was also nonsignificant (effect = 0.07, 95% CI [-0.14, 0.33]) when it solely played the role of mediator. Thus, the indirect effect of team coordination on the relationship between team structure and team performance is stronger than team learning.

Hypothesis 3 proposed that team longevity will moderate the relationship between team structure and team coordination. As expected, the interactive term between team structure and team longevity was positive and significant ($b = 0.15$, $p < 0.05$) when it was added in model 7 (M7). To further test this moderation effect, we conducted and then graphed simple slope tests as suggested by Dawson (2014). The results indicated that the relationship between team structure and team coordination is positive and significant at both high levels of longevity (1 *SD* above mean, $b = 1.08$, $p < 0.01$) and low levels of longevity (1 *SD* below mean, $b = 0.60$, $p < 0.01$).

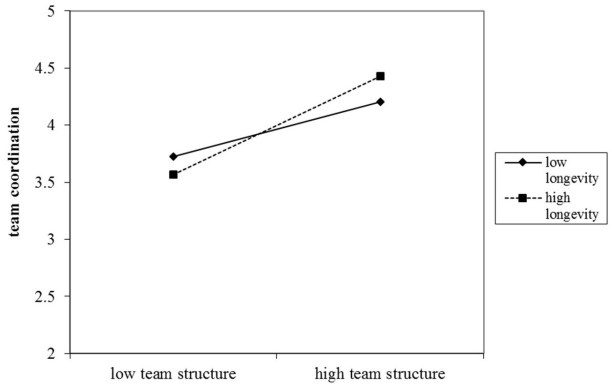

FIGURE 3 | Study 2: The moderation effect of team longeivty on the relationship between team strcture and team performance (study 2).

However, as shown in **Figure 3**, this positive relationship was steeper when team longevity was high. Overall, hypothesis 3 was supported.

We tested this moderated mediation effect using the bootstrapping method recommended by Edwards and Lambert (2007). As **Table 6**, the results of bootstrapping reports, the indirect effect of team structure on team performance via team coordination was positive and significant (95% confidence interval does not include 0) at all three levels of team longevity. Nevertheless, the effect size of the indirect effect was greater for teams with high levels of team longevity (1 SD above mean) than for low-longevity teams (1 SD below mean). This difference of effect size was significant (at 95% confidence interval that does not include 0). These results supported Hypothesis 3. Finally, we compared the effect of team coordination and team learning using the bootstrapping method with 5000 bootstrap samples. The results show that the indirect effect via team coordination was significant at 95% confidence intervals (effect = 0.53, [0.06, 0.95]), whereas the indirect effect via team learning was nonsignificant (effect = 0.02, [-0.25, 0.25]).

DISCUSSION

Though many studies suggest that team structure mainly influences team performance through team learning or creativity (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013), we proposed that team structure can act as a coordinating mechanism, which in turn improves team task coordination and ultimately, boosts team performance. We conducted two field studies to test our three hypotheses. The results show that team structure benefits team performance via team coordination. Moreover, we proposed that the effect of team structure on performance via coordination is likely to be based on team longevity levels. This hypothesis was also supported in our two field studies, such that the positive relationship between team structure and team coordination is stronger when team longevity is high.

TABLE 6 | The bootstrap results for moderated mediation effects – team coordination as mediator and team longevity as moderator (study 2).

Team longevity	Indirect effect	BCaL95	BCaU95
Low	0.40	0.10	0.82
Average	0.59	0.11	1.08
High	0.77	0.15	1.56
Diff (high vs. low)		0.01	1.01

Bootstrapping sample = 5,000.

This study contributes to relevant literature in two ways. First, we contribute to the team structure literature by finding that team structure is likely to improve team performance by supporting team coordination. Most studies on team structure focus mainly on its effect on team learning (e.g., Bunderson and Boumgarden, 2010; Bresman and Zellmer-Bruhn, 2013) and creativity (e.g., Hirst et al., 2011). We explored whether team structure can also help coordinate team members and team tasks, a critical issue in team work literature. Our results indicate that team structure can also benefit team performance by improving team coordination. Moreover, we compared the mediated effect of team coordination with team learning on the relationship between team structure and team performance in study 2, and found the team coordination effects was stronger than the team learning effect. Kozlowski and Bell (2013) suggest that team learning is a typical cognitive mechanism, and team coordination is a vital behavioral mechanism that influences team effectiveness. Most research on team structure investigates its effect through cognitive mechanisms (e.g., learning and creativity) (e.g., Bunderson and Boumgarden, 2010; Hirst et al., 2011). However, our findings show that team structure mainly influences team performance through behavioral (i.e., coordination) rather than cognitive mechanisms.

Secondly, this study advances research on team structure by highlighting the importance of temporal factors on team functioning. Studies suggest that the effect of team structure depends on organizational structure (e.g., Bresman and Zellmer-Bruhn, 2013) and individual goal orientation (e.g., Hirst et al., 2011). In other words, drawing from these previous studies (e.g., Hirst et al., 2011; Bresman and Zellmer-Bruhn, 2013), the effect of team structure may be influenced by the organizational context and individual personalities on the team. However, they overlook the effect of team context. Many researchers claim that time (i.e., the time that the team has been working together is a basic factor that shapes team processes and functions (e.g., Gersick, 1988; Chang et al., 2003; Harrison et al., 2003), however, team structure research fails to adequately explore the temporal factor. We found that team longevity can moderate the effect of team structure on team coordination. In other words, the coordinated effect of structure may vary across a team's longevity. We found that the effect of team structure is also contingent on team context, especially influenced by the team's longevity or development stage.

PRACTICAL IMPLICATIONS

This study offers insights for managers. In responding to the challenges of a dynamic environment, many contemporary organizations employ a team-based flat structure rather than a department-based tall structure. Note that today's teams are also more or less structured, so how best to cope with team structure is critical for managers. Drawing from the logics of organizational structure change, some managers may contend that team structure should be eliminated or attenuated to free team members. However, our findings suggest that these attempts to eliminate or attenuate team structure *may reduce the benefits of coordination and performance from team structure*. Team structure can effectively integrate individual work through establishing clear rules, procedure, and roles for team task, then team productivity and efficiency can be elevated. Team members' goal may struggle with each other and be inconsistent with collective goal, and then lead to chaos and inefficiency within team. The problem of loss in team structure is likely to more salient in current organizations, in which a body of them have employed a flat structure at organizational level. It because the teams in these flat-structure organizations do not have substitute for team structure from organizational structure (Bresman and Zellmer-Bruhn, 2013). Moreover, we suggest that the positive effect of team structure on coordination is likely to be stronger for teams that have existed for a long time vs. newly formed or young team. Therefore, managers could make more structured arrangements to help teams establish routines and carry out action plans when task effectiveness or efficiency is necessary.

LIMITATIONS

Like most empirical studies, this study has several limitations. First, as a cross-sectional study, we cannot make any causal inferences. Though no evidence supports that improved performance can lead to a high level of team structure, experimental studies are required to test our causal logics. Second, although we employed several methods to attenuate common method bias (e.g., assessing variables from different sources), we collected data in just at one time point. This process could create the problem of common method bias about time (Podsakoff et al., 2012). Future studies could collect data at different points of time.

CONCLUSION

Although most relevant research on team structure focuses on its effect on learning or creativity (e.g., Bunderson and Boumgarden, 2010; Hirst et al., 2011), we propose that team structure is likely to help teams address a basic problem of team function, that is, coordination. To test our hypotheses, we conducted two field studies with 56 and 67 work teams. We found that higher levels of team structure, achieved by improving team coordination, improved team performance. In addition, we found that the relationship between team structure and team coordination is moderated by team longevity, such that the positive relationship between team structure and coordination is stronger when the team has worked together for a longer time period, that is, when team longevity is high.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

The study of "How Team Structure Can Enhance Performance: Team Longevity's Moderating Effect and Team Coordination's Mediating Effect" involving human participants was reviewed and approved by the Ethics Committee of Department of Psychology and Behavioral Sciences in Zhejiang University (No. 201902), China. Written informed consent to participate in this study was provided by the participants.

AUTHOR CONTRIBUTIONS

HJ completed the research idea, data analysis, and writing of the draft. JY developed the theoretical framework and the theoretical hypotheses together with HJ, and discussed the revisions of the manuscript. Both authors contributed to the article and approved the submitted version.

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Interbrain Synchrony in the Expectation of Cooperation Behavior: A Hyperscanning Study Using Functional Near-Infrared Spectroscopy

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Expectation of others' cooperative behavior plays a core role in economic cooperation. However, the dynamic neural substrates of expectation of cooperation (hereafter EOC) are little understood. To fully understand EOC behavior in more natural social interactions, the present study employed functional near-infrared spectroscopy (fNIRS) hyperscanning to simultaneously measure pairs of participants' brain activations in a modified prisoner's dilemma game (PDG). The data analysis revealed the following results. Firstly, under the high incentive condition, team EOC behavior elicited higher interbrain synchrony (IBS) in the right inferior frontal gyrus (rIFG) than individual EOC behavior. Meanwhile, the IBS in the IFG could predict the relationship between empathy/agreeableness and EOC behavior, and this prediction role was modulated by social environmental cues. These results indicate the involvement of the human mirror neuron system (MNS) in the EOC behavior and the different neural substrates between team EOC and individual EOC, which also conform with theory that social behavior was affected by internal (i.e., empathy/agreeableness) and external factors (i.e., incentive). Secondly, female dyads exhibited a higher IBS value of cooperative expectation than male dyads in the team EOC than the individual EOC in the dorsal medial prefrontal cortex (DMPFC), while in the individual EOC stage, the coherence value of female dyads was significantly higher than that of male dyads under the low incentive reward condition in the rIFG. These sex effects thus provide presumptive evidence that females are more sensitive to environmental cues and also suggest that during economic social interaction, females' EOC behavior depends on more social cognitive abilities. Overall, these results raise intriguing questions for future research on human cooperative behaviors.

Keywords: expectation of cooperation, hyperscanning, fNIRS, interbrain synchrony, sex effects

INTRODUCTION

Expectation of cooperation (hereafter EOC) concerns how we think that another person is going to cooperate (Ng and Au, 2016). Pruitt and Kimmel proposed the "target/expectation theory" of cooperative behavior and highlighted the important role of EOC in establishing and promoting cooperative behavior (Pruitt and Kimmel, 1977; Sy et al., 2011). Previous research has postulated that an increasing trend in EOC enhances cooperation in general. However, EOC is not a sufficient condition for cooperation, as the positive effect of EOC on cooperation was moderated by individual differences and social environmental cues (Batson and Ahmad, 2001; Braver and Bongiolatti, 2002).

Bogaert et al. found that individuals with a pro-social social value orientation or higher trust toward others may expect that the other person is more likely to cooperate (Bogaert et al., 2011). Smeesters et al. (2003) reported that pro-social individuals expect more cooperation outcomes from their partners than do pro-selfs (Smeesters et al., 2003). The empathy–altruism hypothesis claims that empathy induction allows individuals to understand other people's views and to imagine the feelings of others, which leads to an increase in individuals' expectations of cooperation with others, and this expectation trend ultimately increases individuals' willingness to cooperate (Kelley and Stahelski, 1970; Dawes et al., 1977). Recent empirical research shows that cooperative behavior in social dilemmas is only one kind of a more general class of behavior, namely, moral behavior, which includes reciprocity, respecting others' property, honesty, equity, efficiency, as well as many others (Capraro and Perc, 2018). Meanwhile, some studies have reported that agreeableness predicts cooperation in different economic games (Ben-Ner et al., 2004; Pothos et al., 2011; Volk et al., 2011). It appears that agreeableness is positively associated with pro-social behavioral tendencies and at least accounts for some specific aspects of cooperation (Zettler et al., 2013). Similarly, this effect can also be extended to the sex effects modulating the relationship between EOC and cooperative outcome because females are generally considered pro-social and moral, while males are more likely to exhibit self-individual tendencies (Gregory et al., 2010; Lafko, 2015). Previous studies have also confirmed that females expect more cooperation behaviors from their partners than males (Bogaert et al., 2011).

Bogaert et al. (2011) declared that the relationship between EOC and cooperative behavior in social dilemmas is also moderated by social environmental cues (Bogaert et al., 2011). Accumulated researches have confirmed the modulation effect of social cues, e.g., Ng and Au (2016) found that game riskiness moderated the effect of EOC on cooperation such that the positive effect of EOC on cooperation was stronger for more risky games than for less risky games (Ng and Au, 2016). A similar finding is that people expect more cooperation when the payoff from mutual cooperation is higher (Charness et al., 2016). One plausible explanation is that a low incentive for mutual cooperation leads to higher risks of defection.

Beyond and based on experimental research, many mathematical and agent-based models have been presented to study cooperation in the social dilemma. These game theories reveal the essence of cooperation and competition: the ultimate goal is to maximize one's own interests. From the earliest Nash equilibrium to the latest sub-game perfect equilibrium, these models have changed from static models to dynamic models, pure strategies to mixed strategies, and symmetric to asymmetric conditions. At the same time, it is also permeated and influenced by other methods and theories, e.g., Capraro and Perc (2018) studied the moral behavior with methods of statistical physics, which improved our understanding of the emergence of cooperation, also leading to new insights and contributing toward finding answers of cooperation and competition in social dilemma (Capraro and Perc, 2018). Meanwhile, the experimental research of social dilemmas and the establishment of models have gradually extended to the frame of multiple individuals and mixed strategies, e.g., in one economic exchange, N actors, relying on continuous production strategies and price strategies to participate M kinds of commodities ($N, M > 1$).

With the development of hyperscanning techniques, research on cooperative behavior has shifted from an experimental single-brain to a natural multi-brain framework (Hasson et al., 2012; Schilbach et al., 2013). Researchers have unraveled the underlying neural substrate of cooperative behavior in human–human interaction situations based on extensive behavioral researches that have clarified the involvement of cognitive control coupled with the mentalizing and mirror neuron networks in two-person cooperative behaviors. Thus, recent hyperscanning studies have revealed increased synchronized activity in the right superior frontal cortices and the medial prefrontal region across participants in cooperative actions (Funane et al., 2011; Cui et al., 2012; Dommer et al., 2012; Liu et al., 2016) and the right temporo-parietal junction in face-to-face economic cooperation (Tang et al., 2016) and synchrony of the anterior cingulate cortex and the prefrontal areas between the brains of paired subjects playing the prisoner's dilemma game (PDG) (Astolfi et al., 2011). Moreover, team cooperative creativity studies have also confirmed increased inter-brain synchrony (IBS) in centralized mirror neuron networks and mentalizing systems (Lu et al., 2018; Xue et al., 2018; Mayseless et al., 2019). All these hyperscanning studies suggest that the mirror neuron networks and mentalizing systems are important for better cooperation and teamwork. It should be noted that several literatures have pointed an over-interpretation of the mirror neuron system (MNS) (Keysers, 2015). The present study follows the viewpoint of most researchers that MNS plays a part in social cognition.

Although much is known about the mechanism of team cooperative behavior based on several hyperscanning studies (Mayseless et al., 2019), little is known about the issue of team EOC behavior. Previous research indicates that EOC behavior involved the "social cognitive system" (together with the "reward system" and the "cognitive control system" forming the three psychological processes underlying social dilemma), which takes charge to process trust and threatening signals (e.g., mind reading) to urge people to decide in a social-orientation way (Van Lange et al., 2013), but these assumptions are based on the results of a single-brain framework study and the modulating effect of social environmental cues and individual differences on the

relationship between EOC and cooperative behavior with their underlying neural substrate.

Since hyperscanning has promoted the study of social interaction behavior in more natural conditions and the core role of EOC in promoting social decision-making, in the present study, by setting up separate expectations stage and team co-expectations stage, the interpersonal neural mechanisms underlying the EOC behavior, especially co-expectation behavior, were analyzed using a hyperscanning technique of functional near-infrared spectroscopy (fNIRS). The participant dyads' activations in the prefrontal and the bilateral inferior frontal regions, i.e., the regions of interest (ROIs), are measured simultaneously with the performance of a modified PDG.

Our goal and hypotheses for the present study were threefold: First, social environmental cues, individual differences (i.e., empathy traits, agreeableness, and gender in this study), and EOC behavior were assessed in order to reveal how they modulate the relationship between EOC behavior and cooperative outcome. These effects might yield distinct IBS patterns in related regions between conditions. Second, previous hyperscanning studies have shown significant differences between separate and team cooperative actions in two-person cooperative missions (Xu et al., 2012; Baker et al., 2016); thus, the participant dyads would show different IBS patterns across ROIs in these two separate stages, that is, the participants might show higher IBS in the co-expectation stage than in the separate expectation stage. Third, since some researches have reported gender effects in social interaction situations (Cheng et al., 2015; Zhang et al., 2017a,b), males and females might display different IBS patterns of EOC behavior in the present study.

MATERIALS AND METHODS

Participants

Sixty-two healthy, right-handed university students (32 females and 30 males, mean age = 22.3 ± 2.4 years old, range 22–30 years) were recruited. All participated in pairs (31 pairs in total) with a partner of the same sex, and the participants in a dyad were unacquainted (strangers). The participants had normal or corrected-to-normal vision and were without psychiatric disorders or a psychiatric family history. Informed written consent was obtained from all the participants. The Southeast University Institutional Review Board approved all aspects of the experiments.

Experimental Procedure

The present study used an improved three-person PDG. Two participants sitting side by side acted as cooperators playing a computer-based PDG (see details in **Figure 1**). They were labeled as participants #A and #B. Prior to the experiment, the experimenter explained the rules. It should be noted that suggestive words like cooperation, non-cooperation, pro-social, or pro-self were never used in the instructions. The participants were given several practice rounds to familiarize themselves with the game and were prohibited from conversing verbally during the experiment. The participants were then asked to rest for 30 s, during which they were required to relax their minds and remain as motionless as possible (Jiang et al., 2015). The tasks were implemented using E-prime 2.0 (Psychology Software Tools, Inc., Pittsburgh, PA, United States).

The present PDG contained one selection stage and two expectation stages. First, the participants in the dyads had to choose a red or a black card, which formed selection scheme A and scheme B, and then expect their opponent's (i.e., the computer) selection separately. Following a 5-s communication, they formed a mutual expectation. Finally, the computer uncovered its selection, which was a randomly chosen scheme (selection scheme A or B) in order to execute the prisoner's dilemma matrix (**Figure 1**). The feedback in each round included the choice of selection scheme and the final judgment.

In a classic two-person PDG, if both players choose to cooperate, both receive the reward outcome (R). If one chooses to cooperate and one chooses to defect, the one who defected receives the temptation outcome (T), while the one who cooperated receives the sucker outcome (S). If both players choose to defect, both receive the punishment outcome (P) (Rapoport, 1967a). In the present study, there were two basic reward outcomes (R) for mutual cooperation: 3 yuan and 7 yuan (yuan is China's currency), forming the low-incentive reward (hereafter LIR) conditions and the high-incentive reward (hereafter HIR) conditions. The two distinct trials (i.e., LIR and HIR) were performed in a random order. The temptation outcome was 10 yuan; the sucker outcome and the punishment outcome were 0 yuan (**Table 1**). The participants were told that their winnings would be given to them as remuneration after they completed the experiments, and their performance in the two expectation stages would also affect their remuneration. The monitor was used to present the stimuli, and keyboards were used to collect all the selection and expectation choices.

The feedback options of the opponent (i.e., the computer) were controlled by a pre-configured E-prime program following the tit-for-tat strategy, whereby the opponent always makes the same choice that the two participants made in the previous trial (Sheldon, 1999; Van Lange and Visser, 1999). Previous research has reported that individualists often cooperate when confronted with a partner playing a tit-for-tat strategy because this would increase their personal benefits (Kuhlman and Marshello, 1975). Moreover, in order to ensure that the subjects could not detect this strategy in the present study, we added two types of interference feedback choices to confuse and mislead the subjects: (1) defect when the dyads choose to cooperate and (2) cooperate when dyads choose to defect. All the participants were interviewed after the experiment, and 87% of them (54 of the 62 subjects) believed that they were interacting with a real person.

The total experiment included 60 trials (30 trials for HIR and LIR, respectively), with each round lasting approximately 50 s. The Chinese version of the empathy questionnaire (empathy questionnaire for Chinese adults including 40 items on four-point scales) and the Big Five Questionnaire in Chinese version (BFQ) were collected from each participant after the test. By focusing on the separate and team co-expectation actions of the dyads, this modified paradigm allowed us to assess the behavioral and the neural difference of the EOC behavior. Meanwhile, the design

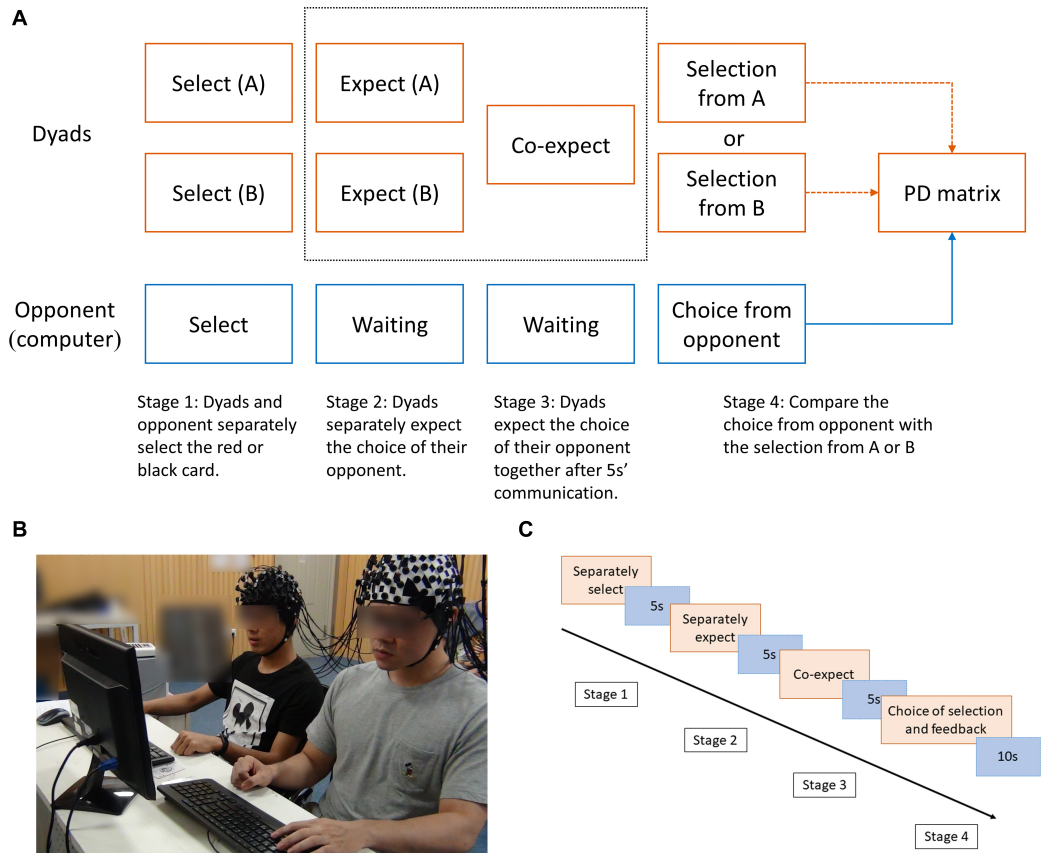


FIGURE 1 | (A) Main experimental procedure. The gray dotted box represents the expectation of cooperation behavior. **(B)** Experimental setup. The dyads sitting side by side as cooperators. **(C)** Time process of one trial. The time process was divided into four periods (separate selection, separate expectation, co-expectation, and judging period).

setting of stranger dyads of the same sex and different incentive levels allowed the assessment of sex effects and modulation of social environmental cues.

Apparatus

We used a 30-channel fNIRS system (LABNIRS; Shimadzu Co., Japan) to simultaneously measure the concentration changes of oxygenated (oxy-Hb), deoxygenated (deoxy-Hb), and total hemoglobin (total-Hb) in the participants' prefrontal and bilateral inferior frontal regions. For each participant in the dyad, one "3 × 3" and two "2 × 2" measurement patches were attached to a regular swimming cap with a 3-cm distance between one emitter and one detector, i.e., one channel, covering the prefrontal cortex (PFC) and bilateral inferior frontal gyrus (IFG), respectively. A 3D electromagnetic tracking device (FASTRAK; Polhemus, United States) was used to measure the precise positions of all fNIRS channels. The sampling rate was 42 Hz. The positions of all fNIRS channels and Montreal Neurological Institute brain space are reported in **Figure 2**.

Data Analysis

We used the HOMER2 MATLAB package to remove longitudinal signal drift, motion artifact, and physiological noise, with the band-pass filter set to 0.01–0.1 Hz. HOMER2 is a set of MATLAB scripts used for analyzing fNIRS data to obtain estimates and maps of brain activation (see details in https://homer-fnirs.org/). After data preprocessing, the fNIRS data were further divided into four periods (separate selection, separate expectation, co-expectation, and judging period) according to the experimental design. We mainly focused on two expectation stages and the judging period in the present study. In the CE (short for co-expectation) stage, choices from dyads were classified into cooperative expectation (i.e., expecting the computer to choose the red card) and defective expectation (i.e., expecting the computer to choose the black card). In the SE (short for separate expectation) stage, the definition of the dyads' expectation choices was in line with those of the CE stage, except that the roles of the two members in a pair might differ. Note that the dyad members might make different choices in the SE stage. This situation is not involved in the present study (e.g., one expects red, while the other expects black) (see the details in **Table 2**).

To examine the inter-brain coupling between the dyads, we used the wavelet coherence MATLAB package to calculate the wavelet coherence (WTC) in order to quantify the inter-brain synchrony of each dyad. Wavelet coherence was used to measure the cross-correlations between time series. Compared with

TABLE 1 | The modified prisoner's dilemma game matrix in the present study.

	Cooperate (red)	Defect (black)
Cooperate (red)	3/7	10
Defect (black)	10	0

There were two basic reward outcomes for mutual cooperation: 3 yuan (low incentive reward) and 7 yuan (high incentive reward) and performed in a random order.

traditional correlation methods, wavelet coherence measures the correlation between two signals' components on both frequency and time domains. Moreover, it is more capable of uncovering locally phase-locked behavior than the Fourier analysis (Grinsted et al., 2004). WTC has been used successfully in previous fNIRS hyperscanning studies (Cui et al., 2012; Cheng et al., 2015; Zhang et al., 2017a,b). In the present study, we obtained WTC in each event and averaged them. In order to remove the high- and low-frequency noises, such as those associated with respiration (about 0.2–0.3 Hz) and cardiac pulsation (about 1 Hz), frequency period of 5–100 s (corresponding to frequency 0.01–0.2 Hz, respectively) was selected for statistical analyses (see the example in **Figure 3B**). Note that we primarily focused on the oxy-Hb data since the oxygenated signal was more sensitive to changes in cerebral blood flow (Hoshi, 2003; Lindenberger et al., 2009).

STATISTICAL TEST AND RESULTS

Behavioral Data

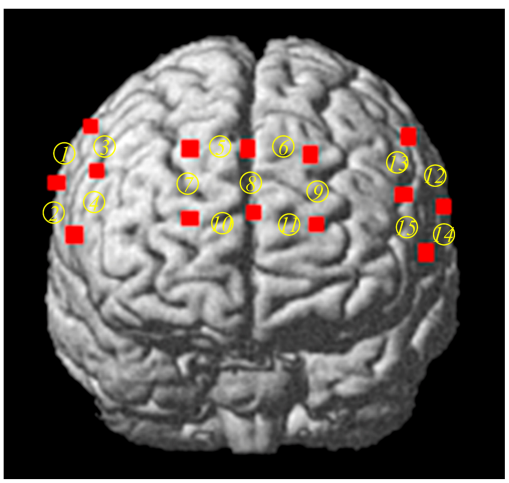
Individual Differences

The participants' empathy was assessed with a four-scale (1: strongly disagree to 4: strongly agree) questionnaire. We also extracted the agreeableness score from the BFQ. The empathy score and the agreeableness score of each dyad were obtained *via* averaging the scores of the two participants within each dyad. To examine the effect of sex and task type on individual trait scores (empathy and agreeableness), a two-way ANOVA [sex (male vs. female) × task type (LIR vs. HIR)] was conducted on the empathy score and agreeableness score, respectively, from all the dyads. As expected, the results did not reveal a significant main effect of task type, sex, and interaction effect ($P > 0.05$). Pearson correlation analyses were conducted to calculate the relationship between agreeableness and empathy scores. The results indicated that the agreeableness and the empathy scores were positively correlated ($r = 0.373$, $p = 0.011$, two-tailed).

Reaction Times and Reaction Choices

In the SE stage, in order to examine the effects of sex, task type, and expectation type on the reaction times (RTs) and reaction choices (i.e., the number of each kind of selection scheme from the participants), three-factor repeated-measures ANOVA [sex (male vs. female) × task type (LIR vs. HIR) × expectation type (cooperation vs. defection)] was conducted on the RTs and reaction choices of all the dyads. The RT of each dyad was obtained *via* averaging the RTs of the two participants within each dyad. For the RTs, there was a significant main effect for expectation types (cooperation vs. defection) [$F(1, 29) = 9.156$, $p = 0.003$, $\eta_p^2 = 0.269$; false discovery rate (FDR)-corrected], and the *post hoc* test revealed that the average reaction time of cooperative expectation ($M = 2{,}141.57$ ms, $SD = 1{,}824.08$) was shorter than that of defective expectation ($M = 2{,}449.66$ ms, $SD = 2{,}118.70$). No significant effect was found for the reaction choices.

A Positions of fNIRS channels.



B MNI of all fNIRS channels.

Ch	Brodmann area	MNI coordinates			Probability
		x	y	z	
1	R B44 - Inferior frontal gyrus	48	30	−6	0.46
2	R B46 - Inferior frontal gyrus	44	52	20	0.73
3	R B45 - Inferior frontal gyrus	54	14	10	0.42
4	R B45 - Inferior frontal gyrus	38	26	−6	0.46
5	R B9- Dorsolateral prefrontal cortex	12	49	47	1
6	B9- Dorsomedial prefrontal cortex	-10	50	49	0.435
7	R B9- Dorsolateral prefrontal cortex	19	56	40	0.861
8	B9- Dorsolateral prefrontal cortex	1	56	39	0.814
9	L B9- Dorsolateral prefrontal cortex	-18	57	39	0.829
10	B10- middle Frontopolar area	15	65	32	0.726
11	B10- middle Frontopolar area	-11	65	32	0.758
12	L B44 - Inferior frontal gyrus	-48	24	28	0.75
13	L B45 - Inferior frontal gyrus	-52	56	-14	0.76
14	L B46 - Inferior frontal gyrus	-44	40	8	0.55
15	L B45 - Inferior frontal gyrus	-38	30	−6	0.73

FIGURE 2 | (A) Positions of functional near-infrared spectroscopy (fNIRS) channels and **(B)** the Montreal Neurological Institute (MNI) brain space of fNIRS channels. Six optodes (three emitters and three detectors) were attached to the forehead in a 2 × 3 lattice pattern, forming seven measurement channels, covering approximately the middle parts of the frontopolar area and the dorsal lateral prefrontal cortex. The remaining two optodes (two emitters and two detectors) were placed on the bilateral inferior frontal regions in two 2 × 2 lattice patterns forming, eight measurement channels. The probability here is that our measured MNI position covers the brain area.

TABLE 2 | Choices by dyads in the two expectation stages.

	Separate expectation		Co-expectation
	Sub #A	Sub #B	
Expectation choices	Red	Red	Red or black
	Red	Black	
	Black	Red	
	Black	Black	

Expectation choices were classified into cooperative expectation (expecting the computer to choose the red card) and defective expectation (expecting the computer to choose the black card).

In the CE stage, a similar three-factor repeated-measures ANOVA [sex (male vs. female) × task type (LIR vs. HIR) × expectation type (cooperation vs. defection)] was conducted. For the RTs, there was a significant interaction effect between expectation type and task type [$F(1, 29) = 6.670$, $p = 0.010$, $\eta_p^2 = 0.030$ (FDR-corrected)]. A simple effect analysis revealed that, under the HIR condition, the dyads formed cooperative expectations ($M = 1{,}857.47$ ms, $SD = 2{,}722.262$) faster than defective expectations ($M = 2{,}043.06$ ms, $SD = 1{,}896.799$). For the reaction choices, there was a significant interaction effect between task type and expectation type [$F(1, 29) = 3.470$, $p = 0.033$, $\eta_p^2 = 0.107$ (FDR-corrected)]. A simple effect analysis revealed that, under the HIR condition, the dyads tended to make more cooperative expectations ($M = 21.66$, $SD = 3.93$) than defective expectations ($M = 8.34$, $SD = 3.93$).

Interbrain Synchrony

In the SE stage, the fact that the dyad members usually make different expectations (e.g., one expects red, the other expects black) could not make us analyze the effect of expected type (cooperation vs. defection) on IBS quantified by WTC.

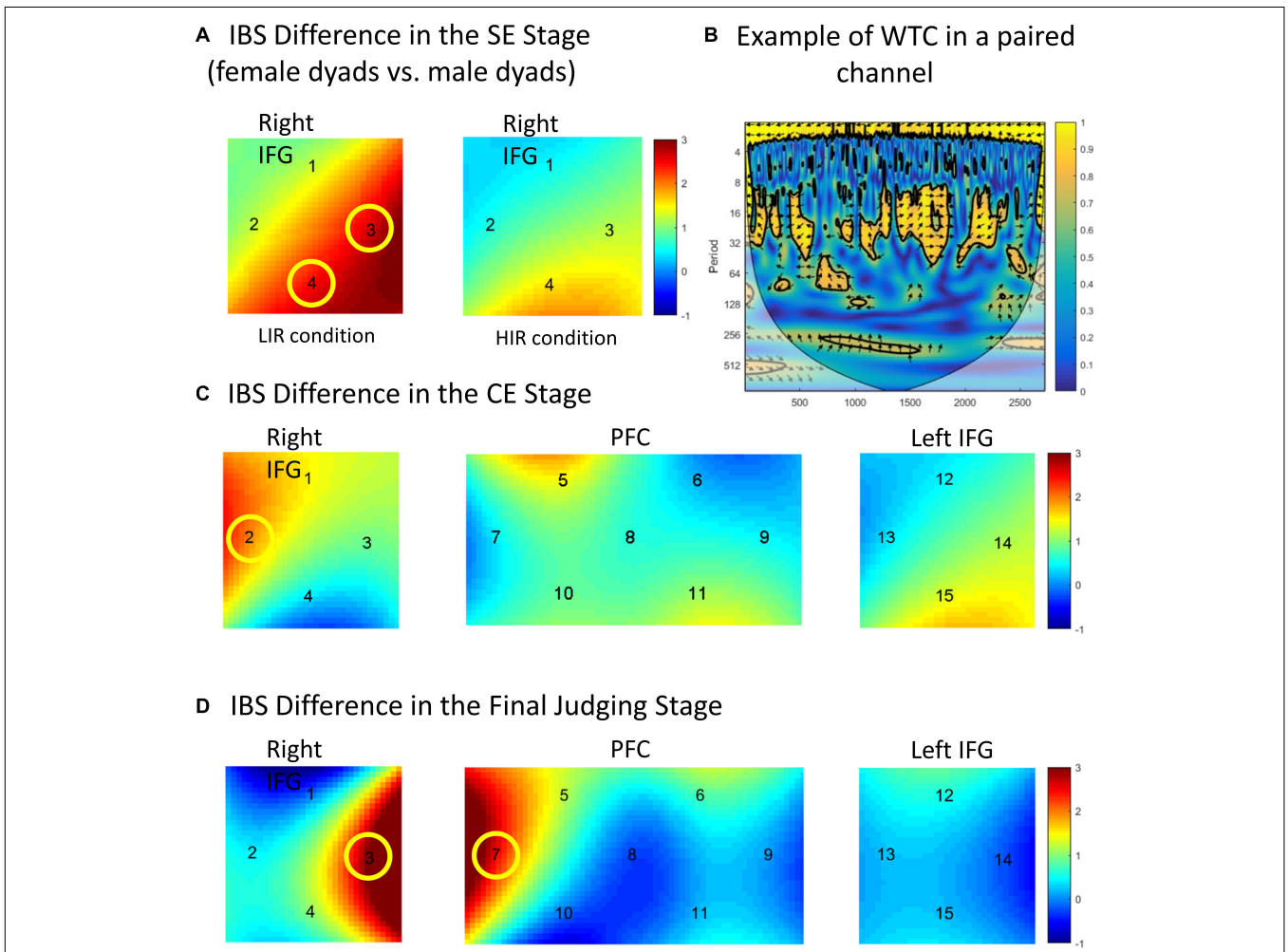


FIGURE 3 | (A) Interbrain synchrony (IBS) differences in the separate expectation stage. Female dyads evoked higher IBS than male dyads in the right inferior frontal gyrus (IFG) (CH 3 and 4) under the low incentive reward (LIR) condition. **(B)** Example of wavelet coherence. The data were from two participants' the same channel (CH 1). **(C)** IBS differences in the co-expectation stage. IBS under the high incentive reward condition was higher than that under the LIR condition in the right IFG (CH 2). **(D)** IBS differences in the final judging stage. Successful team co-expectation yielded higher IBS than unsuccessful team co-expectation in the right IFG (CH 3) and the dorsal lateral prefrontal cortex (CH 7). Colored bars indicate *t*-values.

Thus, a two-factor repeated-measures ANOVA [sex (male vs. female) × task-type (LIR vs. HIR)] was conducted of the coherence values of all scalp channels from all the dyads. The IBS increase was defined as a higher average coherence value. There was no main effect of sex or task type on all the channels ($P > 0.05$). There was a significant interaction effect between task type and sex in the right IFG [CH 3: $F(1, 29) = 8.673$, $p = 0.009$, $\eta_p^2 = 0.301$; CH 4: $F(1, 29) = 9.184$, $p = 0.002$, $\eta_p^2 = 0.317$ (FDR-corrected)]. A simple effect analysis revealed that, under the LIR condition, the female dyads evoked a higher IBS than the male dyads in the right IFG (CH 3: $p = 0.012$; CH 4: $p = 0.004$) (see the details in **Figure 3A**).

In the CE stages, a three-factor repeated-measures ANOVA [sex (male vs. female) × expectation type (cooperation vs. defection) × task type (LIR vs. HIR)] was conducted on all the channels. In the right IFG (CH 2), there was a significant main effect of task type [$F(1, 29) = 12.860$, $p = 0.001$, $\eta_p^2 = 0.331$ (FDR-corrected)]. *Post hoc* tests revealed a significantly greater coherence under the HIR condition than under the LIR condition ($p = 0.001$). There was no other significant main effect and interaction effect ($P > 0.05$) (see the details in **Figure 3C**).

In the final judging stages, the IBS evoked by expectation results (i.e., dyads' co-expectation correctly predicts their opponent's choice or not) was analyzed. Three-factor repeated-measures ANOVA [sex (male vs. female) × expectation result (successful expectation vs. unsuccessful expectation) × task type (LIR vs. HIR)] was conducted in the coherence values of all the channels from all the dyads. There was a significant main effect in expectation result in the right IFG [CH 3: $F(1, 29) = 7.158$, $p = 0.012$, $\eta_p^2 = 0.224$ (FDR-corrected)] and the dorsal lateral prefrontal cortex (DLPFC) [CH 7: $F(1, 29) = 10.836$, $p = 0.001$, $\eta_p^2 = 0.307$ (FDR-corrected)]. *Post hoc* tests revealed that there was a significant coherence increase in the right IFG and the DLPFC if the dyads formed a successful co-expectation (successfully expect the choice of their opponent) (CH 3: $p = 0.012$; CH 7: $p = 0.001$). There was no main effect of sex or task type ($P > 0.05$) (see the details in **Figure 3D**).

In order to test the effects of sex and stage type (SE vs. CE vs. baseline vs. judging stages) on IBS, a two-factor repeated-measures ANOVA [sex (male vs. female) × stage type (SE vs. CE vs. baseline vs. judging stages)] was conducted of the coherence values from all the dyads. There was a significant main effect of stage type in the rIFG [CH 2: $F(1, 29) = 9.064$, $p = 0.003$, $\eta_p^2 = 0.284$ (FDR-corrected); CH 3: $F(1, 29) = 7.268$, $p = 0.011$, $\eta_p^2 = 0.237$ (FDR-corrected)] and the middle frontopolar area [CH 10: $F(1, 29) = 11.708$, $p < 0.001$, $\eta_p^2 = 0.325$ (FDR-corrected)]. *Post hoc* tests revealed that the IBS in the SE, CE, and judging stages were significantly higher than the baseline in the rIFG [SE (CH 2: $p = 0.023$); CE (CH 2: $p = 0.012$; CH 3: $p = 0.008$); judging stage (CH 2: $p = 0.015$)], and the IBS in the SE and CE stages were significantly higher than the baseline in the middle frontopolar area [SE (CH 10: $p = 0.012$); CE (CH 10: $p = 0.007$)]. There was a significant interaction effect between stage type and sex in the DMPFC [CH 6: $F(1, 29) = 8.136$, $p = 0.008$, $\eta_p^2 = 0.247$ (FDR-corrected)]. A simple effect analysis revealed that there was a significant coherence increase in the CE stage over the SE stage in female dyads ($p = 0.010$), but not in male dyads ($p = 0.390$). There were no significant main effects ($P > 0.05$).

The Neural–Behavior Relationship

To assess the relationship between the dyads' individual differences and IBS, a Pearson correlation analysis was conducted to calculate the relationship between IBS values and empathy/agreeableness scores. We regarded the individual differences as a coupled unit, and the mean scores of the dyads' empathy and agreeableness scores were calculated.

In the SE stage, when the dyads formed cooperative expectations under the HIR condition, IBS and agreeableness were positively correlated in the right IFG (CH 4: $r = 0.653$, $p = 0.009$; CH 15: $r = 0.546$, $p = 0.020$).

In the CE stage, when the dyads formed cooperative expectations under the HIR condition, IBS and agreeableness/empathy were positively correlated in the IFG [empathy (CH 2: $r = 0.536$, $p = 0.021$ and CH4: $r = 0.514$, $p = 0.024$); agreeableness (CH 1: $r = 0.634$, $p = 0.010$; CH 3: $r = 0.675$, $p = 0.004$; CH 4: $r = 0.537$, $p = 0.021$; CH14: $r = 0.663$, $p = 0.007$)]. When the dyads formed defective expectations, IBS and empathy were negatively correlated in the right IFG (CH 2: $r = -0.523$, $p = 0.021$). This relationship was not significant in other brain cortexes and conditions ($P > 0.05$) (see the details in **Table 3**; only significant results are reported).

DISCUSSION

In the present study, we used an fNIRS hyperscanning system to simultaneously measure the pair of participants' IBS in an iterated modified PDG to investigate the EOC behavior. To the best of our knowledge, the present study is the first such attempt to investigate the underlying substrate of inter-brain synchrony of the EOC behavior in human-to-human interaction.

Our behavioral and inter-brain results confirmed the initial hypothesis regarding the mediating effect of individual differences, social cues, and sex. The behavioral results demonstrated that cooperative expectation was a common tactic across all conditions of the present study, i.e., higher rates in the CE stage and shorter reaction times in the SE stage. Moreover, the incentive level modulated the EOC behavior, i.e., more cooperative expectations and shorter reaction times under the HIR condition. A previous study found that a person may also expect the other players to be more likely to cooperate in larger incentive games, showing that HIR is more conducive to cooperation (Rapoport, 1967b). However, this modulation was only found in the CE period. One possible interpretation is that the mutual communication (in the CE stage) promoted cooperative expectation under the HIR condition, yet the "fear" of being defected by their opponent (pursuing the temptation outcome) reduced the likelihood of cooperative behavior under the LIR condition. However, the results did not reveal differences between male and female dyads in all conditions. This was consistent with the behavioral findings of previous

TABLE 3 | The neural–behavioral relation in all conditions.

Stage	Task	Expectation	CH	Region of interest	Individual differences—interbrain synchrony	
					Empathy	Agreeableness
Separate expectation	Low incentive reward	Cooperation	–	–	–	–
		Defection	–	–	–	–
	High incentive reward	Cooperation	(4)	Right inferior frontal gyrus	–	0.653**
			(15)	Left inferior frontal gyrus	–	0.546*
		Defection	–	–	–	–
Co-expectation	Low incentive reward	Cooperation	–	–	–	–
		Defection	–	–	–	–
	High incentive reward	Cooperation	(1)	Right inferior frontal gyrus	–	0.634**
			(2)	Right inferior frontal gyrus	0.536*	–
			(3)	Right inferior frontal gyrus	–	0.675**
			(4)	Right inferior frontal gyrus	0.514*	0.537*
			(14)	Left inferior frontal gyrus	–	0.663**
		Defection	(2)	Right inferior frontal gyrus	−0.523*	–

*The number inside the parentheses represents the number of the dyads who showed significant correlation based on the correlation analysis. *$p < 0.05$. **$p < 0.01$.*

hyperscanning studies, especially in the study of decision-making behaviors (Zhang et al., 2017a).

Social Environmental Cues Evoked Differences in IBS Performance

Concerning the IBS of EOC, although there was no significant difference between incentive levels in the behavioral data, the inter-brain analysis showed significant findings. i.e., the participant pairs showed an increase in IBS value under the HIR condition than that of the LIR condition in the right IFG (CE stage). Concerning interpersonal interactions, previous studies have demonstrated that the MNS, mainly including the IFG and the inferior parietal lobule, enables an individual to understand others' actions and intentions *via* embodied simulation (Iacoboni, 2008; Liu et al., 2017). Numerous studies have shown that interaction in synchrony with other persons fosters the IBS in the IFG, e.g., Koike et al. (2015) have examined the neural substrates of shared attention in a real-time mutual gaze task and demonstrated IBS in the right IFG (Koike et al., 2015). Mayseless et al. examined creative problem-solving involving team cooperation in a naturalistic study design and found an increased IBS for cooperation in the left IFG (Mayseless et al., 2019). With respect to the higher IBS values in the IFG under the HIR condition in the present study, combined with the behavioral results, one plausible explanation is that higher incentives induce common goals and less self-other distinction, and it is thus relatively simple to achieve a mutual understanding of actions and intentions (Liu et al., 2015). In general, the present findings revealed a modulation effect of external environmental cue (i.e., incentive levels) in the inter-brain networks. At the same time, the modulation effect of external environmental cues was absent in the SE stage, that is, there was no significant IBS difference between task type (HIR/LIR) in the SE stage. Considering the behavioral results (no significant difference between task type in RTs and reaction choices), one reasonable explanation is that, in indirect social interaction situations (respective action without direct interaction), the dyad members expect separately and lack communication. This resulted in the absence of interbrain synchrony across task types. This finding also provided a new neural indicator (i.e., IBS) and underlying neural substrate between individual EOC behavior and team EOC behavior.

Moreover, in the final section stage, successful expectation elicited higher IBS than unsuccessful expectation in the right IFG and the DLPFC. Previous studies have shown that the right DLPFC is activated in moral decisions and involved in a more "cognitive" subsystem that elicits utilitarian reasoning (Sanfey et al., 2003). Liu et al. (2012) investigated the neural mechanism of intertemporal choice and found that the IFG and the DLPFC was active in a reward-based model (Liu et al., 2012). Thus, it is not difficult to understand the findings in the present study, that is, in the final section stage, compared with unsuccessful expectation, successful expectation seems to be an affirmation and self-reward to dyads. Meanwhile, as described in the "Materials and Methods" sections, the performance of the expectation directly affects their remuneration. This reward stimuli leads to the synchronous activation in the right IFG and the DLPFC of the dyads.

Similarly, the significant differences of IBS between the task states (SE, CE, and judging stages) and the resting stage (i.e., baseline) indicated the successfully experimental paradigm and the involvement of MNS in the EOC behavior in a social interaction context. Meanwhile, the IBS of the SE and the CE stages are significantly higher than the resting stages in the Bradman 10 area (the middle frontopolar area). Based on previous research on the relationship between neural substrate and social cognition, a significant activation of this region may be related to multitasking (i.e., advanced cognitive retrieval) and mentalizing (Okamoto et al., 2004; Maidan et al., 2015). This area has also been proven responsible for playing a role in promoting cognitive and mentalizing abilities in a two-person decision-making task (Balconi et al., 2017). In the present study, we believe that the expectation behavior yielded the synchronous

activation in the Bradman 10 area. This needs to be confirmed by future research.

IBS in the IFG Predict the Relationship Between Empathy/Agreeableness and EOC Behavior

The neural–behavioral results also suggest a prediction role of IBS in the relationship between empathy/agreeableness and EOC behavior. First, the IBS of the IFG in relationships between trait of empathy and outcomes of the EOC behavior was demonstrated only under HIR task in the CE stage, but not under LIR task in the SE stage. As discussed above, a higher incentive involves common goals and less self-other distinction, making it relatively simple to achieve a mutual understanding of actions and intentions (Liu et al., 2015). Meanwhile, concerning the lower involvement of empathy in the SE stage, the absence of a prediction role of IBS under LIR task in the SE stage is not difficult to understand. Our research showed that empathy could predict EOC behavior at least in the inter-brain level, which strongly complements the modulation effect of empathy on cooperative behavior.

Otherwise, the IBS of the IFG in relationships between agreeableness and the outcomes of the EOC behavior was demonstrated only in the HIR task, but not in the LIR task. Previous research has suggested that agreeableness accounts for some specific aspects of cooperation (Zettler et al., 2013). Regarding the relationship between personality and behavior, it is generally accepted that personality traits, with environmental factors, jointly determine the individual's behavior (Magnusson, 1990). Meanwhile, a previous hyperscanning study has shown that the participants' empathy was significantly correlated with their IBS values in the bilateral IFG (Liu et al., 2017). The results of the present study show that EOC behavior is also regulated by both personality traits and environmental factors. This finding extends not only to the neural indicators (i.e., IBS) but also the new content (i.e., EOC behavior) to the study of the relationship between personality and behavior.

Social Environmental Cues Modulate Sex Effects in the Two Expectation Stages

With respect to the sex effect, the social environmental cues modulate an IBS difference between sex in the SE stage; the coherence value of the female dyads was significantly higher than that of the male dyads under the LIR condition in the rIFG. As described above, the rIFG enables an individual to understand others' actions and intentions (Iacoboni, 2008; Liu et al., 2017). Thus, this result indicates that females are more sensitive to their partners in indirect social interaction situations. Previous research has demonstrated that, during economic social interactions, males may primarily depend on non-social cognitive abilities to make risky decisions in a social interaction, while females may use both social and non-social cognitive abilities (Zhang et al., 2017a). Our interpretation of the sex effect found in the right IFG is that females were more sensitive to the social environmental cue (incentive level), resulting in a higher IBS value than in males during the SE stage. This might also support the evolutionary biological perspective that females are more sensitive to imperceptible changes (Hyde, 2005). A previous fMRI study found that social interactions evoke four to seven brain areas in males but as many as 14–16 brain areas for interpreting meaning, tone, and body language in females (Balliet et al., 2011).

Furthermore, among the most interesting findings in this study is the sex effect between individual expectation (SE stage) and co-expectation (in the CE stage) in the DMPFC. For the interpretation of this result, two closely optimal explanations may make sense. Concerning the impact of social cues and the less involvement of indirect interaction in the SE stage, a higher IBS of cooperative expectation in the CE stage is not hard to understand. The alternative possibility is that the IBS value increase in the DMPFC might indicate the pro-social effect, which refers to a phenomenon whereby people tend to be more pro-social after synchronizing behaviors with others (Reddish et al., 2013; Endedijk et al., 2015). Previous studies have shown that synchronously moving with others (e.g., walking, singing, and tapping) fosters pro-sociality (Wiltermuth and Heath, 2009; Kirschner and Tomasello, 2010; Cirelli et al., 2014; Koehne et al., 2016). In a multi-brain frame research, Hu et al. (2017) studied the mutual pro-sociality effect using a simultaneous key pressing task after silent time-counting and found IBS in the left middle frontal cortex (Hu et al., 2017). In our work, the female dyads showed a stronger cooperative tendency in neural network (DMPFC) after a short synchronous interaction (i.e., co-expectation behavior). To some extent, our results complement the neural information of mutual pro-sociality effect. Moreover, the DMPFC is thought to be part of the theory-of -mind brain networks, activated by considering the intentions of another individual in social processing (Isoda and Noritake, 2013). Rilling et al. (2004) reported that partner feedback in the PDG reliably activates the DMPFC, and this activation is engaged more when playing with a human than a computer partner (Rilling et al., 2004), indicating that females are sensitive to feedback even when interacting with a computer opponent. These results are also supported by the "theory of social representations," which posits that individuals' social behavior is controlled by their inherent "representations system," and this "representations system" is affected by certain social factors such as culture and education. According to the "theory of social representations," the sex effect in the current study demonstrated that males and females execute different "representations systems" during economic social interaction, while females' EOC behavior depends on more social cognitive abilities.

The Effect of Group Size and Possible Applications in the Future

The EOC behavior is inevitably affected by the size of the group, which is the decisive factor that determines

whether the spontaneous and rational pursuit of individual interests will lead to a favorable group behavior (Olson, 1971). A recent study has shown that the deficits scaled approximately linear with group size; the negative trends tended to accelerate a little faster downward for larger groups (Wang et al., 2020). Olson declared that the more people who share the benefits and the lesser the individuals who carry out activities for the realization of the group benefit, economic or rational individuals will not act for the common interests of the group (Olson, 1971). However, most of the conclusions and hypotheses are based on previous studies drawn from the public goods game, which combined the conflicts between individual interests and group interests. In the present research, we pay more attention to the group behavior that align individual interests with collective interests. Therefore, we have to be aware of the doubt if the EOC behaviors also conform to the rule of group size, the latter needing to be confirmed by future studies.

There is, in addition, one further point to make. For the purpose of application and practice, the research outcome of the EOC behavior and social dilemma should also apply to future research and daily life. A very recent research shows that communicating sentiment may also increase cooperation, which in turn can lead to better climate agreement—a very well-known social dilemma (Wang et al., 2020). The study of EOC behavior promotes the understanding of neuroeconomic research. On the other hand, the application of game theory in daily life facilitates the solution of economic and even global problems, for example, using the game theory to study and solve the problem of water resources allocation (Wang et al., 2003) and global climate change (Wang et al., 2020). In the solution of these practical and global problems, the in-depth study of EOC behavior will make important contributions.

Finally, the present study also comes with limitations and further questions for future research. First, it should be noted that the sex effects found for the Chinese sample are highly consistent with sex stereotypes in the Chinese culture, where females traditionally have been expected to be more neurotic and tender-minded than males. These sex effects in previous cooperative behaviors might differ across cultures, e.g., Cheng et al. (2015) and Baker et al. (2016) both used the computer-based cooperation task to study cooperative behavior, notably finding completely different results of significant IBS (Cheng et al., 2015; Baker et al., 2016). An intriguing possibility is that cultural differences between study populations drawn from predominantly Asian vs. Western societies lead to different patterns of inter-brain coherence during cooperation (Baker et al., 2016). In addition, our participants were concentrated among college students, which may present some kind of personality homogeneity. Previous studies have confirmed that individuals can present the heterogeneity, which may help to promote the expectation of cooperation (Li et al., 2019a,b). Therefore, whether the results of this study can be generalized to a wider range of people also needs further confirmation in future studies. Second, the fact that computer opponents are able to activate the network, albeit to a lesser extent than human opponents, suggests that this neural system can also be activated by reasoning about the unobservable states of non-human systems. However, we still suggest further research to consider human opponents as a new orientation. Finally, as the sample size was relatively small, further empirical testing is needed to confirm the present findings, especially regarding the sex effects.

CONCLUSION

The present study concludes with three main findings. First, HIR condition showed higher IBS values than LIR condition in the IFG, which might reveal a modulation effect of external environmental cue (i.e., incentive levels) in the inter-brain networks. Second, IBS in the IFG predicts the relationship between empathy/agreeableness and EOC behavior. This finding strongly complements the modulation effect of empathy on cooperative behavior and provides new neural indicators (i.e., IBS) and new content (i.e., EOC behavior) to the study of the relationship between personality and behavior. Third, there was a sex effect between team and individual EOC behavior in the DMPFC, and in the SE stage, the coherence value of the female dyads was significantly higher than the male dyads under the LIR condition in the rIFG. This sex effect thus provides a presumptive evidence supporting the evolutionary biological perspective that females are more sensitive to imperceptible changes in neurological levels as well as that, during economic social interaction, females' EOC behavior may depend on more social cognitive abilities. These results suggest that males and females may have different "representations systems" in the processing of EOC behavior and also indicate a pro-social effect in female dyads. Overall, this research on EOC behavior in the human-to-human interactions raises intriguing questions for future research.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Southeast University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

MiZ and MeZ designed the research and wrote the manuscript. MiZ and HJ performed the research. MiZ analyzed the data.

All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.542093/full#supplementary-material

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When Does Educational Level Diversity Foster Team Creativity? Exploring the Moderating Roles of Task and Personnel Variability

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This study explores how the variability of the work environment shapes the impact of educational level diversity on team creativity. By adopting an integrative framework—"status characteristics–information elaboration" model as a theoretical lens, we propose and examine the moderating roles of task and personnel variability in educational level diversity–team creativity relationship. Utilizing multiple survey data collected from 90 knowledge work teams, the empirical results indicate that educational level diversity is more conducive to team creativity when teams are confronted with more variable tasks and when teams experience less frequent personnel changes. The findings of this study provide valuable insight on the conditions under which team diversity's information potential is more likely to realize and contribute to a more context-based understanding of the relationship between diversity and creativity.

Keywords: team creativity, educational level diversity, task variability, personnel changes, moderating analysis

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INTRODUCTION

Confronted with turbulent circumstances, organizations become increasingly dependent on teams to carry out creative work to maintain the flexibility and sustained competitive advantages (Horwitz and Horwitz, 2007; Kearney et al., 2009; Hoever et al., 2012; Van Dijk et al., 2012; Van Veelen and Ufkes, 2019). Despite the recognition of the importance of team creativity, which is defined as the generation of novel and useful ideas regarding products, processes, and procedures (Amabile, 1996; Shin and Zhou, 2007), the conditions that foster team creativity require further investigation (Shalley et al., 2004; Shin and Zhou, 2007; Hoever et al., 2012). One of the most concerned and contentious issues is the creative impact of team demographic diversity (e.g., sex, educational level) (i.e., Milliken and Martins, 1996; Joshi, 2006; Bell et al., 2011; Guillaume et al., 2017).

In the past few decades, research on team demographic diversity–creativity relationship has not arrived at a consistent result. Some argue that demographic diversity may bring the risk of interpersonal conflicts, undermine team coordination, and hinder team creativity from the perspective of social categorization (Williams and O'Reilly, 1998; Dahlin et al., 2005; Van der Vegt et al., 2006; Joshi et al., 2011), whereas others argue that demographic diversity is thought to foster creativity by providing heterogeneous knowledge, experience, and perspectives from the perspective of information elaboration (Milliken and Martins, 1996; Nijstad and Paulus, 2003; Hülsheger et al., 2009; Bell et al., 2011; Curşeu et al., 2012; Van Dijk et al., 2012). Besides, from the perspective of status characteristics, demographic diversity is deemed to indicate the differences in

possession of socially valued assets or resources, referring to that employees with higher educational level or longer tenure easier make their voices heard, and such status characteristic differences may lead to the suppression of some team members' opinions and impede team creativity (Harrison and Klein, 2007; Bell et al., 2011).

As to reconcile the mixed results of the relationship between demographic diversity and team creativity, current research has moved away from investigating the main effect and shifted its focus on the context under which demographic diversity teams could realize their creative potential (i.e., Zhang, 2016; Guillaume et al., 2017; Lu et al., 2018). The present study builds on this trend and aims to identify the contingent factors between educational level diversity and team creativity by examining the moderating roles of task and personnel variability. We focus on educational level diversity primarily because it becomes one of the management challenges on how to make members with diversified educational levels play the synergy effect of teamwork under the contemporary trend where people have more discretion at education, such as junior college/vocational education and undergraduate and graduate (master or doctoral).

The present study extends the pieces of literature on diversity and creativity in several ways. First, in consistency with the latest conceptual framework proposed by Harrison and Klein (2007), this study takes the specific form of educational level diversity (separation and disparity) into consideration. By proposing an integrative theoretical framework—"status characteristics–information elaboration" model, this study offers a comprehensive rationale for understanding the relationship between educational level diversity and team creativity. Second, this study answers the call for context-based research in the field of diversity–creativity relationship by examining the moderating roles of task and personnel variability. Adopting the theoretical lens of the "status characteristics–information elaboration" model, this study is devoted to exploring the conditions under which the positive information synergy of educational level diversity would be realized, whereas the negative status-based problems would be avoided. Finally, by conducting multiple surveys in the field, the study addresses the current lack of empirical evidence on team creativity.

THEORY AND HYPOTHESES DEVELOPMENT

A Closer Look at Team Educational Level Diversity

Team diversity is generally defined as the distributional differences among team members with respect to a specific personal attribute (Jackson et al., 1995; Harrison and Klein, 2007). As suggested by the recent advanced theoretical framework, team diversity that involves most demographic characteristics (e.g., sex, age, or educational level) can be displayed as three distinctive patterns—separation, variety, and disparity (Harrison and Klein, 2007). The three manifestations of team diversity seem to be equivalent when each is minimized; with increasing diversity, they become more differentiated in shape, meaning, relevance to key theoretical perspectives, and possible consequences.

Separation diversity indicates differences in position or opinion among team members (Harrison and Klein, 2007). When focusing on separation, team diversity indicates the extent to which disagreement or opposition among team members is present. Maximum separation occurs when team members are equally split and at opposing end-points along the continuum of a concerned attribute. Based primarily on social categorization theory, the literature tends to propose that team separation diversity has a negative impact on team identification, cohesion, and cooperation.

Variety diversity indicates differences in kind or category of knowledge or experience among team members (Harrison and Klein, 2007). When variety is stressed, team diversity indicates the extent to which the team knowledge base is redundant. Maximum variety occurs when each member represents a distinctive category of the concerned attribute. Based primarily on information elaboration theory, the literature tends to propose that team variety diversity has a positive impact on access to a wider range of knowledge and cognitive resources.

Disparity diversity indicates differences in possession of socially valued assets or resources such as pay and status among team members (Harrison and Klein, 2007). When focusing on disparity, team diversity indicates the extent to which team members' viewpoints and opinions are treated unequally (Bell et al., 2011). The maximum disparity occurs when one team member dominates the others during task execution. Although disparity diversity has rarely been addressed in the field of team diversity, the differences in the proportion of valued resources such as pay and status among team members are likely to give rise to conformity, vicious competition, and information asymmetry (Harrison and Klein, 2007).

Research on Educational Level Diversity and Team Creativity

Most of the extant research on the relationship between educational level diversity and team creativity, which adopted the perspective of social categorization and/or information elaboration, stressed the separation, and/or variety diversity (e.g., Van der Vegt and Bunderson, 2005; Somech, 2006; Shin and Zhou, 2007; Cannella et al., 2008). Specifically, on the one hand, differences in educational level are considered as the basis of team separation or subdivision and are proposed—from the perspective of social categorization—to provoke interpersonal conflicts and cooperation dilemmas, which are detrimental to team creativity (e.g., Milliken et al., 2003; Shin and Zhou, 2007). On the other hand, differences in educational level are considered as an indicator of variety and non-redundancy of cognitive resources and are proposed—from the perspective of information elaboration—to provide intellectual support and optimized information processing, which are beneficial to team creativity (e.g., Ancona and Caldwell, 1992; Shin and Zhou, 2007). Unfortunately, however, differences in educational level have seldom been viewed from the form of disparity, which refers to the vertical distributional differences of the possession of

valued and desirable task-related resources among team members (Jackson et al., 1995; Harrison and Klein, 2007).

As suggested, the creative impact of educational level disparity diversity can be elaborated based on status characteristics theory (Bunderson, 2003; Harrison and Klein, 2007). The team status of a member is understood to depend on his/her performance expectations, which are based on his/her possessions and the extent to which these possessions are important for task completion and goal attainment (Berger et al., 1986; Bunderson, 2003). When an individual is expected to achieve higher performance, he/she will be given a more prominent role, and his/her opinions are likely to be widely acknowledged and deeply processed. Educational level is likely to influence performance expectations and team status (Berger et al., 1986; Bunderson, 2003; Van der Vegt et al., 2006). With increased educational level disparity diversity, the distribution of educational resources is more centralized, and the gap between members of "higher" and "lower" status is greater.

Based on status characteristics theory, it is assumed that educational level diversity, typically involving the unequal team status of members, negatively affects divergent thinking, in-depth communication, and knowledge use. On the one hand, members with higher team status are likely to shift their focus from accomplishing tasks to retaining their grip on influence and power (Klein et al., 2004), most likely by monopolizing critical task-related resources, dominating team processes, and imposing their viewpoints upon others. On the other hand, members with lower team status, whose perspectives are seldom taken into account, are likely to refrain from expressing divergent opinions and to submit to members with higher team status (Harrison and Klein, 2007).

In summary, the three connotations of team educational level diversity differ in their possible consequences consistent with the theoretical perspectives that are most relevant to them. Therefore, to further examine the complicated relationship between educational level diversity and team creativity, researchers should adopt a more integrative and comprehensive theoretical framework. Combining the trend that the research focus in the field of team diversity should be shifted to identifying critical contexts, under which team creativity is more likely to be facilitated or hindered, to provide greater theoretical and practical implications. The following section proposes and explicates hypotheses about the moderators intervening in the relationship between educational level diversity and team creativity.

Moderators in the Creative Impact of Team Educational Level Diversity

This study focuses on the separation and disparity form of educational level diversity. Although the existing literature has made great progress in understanding the moderators between diversity–creativity relationship (e.g., Shin and Zhou, 2007), few of them take the negative impact of diversity-related inequal status into consideration (Van Knippenberg and Schippers, 2007; Hoever et al., 2012). To address this gap, we propose the integrative "status characteristics–information elaboration" theoretical framework and hypothesize the moderating roles of task and personnel variability. **Figure 1** depicts the theoretical model.

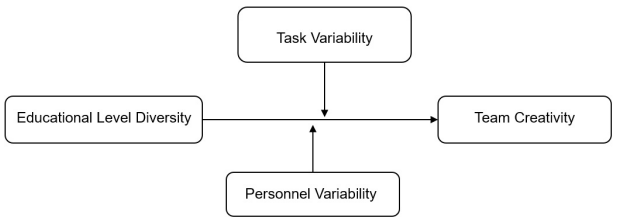

FIGURE 1 | Research model of the moderating roles of task and personnel variability between educational level diversity and team creativity.

Moderating Role of Task Variability

Task variability represents the extent to which a task is varied and variable (cf. Dewar et al., 1980; Diefendorff et al., 2006). Variable tasks are characterized as uncertain and complex and involve a much wider range of task-related knowledge, skills, and distinctive activities, whereas unvaried tasks are predictable, repetitive, and well defined, and they can be performed using standardized procedures (Diefendorff et al., 2006; Rico et al., 2008; Rousseau and Aube, 2010). In extant research, the extent to which team tasks are variable has been widely acknowledged as a significant impact factor for teamwork (Bowers et al., 2000; Diefendorff et al., 2006; Horwitz and Horwitz, 2007; Rico et al., 2008; Rousseau and Aube, 2010; Keller, 2012; Van Dijk et al., 2012).

The content and essence of a task determine the knowledge, skills, and capabilities required to perform it and are thought to interfere with the impact of educational level diversity on team creativity. Consistent with status characteristics theory, the difference among team members in the educational level is commonly regarded as a source of inequity of members' influences on team collective decisions and actions. Such inequity affects the sense-making process of less-educated team members and is considered to suppress their different voices and fresh ideas, which undermines team creativity. Invariable tasks, for which limited and well-defined knowledge and skills are required, are repetitively executed over time, and team members tend to get stuck in the mindset and be restrained in their fixed roles.

Furthermore, teams in charge of tasks lacking variability tend to develop and comply with sets of standard processes and procedures (Diefendorff et al., 2006). Such routine tasks blind team members to the utilization of divergent cognitive resources because they prefer to rely on simple cues, stereotypes, and standard procedures rather than exploring and processing more task-related information (Kearney et al., 2009; Petty et al., 2009). The inequity of members' influences on team collective decisions and actions will be strengthened during the repetitive execution of routine tasks. Therefore, when teams are confronted with unvaried tasks, the higher the level of team educational level diversity, the more team creativity is likely to suffer.

Conversely, when responding to variable tasks, teams tend to remain flexible instead of settling into a routine, which is likely to attach increasing significance to the potential of team educational level diversity for information elaboration. Teams need to develop a shared understanding of the new task and re-identify critical resources required for task completion. Accordingly, the expected performance contribution of each member in different tasks will be adjusted, which reduces the possibility for teams to form a fixed unequal social status and inequal treatment to members' opinion. Thus, task variability would weaken the negative impact of educational level diversity on team creativity by hindering the emergence and/or solidification of social hierarchy/inequal status within the team. Furthermore, variable tasks can motivate team members to engage in cognitive activities that affect the extent to which task-related information is explored and processed (Kearney et al., 2009), the tolerance of ambiguity, and team creativity (Cacioppo et al., 1996). Because variable tasks involve many exceptions, unexpected situations, possibilities, and alternatives and require a larger knowledge base and more in-depth discussions, team members are encouraged to share unique information, propose different perspectives, make fresh attempts to perform the task, and seek novel solutions (Petty et al., 2009). Therefore, when teams are confronted with variable tasks, team educational level diversity is more likely to be regarded as a cognitive conduit and a large information repository for team creativity. The higher the level of team educational level diversity, the more likely it is that team creativity will be induced. Therefore, we propose the following hypothesis.

Hypothesis H1: The relationship between team educational level diversity and team creativity is moderated by team task variability such that team educational level diversity is more positively related to team creativity when there is a higher level of task variability.

Moderating Role of Personnel Variability

Personnel change has become increasingly prevalent in managerial practice, aggravating the turbulence and fierceness of the competition. The extent to which personnel variability is present in teams is thought to provide crucial contextual influence on team creativity and calls for further understanding. In this study, we propose that team personnel variability moderates the relationship between team educational level diversity and team creativity. Specifically, in teams with a more frequent personnel change, team members are likely to attach great importance to the establishment and preservation of a relatively reliable and fixed mode at the expense of fresh attempts by trying to remain immune to the changes of team members (Madsen et al., 2003). This pattern seems to intensify the dominance of certain team members with higher team status while keeping members with lower team status from sharing their unique perspectives or proposing different opinions (Gruenfeld et al., 1996). Moreover, personnel variability is accompanied by changes in the quality and quantity of the team's knowledge base. Because team educational level diversity indicates the distinctiveness of the task-related resources possessed by each member, from the perspective of information elaboration, it is believed that when there is more team educational level diversity, team knowledge is less redundant, and team creativity will be more improved.

By contrast, in teams with a less frequent personnel change, the accumulation of collaboration provides more opportunities for team members to develop mutual understanding other than using an educational level as the main evidence for performance expectations. Also, the lower level of personnel variability may give full play to the positive synergy brought by educational level diversity (Horwitz and Horwitz, 2007). It has been suggested that differences in demographic characteristics make it easier for teams to arrive at a consensus on the distribution of the team's cognitive resources and to avoid cognitive redundancy and replicative efforts (Lewis et al., 2007; Wageman et al., 2012). Relevant research indicates that collective working experience enhances team identification, cohesiveness, trust, and the sense of belonging (Gruenfeld et al., 1996; Williams, 2001; Webber and Donahue, 2001; Van der Vegt et al., 2010), which are likely to undermine the negative impact of team educational level diversity. Based on the discussion earlier, we propose the following hypothesis.

Hypothesis H2: The relationship between team educational level diversity and team creativity is moderated by team personnel variability such that team educational level diversity is more positively related to team creativity when there is a lower level of personnel variability.

MATERIALS AND METHODS

Sample and Data Collection

Data were collected from 90 teams in 36 organizations in China that were engaged in the industries of manufacturing, real estate, finance, information technology, software development, telecommunications, energy, and consulting. All these teams were in charge of knowledge-based tasks, such as product development, providing solutions, architecture design, and customer service. Initially, we contacted the immediate superiors of these teams or the middle-rank managers of the companies, briefly introduced the purpose of the survey, and promised the exclusive use of data for research and feedback in return. After obtaining their permission, we asked for a coordinator's help in distributing and collecting questionnaires to ensure the efficiency of the process.

Of 122 invited teams, responses were received from 99 (81.1%). We filtered the data by omitting questionnaires with the same score for all items or more than half missing values and excluding teams that lacked data from team leaders and/or 50% or more of the members (see Rulke and Galaskiewicz, 2000; Bunderson, 2003). The final sample consisted of 373 valid individual cases from 90 teams (73.8%), including 17 R&D teams (18.9%), 25 marketing and sales teams (27.8%), 23 technical service teams (25.6%), and 25 teams with other functions (27.8%). Team sizes ranged from 3 to 13 members (mean = 6.18, *SD* = 2.80). The average team longevity is 39.7 months (*SD* = 30.3). The average age of the team members was 29.4 years (*SD* = 6.34), 60.5% of the team members were male, and 86.0% of the team members had earned a college diploma or above.

Measures

All measures were adapted from well-established measures published in top academic journals according to our research. We created Chinese versions of these measures by strictly following a translation-back translation procedure. Additionally, data were collected from multiple sources to minimize potential common method biases. Specifically, team educational level diversity was calculated based on team members' demographic data, team creativity was rated by team leaders, task variability was rated by team members, and team personnel variability was obtained from archival data.

Team Educational Level Diversity

Team educational level diversity was measured with the coefficient of variation indexes (standard deviation divided by the mean, Allison, 1978). Educational level was divided into five grades, from "1" for "high school or below" to "5" for "doctoral or above." The mean coefficient of variation of educational level across the sample of teams was 0.20 ($SD = 0.15$).

Team Creativity

Team creativity was measured by six items according to a scale developed by Neil and Michael (1998) and Chen (2006). Sample items included "Our team always expands new knowledge and skills related to the task" and "Our team always proposes original solutions." For each item, the leaders were asked to indicate the extent to which they agreed with the items on a five-point Likert scale ranging from 1 (absolutely disagree) to 5 (absolutely agree). The Cronbach's alpha for the scale was 0.89.

Task Variability

Task variability was measured by four items adapted from a scale developed by Robert et al. (1980) and reverse scored. Sample items included "Members of our team do the same job in the same way every day" and "Most jobs of our team are almost the same." For each item, team members were asked to indicate the extent to which they agreed with the items on a five-point Likert scale ranging from 1 (absolutely disagree) to 5 (absolutely agree). The Cronbach's alpha for the scale at the individual level was 0.83.

Personnel Variability

Personnel variability was calculated based on archival data using the formula of dividing the number of personnel change incidents during the last year by the team size (Arrow and McGrath, 1995). We selected a 1 year period for this study under the assumption that 1 year was sufficient for team personnel change and for new members to have observable effects on team outcomes (see Van der Vegt et al., 2010).

Control Variables

We controlled several variables to enhance the validity of the results. Consistent with relevant research, we controlled team type, size, longevity (the average team tenure of team members), and sex (the percentage of women in teams). Also, we also controlled the mean of team members' educational level to explore whether team educational level diversity explained team creativity after controlling for the impact of elevated levels of these continuous variables (Bell et al., 2011).

Level of Analysis

We examined within-group agreement (rwg) values based on uniform null distribution before aggregating task variability from the members' ratings to the team-level variable (James et al., 1984). The median of the rwg of task variability was 0.89, which was well above the conventionally acceptable rwg value of 0.70 (James et al., 1984). Additionally, we calculated the intraclass correlation coefficient ICC (1) and ICC (2). The means of ICC (1) and ICC (2) for task variability were 0.28 and 0.62, respectively. As shown, the indexes of ICC (1) were greater than 0.12 (James, 1982), and the indexes of ICC (2) were greater than 0.60 (Bliese, 2000). Accordingly, task variability was qualified for aggregation to the team level.

RESULTS

Table 1 presents the means, standard deviations, and correlations for the study variables. Consistent with most findings, team educational level diversity, and team creativity had a non-significant relationship ($r = -0.09$, $p > 0.1$).

We adopted hierarchical regression analyses to further examine the hypotheses. To minimize any potential threats of multicollinearity, we standardized predictor variables before calculating the cross-product terms (Aiken and West, 1991). We entered the control variables into Model 1 and added the independent variable and moderators into Model 2. The interaction terms were added into Model 3. The results are displayed in **Table 2**.

As shown in Model 2, no significant relation was found between team educational level diversity and team creativity. The moderating effects were examined in Model 3. As indicated, both team educational level diversity × task variability ($\beta = 0.44$, $P < 0.05$) and team educational level diversity × personnel variability ($\beta = -0.30$, $P < 0.05$) were significantly related to team creativity and explained a significant amount of variance ($\triangle R^2 = 0.09$, $\triangle F = 4.23$, $p < 0.05$).

Figures 2, **3** describe the patterns of the moderators' impact on the relationship between team educational level diversity and team creativity. As depicted in **Figure 2**, team educational level diversity is more positively related to team creativity when task variability was higher. The simple slope test further showed that at a high level of task variability, educational level diversity was positively and significantly related to team creativity ($\beta = 0.32$, $p < 0.01$); however, at a low level of task variability, the relationship between educational level and team creativity was not significant ($\beta = -0.11$, $p > 0.1$). Thus, Hypothesis 1 was supported. As depicted in **Figure 3**, team educational level diversity was more positively related to team creativity when team personnel variability was lower. The simple slope test further showed that at a low level of personnel variability, educational level diversity was positively and significantly related to team creativity ($\beta = 0.28$, $p < 0.05$); however, at a high level of personnel variability, the relationship between educational level and team creativity was not significant ($\beta = -0.07$, $p > 0.1$). Thus, Hypothesis 2 was supported.

TABLE 1 | Means, standard deviations, and correlations (n = 90).

Variables	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. R and D[a]	0.19	0.39														
2. Sales[a]	0.28	0.45	−0.30**													
3. Technical service[a]	0.26	0.44	−0.28**	−0.36***												
4. Other[a]	0.28	0.45	−0.30**	−0.39***	−0.36***											
5. Team size	6.18	2.80	−0.09	−0.01	0.12	−0.02										
6. Team longevity	39.69	30.33	−0.21*	−0.12	0.11	0.19*	0.24									
7. Gender[b]	0.37	0.33	−0.34**	0.29**	−0.17	0.17	0.08	−0.03								
8. Educational level	2.62	0.81	0.26*	−0.32**	0.17	−0.07	0.10	−0.07	−0.19*							
9. Age diversity	0.12	0.08	−0.30**	−0.02	−0.13	0.41***	0.04	0.32**	0.05	−0.34**						
10. Gender diversity	0.26	0.22	−0.16	0.04	−0.01	0.10	0.19	−0.02	0.30**	0.17	−0.02					
11. Tenure diversity	0.57	0.33	−0.26*	0.28*	0.02	−0.07	0.08	−0.00	0.17	0.09	0.19	0.06				
12. ELD	0.20	0.15	−0.14	0.04	−0.00	0.09	0.20*	0.16	0.02	−0.37***	0.43***	−0.11	0.20			
13. Team creativity	4.00	0.66	0.08	−0.01	−0.03	−0.04	−0.22*	−0.19*	−0.10	−0.01	−0.15	−0.04	−0.07	−0.09		
14. Task variability	1.50	0.58	0.23*	−0.15	0.15	−0.19*	0.07	−0.23*	−0.21*	0.48***	−0.23*	0.04	0.11	−0.13	0.05	
15. PV	0.94	0.91	−0.08	−0.10	0.33**	−0.15	−0.15	0.09	−0.06	0.08	−0.07	0.16	−0.13	−0.20	0.03	−0.12

[a]*Dummy variable, R&D = Research and development team, Other teams include human resource, finance, production, etc.* [b]*Dummy variable for gender, mean gender of each team is reported. ELD, educational level diversity; PV, personnel variability. *p < 0.05, **p < 0.01, ***p < 0.001.*

TABLE 2 | Summary of hierarchical regression analysis results (n = 90).

Variables	Team creativity		
	Model 1	Model 2	Model 3
Step 1: control variables			
RandD[a]	−0.01	−0.02	−0.05
Technical service[a]	−0.01	−0.01	0.01
Other[a]	0.04	0.05	0.05
Team size	−0.17	−0.17	−0.24
Team longevity	−0.12	−0.12	−0.13
Gender	−0.11	−0.11	−0.18
Educational level	−0.07	−0.09	0.00
Age diversity	−0.14	−0.15	−0.16
Gender diversity	0.03	0.03	0.06
Tenure diversity	−0.02	−0.03	0.03
Step 2: independent variable and moderators			
Educational level diversity		0.01	0.16
Task variability		0.04	0.06
Personnel variability		0.01	−0.16
Step 3: moderation			
ELD × task variability			0.30*
ELD × personnel variability			−0.27*
R^2	0.09	0.09	0.18
$\triangle R^2$	0.09	0.00	0.09
$\triangle F$	0.79	0.37	4.18*

*ELD, Educational level diversity, a dummy variable. Standardized regression coefficients are reported. *p < 0.05.*

DISCUSSION

In recent decades, scholars have embraced the advantages and avoided the impediments of diversity in teams. Considering the prominence of team creativity and the emergent call for more context-based research, we focused on the contextual boundaries in which team educational level diversity was more likely to be conducive to team creativity. As hypothesized, both the variability of task and personnel moderated the relationship between team educational level diversity and team creativity. Specifically, the empirical results indicated that when teams were confronted with more variable tasks or experienced a lower frequent personnel change, team educational level diversity was more likely to facilitate team creativity.

Theoretical and Practical Implications

Adopting a nuanced view, we paid particular attention to the conceptualization of team educational level diversity and advanced into the uncharted territory of team diversity research by taking into account the creative effect of team educational level disparity diversity. Although scholars have attached great significance to the potential of assembling members with different educational levels, the substance and pattern of these differences have seldom been examined. The most recent conceptual framework indicated that the ambiguity of the creative effect of team diversity was, to some extent, attributable to ignorance of the complexity of team diversity. In accordance with Harrison and Klein's (2007), we stressed and addressed the lack of understanding of the disparity pattern in team diversity. Moreover, integrating the disparity pattern of team educational level diversity, we explained the rationale for how educational level diversity affects team creativity in the light of social categorization theory, information elaboration theory, and status characteristics theory, which helped us to gain a much more comprehensive understanding of the creative impact of team educational diversity.

This study also contributed to the team creativity literature. Because creativity is important at the team level for the survival and development of organizations, there is a need for deeper understanding and empirical evidence on how diversity affects team creativity (e.g., Shin and Zhou, 2007). We conducted a

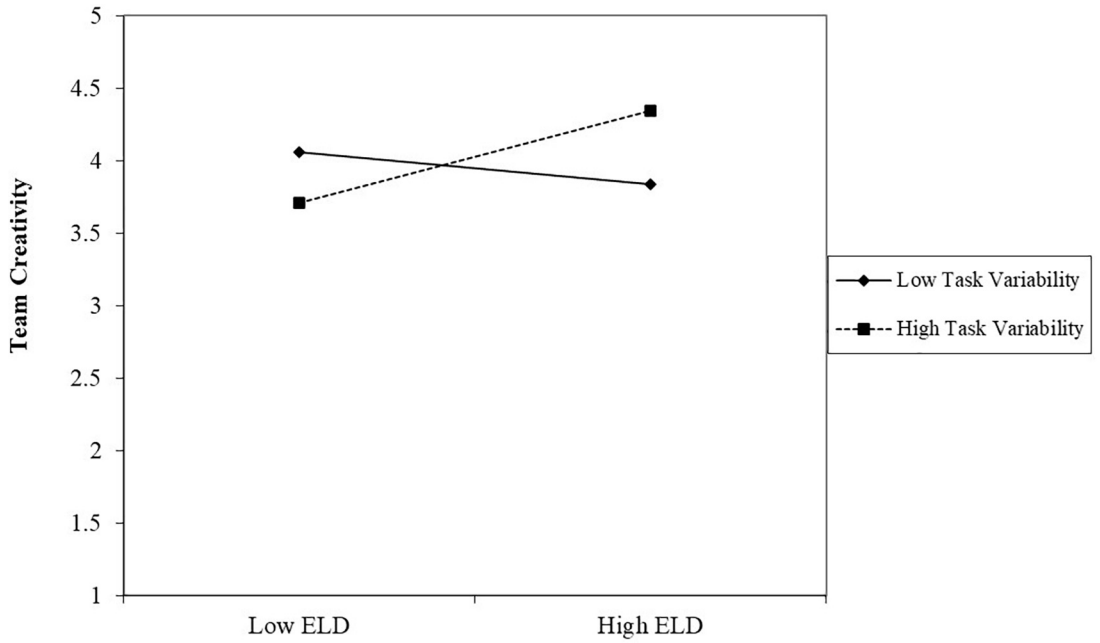

FIGURE 2 | The moderating role of task variability between educational level diversity and team creativity.

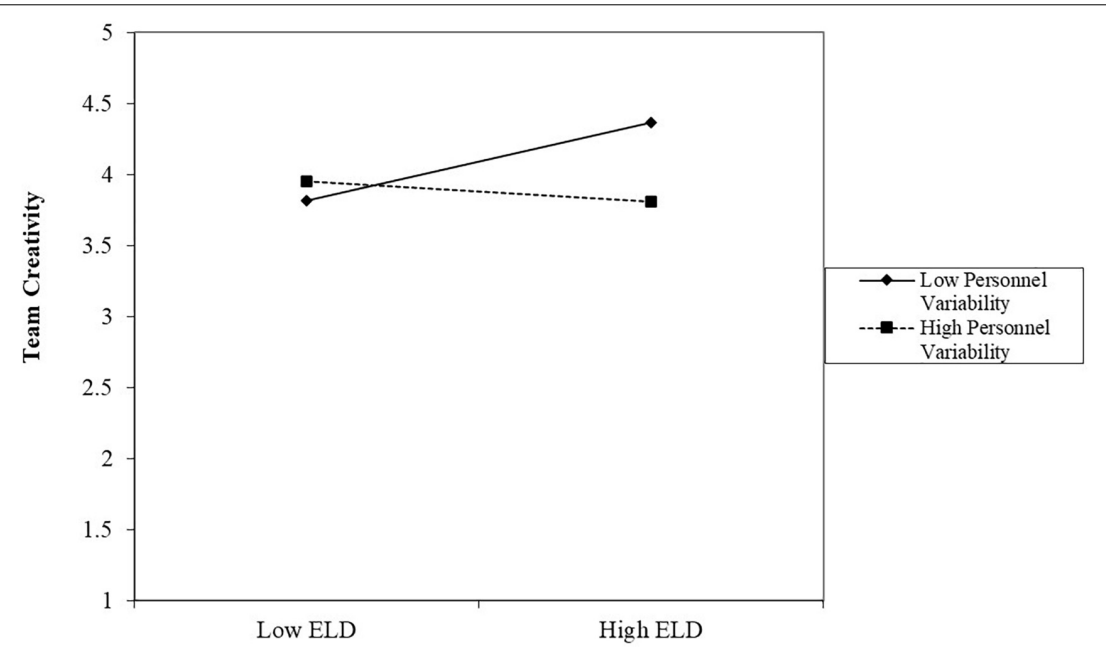

FIGURE 3 | The moderating role of personnel variability between educational level diversity and team creativity.

field study and collected data from multiple sources to achieve higher ecological validity, complementing the laboratory studies that are more frequently conducted in team creativity research; furthermore, we increased the reliability of the results by minimizing common method biases.

Finally, we answered the call for more context-based research in the field of diversity and creativity by theorizing and examining the moderating role of task and personnel variability (Jackson et al., 2003; Rico et al., 2008). The empirical results suggested that team educational level diversity may foster or impede team creativity, which was contingent on the extent to which tasks and personnel were changeable in teams. The coexistence of potential and threats in the differences of educational level among team members calls for greater research attention to clarify the

substance of diversity and to investigate the boundary conditions that encourage or inhibit the expected consequences.

This study has certain practical implications. On the one hand, the possible consequences of differences in demographic characteristics should be considered more comprehensively when building a team. To address increasingly fierce competition, it is common to adopt teams consisting of members with different demographic characteristics. However, in addition to the benefits of diverse information, there may be threats induced by social categorization and the inequity of task-related resources largely ignored. Therefore, it is more important to identify the forms of the distributional difference in team members' demographic characteristics, to estimate possible pros and cons, and to make real-time adjustments rather than focusing simply on superficial composition. On the other hand, the contextual condition should be considered when team diversity is adjusted. The results of this study indicate that less variable tasks and a higher team membership change tend to invoke a negative impact of team educational level diversity on team creativity, whereas variable tasks and a lower team membership change may have positive effects on team creativity.

Limitations and Directions for Future Research

Firstly, the cross-sectional design of this research failed to provide direct evidence of a causal relationship. Although our hypotheses were theoretically driven, future research should adopt a longitudinal or experimental design to provide more convincing evidence of causality. Secondly, no objective measures are taken of team creativity. Although it was prevalent to invite team leaders to evaluate team creativity (e.g., Shin and Zhou, 2007), future research should adopt an objective measurement for team creativity to improve the robustness of the results. Thirdly, we focused on the team level. As suggested, future research in the field of workplace demographic diversity should attempt to bridge the macro and micro theoretical domains (Joshi and Roh, 2009) with more concern for cross-level contextual variables and multilevel research. In addition, it would be more convictive to measure the particular shape of the educational level distribution for arguing that educational level is not a unitary construct as its effect on team creativity. Further, the follow-up studies are required to investigate other moderators and underlying mediators in the relationship between educational level diversity and team creativity.

CONCLUSION

This study focuses on the separation and disparity form of educational level. Based on an integrative "status characteristics–information elaboration" theoretical framework, we propose that task and personnel variability are important contextual factors that moderate the effect of educational level diversity on team creativity. When teams were confronted with more variable tasks or fewer personnel changes, educational level diversity was more likely to facilitate team creativity.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Research Ethics Board of the Academy of Neuroeconomics and Neuromanagement in Ningbo University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

WG takes charge of the conduct of the study, including the conception of the work, the collection, analysis and interpretation of data, as well as drafting and revising the manuscript. CG contributed to data collection, interpretation, and the revision of the manuscript. DW made substantial contributions to the conception of the work and the revision of the manuscript. All authors contributed to the article and approved the submitted version.

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An Analysis of the Generalizability and Stability of the Halo Effect During the COVID-19 Pandemic Outbreak

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The influence on the global evaluation of a person based on the perception of a single trait is a phenomenon widely investigated in social psychology. Widely regarded as *Halo effect*, this phenomenon has been studied for more than 100 years now, and findings such as the relationship between aesthetic perception and other personality traits—such as competence and trustworthiness—have since been uncovered. Trustworthiness plays an especially crucial role in individuals' social interactions. Despite the large body of literature published on the Halo effect, and especially on the relationship between aesthetic appearance and perceived trustworthiness, little is known about the overall generalizability of the effect, as almost all of the studies have been conducted on adult participants from Western countries. Moreover, little is known about the stability of the effect over time, in the event of major destabilization, such as the outbreak of a pandemic. In this work, the cross-cultural generalizability of the *Halo effect* is investigated before and during the first few months of the COVID-19 pandemic. An analysis of the generalizability and stability over time of the *Halo effect* is presented. Participants ($N = 380$, $N = 145$ Asians, $N = 235$ Caucasians) have been asked to rate the aesthetic appearance and perceived trustworthiness of a set of human faces of different ages, gender, and ethnicity. Result of our analysis demonstrated that the *Halo effect* (Aesthetic $\times$ trustworthiness) is influenced by the age of presented faces, but not by their gender or ethnicity. Moreover, our results show that the strength of the effect can be affected by external events and that the volatility is higher for adults' than children's faces.

Keywords: halo effect, aesthetics, trustworthiness, SARS-nCoV-2, ethnicity

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1. INTRODUCTION

The *Halo effect* (HE) is a cognitive bias in impression formation whereby the general evaluation of individuals' attributes is based on the evaluation of a single attribute (Nisbett and Wilson, 1977). When applied to aesthetic appearance, the HE is observed when the physical appearance is used as a basis for the evaluations of other attributes that are unrelated to appearance whatsoever. For example, a stranger who looks good is also perceived as intelligent or smart, even though intelligence and smarts are unrelated to physical attractiveness (Todorov et al., 2009). As a subclass of the confirmation bias in impression formation (Nickerson, 1998), the HE is known to be intuitive, pervasive, and constant (Cooper, 1981; Feldman, 1986; Kozlowski et al., 1986; Feeley, 2002). The HE is a widely investigated psychological phenomena, with an impact on different

academic fields such as social psychology, computer science, and empirical aesthetics (Hartmann et al., 2008; Todorov et al., 2009; Tuch et al., 2012; Ferrari et al., 2017).

1.1. Aesthetics and Trustworthiness

The term "Halo Effect" was first proposed by Thorndike (1920) to describe the radiating effects of a single attribute on the evaluations of other attributes. The term resonates with paintings from the medieval period, in which saints were often crowned with a glowing circle around their heads, representing their general reverence or goodness. Empirically, the HE has been observed in numerous domains of impression formation. Early demonstrations of the effect (e.g., Asch, 1946), for instance, have shown that central attributes, such as social warmth or physical appearance, have predictable and radiating effects on the inferences of other attributes. Compared to an unattractive person, an attractive person is often assumed to be happier, more competent at work, more successful in marriage, even though none of these inferences are supported by evidence (Dion et al., 1972). Consistent with this work, other studies have demonstrated the HE of physical appearance in a host of social domains, from intellect (Landy and Sigall, 1974) and personality (Little et al., 2006) all the way to moral deservingness (Dion, 1972; Forgas et al., 1983), integrity (Dion, 1972), and many more (see Eagly et al., 1991, for a review).

Together, these results cast light on the associative nature of impression formation. That is, inferences about others are generally guided by the implicit rule that whatever good (e.g., beautiful) goes with the good (e.g., generous), and whatever bad (e.g., unattractive) goes with the bad (e.g., unintelligent). Such a rule, compatible with the Gestalt principle of coherence (Thagard, 2000), is regarded as a cognitive explanation for the HE. In the next paragraphs, we focus on how appearance may affect the perception of trustworthiness.

The impact of aesthetic appearance on perceived trustworthiness, also known as HE aesthetics × trustworthiness (Todorov et al., 2009), has been studied since the early years of the twentieth century. Unlike aesthetic appearance, trustworthiness is a global or "umbrella" trait that is fundamental to social perception (Fiske et al., 2007), with diverse implications in numerous life domains, such as in assessing another person's good or ill intentions.

Other works have replicated the impact of aesthetic appearance on perceived trustworthiness, with more aesthetically/physically attractive individuals being perceived as more trustworthy. For example, in a study conducted by Carter (1978) on the appearance of counselors—a replication of a previous study conducted by Cash et al. (1975)—revealed that attractive counselors are also perceived as more intelligent, warm, competent, and trustworthy. The strength of the effect was further confirmed in a review (Eagly et al., 1991) where aesthetic attractiveness was found to be positively linked with perceived social competence across 76 studies.

1.2. But Is Attractive Always Trustworthy?

Despite the large body of literature on the relationship between aesthetic appearance and trustworthiness, several questions remain unanswered. Almost all of the available literature focused, in fact, on adult individuals sampled from the WEIRD population, rendering generalizability an issue (Henrich et al., 2010; Jones, 2010). Moreover, even though some studies have been conducted on children's faces, demonstrating that the effect exists in children (Dion et al., 1972), there are limited comparisons on the impact of adults vs. children targets. As children's faces are known to be special stimuli that automatically capture adults' visual attention and elicit parental care (Brosch et al., 2007; Proverbio and De Gabriele, 2019; Venturoso et al., 2019), the HE may be present with different strengths between adult and child faces. Not only children's faces, but also adults' faces with facial traits that resemble the stereotypical traits of children, such as big round eyes, have been shown to influence adult viewers' estimations such that baby-faced adults are perceived as more trustworthy, warm, and innocent (see Zebrowitz, 1997, for a review). Moreover, repeated exposure to the same face has been reported to influence viewers' judgments of others' traits and skills, such as in the judgment of politicians' competence (Zajonc, 2001; Verhulst et al., 2010).

Finally, controversial results have been found for what concerns the importance of the rated individuals' gender. Significant differences between the scores given to males and females have been found in the works of Carter (1978), but not in others (Wetzel et al., 1981). One possibility for this is that in Carter (1978), there was an additional stereotype playing a part in the interaction participant gender × counselor gender), which is in people's mental representation of the stereotypical counselor (Chambers, 1983). To overcome the limitations of previous studies, this study aims to verify how the (a) ethnicity (ingroup vs. outgroup), (b) age (adult vs. baby), (c) gender (male vs. female), and (d) aesthetic attractiveness combine in shaping trust perception. More specifically, in this work, we investigate the aesthetics and trustworthiness perception of Asians and White/Caucasians adults raters of both adults' and children's faces, both males and females, of Asians and Caucasians ethnicities.

The data collection stage of the project, with the methods described in section 2.2, started in August 2019 and continued through April 2020. The data collection phase overlapped with the COVID-19 pandemic outbreak. Serendipitously, the data collected for this project allowed us to investigate the stability of the HE over time over time. One additional hypothesis—H_2—was therefore added to study such effects.

1.3. Aim and Hypothesis

We formulated two hypotheses. The first hypothesis, analytic plan, and method were pre-registered on the Open Science Framework; the second hypothesis was formulated after beginning the data collection. The complete analytic plan is reported in section 2.3.

H_1: *"Aesthetic attractiveness is positively correlated with perceived trust (HE). We predict the age of presented face to have an effect on the strength of the relationship, with the strength of the correlation higher for adults than for children's targets, but not the ethnicity or the gender of presented face."*

Rationale: Children's faces elicit parental care regardless of kinship and hence, capture greater attention compared to adults faces (Brosch et al., 2007; Glocker et al., 2009; Parsons et al., 2011; Venturoso et al., 2019). Additionally, a recent study conducted by Collova et al. (2019)—based on a two-dimensional model (trustworthiness and dominance) from Oosterhof and Todorov (2008)—investigated whether children's faces elicit the same signal threat responses to adults' faces. Results of Collova's studies revealed that adults rate children's faces on different dimensions to adults' faces. More specifically, when rating children's faces, the evaluation is not based on trustworthiness. This suggests that evaluation of children's faces are not judged on their perception of trustworthiness, regardless of how aesthetically attractive they are. If so, one should expect the relationship between aesthetic appearance and trustworthiness to be stronger for adults' ratings of adults' faces as compared to children's faces. Therefore, we can expect the relationship between aesthetic appearance and trustworthiness to be stronger for adults' ratings of adults', as compared to adults' ratings of children's faces. From prior work, we know that gender (Wetzel et al., 1981) and ethnicity (Xu et al., 2012) do not seem to moderate the HE. But for the sake of completion, we decided to investigate these two demographic variables, with the expectation that neither gender nor ethnicity will have a significant impact on our observed results. In line with previous studies, we do not expect to find a significant impact of gender on the strength of the effect. With regard to ethnicity, differences may be present in the aesthetic ratings given to individuals of the ingroup or of the outgroup. However, as the implicit judgment of trustworthiness is based on the elaboration of facial cues that occur faster than the elaboration of ethnicity-specific traits (e.g., shape of the eyes; Engell et al., 2007), we do not expect any differences between the strength of the effect for ingroup and outgroup are expected.

H_2: *"When individuals are asked to rate the aesthetic and trustworthiness of others' faces, we expect to see changes in the variability of the ratings after the diffusion of news about COVID-19 in trustworthiness but not aesthetic judgments toward adults but not children's faces."*

Rationale: Research has established that Asian and Caucasian faces are perceived as distinct categories (Zhou et al., 2020). In a study conducted by Xu et al. (2012), it was reported that when making inferences about the trustworthiness of others from their aesthetic appearance, Chinese and Caucasians adopt the same strategies. However, Koopmans and Veit (2014) found that negative inter-ethnic contact can cause reduced trust toward members of the outgroup. In light of the COVID-19 pandemic global threat, following the diffusion of news about the spreading of the novel coronavirus in China, and with politicians targeting a specific ethnic group (Zheng et al., 2020), we can expect the situation to bias non-Asians against Asians, hence reducing Caucasians' estimation of trustworthiness, but not of aesthetics, toward Asian adults' faces. Previous research work by Fincher et al. (2008) highlighted that regions with a stronger history of contagious diseases are more likely to adopt collectivistic behaviors, including outgroup hostilities. It is therefore possible that, with the subsequent outbreak in Western countries, together with the adoption of specific measures to counter the diffusion of the virus in Eastern countries, collectivist beliefs brought about a reduction in the perceived trustworthiness, but not aesthetics, of Caucasians as evaluated by Asians. Such findings will suggest that salient threats of contagion, such as during the COVID-19 pandemic, may elicit the tendency to prefer interactions with familiar ingroups and reject unfamiliar outgroups. This tendency, given its strong evolutionary undertone, should be present in most people regardless of their culture. Account for this assumption, one should expect a global reduction of trust in the perception of adult faces, regardless of the cultural backgrounds of these adult faces. Such global reduction, however, should not be observed in the aesthetic perception, which unassociated with the threat of contagion. Taken together, these hypotheses suggest that we should see a generalized reduction of trust, but not aesthetics, toward both Asians and Caucasians adults' faces. For evaluation of children's faces, a different situation is expected. In an event-related potential (ERP) study conducted by Proverbio and De Gabriele (2019), it is reported that the other-race effect does not apply to infants' faces, supporting the specificity of the age of a face over its ethnicity for young faces. Differences in adults' perception of adults' and children's faces in other-race effects studies were also reported by Kuefner et al. (2008), in a series of three experimental studies. These findings suggest that the salience of infants' and children's faces should limit the impact of race on the estimation of other traits. Building on the work from Collova et al. (2019) reported above (H_1), we can expect an early evaluation of infants' faces not to have an influence on perceived trustworthiness. Taken together, findings on the specificity of infants' and children's faces suggest that the age dimension plays a prominent role, more than the possible perceived threat dimension, in the evaluation of children's faces. It is therefore possible that, when presented with faces of children, adults' trustworthiness judgments are less likely to be influenced by the aesthetic traits of a child's face, as compared to when they are rating an adult's face. From a biological point of view, this behavior would reflect mammals', and especially humans', altruistic responses toward infants (Preston, 2013). Consequently, we do not expect any difference in the judgment of both the aesthetic and trustworthiness of children's faces before and during the initial stages of the COVID-19 pandemic outbreak.

2. METHODS

2.1. Participants

The study was approved by the Internal Review Board of Nanyang Technological University (PSY-IRB-2019-008 and IRB-2019-10-019) and conducted according to the declaration of Helsinki. Informed consent was obtained from all the participants before the study. Participants ($N = 380$, M age $= 25.0 \pm 8.49$) voluntarily participated and were recruited through the Nanyang Technological University's School of Social Sciences Research Participation System or online through different social media platforms , including Facebook, Twitter, and the Subreddit community "samplesize," with no geographical constraints. These social media and communities were selected in order to ensure our Caucasian sample would be composed of participants

TABLE 1 | Participants' demographic information.

Ethnicity	Gender	*N*	Age
Asian	Male	75	22.5 ± 1.83
	Female	70	21.0 ± 3.06
Caucasian	Male	80	29.0 ± 11.81
	Female	155	26.0 ± 8.99

from different geographical areas, and especially North America and Europe. The gender and ethnicity of participants are reported in **Table 1**.

2.2. Study Design

2.2.1. Stimuli

Participants were presented with 64 faces of two different age groups (32 adults, 32 children), genders (32 males, females), and ethnicities (Asians, Caucasians). This structure allowed for the presentation of eight faces per combination of age, gender, and ethnicity (e.g., 8 adult Asian male faces). Front-facing images of faces ($N = 64$) were selected from the FFHQ Dataset (Karras et al., 2019), a dataset containing 70,000 high-quality (1,024×1,024) images published on Flickr2, an online photo management, and sharing tool, under different creative commons and public domain licenses (Creative Commons BY 2.0, Creative Commons BY-NC 2.0, Public Domain Mark 1.0, Public Domain CC0 1.0, or U.S. Government Works license). The dataset itself is released under the Creative Commons BY-NC-SA 4.0 license by NVIDIA Corporation and has been successfully used in previous publications (Karras et al., 2019; Kynkäänniemi et al., 2019; Wang et al., 2019; Zhao et al., 2020). Stimuli selection was conducted in such a way to create groups of eight ($N = 8$) faces for each possible combination of age, gender, and ethnicity. While values of aesthetics pleasantness were not available in the source dataset, images were selected with the aim to cover all the possible spectrum of values for aesthetics for each combination of age, gender, and ethnicity. More specifically, for each combination, four ($N = 4$) images were selected among those we expected would have obtained low (< 50) values of aesthetics, and four ($N = 4$) we expected would have been rated high (> 50) in aesthetics. The manipulation successfully worked, as values that covered the whole spectrum of possible ratings were obtained, and enough variance was achieved for the set of faces in both aesthetics and trustworthiness ratings, of which we expected four images to receive lower ratings in aesthetics and four to receive higher ratings in aesthetics. Selected faces were presented in random order, with no time constraints.

2.2.2. Procedure

After having signed the informed consent, participants were instructed about the scope and procedure of the experiment, as well as the taxonomy employed in the study. Participants rated each face for aesthetic pleasantness (*"How much do you like this person?"*) and trustworthiness (*"How much do you trust this person?"*) on a 100-point sliding scale, anchored from 1 being "not at all" not to 100 = "extremely." The effectiveness of the first question at measuring aesthetic pleasantness has been verified comparing our results with previous works that focused on the relationship between liking and trustworthiness. More details are reported in section 4.

2.3. Analytic Plan

The analytic plan was pre-registered on the Open Science Framework. Additional information can be found online on the Open Science Framework (https://osf.io/5cge3). A power analysis was conducted to estimate the number of participants required for this study (H_1). Given that previous works have found the effect size for the HE of human faces to be of medium strength, to take into account a possible bias in published works (Collaboration, 2015; Camerer et al., 2018), we assumed a very weak effect size to estimate the required number of participants. Assuming six groups (children/adult, male/female, Asian/Caucasian), a very weak effect size (Cohen's d = 0.1), and to achieve a power of 0.95 at a 0.05 alpha value, a power analysis conducted in G*Power (Faul et al., 2007, 2009) revealed that $N = 330$ participants are required to perform an analysis of variance. The strength of the HE is measured as the Pearson's correlation between aesthetic and trustworthiness ratings. To test H_1, a 2×2×2 analysis of variance was employed to control for the existence of significant effects of gender, age, and ethnicity on the strength of the HE, measured as the Persons' correlation between aesthetics and trustworthiness judgments. A *z*-test is employed as a *post-hoc* test to test whether the HE is stronger for adults than children faces. Additionally, a confirmatory analysis is conducted by means of a multiple linear regression analysis.

For what concerns the second hypothesis (H_2), four Levene's tests for equality of variance have been conducted on aesthetics and trustworthiness, comparing the variance of data collected before and after the diffusion of news about the novel coronavirus, once for adults' faces and one for children's faces. As a threshold, we used February 1, 2020, which is, according to *Google Trend*2, the moment in which people started to show interest toward the SARS-CoV-2. In order for H_2 to be verified, we expected significant differences in the variance of trustworthiness ratings toward adults' faces before and after our threshold date, but not for adults' faces aesthetics ratings, nor for both aesthetics and trustworthiness ratings toward children's faces. To take into account the multiple numbers of tests conducted, a correction for multiple tests using the Benjamini–Hochberg procedure, with a false discovery rate of 0.10, is employed.

3. RESULTS

3.1. Effect of Ethnicity, Age, and Gender on the Strength of the Halo Effect

To evaluate the effects of ethnicity, age, and gender on the strength of the HE, measured as the Pearson's correlation between aesthetics (mean = 55.97 ± 19.81) and trustworthiness (mean = 53.83 ± 21.82), an analysis of variance has been conducted. Results of the analysis of variance revealed only a main effect of age (F-value = 9.753, p-value = 0.00194, η_p^2=0.03,

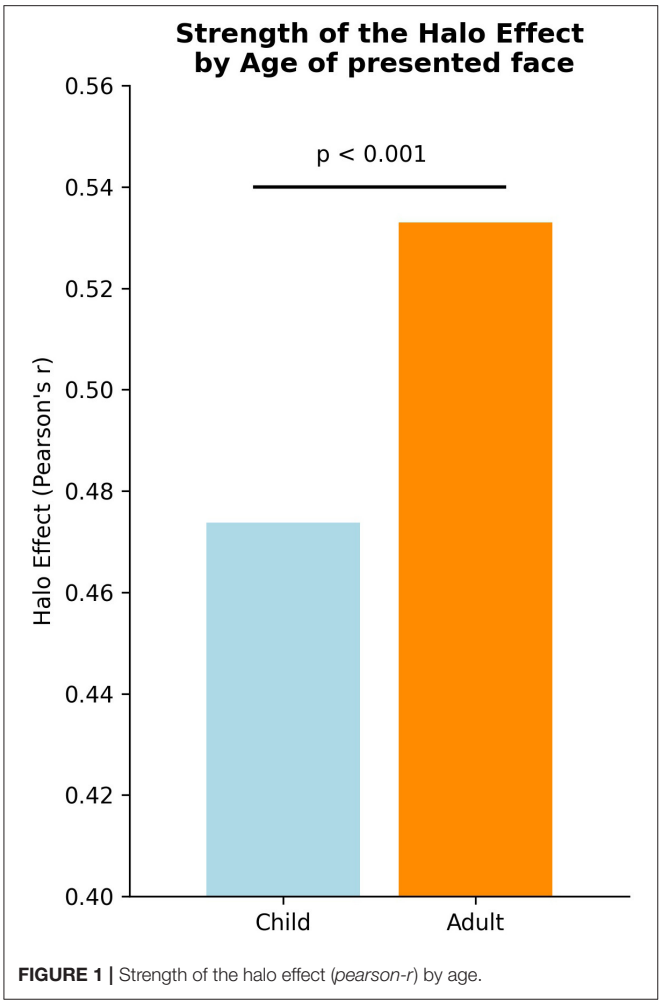

FIGURE 1 | Strength of the halo effect (*pearson-r*) by age.

Effect size f = 0.18, correlation among repeated measures = 0.503, achieved power = 1.0) but no main effect of gender or ethnicity, as well as no significant effects of the interaction between age and gender, or gender and ethnicity on the strength of the HE (aesthetics × trustworthiness). A significant interaction between face's age and ethnicity (ingroup vs. outgroup) is highlighted (F-value = 6.31, p-value = 0.0124), such that the differences in strength of the HE between Ingroup's Adults and Children faces (t-value = 3.98, uncorrected p-value= $7.11 \cdot 10^{-5}$) are bigger than the differences between Outgroup's Adults and Children faces (t-value = 1.22, uncorrected p-value = 0.221). This may however be caused by the diffusion of news about the COVID-19 pandemic outbreak. In fact, by repeating the analysis only on a subset of data collected before the initial diffusion of information about the novel coronavirus (N = 179), the interaction between ethnicity (ingroup or outgroup) and age of presented faces is not significant (F-value = 2.465, uncorrected p-value = 0.118).

These results suggest that the strength of the relationship between aesthetics and trustworthiness (Pearson's r = 0.676, p = < 0.001) are influenced by the age of presented faces, which is whether it is a child or an adult face but not by its gender or ethnicity. Taken together, the findings suggest that, at a general level, when adult raters make inferences about others' aesthetic and trustworthiness, they do not rate people of different gender or ethnicity differently, but they adopt different strategies for adults and children.

More specifically, the strength of the relationship between aesthetics and trustworthiness is significantly higher (z-test t = 3.626, p-value = 0.000287, **Figures 1**, **2**) for adult (M = 0.53 ± 0.41) than for children faces (M = 0.47 ± 0.46). These results indicate that adults are more likely to estimate the trustworthiness of other adults from their aesthetic appearance, while the estimation is less consistent when it comes to predicting the trustworthiness of children from their appearance.

Additionally, the strength of the relationship between the two variables has been further confirmed using a multiple linear regression analysis, with the formula reported in Equation (1). Results are reported in **Table 2**.

$$Trustw. = Int. + Aesthetics \times X_1 + Age \times X_2 + Gender \times X_3 + Ethnicity \times X_4 \quad (1)$$

A subsequent exploratory analysis revealed that the effect is significantly stronger for Asian participants, as compared to Caucasian participants (t = 13.2, uncorrected p-value = $9.68 \cdot 10^{-39}$). Further exploring the difference between Asian and Caucasian participants, both groups showed no significant differences in the *HE* elicited by younger faces of their same ingroup and outgroup (Asian participants: $t = -0.67$, uncorrected p-value = 0.503; Caucasian participants: $t = -0.935$, uncorrected p-value = 0.351). Focusing on the behavior of a single ethnic group (e.g., Asians participants), no differences have been found on the correlation of aesthetics and trustworthiness ratings of Asian (ingroup) and Caucasian (outgroup) faces (t = −1.551, uncorrected p-value = 0.122). On the other hand, the strength of the *HE* —measured as the correlation between aesthetics and trustworthiness ratings—is significantly higher for ingroup (Caucasian) as compared to outgroup (Asian) faces (t = 4.026, uncorrected p-value = $6.697 \cdot 10^{-05}$).

3.2. Association of SARS-CoV-2 on the Strength of the Halo Effect Over Time

Four (N = 4) Levene's tests for equality of variance have been employed to compare the variance of data (aesthetics and trustworthiness) collected before and after the initial diffusion of news about the novel coronavirus (H_2). The Benjamini–Hochberg procedure, with a false discovery rate of 0.10, is employed to take into account the number of performed tests. Results of the comparison between the variability in aesthetics and trustworthiness judgments toward both adults' and children's faces are reported in **Table 3**. Results (q-values) highlight significant changes in the variability of trustworthiness ratings toward adults' faces before and after the beginning of the COVID-19 pandemic outbreak, but not in aesthetics ratings given to adults' faces, nor to aesthetics or trustworthiness ratings given to children's faces.

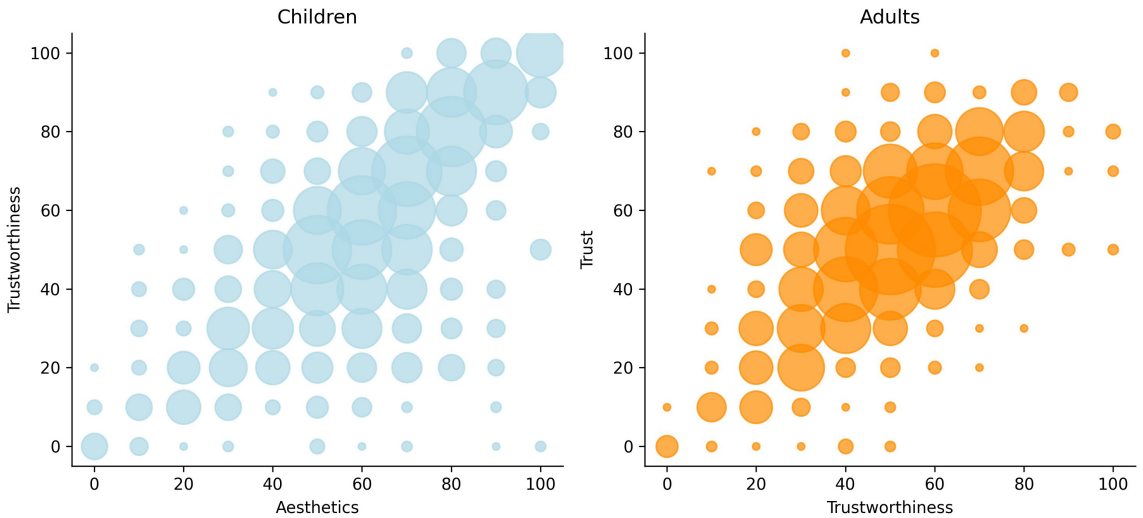

FIGURE 2 | Distribution of aesthetics and trustworthiness judgments by age.

TABLE 2 | Results of the multiple linear regression used to investigate the strength of the HE and the influence of age, gender, ethnicity, and aesthetic on trustworthiness.

	Coeff.	std. err	*t*	*P* > |t|	C.I.
Intercept	7.4930	1.007	7.445	0.000*	[5.519, 9.467]
Aesthetic	0.7797	0.014	55.726	0.000*	[0.752, 0.807]
Age	5.1196	0.554	9.243	0.000*	[4.034, 6.206]
Gender	0.4762	0.534	0.839	0.372	[−0.570, 1.522]
Ethnicity	−0.2078	0.533	−0.390	0.697	[−1.253, 0.838]

*$P < 0.001$.

TABLE 3 | Results of Levene's test of variance for aesthetics and trustworthiness judgments toward adults' and children' faces (*q*-values are evaluated using the Benjamini–Hochberg procedure at a 0.10 false discovery rate).

Age	Variable	Statistic	Uncorrected *p*-value	*q*-value
Adult	Aesthetics	4.633	0.034	0.05
	Trustworthiness	5.557	0.021	0.025
Children	Aesthetics	2.077	0.105	0.1
	Trustworthiness	3.861	0.053	0.075

4. DISCUSSION

Based on previous works within the field of the *HE*, we hypothesized that the impact of perceived aesthetic on trustworthiness judgments would depend on the age of presented faces, but not on their gender or ethnicity (H_1). Results of the analysis of variance show the main effect of the age of presented faces but not of gender or ethnicity, nor of any interaction effect between gender and ethnicity, confirming H_1. Moreover, our *post-hoc* *z*-test confirmed that the relationship between aesthetics and trustworthiness is stronger for adults' as compared to children's faces. In light of the results here presented, our analysis supports the specificity of children's faces. In fact, only the age of the presented faces but not the gender or age influenced the strength of the HE in our sample, measured as the Pearson correlation between individuals' aesthetic appearance and perceived trustworthiness. As reported in previous works on the Baby Schema effect (Venturoso et al., 2019), younger faces elicit specific responses in adult viewers. A possible explanation for this may be drawn from the evolutionary perspective. In fact, the cure of the offspring plays a central role in the survival of the species, and therefore adult individuals may be more prone to trust a younger individual even though the perceived aesthetic appearance is low. On the other hand, when looking at adult faces, the evaluation of someone's trustworthiness is largely based on made on the basis of the appearance.

Our exploratory analysis further confirmed the specificity of children's faces. In fact, both Caucasian and Asian participants revealed no significant differences in the strength of the *HE* when exposed to either children of their same ingroup or of their outgroup. While the same can be said for Asian adults looking at Asian and Caucasian adult faces, this does not hold true for for the Caucasians in our pool of participants, who indeed showed significant differences in the strength of the *HE* when exposed to faces of other Caucasians (higher Halo) as compared to adult Asians (lower Halo). This confirms previously published results on both the specificity of children faces, and significant differences in adults' physiological activation (Esposito et al., 2014). While this goes beyond the initial plan of this work and has been in fact not treated as hypothesis confirmation but as exploratory analysis, the general findings here reported about the *HE* are in line with previous works that investigated cross-cultural differences across Asians and Caucasians with different methodologies. Future work should

investigate significant differences between the strength of the Halo in Asian and Caucasian participants by properly defining one or more hypotheses and by recruiting an adequate number of participants to verify novel hypotheses with adequate power.

On the subject of the stability of the HE over time (H_2), the analysis of the variance of data collected before and after the diffusion of news about the novel coronavirus (section 3.2), revealed that adults' faces trustworthiness ratings, but not aesthetics ratings, significantly differ in the data collected before and after the diffusion of news about the novel coronavirus. Differently, no changes are found in the aesthetics and trustworthiness judgments of children's faces. These results are in line with our predictions on the specificity of children's faces. While our results confirm the possibility of modulating the strength of the HE, the current dataset does not allow the study of the qualitative impact of an external event, nor we can claim that changes in the stability are caused exclusively by the current pandemic and public policies. Future studies should address this problem by empirically presenting the external events, using a priming procedure, and measuring the impact over time with a longitudinal and experimental approach.

Despite the strength of the results here presented, there are several limitations worth highlighting. As mentioned earlier, the data collection stage started before and continued during the novel coronavirus pandemic outbreak. To reiterate, significant differences were found in the trustworthiness ratings given to adults faces before and during the pandemic outbreak. Therefore, while our first hypothesis (H_1) has been empirically verified accordingly to our preregistered plan, we cannot rule out the possibility that the overall world's situation played an indeterminate role in shaping our results, nor that events other than the COVID-19 pandemic outbreak influenced our results. Future works should investigate the stability of the effect under a controlled condition, such as by using a prime. Moreover, while we targeted Asian and Caucasian participants, we have not investigated the influence of participants' ethnicity at a more specific level (e.g., Chinese, Japanese, and Korean). Future studies should focus on a single ethnic group to verify the consistency and generalizability of the results here presented. Additionally, while participants were informed of the scope of the experiment, including the fact that we were specifically interested in aesthetic appearance, participants whose first language is not English may not have a specific counterpart for this concept. Future works should investigate participants' behavior using questions posed in their native language. An additional note has to be placed on the terminology employed in this study. A possible critique is that the experimental setup does not allow to measure aesthetic pleasantness, but liking. While this is a valid critique, participants were informed of the scope of the experiment before enrolling and at the beginning of the experiment. Moreover, our results differ significantly from other works that investigate the relationship between liking and trustworthiness using a similar paradigm [e.g., Todorov et al., 2009, comparison with Study 3 ($N = 83$, $\rho = 0.89$) z-value $= 4.816$, p-value $= 0.0002$], with the same direction (the strength of the relationship between liking and trustworthiness is higher than the correlation between aesthetic appearance and trustworthiness) reported in other works that compared both the aesthetic appearance and liking with trustworthiness (e.g., Ramos et al., 2016, see **Tables 1**, **2**).

5. CONCLUSION

In this work, we investigated the generalizability and stability over time of the *HE* (esthetic × trustworthiness). Our results show that the strength of the correlation between the perceived aesthetic and trustworthiness of strangers' faces is affected by the age of presented faces, but not by their ethnicity or gender. These results support the body of literature on the specificity of children faces. Moreover, this research serve to add to the limited amount of works that investigated the consistency of the *HE* elicited by aesthetics and trustworthiness across different cultures, and especially in Asian and Caucasian individuals. Additionally, our results show that when a major event that disrupts people's perception of others is presented, such as the SARS-CoV-2 pandemic outbreak, the strength of the association between perceived aesthetics and trustworthiness is less stable for adults' as compared to children's faces. This is, to the best of our knowledge, the first study that examines (i) the effect of gender, age, and ethnicity simultaneously on the strength of the relationship between aesthetics and trustworthiness, as well as the stability of the HE over time when measures that can affect trustworthiness judgments of others (e.g., social distancing) are in place. From a more practical point of view, our results are open to the possibility that external events or actions can affect the relationship between aesthetics and trustworthiness. For example, individuals may use tactics to increase their own perceived trustworthiness or to reduce the perceived trustworthiness of others. We can think of politicians, for example, salesmen, or more in general, activities that require us to interact with a stranger and to evaluate the trustworthiness of a person before approaching or interacting with him or her. Overall, results of our work confirm the generalizability of the HE across cultures, as well as the specificity of children's faces. Additionally, our work provides a first investigation of the stability of the HE over time. Future studies should investigate the effect on more specific ethnic subgroups (e.g., Japanese vs. Chinese), when the stability of the HE is systematically influenced by mean of an experimental paradigm (e.g., priming), and in a period of time where there is a limited influence of external events on judgment toward others' traits.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://doi.org/10.21979/N9/5IIVOM.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board—Nanyang Technological University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GG and GE conceptualized, designed, and conducted the study. AL and PS revised the analytical method. GG drafted the manuscript, while all the authors contributed to the final version of the manuscript. GE supervised the project.

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Interpersonal Emotion Regulation: From Research to Group Therapy

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The concept of interpersonal emotion regulation (IER) refers to a variety of processes in which emotion regulation occurs as part of live social interactions and includes, among others, also those interpersonal interactions in which individuals turn to others to be helped or to help the others in managing emotions. Although IER may be a concept of interest in group therapy, specific theoretical insights in this field appear to be missed. In this article, we firstly provide a review of IER definitions, of classifications of IER strategies, and of IER clinical conceptualizations. Afterwards, we discuss the relevance of considering IER for group therapy, both in terms of non-specific group therapeutic factors and of group therapy techniques promoting adaptive emotion regulation, underlining the potentially relevant role of IER behaviors as intrinsically involved in group experience.

Keywords: interpersonal emotion regulation, emotion regulation, clinical models, groups, group therapy

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INTRODUCTION

When emotions arise, individuals may use a number of processes to "influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998, p. 271). Although research has mainly focused on emotion regulation considering the individual as a single isolated person, emotion regulation also involves interactive processes. Indeed, individuals often turn to others both to be helped and to reciprocally help the others in understanding and managing emotions that arise from everyday life and that involve interpersonal communication and social interaction as part of individuals' emotion regulation processes. Interpersonal emotion regulation (IER) was first mentioned by Rimé (2007), who focused on individuals' social sharing following emotional experiences. According to Rimé, IER works as an interpersonal regulatory signal that people use as emotion regulation attempts in the aftermath of an emotional experience. From Rimé's work, several interactive interpersonal processes involved in emotional management, such as social coping, social support, altruisms, and prosocial behaviors have been brought together within the IER framework; this has led to the theoretical configuration of IER as an umbrella concept including a variety of phenomena, conceptualizations, and research currents.

Interpersonal influences of emotion regulation are clearly observable in group therapy. For example, in the here-and-now of a group session, the therapist has the opportunity to observe the spontaneous manifestations of phenomena such as patients' overreliance or underuse of the group to regulate emotions, help request/provision, adoption of

adaptive/maladaptive strategies to regulate internal states in relation to other group members and many others. IER may constitute a useful framework to understand and take advantage of these phenomena in group therapeutic interventions. However, theoretical developments on IER in the field of group therapy are lacking in the literature so far. With the present article, we reviewed IER definitions, classifications of IER strategies and clinical conceptualizations of IER as a potentially relevant concept for mental health, with the specific aim of providing theoretical insights on the clinical implications of IER in group therapy.

DEFINING INTERPERSONAL EMOTION REGULATION

A common point of all theoretical definitions is considering of IER a set of processes occurring in the context of social interactions that aim to emotion regulation. In most definitional attempts (Niven et al., 2009; Zaki and Williams, 2013; Dixon-Gordon et al., 2015; Williams et al., 2018), the motivation to modify emotions is usually emphasized because it distinguishes IER from other processes, such as emotional contagious or social coping. In fact, these processes are similar to IER in their behavioral manifestations—they occur in social interaction and involve emotional components–but they have no specific regulation goal. In this perspective, some authors have considered the presence of a regulatory goal a signal of intentionality, control, and conscious awareness of the regulatory process, affirming that implicit forms of emotional influence cannot be considered forms of IER (Niven et al., 2009; Dixon-Gordon et al., 2015). However, it should be noted that forms of emotion regulation of individuals pursuing regulatory goals in the absence of voluntary intention have been described in the case of intrapersonal regulation (Mauss et al., 2007; Koole and Rothermund, 2011). There is no reason to exclude that, in relation to unconscious emotion regulation goals, individuals may use the interaction with the others as a strategy. For example, a person may share his/her anxious feelings with a friend without being aware of the regulatory function of his/her emotional sharing.

Less consistent appears to be the definition of IER on the basis of regulation targets. If early contributions, in line with traditional models of regulation, considered the self the unique target of emotion regulation (Rimé, 2007; Marroquín, 2011), more recent contributions have extended the concept also to extrinsic aspects of emotion regulation, considering the other person the target (Niven et al., 2009; Zaki and Williams, 2013). An example of extrinsic IER may be represented by providing comfort in order to regulate another person's sadness. This extension of IER to extrinsic regulation has weakened the theoretical boundaries of the concept, including empathic, supportive, and prosocial behaviors within the concept of IER in all cases in which these processes have regulatory goals (Zaki, 2019).

Another element considered in IER definition is the difference with traditional intrapersonal regulation. Intrapersonal and interpersonal aspects of emotion regulation can be viewed as part of the continuum of self-involvement in regulatory processes. On one extremity, we find self-regulation processes (intrapersonal regulation) and, on the other extremity, we find the absence of self-involvement in regulatory processes (regulation by others or regulation of others), with co-regulation in the halfway position (Campo et al., 2017). For this reason, in some cases, it is not possible to establish a clear boundary between intrapersonal and interpersonal regulation processes. For example, a person may intrapersonally reappraise a situation using recalling a suggestion provided by a friend in past situations, or he/she may suppress emotional reactions on the basis of parental education. Several authors, therefore, adopted an operational definition of IER as regulatory processes that happen in the context of live social interactions (Zaki and Williams, 2013; Williams et al., 2018). Maintaining an operational focus, though the importance of co-regulatory processes is widely recognized in IER literature, the complex dynamic of reciprocal influences is supposed to be better understood using emotional system theories and methodologies (Butler et al., 2014).

INTERPERSONAL EMOTION REGULATION STRATEGIES

People may use different strategies for emotion regulation in social interactions. In clinical psychology, early theoretical efforts aimed to the classification of IER strategies extended traditional models of intrapersonal emotion regulation to interpersonal regulatory phenomena. With reference to the traditional Gross's process model, Marroquín (2011) has listed a series of interpersonal influences that may occur when considering attention deployment and cognitive change steps of the emotion regulation process. According to Marroquín, when considering the step of attention deployment, the others may intervene in one person's emotion regulation process distracting the person from a situation, for example, by reorienting the person to neutral/positive stimuli, by providing neutral/positive stimuli, or by helping the person to focus on concrete or non-self-relevant stimuli. In the step of cognitive change, interpersonal influence may involve the generation and the selection of alternative interpretations, the highlight or supply of schema-inconsistent information, the explicit correction of cognitions, and the addition of flexible processing resources. Christensen and Haynos (2020), also starting from Gross's model, have conceptualized IER as strategies involving situation selection or situation modification (for example, IER strategies helping individuals to avoid exposure to situations that elicit an emotional response or helping individuals to change that situation), as well as response modulation (for example, expressive suppression may be used to deal with perceived social concerns about the appropriateness of one's expressed emotions).

Zaki and Williams (2013) introduced the distinction between response-dependent IER that requires particular qualities of another person's response (for example, after emotional sharing the person may receive support depending on the response of the other), and response-independent IER, which does not require a

particular response from the other person (for example, labeling the emotion as effective regardless of the others' response).

An empirically based classification of IER strategies was provided when creating the *Interpersonal Emotion Regulation Questionnaire* (IERQ; Hofmann et al., 2016), which evaluates the ways a people use others to regulate his/her own emotions (intrinsic IER). Interestingly, a qualitative data analysis was used to generate the items and to create an empirically based IER model. The results was a 20-item questionnaire evaluating the following subscales: (a) Enhancing positive affect, which describes the tendency to seek out the others in order to increase feelings of happiness and joy (item example "Because happiness is contagious, I seek out other people when I'm happy"); (b) Perspective taking, which involves the use of others in order to be reminded not to worry and that others have it worse (item example: "Having people remind me that others are worse off helps me when I'm upset"); (c) Soothing, which consists in seeking out the others for comfort and sympathy (item example: "I look to others for comfort when I feel upset;" (d) Social modeling, concerning looking to others to see how they might cope with a given situation (item example: "If I'm upset, I like knowing what other people would do if they were in my situation").

In the field of developmental psychology, a list of adaptive and maladaptive extrinsic IER strategies has been provided by Pacella and López-Pérez (2018) as part of the implementation of an online serious game that evaluates how children engage in modifying the emotions of others. In this list, they include positive affective engagement, cognitive engagement, distraction and humor as adaptive strategies, and suppression, co-rumination, avoidance, diminishing comparisons, and negative behavioral engagement as maladaptive strategies.

CLINICAL MODELS OF INTERPERSONAL EMOTION REGULATION

Early theoretical contributions in the field of IER have considered its implication for emotional disorders conceptualization and treatment (Marroquín, 2011; Hofmann, 2014; Christensen and Haynos, 2020), assuming the key role of IER as a mediator factor in the widely described negative association between depression and social support (Marroquín, 2011). According to this view, depression is negatively influenced by the lack of opportunities to interpersonally regulate emotions in socially supporting context, and this problem plausibly concerns any psychopathology that is influenced by social isolation.

Subsequent contributions have observed both the positive and the negative consequences of IER for psychopathology. Hofmann (2014) theorized that IER strategies can be a protective factor for anxiety and mood disorders at the extent to which they weaken the effects of emotional distress but, on the other hand, they can also perpetuate psychopathological symptoms, such as in the case of one's exaggerated dependency on others to regulate his/her own emotions. The issue of dependency/autonomy imbalance in regulation behaviors calls into consideration clinically relevant contributions of developmental psychology. Recent findings have revealed significant age effects in extrinsic IER, showing that older children and adolescent use more adaptive and more sophisticated/various extrinsic regulation strategies compared to younger children (López-Pérez et al., 2016; Pacella and López-Pérez, 2018; Gummerum and Lopez-Perez, 2020; López-Pérez and Pacella, 2021). In line with developmental views of psychopathology, maladaptive forms of IER can be attributed to deficiencies in individual development related to interpersonal components of emotion regulation in early relationships (Mikulincer et al., 2003; Shaver and Mikulincer, 2007; Messina et al., 2016a).

Dixon-Gordon et al. (2015) have listed failures that could occur in different steps of IER processes, causing peoples' dysregulation. According to the authors, in the case of intrinsic IER, failures in emotion regulation may be related to the overreliance on others to regulate emotions, underuse of social environment to regulate emotions, selection of inappropriate or unhelpful others, overreliance on particular individuals, unavailability of others to regulate emotions, or selection of inappropriate settings. About extrinsic IER, failures in regulating others' emotions may be related to excessive attempts or failures to regulate others' emotions or selection of inappropriate settings for emotion regulation.

A focus on IER clinical features has been provided also in the construction of the questionnaire *Difficulties in Interpersonal Emotion Regulation* (DIRE; Dixon-Gordon et al., 2018), which evaluates the relevance of IER strategies in psychopathology. The questionnaire presents a series of scenarios and asks the individuals to indicate the likelihood according to which they would respond to each scenario referring to the listed ways, which include intrinsic IER forms together with some intrapersonal emotion regulation strategies such as distraction and avoidance. The items describing each strategy were generated on the basis of previous theories and research and involved the following strategies: talking about one's emotions, seeking reassurance, seeking problem-solving support, and venting. The factorial analysis revealed two factors: the first factor included reassurance-seeking items (item example "keep asking for reassurance") and the second factor included venting items (item example "raising voice or complaining"). Both factors were associated to negative mental health outcomes.

With regard to empirical investigation of IER in the clinical context, early quantitative studies have found IER peculiarities in psychopathological sample. For example, in cases of anxiety and depression (Altan-Atalay and Saritas-Atalar, 2019), of borderline personality disorder (Dixon-Gordon et al., 2016; López-Pérez et al., 2017), and of substance addiction (Dingle et al., 2018), individuals have appeared to have significantly different IER behaviors.

Diary-based studies of romantic partner relational dynamics have provided interesting insight regarding positive and negative consequences of IER. For example, touch (Debrot et al., 2013) and humor (Horn et al., 2019) have emerged to be effective forms of IER. Positive and negative consequences of IER in couples have been investigated also considering their association with emotional disorder symptoms. Horn and Maercker (2016) have considered the effects of co-reappraisal (cognitively

changing a situation's meaning during a conversation with the partner) and co-brooding (passive repetitive focus on negative content, which is unwanted, rigid and perceived as unpleasant during a conversation with the partner) on three different symptoms of maladjustment: preoccupation, failure to adapt, and depression. Co-brooding was a significant predictor of all maladjustment symptoms, whereas co-reappraisal was predictive of less depressive symptoms and lower adjustment to the disorder symptoms in the female sample. Thus, IER seems to have an important role in mitigating or intensifying the severity of emotional disorders.

WHICH IMPLICATIONS FOR GROUP THERAPY?

Interventions directly targeting emotion-regulation skills have been largely encouraged by clinical psychology literature (Berking et al., 2008; Messina et al., 2016b, 2020; Frederickson et al., 2018; Grecucci et al., 2020). Referring to the social dimension of emotion regulation, interventions aiming to improve emotion-regulation skills appear to be potentially relevant. Therefore, group therapy may be a promising context in the work on the interpersonal features of emotion regulation (and dysregulation).

On the basis of the extant state of art on IER conceptualization and empirical research, early applications of IER conceptualizations can be contextualized in group therapy. First, regardless of the explicit therapeutic purpose of the group, the experience of being part of a group could have therapeutic effects, as well as it is observed in self-help or psychological support groups (Marogna and Caccamo, 2014). Several aspects of group experiences may have therapeutic implications. First, the group is a natural source of social support. Second, altruism has also been recognized as a therapeutic group factor to the extent that in groups, patients find real opportunities to be helpful to others (extrinsic regulation). Thus, the group experience implies potential sources of corrective relational experiences when facing negative experiences in the outside world (Caccamo et al., 2017, 2018).

Second, the therapist may promote the use of constructive IER strategies during the course of the group therapy. Among numerous possibilities, examples of therapists' interventions aiming to promote IER within group therapy experience are the following:

- he/she can invite the group members to share emotions (social sharing);
- he/she can invite the group members to provide alternative interpretations of individual points of view (cognitive change/perspective taking);
- he/she can invite the group members to share their own experiences in coping with the emotional experiences reported by another member (social modeling).

Third, the therapist may discourage the use of dysfunctional IER strategies (such as venting), focusing the group attention on the relational consequences and on the emotional outcomes, promoting the group discussion (and awareness) of more appropriate alternative strategies.

Fourth, the group is an optimal context to observe the spontaneous manifestations of IER phenomena in the interactions among group members. The therapist may stimulate individual and group awareness concerning the use of IER strategies. In this regard, he/she can:

- point out regulatory attempts related to behavioral manifestations;
- promote the reflection on positive/negative consequences of IER behaviors in terms of relational quality and emotional outcomes;
- point out social phenomena such as overreliance/underreliance on others to regulate emotions (how much the person use the group, the therapist, or a specific group member to regulate his/her emotions?)
- point out phenomena such as selection of inappropriate or unhelpful others (for example, reflecting on different outcomes of IER that the person may have in the group compared with dysfunctional everyday life relations);
- point out the selection of inappropriate moments (for example, asking for help during another member's important moment of social sharing).

Finally, all the described strategies may be effectively adopted only when a suitable context for effective emotion regulation is available. In this perspective, the therapist may have a key role in establishing a positive atmosphere of acceptance, respect, and non-judgment regarding emotional expression and regulation attempts from group members. Indeed, emotion regulation is not only a matter of strategy: it also implies a sense of curiosity about emotions, a perspective that does not consider emotions and thoughts as threats, but rather as mental phenomena which are precious sources of information on one's current mental state.

OUTSTANDING ISSUES AND FUTURE DEVELOPMENTS

The definitions of IER reviewed in the present article have provided a useful basis for the conceptualization of IER phenomena in group therapy. Several aspects of available IER strategy classifications and clinical models may help group therapists in recognizing aspects of group functioning which may be potentially relevant in therapy sessions. However, classification of IER strategies specific for group therapy context should be provided in future works. With regard to empirical investigations on IER, group therapy research is still missing. Both quantitative and qualitative studies have offered interesting insights on IER phenomena, but only specific forms of regulation and specific pathological samples have been investigated. Extant research on IER actually appears to be scattered and limited in providing concrete clinical implications, and we are far from having a comprehensive empirically founded perspective of IER to be used for clinical practice. In this context, a positive starting point is the availability of standardized and non-standardized scales to evaluate IER in adults, as well as of new promising

methodologies for the assessment of IER in the developmental age which may both offer a strong basis for future research on IER. In particular, the employment of IER scales could be useful in future research investigating the potential mediating role of IER in the recognized link between attachment style, dyadic adjustment, and individual well-being (Calvo and Bianco, 2015; Calvo et al., 2015, 2020; Ghedin et al., 2017).

AUTHOR CONTRIBUTIONS

IM contributed to conception and wrote the first draft of the manuscript. SG and CMar contributed to literature review and article collection. VC and CMas wrote the final version of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Estimating Group Stress Level by Measuring Body Motion

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Understanding employee stress has become a key issue for top management for corporate growth and risk reduction. So far, annual employee satisfaction surveys (ESs) have been conducted to assess the soundness of an organization. However, since it is difficult to collect questionnaires quantitatively and continuously, there is a need for a practical method that can be used to frequently measure group stress levels with a small burden on employees. We propose such a method and evaluated four combinations of approaches, using activity/rest duration distributions from body motion data and generating estimation models on an individual/group basis. The optimal result was obtained when modeling was made on a group basis by using the activity duration distribution ($r = 0.928$, $p < 0.001$, estimation error: 1.36%), making it possible to assess the degree of the stress of employees quantitatively and easily, and this showed the possibility of this method being useful as a management guide for companies.

Keywords: group stress level, body motion, wearable sensor, duration distribution, work satisfaction, organizational management

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INTRODUCTION

In recent years, not only improving efficiency but also reducing employee stress and improving well-being are being recognized as corporate management issues. Because stress interferes with the creativity of employees and increases the turnover rate (Avey et al., 2009), it hinders the growth potential of companies. Employee satisfaction surveys (ESs) are a widely practiced method for grasping the state of an organization. ESs have questions about relationships with supervisors and colleagues at work, motivation, stress, etc. It is common for all employees to answer one once or twice a year. The average value and standard deviation of each department or business unit in the results are calculated and used to decide workplace strategies and personnel policies (Harter et al., 2002). However, the problem with using a questionnaire is that data cannot be collected continuously at short intervals. As a result, decision making may be delayed without noticing an increase in risks. The reason continuous collection is not possible is that the recovery rate and reliability of the answers decrease as the same question is repeated. In addition, methods of measuring human stress by using physiological indicators such as saliva and blood are already known (Booij et al., 2015; Ogino et al., 2017). However, due to the burden and cost of physiological index methods, they are not suitable for collecting long-term data from many employees. For the above reasons, there has been a need for a means of measuring the stress level of an organization with many employees continuously and objectively without interrupting daily work.

The purpose of this study is to estimate the average degree of stress at work by using acceleration data from wearable terminals. Teams or team members wear wearable terminals that include acceleration sensors and that collect data on their body movements. However, if this is an official initiative in a company, the company cannot order that employees be measured for 24 h including

during their private time. Therefore, to consider practicality, we have to add the constraint of targeting measurement data obtained only during working hours. The reason we focused on body movement is because we had the following prior research. Although people tend to think that they consciously understand and control themselves, Pentland (2010) proposed the idea of the "honest signal," which is a non-verbal and unconscious signal made by the body that includes an enormous amount of information about humans themselves. In fact, Nakamura reported that stress differences appear in statistical distributions of body activity (Nakamura et al., 2007). Furthermore, a scaled distribution of mice showed the same tendency as that of humans (Nakamura et al., 2013). These findings support the existence of universal honest signals among animals.

The conventional study (Nakamura et al., 2007) does not describe a method of identifying the degree of stress in healthy people and the case of using data obtained only during working hours. This study extends Nakamura's study (Nakamura et al., 2007), assuming that it will be used in an actual workplace as an alternative to the ESs. If this is realized, the following added value can be expected in management. For example, changes in the average stress level of a department can be monitored daily, and when it increases, managers can quickly notice and intervene. Also, there has been no way to collect continuous stress data in the same organization. However, statistical analysis of continuous data linked to employee work and activity records will likely reveal the factors that affect stress. It is expected that such added value will be welcomed by many companies.

The outline of this paper is as follows. Conventional research and the contribution of this research are described in Section Related Work and Contribution. In Section Method, four approaches of the proposed method are proposed. They are applied to experimental data in Section Experiments, and the evaluation results for the estimation accuracy of each are described. In Section Discussion, we discuss the reason for the approach that obtained the highest estimation accuracy and describe the limitations of this research and future issues. Finally, we conclude in Section Conclusion.

RELATED WORK AND CONTRIBUTION

Related Work

Nakamura found a universal law of physical movement (Nakamura et al., 2007). The specific procedure is as follows. The frequency obtained by a wristband-type acceleration sensor is divided into static or active states with a pre-determined threshold. It was also shown that the cumulative proportion distribution of the duration of the static state follows a power law, while that of the duration of the active state obeys stretched exponential functions. Although the scale is different, it has been confirmed that the movement patterns of a mouse (Nakamura et al., 2013) and ant (Hayashi et al., 2015) follow the same distribution, indicating that the law is likely to be common to animals as well as humans. Furthermore, the same study (Nakamura et al., 2007) describes the finding that differences in depressed patients and healthy individuals appeared in the slope of the resting duration distribution and that the distributions of resting duration and activity duration are independent.

Other studies have shown that the flow conditions when people are immersed such as in thinking, desk work, and writing and the excitement of conference participants appear in acceleration data that measures physical movement (Ara et al., 2009; Olguin et al., 2009; Akitomi et al., 2013). In addition, Smarr et al. (2016) indicates that compressing three-axis data into one axis is sufficient for estimating circadian rhythm by using a wristband-type acceleration sensor. This implies that the acceleration of the body contains a large amount of information. Furthermore, as techniques for estimating stress with something other than acceleration, there are techniques using the pressure in rhythm or key strokes during typing (Nozawa et al., 2013) and those using facial expressions, voice, and heartbeats (Jovanov et al., 2003; Pavlidis et al., 2007; Mitsuyoshi, 2015).

In addition, new services using email transmission/reception and chat log analysis, smile detection technology, etc. have been proposed for managers and human resources (Reilly, 2018). This suggests that management has a high need for more frequent understanding of the health of an organization. However, ways have not been sufficiently considered yet of continuously feeding back the status of a workplace without putting a burden on the employees.

Contribution

The purpose of this study is to estimate the average degree of stress at work by using acceleration data from wearable terminals. The novelty is that doing so estimates the degree of stress in a workable healthy population and has the restriction of using only measurement data obtained during working hours. This contributes to quantifying the health of a workplace more frequently than the ESs.

METHODS

We propose a method that extracts the duration of rest and the duration of activity from an acceleration sensor attached to the body and focuses on the slope of each cumulative distribution fitted to a function.

Based on Pentland's suggestion that unconscious signals reveal various human characteristics, we hypothesize that information that enable us to estimate the degree of stress is hidden in human movement data. Therefore, we adopt the two mathematical pattern of physical movement called power law of static duration and stretched exponential function of active duration that Nakamura have found. Furthermore, since we hypothesized that stress at work is not only individual-dependent but also a collective phenomenon, we adopted two methods, one is to aggregate by individual and the other is to aggregate by organization. In this paper, we evaluate the four approaches that conbination of two mathmatical pattern and two aggregation way as shown in **Table 1**.

Nakamura et al. (2007) showed that the cumulative distribution of resting duration can be fitted with power law (1), and that of the active duration can be fitted with

TABLE 1 | Four approaches as hypotheses.

Approach	Si	Sg	Ai	Ag
Data	Static (resting) duration		Active duration	
Fitting function	Power law		Stretched exponential function	
Feature value	Slope (γ)		Slope (β)	
Modeling unit	Individual	Group	Individual	Group

stretched exponential function (2).

$$\begin{aligned} P_c\,(x \geq T) &= \alpha \cdot T^{(-\gamma)} \quad (\alpha,\ \gamma : const.) \qquad (1)\\ P_c\ (x \geq T) &= \exp\left(-\alpha \cdot T^{\beta}\right) \quad (\alpha,\ \beta : const.)\\ &= \exp\left(-\alpha^{\frac{1}{\beta}} \cdot T\right)^{\beta}\\ \Leftrightarrow\ \ln P_c &= -\left(\alpha^{\frac{1}{\beta}} \cdot T\right)^{\beta}\\ &= -\left(\alpha' \cdot T\right)^{\beta} \quad \left(\alpha' = \alpha^{\frac{1}{\beta}}\right) \qquad (2) \end{aligned}$$

On the basis of this, we will examine and evaluate the four approaches shown in **Table 1** as hypotheses. First, two patterns are provided using the distribution of (S) static/resting duration and (A) activity duration; then, two patterns are provided. One (i) obtains an average of a group after creating a stress-estimation model for each individual in the group, and the other (g) creates a stress-estimation model for the entire group as a whole. By combining these, there are four possible approaches: approach Si (static and individual), which creates a model on an individual basis with static data, approach Sg (static and group) with a group model and static data, approach Ai (active and individual) with an individual model and active data, and approach Ag (active and group) with a group model and active data. Those using static duration data adopt γ, which indicates the slope of the power law, as a feature of the model. Those using active duration data adopt β, which indicates the slope of the stretched exponential function.

A flowchart of the four approaches to estimated model generation is shown in **Figure 1**. The group unit models (approach Sg or Ag) proceed to Steps 1–5g, and 6g, and the individual unit models (approach Si or Ai) proceed to Steps 1–5i, and 6i. The process of each step is described below.

Step 1: Calculating Body Acceleration Frequency

The frequency per minute is calculated from three-axis acceleration sensor data. After the data are transformed to one-axis data, a high pass filter is applied, and the frequency is obtained by counting the number of zero crosses per minute.

Step 2: Identifying Whether State Is Active or Resting

A state is identified as "active" or "resting (static)" every 1 min by judging if the acceleration frequency is above or below a pre-defined threshold. Nakamura's study (Nakamura et al., 2007) revealed that the definition of threshold does not affect the function fitting in Steps 5i and 5g because the distributions follow universal laws. Therefore, we defined a common threshold for all subjects.

Step 3: Generating Histogram of Individual Duration

Histograms are generated by counting the number of occurrences per active duration T_A in the data of each individual *i*. Similarly, histograms of static duration T_S are also generated.

Step 4: Generating Histogram of Group Duration

This step is performed only in the case of Approaches Sg and Ag. Individual histograms are summed at each T to calculate the cumulative occurrence probability of the population at T to obtain a cumulative distribution function P_c.

Steps 5i, 5g: Fit Function

According to the research by Nakamura et al. (2007), in Step 5i, the cumulative occurrence ratio of the static duration is fitted with power law (1), and in Step 5g, that of the active duration is fitted with stretched exponential function (2). As a result, constants γ and β indicating the slope of each distribution are calculated. The fitting is performed so as to minimize the sum of absolute values of logarithmic differences in the *y*-axis direction.

Steps 6i, 6g: Generating Model for Estimating Stress Level

In each approach, a simple regression model for estimating the degree of stress is generated. Here, the value of a stress questionnaire used as a reference is an objective variable, and the inclination of each distribution is an explanatory variable. The datasets used for model generation are in individual units for Approaches Si and Ai and in group units for Approaches Sg and Ag. Therefore, in the case of a group unit, the average of the questionnaire values is used. Also, the slope value is γ for Approaches Si and Sg and β for Approaches Ai and Ag.

EXPERIMENTS

Method of Measurement

To measure human behavior in the workplace without interrupting work, we chose a name-tag shaped wearable sensor node (Wakisaka et al., 2009) (**Figure 2**). Workers put the nodes on when they arrive at work and work as usual with them on while in their office. The nodes are stored in a cradle while the owners are away from the office, where they stop sensing. Thus, the nodes continuously measures an owner's face-to-face communication and body motion in the workplace. Face-to-face communication is detected by transmitting infrared signals between sensor nodes when they face each other at about 3 m. An accelerometer in the nodes measures body motion at a frequency of 51.2 (Hz) and can detect slight movements such as keyboard typing. Moreover, the threshold value that divides static/active in Step 2 of **Figure 1** is the minimum frequency that can be detected by this sensor node. In other words, the state is classified as static only when the worker has almost completely stopped.

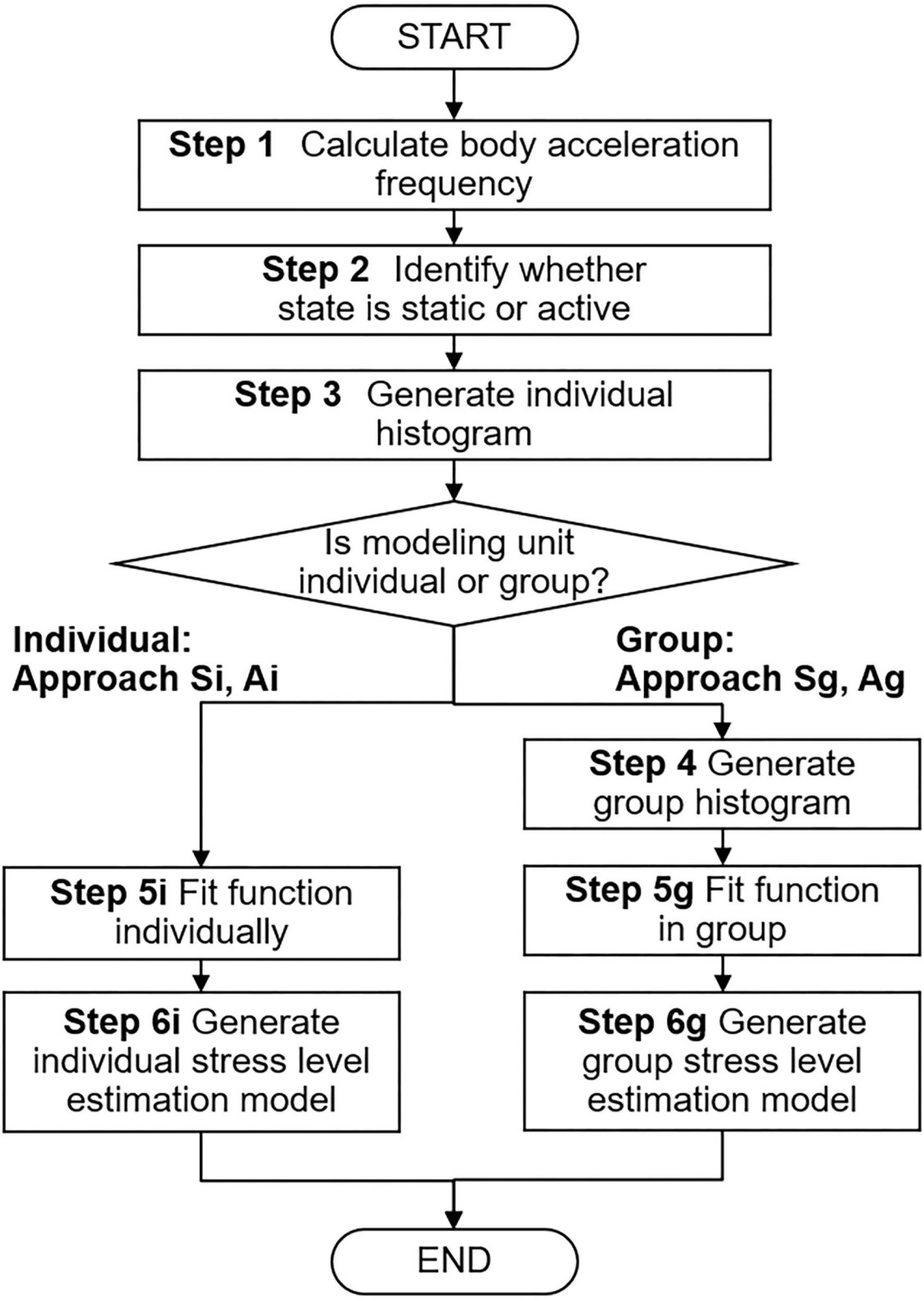

FIGURE 1 | Flowchart of four approaches to estimated model generation. Individual unit models (approach Si or Ai) proceed to Steps 1, 2, 3, 5i, and 6i, and group unit models (approach Sg or Ag) proceed to Steps 1, 2, 3, 4, 5g, and 6g. In Steps 5i and 5g, approaches Si and Sg use power law, and approaches Ai and Ag use stretched exponential function for function fitting.

A

Controller	Low Power 8-bit MPU	
Storage	Internal flash memory (2 GB)	
Sensors	F2F	F2F Infra-red (120°, 3-m range)
	Motion	3-axis + 3-axis Acceleration, 51.2 [Hz]
Communication	Wired	USB 2.0
	Wireless	Bluetooth 4.0 (low energy)
Battery Life	24 hours	
Size/Weight	82.0 × 58.7 × 8.8 [mm]/39 [g]	

B

FIGURE 2 | Name-tag shaped wearable sensor node. Nodes continuously measure owner's body motion and face-to-face communication in workplace without interrupting work. Accelerometer in nodes measures body motion at frequency of 51.2 (Hz). Face-to-face communication is detected by transmitting infrared signals between sensor nodes when they face each other at about three meters. **(A)** Specifications **(B)** Appearance This image has been previously published. https://dl.acm.org/doi/fullHtml/10.1145/3358695.3360923.

Reference of Value

The Center for Epidemiologic Studies Depression (CES-D) questionnaire was adopted as the reference in Steps 6i and 6g (Radloff, 1977; Hann et al., 1999). This is a questionnaire developed by the National Institute of Mental Health for screening depressive conditions and is widely adopted by psychiatrists. The questionnaire has 20 questions such as "I felt depressed," "My sleep was restless," and "I was happy (inverted scale)." Respondents look back over the past week and respond in four stages, numbered 0–3, to the number of days they felt that way. As a result, the depression scale of a respondent is calculated by adding together these scores on the questionnaire and creating an integer from 0 to 60. Although the cut-off point for suspected depression on the CES-D is 16, it has been reported that almost 30% of Japanese adults score 16 points or more, which tends to be overestimated compared to the actual prevalence of depression in Japan (Kaneita et al., 2006). Therefore, a cut-off of 26 points has been proposed in Japan. Although the CES-D is not a questionnaire designed to measure the level of stress at work, it is a strong reflection of the level of stress in the workplace because it assesses the subjective perceptions felt as a result of work that takes up about half of the weekday. Therefore, in this paper we consider the value of CES-D to be the stress level of the worker, and furthermore, we consider the average of the group members' CES-D values to be the stress level of the whole group.

TABLE 2 | Research participants.

Company	Industry	Department
A	Finance	Planning
B	Finance	Planning
C	Manufacturing	Engineering
D	Manufacturing	Engineering
E	Manufacturing	Engineering
F	Manufacturing	Engineering
G	Software	Engineering
H	Software	Engineering
I	Software	Engineering
J	Software	Engineering

Total number of participants was 486 in 10 companies (average of 48.6 ± 29.2 people). Target organizations were selected on condition that work was done inside and at desks.

Research Participants

We used data acquired by 10 companies in Japan with 486 people (average of 48.6 ± 29.2 people). **Table 2** shows the industry type and job type (department). The target organizations with common characteristics that they are desk work with a little outing were selected. Additionally, several managers and secretaries were included since the experiment participants were designated as whole of departments. Although we could not obtain information on age and gender of the participants, all are in their 20s and 60s. In addition, all employees in the selected organization were informed of the purpose of the experiment and data usage and asked for their consent to participate. Then those who agreed became the participants of this experiment. Only a few people from each organization who disagreed did not wear sensors or answer questionnaires. Since there were few outings, most sensor data taken during working hours were able to be acquired. Sensor data for 1 week including or immediately before the questionnaire response date were used for evaluation of the experiment.

Results

Figure 3 shows the cumulative occurrence ratio distribution of the static and activity duration of the 10 companies acquired by the name-tag shaped sensor node. The static distribution in **Figure 3A** dropped linearly, and the difference between the 10 groups was small, whereas the active distribution in **Figure 3B** decreased with a gentle curve with the differences between groups.

The evaluation results for the four approaches are shown in **Table 3** and **Figure 4**. The most accurate approach was Ag, which generates an estimation model on a group basis by using active duration. The resulting correlation coefficient r of this model was 0.928, and the error rate was 1.36%. Since the significance level was $p < 0.001$, the accuracy of this model was sufficiently effective

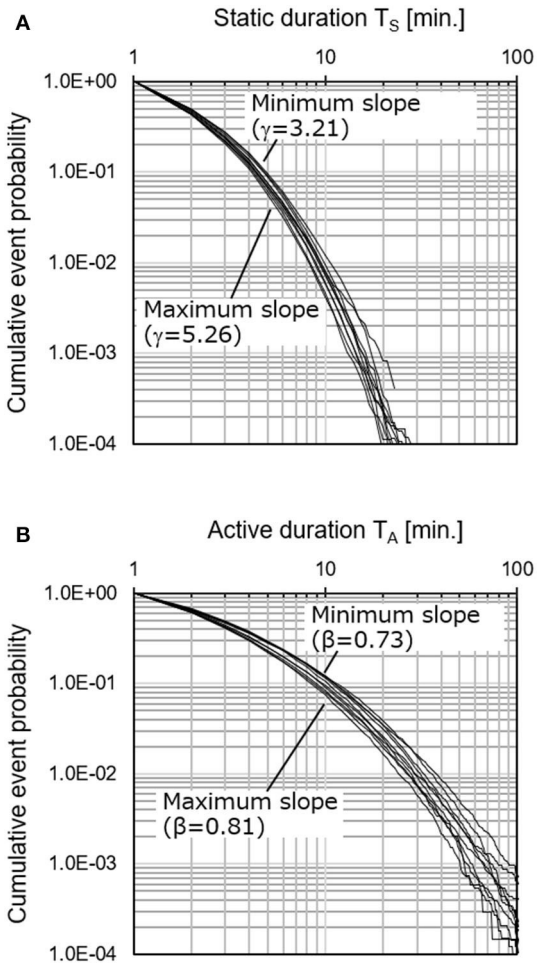

FIGURE 3 | Cumulative occurrence ratio distribution of static and activity duration of 10 companies acquired by name-tag shaped sensor node. Static distribution **(A)** dropped linearly, and difference between 10 groups was small, whereas active distribution **(B)** decreased with gentle curve with differences between groups. **(A)** Static (Resting) Duration **(B)** Active Duration.

for estimating the average degree of stress of the population. None of the other approaches reached a significance level of $p < 0.05$. As obtained with Equation (3) of Approach Ag, constant a had a positive value. That is, this means that the average stress levels tended to be higher as the slopes β in **Figure 3B** became steeper.

$$\textit{Estimated group stress level} = a \cdot \beta + b \quad (a,\ b : const.) \tag{3}$$

DISCUSSION

What Physical Activity Duration Represents

The average stress level was able to be estimated by approach Ag, which made a model comprised of activity duration distribution and group unit. In this section, we discuss the reasons.

TABLE 3 | Result of estimating group stress level.

Approach	Si	Sg	Ai	Ag
Sample size *n*	431	10	431	10
Correlation coefficient *r*	−0.006	−0.373	0.114	0.928***
Average error	1.92	2.19	1.85	0.82
Average error rate	3.20%	3.64%	3.08%	1.36%

****p < 0.001.*

Approaches Si, Ai calculated estimated stress level from body rhythm for each individual and calculated average value of group and used it as estimated average stress level of group. Approaches Sg, Ag directly estimated average stress level of group as described in Step 6g. Finally, difference between these estimated average group stresses and those estimated with questionnaire was calculated as error. Correlation coefficient between estimated stress level and that of questionnaire was r. Also, in each approach, cross validation for 10 divisions was performed to evaluate prediction accuracy of estimated models, and average errors of 10 trials were output. Average error rate is value of average error divided by 60, which is difference between maximum and minimum of CES-D questionnaire.

Nakamura's previous study (Nakamura et al., 2007) stated that there was a difference in the slope of the resting duration distribution between depressed patients and healthy people, while there was no difference in the active duration. However, in this study, a difference in terms of the degree of stress did not appear for either Approach Si or Sg using static duration. The reason a difference does not appear in the static duration distribution in our example is considered to be due to the measured hours. In Nakamura's previous study, they performed measurements for 24 h continuously for several days, but in our experiment, only working hours during the daytime were used. In other words, it is thought that the frequency of the occurrence of the resting state during sleep is a strong factor that separates depressed patients from healthy people. As shown in **Figure 3A**, it is considered that a difference did not appear because a long-lasting static state is less likely to occur compared with the active state in the data of the workplace. Here, although the previous research (wristband type) and this research (name-tag type) are different in terms of the form of the sensor being worn, the movement of the arms and that of the trunk are linked. In addition, since the universal characteristics of the distributions of static and active durations were reproduced, it is considered that the form does not greatly affect the difference in the distribution inclination.

It is an interesting question why the active duration was effective. Comparing the results of Approaches Ai and Ag, Ai, which generated estimation models with an individual unit, was less accurate than Ag with its group unit. From here, it is assumed that Ag is an approach that treats a group as one "closed system." Hypothetically, we consider that the slope of the active duration distribution represents interaction with others, i.e., the influence others exert on each other or being influenced by other people's stress. This will explain the following. Estimation errors did not occur because the sum of the active durations, which are combinations of each individual's stress plus the stress each individual received from others, of each group member and the sum of the questionnaire results were the same because they were obtained for the same system in Ag. However, in Ai, where the

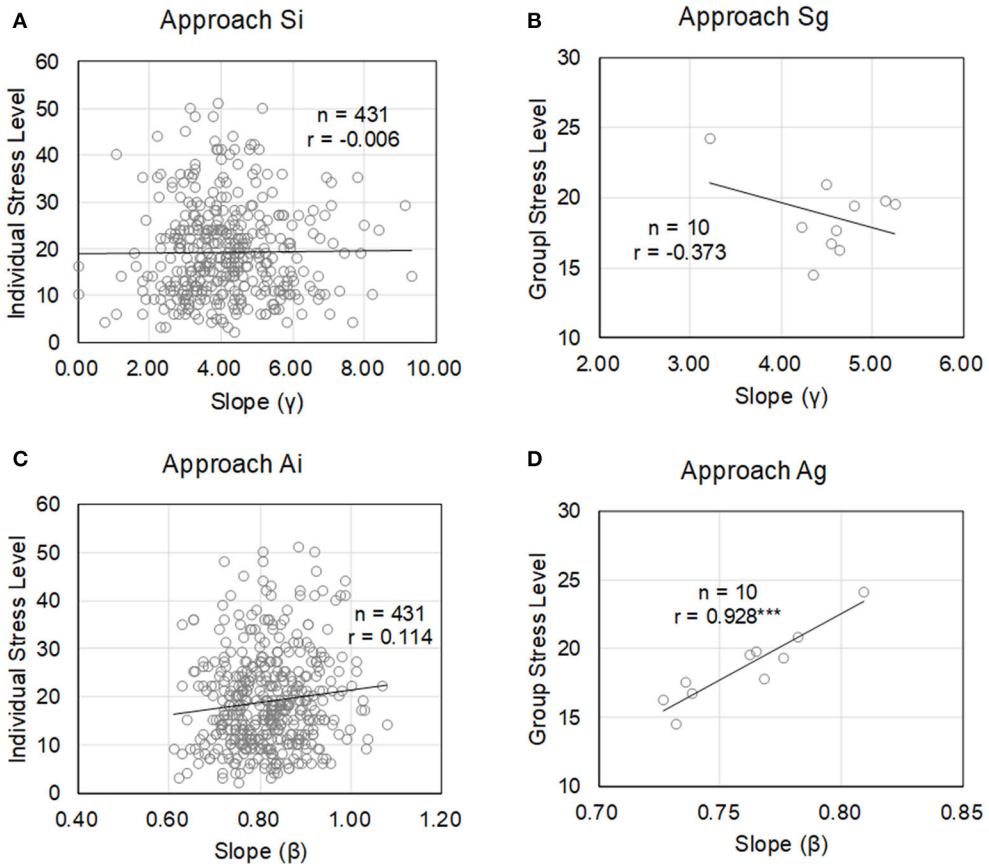

FIGURE 4 | Relationship between slope of each static or active duration distribution and stress level by questionnaire in four approaches. Only Approach Ag showed that the slope can estimate the stress level. **(A)** Approach Si **(B)** Approach Sg **(C)** Approach Ai **(D)** Approach Ag.

individual is one system, the active duration represents the intra-system effect, while the questionnaire is an internal event of the system; this is why a larger estimation error occurred between body motion and the questionnaire. Additional experiments were performed to confirm this hypothesis.

The subject was Company A in **Table 2**. Company A consisted of 38 members from three teams, A1, A2, and A3 (13, 14, and 11 members each). We prepared a data set of sensor data and CES-D questionnaire responses for each of three consecutive weeks. In additional experiments, each week, each team was treated as one group, which produced a total of nine group data sets. It was assumed that people should stay close to each other at the same time in order for interactions to occur within the group. Therefore, we shuffled the data of three teams and 3 weeks to generate nine virtual groups and evaluate the estimation accuracy of the average stress degree. The nine groups were randomly divided into three, and the following two patterns of virtual groups were regenerated.

(a) *Group shuffled:* Three different group pieces were aggregated for the same week, and nine virtual groups were generated.
(b) *Week shuffled:* One of three different weeks per piece for the same group were aggregated, and nine virtual groups were generated.

TABLE 4 | Average error of applying approach Ag for shuffled virtual team.

Group type	Actual group	(a) Group shuffled	(b) Week shuffled
Average error	1.19	3.82	5.28

Result of applying approach Ag for both types of virtual data. Both virtual groups (a) and (b) had worse accuracy than that of actual group.

Table 4 shows the result of applying approach Ag for both types of virtual data.

Here, we discuss the inner/inter-group communication of the participants. **Table 5** shows the dyad ratio, which was calculated for communication done for more than 15 min per day. It shows that Company A had structural characteristics showing that the people had much inner-group communication but little inter-group communication.

In **Table 4**, for both virtual groups (a) and (b), the accuracy was significantly worse than the result of using actual group division (average error = 1.19). Also, (b) was less accurate than (a). This is considered to be because there was some interaction between shuffled people for (a), but interaction across a time barrier never occurred for (b). Therefore, it was suggested from

TABLE 5 | Communication ratio between teams.

	Team A1	Team A2	Team A3
Team A1	**0.321**	-	-
Team A2	0.104	**0.648**	-
Team A3	0.084	0.104	**0.673**

Dyad ratio is calculated for communication done for more than 15 min per day. It shows that company A had structural characteristics showing that people had much inner-group communication but little inter-group communication. The bold values means inner group communication.

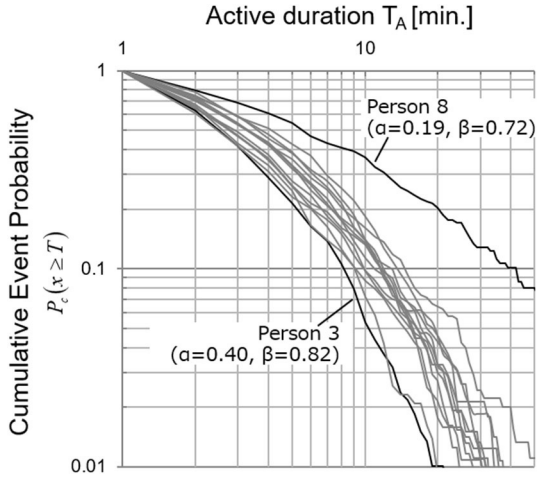

FIGURE 5 | Individual cumulative event probability distributions. Individual cumulative event probability distributions of 14 members of Team A2. This example shows that active state lasting more than 10 min was generated about 10 times as many times as Person 3 for Person 8. This means that physical activity of Person 8 contributed about 10 times that of Person 3 in approach Ag.

the result of the additional experiment that the slope of the active duration distribution of the body reflects the interaction of people working in the same space at the same time.

Figure 5 shows the distribution of active duration in individual units of all of Team A2, and it can be seen that there were large individual differences. When focusing on time $T = 10$, the y-axis value of Person 8 was about 0.4, while that of Person 3 was about 0.04. In other words, it can be said that an active state lasting more than 10 min was generated about 10 times as many times as Person 3 for Person 8. As shown in Step 4 of **Figure 1**, the cumulative frequency of occurrence for all of the members was the cumulative distribution of Team A2. The physical activity of Person 8 contributed about 10 times that of Person 3 to the distribution of the activity duration of the group. As shown in Step 4 of **Figure 1**, the sum total of the occurrence frequency of all of the members was the cumulative distribution of Team A2. This means that the physical activity of Person 8 contributed about 10 times that of Person 3 to the distribution of the group. It was already previously confirmed that measures for normalizing and eliminating differences between individuals are not effective in estimating stress in an organization (Tsuji et al., 2017). In addition, the results of Approach Ai show that the difference in the slope β of an individual's active duration distribution was not related to their stress level. In other words, it is thought that there is a meaning in the individual differences in distribution.

So how does this difference in contribution from physical exercise affect the degree of stress in a group? According to the result of Approach Ag in Section Results, it can be said that the average stress is estimated to be lower for organizations with more contributing people, that is, those who tend to keep moving. From this, it was hypothesized that the slope of an individual's activity duration distribution indicates the amount of energy transmitted to the surroundings and that the stress of the person who receives the energy a lot may be reduced. Assuming that a group is a closed system, the total amount of energy transmitted in the group and that of those who receive it should be equal. This hypothesis can explain why the sum of active durations was able to properly estimate the average stress level of a group with the questionnaire in approach Ag. Also, in the other nine companies in **Table 2**, the communication structures were in line with the definitions of each group, and there was less collaboration across the groups. In other words, they are groups that can be said to be "closed systems," so it is considered that a high estimation accuracy was obtained in the experiment in Section Experiments. To prove this hypothesis, we think that the propagation path of "energy" and the criteria for judging "closed systems" should be clarified, but these will be issues for the future.

Significance and Limitations

This study enabled the average stress level of a group to be continuously measured in a practical way. Since the proposed method can be used to perform measurements automatically, what employees have to do is only wear the sensor terminal while working. The advantage compared with ESs used for making conventional management decisions is that the burden on the employees is small. In addition, the frequency of the ES survey is about once a year, but the group stress level can be observed once a week using the results of this study. In other words, a manager can quickly notice and cope with the risks of declining productivity and increasing turnover. An anthropologist, Dunbar, stated that the number of people that could maintain stable social relations was around 150 (Dunbar, 1992). In organizational psychology research, the number of subordinates that a manager can directly manage, the span of control, is broadly known as about 8–12 (Cathcart et al., 2004). However, there is a large number of companies with more than 150 employees and managers with more than 13 subordinates. Internal surveys such as ESs have been conducted to maintain a smooth social relationship in an organization by capturing group conditions that cannot be directly grasped by human executives and managers. In particular, ESs has been used by executives to take over the helm of a company, but fine control cannot be had with annual input. Therefore, in the midst of organizational change, middle managers frequently talk to their subordinates to make up for a lack of information and provide risk understanding and support (Carter et al., 2013). As the speed of organizational change will increase in the future, it

is expected that managers will be required to grasp and adjust their subordinates' stress risks more quickly. We believe that this technology can significantly contribute to supporting executives and managers in such situations. Furthermore, by obtaining continuous stress level data, statistical analysis combined with records such as PC logs may also be able to find the cause of workplace stress. In other words, we expect that this study can contribute to discovering not only stress risks but also solutions.

However, the limits of the proposed approach, Ag, are the following three points. First, this study may only guarantee estimation accuracy in a "closed system" group which may be charactaristic of Japanes companies. A closed system refers to an organization, as shown in **Table 5**, that has more internal communication and less external communication. In the evaluation of Section What Physical Activity Duration Represents, face-to-face communication time was used as an index indicating the amount of interaction between persons. However, it has not been specified whether something that represents the activity duration is transmitted by verbal information in face-to-face communication or non-verbal information such as gaze or voice height. Therefore, it is necessary to evaluate what defines a closed system in the future. For example, it must be considered whether this system can be applied to remote work, shift work sites, and project work sites where human connections change organically. As discussed in Section What Physical Activity Duration Represents, identifying how "energy" that appears in an individual's physical movement affects the stress of others around them will be a clue to solving this problem. The second limitation is that the proposed method guarantees estimation accuracy only for desk work-oriented jobs. Since the proposed method is calculated on the basis of physical movement, there is a possibility that the slope β of the active duration distribution will change for types of work in which there is continual movement while working, such as nursing, retail, and warehouse work. It is necessary to extend the experimental target, which, in this paper, was office workers, and evaluate the robustness of the proposed method to see whether the same method can be applied with the same parameters to these other types of work. The third limitation is the proposed approach is to try to explain stress only with motion sensor in spite of stress at work can be caused by a lot of variables.

CONCLUSION

In this paper, we proposed a method for estimating the stress level of a group with a focus on body movement, and we evaluate four approaches. As a result, we confirmed that we could perform estimation with high accuracy by using an approach of generating an estimation model of a group unit by using the active duration distribution ($r = 0.928$, $p < 0.001$, estimation error: 1.36%). The feature of this approach is that it is practical. Since a group stress level can be automatically measured simply by wearing a sensor terminal while working, the burden on the employee is small, even if the level is measured more frequently than the ESs), which is conventionally used for management decisions. The results of this study will enable us to observe the state of an organization about once a week, so managers can quickly notice and cope with the risks of declining productivity and increasing turnover rates. From the above, we confirmed the possibility that this study can contribute to supporting executives and managers in their decision making.

Future Work

Future work involves the following two points.

- Identifying a mechanism that represents the duration of physical activity and its effect on the stress level of people around a person.
- Robustly evaluating the proposed method in an experiment with groups from other job types.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hitachi, Ltd., Research & Development Group. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

ST designed the study, analyzed the data, and wrote the manuscript. KA was involved in conceptualizing the study including data collection. KY designed the study and provided feedback. NS was involved in data collection and provided feedback. All authors contributed to the article and approved the submitted version.

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frontiers in Communication

METHODS
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Working Across Faultlines—Assessing Intersubgroup Communication in Teams

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Communication between different subgroups is essential to group success, as different perspectives and knowledge need to be integrated. Especially when subgroups form due to faultlines, hypothetical dividing lines splitting a group into homogeneous subgroups, the resulting subgroups are vulnerable to negative intergroup processes. In this article, we evaluate different methods that have been used to trace communication between faultline-based subgroups and discuss challenges that researchers face when applying those methods. We further present the faultline communication index (FCI) as a novel approach to meet those challenges. We combine techniques from social network analysis with a behavioral process approach to trace communication processes between subgroups and provide scholars with tools to integrate in their own research. We illustrate this approach by observing and coding real time interactions in 29 organizational meetings. Results show that although functional faultline strength does not impact information exchange between subgroups, intersubgroup interactions positively relate to the quality of action plans defined at the end of a meeting. Managers and practitioners who work with diverse teams can be given guidance on how communication between subgroups evolves and how it can be shaped to become more effective. We further discuss implications for future research on communication between subgroups.

Keywords: group diversity, subgroups, interaction analysis, intersubgroup communication, faultlines

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INTRODUCTION

In the year 1999, a Mars orbiter was lost in space because its navigation coordinates could not be transferred from a spacecraft team in Denver to a lab in California, causing a $125 million loss to the NASA. An investigation into the causes revealed that a group of engineers had used the imperial measurement system, while the rest of the research group operated with the metric system.

This is just one of many examples where team communication has failed. However, not only in high impact teams responsible for multimillion-dollar projects communication is essential to group failure or success. Everyday work groups are equally affected by communication challenges. How can similar incidents be avoided? What can be done to ensure that information is sufficiently distributed within a group to produce reliable outcomes? How can we measure if a group successfully coordinates between different subgroups? Which types of groups are especially vulnerable to miscommunication?

Especially when group members refer to different conceptual worlds, as in the introductory example, reaching common ground can be a challenge (Huber and Lewis, 2010). Given that the

workforce becomes increasingly diverse, teamwork represents working in an environment with individuals from different backgrounds, disciplines, or cultures. Many organizations rely on diverse teams that bring diverse perspectives into organizations and might outperform homogeneous groups due to their manifold skills and different sources of knowledge (e.g., Jehn et al., 1999; van Knippenberg et al., 2004; Horwitz and Horwitz, 2007). Besides the opportunities that different perspectives and diverse knowledge within a work group bring to group and organizational success, a central element is the integration of these different perspectives. Especially when a group falls into functional subgroups, i.e., smaller units within the same group separated by certain functional features or affiliations (e.g., discipline, tenure, educational level), bridging differences is essential to reach a common ground (Homan et al., 2008). Not sharing all of the information with the other group members or implying a certain knowledge that not everyone in the group shares can lead to communication failures, as highlighted by meta-analytic findings (Mesmer-Magnus and DeChurch, 2009).

Communication between subgroups and integration of different perspectives is important in any type of group (see Carton and Cummings, 2012 for examples in different contexts). In small groups, research has concentrated on diversity faultlines as hypothetical dividing lines that separate a group into more or less homogeneous subgroups (Lau and Murnighan, 1998; Meyer and Glenz, 2013). They represent a multidimensional measure of team diversity that helps to understand subgroup dynamics in a team. Instead of observing dimensions of diversity such as education level and tenure separately, faultlines consider differences on multiple attributes simultaneously and take the alignment (i.e., the distribution of attributes in a way that homogeneous subgroups form) of these attributes into account (e.g., Lau and Murnighan, 1998; Bezrukova et al., 2007; Carton and Cummings, 2012). A strong faultline implies the formation of subgroups that are homogeneous regarding all attributes under study (for example, a team with a subgroup of blue-collar workers with many years of work experience vs. a subgroup of white-collar workers that graduated recently). The resulting subgroup formation in turn impacts how communication between team members of the same as well as of different subgroups takes place (Harrison et al., 2002).

Given that the exchange and integration of ideas, perspectives and knowledge is seen as a crucial factor in group success (e.g., Mesmer-Magnus and DeChurch, 2009), tools to assess those communication processes between functional subgroups gain importance when studying small group communication. Most research on communication in diverse groups focuses on communication within the group as a whole, neglecting processes between subgroups (van der Kamp et al., 2011; Jiang et al., 2012; Vora and Markóczy, 2012). When addressing communication specifically between subgroups, researchers mostly focus on self-reported connections between group members. While these self-reports are important to understand the perceptions of group members, objective behavioral data is important to gain additional insights into actual (sub)group dynamics (Meyer et al., 2014; Kolbe and Boos, 2019). Additionally, several challenges, for example the comparability across different groups or varying subgroup sizes, accompany the study and assessment of intersubgroup communication (Straube and Kauffeld, 2020).

With the present study, we aim at addressing the following three points: Firstly, we evaluate measures of intersubgroup communication and introduce the faultline communication index (FCI, Straube and Kauffeld, 2020), a measure based on methods from social network research. Secondly, we aim at combining this approach with interaction analysis using the act4teams coding scheme. By this, we integrate specific communication behaviors into analyses of intersubgroup interaction to provide a more complete understanding of what happens in communication between functional subgroups. Thirdly, we explore how intersubgroup communication can shape meeting outcomes in a sample of 29 organizational groups. We extend the literature on faultline-based subgroups and communication by relating functional faultline strength to between-subgroup communication and thus examine the theoretical foundation of inter-subgroup biases in actual team interaction.

Assessing Communication Patterns in Small Groups

When examining communication patterns within small groups, social network analysis provides important foundations to understand connections between group members. It focuses on relationships between individuals denominated as ties (Borgatti et al., 2009). These ties can be used to picture the flow of information between team members or serve as proxies for social support or advice (Cross and Parker, 2004). Often, self-reported connections or ties between team members are used as a proxy for proximity, friendship, and also communication between team members (e.g., Ren et al., 2015). To gain a deeper insight into actual behavioral processes taking place during communication or coordination between pairs of team members or within the whole team, several studies have employed aspects of observed communication behavior to depict communication networks, such as safety communication, use of emails, or verbal expressions (e.g., Miller et al., 2010; Alsamadani et al., 2013; Gloor et al., 2017). Sauer and Kauffeld (2013) proposed a way to assess communication within team discussions through network ties based on speaking turns. A tie between two team members is defined as an utterance of one member following an utterance of another member. With this method, it is possible to gain insights into the interaction structure of small group meetings.

So far, scholars studying the impact of faultlines on group interaction have mainly focused on interactions within the group as a whole, grounding on the argument that increased communication within the group accentuates the differences between group members (Hogg and Terry, 2000; van der Kamp et al., 2011). For example, Vora and Markóczy (2012) used the average of the communication frequency (i.e., the communication ties) between each of the group members to assess communication within the group. Other researchers have focused on an overall perception of communication of each group member to the rest of the group (van der Kamp et al., 2011; Jiang et al., 2012).

Common to these studies and approaches is that they all consider communication processes within the group as a whole. However, theorizing suggests that faultlines especially impact the processes between smaller subgroups within a team (Carton and Cummings, 2013). Thus, key to understanding processes in groups affected by faultlines are the dynamics that take place between the more or less homogeneous subgroups created by the faultline.

Subgroup Analyses—Methods, Pitfalls, and a (Possible) Solution

When turning to interactions between different subgroups, research on analyses of communication between subgroups is scarce (Lau and Murnighan, 2005; Ren et al., 2015; Adair et al., 2017). Most scholars apply methods also used to assess interactions within the whole group.

Lau and Murnighan (2005) used a questionnaire to assess group members' contacts to all other members. They assessed the frequency of communication via email, telephone, and face-to-face in five categories, ranging from less than once a week to more than 16 contacts per week. They averaged the number of a group members' contacts with members from other subgroups. The overall amount of contacts was not taken into account. However, the shared environment of a specific team (e.g., the same work context, shared experiences within the team) always influences individual perceptions and behavior (Kozlowski, 2012). Consequently, the amount and nature of intersubgroup communication will be influenced by the amount and nature of communication that is shared within the whole group.

Also, when we want to depict processes between subgroups, we want to evaluate whether those processes deviate from what would be expected within a given team. Ren et al. (2015) proposed a measure of friendship and animosity ties between members of different subgroups. They calculated the ties between subgroups as the cross-subgroup density (Borgatti et al., 1992), dividing the existing ties between subgroups by the number of all possible ties between subgroups. By this, they took into account that groups with different subgroup constellations have varying possibilities of communicating between subgroups (e.g., a group of six members falling into two subgroups of three with a total of nine possible ties between subgroups vs. falling into one subgroup of four and one subgroup of two with a total of eight possible ties between subgroups).

Ren et al.'s approach is very useful when considering ties between group members of equally large groups with varying subgroup constellations. However, research practice shows that especially in the study of real-world groups, factors such as group size and subgroup constellations are not controllable, compared to experiments. Thus, when we want to capture a more nuanced picture of the group communication at hand, and compare groups with varying amounts of members, researchers face the challenge to compare group processes, such as communication, across groups different in size, and in constellation. When choosing previous approaches (e.g., Ren et al., 2015) that relate intersubgroup communication to possible ties between members, but not to the overall group size, the comparison between different groups is difficult. **Figure 1** illustrates this with different groups of different sizes and subgroup constellations, separated by a strong faultline. In group A and B, there are five members each. In group C, there are four members. In group A, one subgroup of three and one subgroup of two members form. In group B, there is one subgroup of four members and one member forming a solo-split. Consequently, there are less possible connections between members of different subgroups than in group A (four compared to six), while the total number of possible ties within the teams is equal. In group C, there are two subgroups of two members with a total of four possible connections between subgroups. While the possible ties between subgroups are equal in teams B and C, there are more possible ties within the whole team in group B than in group C. This means that intersubgroup interactions are more likely in group C than in group B, because there are less possibilities of intrasubgroup interactions. Relating the intersubgroup ties to only the possible ties between the subgroups would result in a biased comparison.

Taken together, researchers need to consider multiple challenges when working with data on groups and subgroups. **Table 1** summarizes those challenges as well as solutions to these challenges.

To overcome the challenges that accompany approaches used in the past, the FCI (Straube and Kauffeld, 2020) has recently been introduced. In a first step, communication between subgroups can be related to overall team communication, assessed for example through the number and strength of ties between members. This is done by dividing communication between subgroups by team communication (see the Methods section). Next, the number of possible ties in a group, which is dependent upon the group size, is divided by the number of possible ties between subgroups, which is a function of the constellation of subgroups (see **Figure 1**). The two resulting scores are multiplied to calculate the FCI, that relates the actual team communication to the possible ties within the given team. Our methods section gives a detailed description of all steps taken to calculate the FCI including formulas. This procedure presents several advantages for the study of small groups. Firstly, it relates the communication between subgroups to communication within the whole group, taking into account that larger groups offer more communication possibilities for group members than smaller groups. Secondly, the possible connections between all group members as well as between the subgroup members can be taken into account (see **Figure 1**) when studying groups that vary in size or in their subgroup constellations. Thirdly, it is applicable to both perceived connections between a set of group members (self- or externally reported data) as well as observed connections between a set of group members (behavioral data). Lastly, the FCI can be enriched by behavioral data, such as coded interactions between group members, to further explore specific communication behaviors.

How Do They React? Integrating Specific Communication Behaviors Into Intersubgroup Communication Analysis

In addition to the quantity of communication between subgroups compared to the overall team communication, studying specific communication behaviors, such as finding solutions to problems, structuring a discussion, making plans or disagreeing with

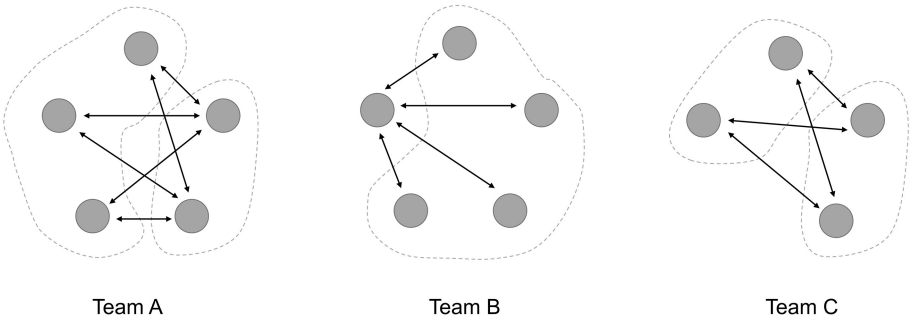

FIGURE 1 | Possibilities of intersubgroup interactions in three exemplary groups. Gray circles represent team members. Dashed lines mark the subgroups in each team. Arrows represent the possible ties between members of different subgroups.

TABLE 1 | Challenges of subgroup analyses and proposed solutions.

Challenges	Proposed solutions
Challenge 1: subgroups are nested in groups, and thus influenced by amount of group communication	Relate intersubgroup communication to team communication
Challenge 2: varying group size between teams making comparisons biased	Include possible ties between all team members into analyses
Challenge 3: different subgroup constellations (i.e., 3:3 vs. 2:4) in equally large teams	Include possible ties between different subgroups into analyses
Challenge 4: self-reports of interaction frequency or tie strength can be biased	Choose a behavioral approach (observed communication ties or coded behavior)

other group members, is extremely relevant to understand communication dynamics in groups (Sunwolf and Frey, 2005; Kauffeld and Lehmann-Willenbrock, 2012; Meinecke and Lehmann-Willenbrock, 2015). While functional communication (i.e., behaviors contributing to advance problem solving and information sharing, aiming to structure a discussion, and fostering a positive climate within the group; Kauffeld et al., 2018) between subgroups offers the possibility to establish positive contact between in- and outgroup and thus diminish the negative effect of social categorization (Pettigrew, 1998), dysfunctional communication (i.e., behaviors directed at criticizing others or complaining; Kauffeld et al., 2018) between subgroups can raise potential for misunderstandings and conflict (Vora and Markóczy, 2012). First results connecting communication networks to functional and dysfunctional behaviors show that functional and dysfunctional meeting networks differ in their structure, underlining the relevance of specific communication behaviors for communication dynamics (Sauer and Kauffeld, 2016).

We propose to combine the calculation of the FCI with the act4teams coding scheme (Kauffeld and Lehmann-Willenbrock, 2012; Kauffeld et al., 2018). The act4teams coding scheme is a coding scheme with mutually exclusive and exhaustive observation categories in which utterances can be classified into one of 44 behavioral codes. These codes are divided into four broader categories: problem-focused behaviors, procedural behaviors (positive and negative), socioemotional behaviors (positive and negative), and action-oriented behaviors (proactive and counteractive). This allows the comparison of positive and negative statements within and between subgroups as well as the comparison of different behavioral categories (see section Meeting Interaction for a detailed description of the coding scheme in this context).

Applying the Analysis of Intersubgroup Communication to Organizational Team Meetings

Besides the methodological extension, a further goal of this study is to show the FCI in application to real-life teams and to develop hypotheses on this. In this context, we shed light on the role of intersubgroup communication in mediating the effects of functional faultline strength on team outcomes in organizational meetings.

Meetings present an opportunity for groups to reflect on their work, discuss problems and goals, and find solutions to everyday work issues (Rogelberg et al., 2006). In organizational meetings, effective communication is the key to success (Kauffeld and Lehmann-Willenbrock, 2012). Designing effective meetings as well as ensuring that measures discussed are taken into action after a meeting are central interests of team managers and organizations (e.g., Scott et al., 2012; Lehmann-Willenbrock et al., 2018). Shifting focus to the way in which team members exchange information within a meeting can lay ground for a deeper understanding of team communication processes and their role in the relationship between team compositional factors and team outcomes.

In this study, we focus on functional faultlines and resulting subgroup formation as they are likely to bring different perspectives and knowledge to a group (e.g., Cronin and Weingart, 2007; Jehn and Rupert, 2008; Polzer and Kwan, 2012). Certain attributes might determine the access to information, for example functional background or the number of years a team member has spent in the organization (Mayo et al., 2017). Integrating these perspectives is crucial for group success

and a challenge to researchers and team managers alike, since a common understanding is needed for a successful integration (Huber and Lewis, 2010). **Figure 2** shows our proposed research model.

The Impact of Functional Faultlines on Group Interaction

Drawing on the categorization elaboration model (CEM, van Knippenberg et al., 2004), positive effects of different perspectives and broader knowledge within a team can only unfold when team members elaborate on information thoroughly. However, social categorization processes can hinder information elaboration and thus performance. This is especially likely when certain conditions are met. When the *comparative fit* between individuals of different subgroups is high, meaning that the similarities between members of the same subgroup as well as the differences to members of a different subgroup are more obvious, social categorization becomes more likely. By definition, this is the case when the faultline is strong, leading to homogeneous subgroups regarding multiple member attributes (Williams and O'Reilly, 1998). Further, a high *cognitive accessibility*, i.e., the ease with which members can be classified into certain social categories, increases the likelihood for social categorization. The cognitive accessibility is especially high for visible attributes (Fiske, 2000), but can also be triggered by contextual primes (i.e., tenure will be more easily accessible in situations where the group discusses problems that can be solved with information regarding the firm's history). Lastly, social categorization becomes more likely when the differences are meaningful to an individual, resulting in high *normative fit*. This is the case when the attributes considered are relevant to the task at hand (van Knippenberg et al., 2007).

This indicates that categorizing oneself and other members into different social categories (which can be different functional subgroups, e.g., Bezrukova et al., 2012) fosters a separation of the subgroups and thus hinders information exchange. In line with the findings on ingroup preference (e.g., Williams and O'Reilly, 1998; van Knippenberg and Schippers, 2007), research shows that especially between heterogeneous members, information exchange is less likely and, when information is exchanged, group members are more likely to exchange information that is common to everyone instead of focusing on unique knowledge (Stasser and Titus, 1985; Mesmer-Magnus and DeChurch, 2009). So far, several studies have focused on team information exchange in the context of faultlines. Groups with a strong educational faultline (based on educational specialty, age, gender, and educational level) have been shown to share less task-relevant information within the whole group than groups with a weak educational faultline (Jiang et al., 2012). Further, information elaboration has been shown to mediate the link between faultline strength and task performance (Meyer and Schermuly, 2012). Additionally, when functional faultlines are strong, subgroups within a team will likely develop separate mental models which are difficult to integrate as well as their own representation of how a task should be conducted and how problems should be solved (Carton and Cummings, 2012). Most of the time, these strategies are implicit and adhering to them could lead to misunderstandings and overall performance inhibitions (Rico et al., 2008). Functional subgroups arising from strong faultlines tend to be highly specialized, as knowledge is mostly integrated within subgroups (Qu and Liu, 2017). This can lead to inconsistent definitions of the team's problems across subgroups, inhibiting information exchange within the team as a whole (Cronin and Weingart, 2007). Understanding how these processes translate into actual behavior in organizational meetings could deliver starting points for designing effective meetings. What remains to be explored is how these information exchange processes between different functional subgroups unfold within a meeting. Given the specific structure of teams affected by faultlines, we propose that:

H1: In groups with strong functional faultlines, information exchange between subgroups is impaired more strongly than in groups with weak functional faultlines.

Intersubgroup Information Exchange and Action Planning in Meetings

As a substantial number of meetings is ineffective and even described as a "waste of time" (Rogelberg et al., 2006), scholars have focused on factors for successful meetings (e.g., Scott et al., 2012; Reiter-Palmon and Sands, 2015; Lehmann-Willenbrock et al., 2018). In this regard, research has shown that the way in

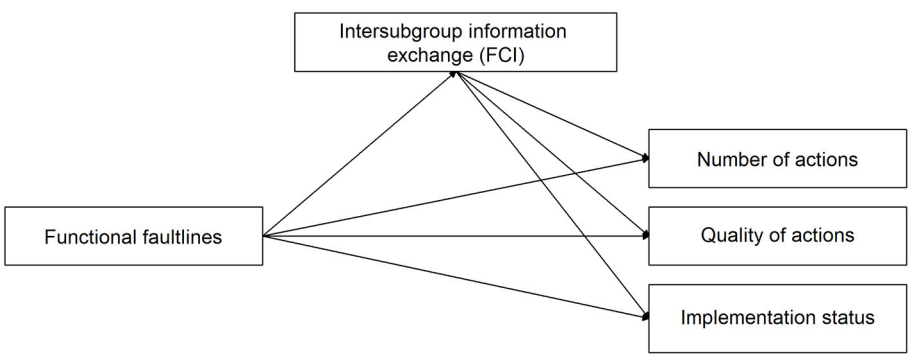

FIGURE 2 | Proposed research model.

which a group communicates within a meeting is central to their success (e.g., Kauffeld and Lehmann-Willenbrock, 2012; Sauer and Kauffeld, 2013).

We argue that effective information exchange is relevant to action planning, that is the development of measures to be taken into action after a meeting, for two reasons: First, elaborating all task relevant information ensures that all available information is taken into account, an important factor in successful collective decision making (e.g., van Ginkel and van Knippenberg, 2008). Second, a common ground is needed for all team members to share an understanding of what the actions that have to be taken include (e.g., Carton and Cummings, 2012). Only then, they are able to work toward implementing these actions.

Research as shown that solutions only foster productivity when they are not only discussed but also implemented later on (Kauffeld, 2006; Lehmann-Willenbrock et al., 2018). To ensure that measures planned in a meeting are also taken into action later on, communicating effectively within a meeting is crucial (Lehmann-Willenbrock et al., 2013). This includes effectively elaborating all task relevant information to develop a shared understanding of goals and actions discussed in a meeting, for example by cross-linking problems and solutions (e.g., Mesmer-Magnus and DeChurch, 2009; Kauffeld and Lehmann-Willenbrock, 2012). This is especially crucial between faultline based subgroups, as they tend to dispose of a broad range of knowledge and expertise. Bringing together these different "thought worlds" (Dougherty, 1992) can enhance team performance and the successful implementation of actions, as all available information needs to be discussed (Lehmann-Willenbrock et al., 2013). On the other hand, not sharing and elaborating on all information between subgroups can lead to different ideas of the desired outcome and thus hinder the quality of action planning after a meeting. We therefore state:

H2: Information exchange between subgroups is positively related to the quality of action planning after a meeting.

Integrating our first two hypotheses and following theorizing on diversity and faultlines in meetings (Gerpott and Lehmann-Willenbrock, 2015; Straube and Kauffeld, 2020), meeting behavior can act as a mediator between faultline strength and group outcomes. Negative effects of faultlines on team outcomes, such as difficulties in developing a common understanding (Carton and Cummings, 2012), might unfold through interactional processes within a group (Meyer et al., 2014). We propose intersubgroup information exchange as a central group process to transmit the effects of faultlines into outcomes:

H3: Information exchange between subgroups mediates the negative effects between faultlines and quality of action planning after a meeting.

METHODS

Participants and Procedure

The data was a subset of a large longitudinal investigation on team interactions and the effectiveness of teamwork. In the present study, a total of 36 work groups ($N = 205$ employees) from the production departments of two medium-sized German companies were examined. These groups represent the total of available team meetings of the last measurement point of the large investigation. We only chose one measurement point to ensure that there was only one meeting per group in the study. There were 18 groups from an electrical company and 18 groups from an automotive supply company. Due to missing information on functional background and organizational tenure from eight individuals in seven teams, not all team members could be allocated to their respective subgroups. Therefore, seven teams had to be excluded, resulting in a final sample of 29 teams ($N =$ 161 employees). Three to seven coworkers participated in each meeting. Eighty-five percent of the group members were male, which is representative of the companies involved. Employees' ages ranged from 17 to 57 years with a mean of 35 years. Approximately 74% had completed technical training, about 12% were untrained workers, and about 1% had completed technical college. Thirteen percent of the participants indicated other training. Organizational tenure varied between 1 month and 39 years with a mean of 10 years. All teams were self-managed. As part of the large longitudinal investigation, all groups participated in an intervention to improve meetings which took place several weeks before the meetings examined in the present study.

The groups discussed a problem-solving task relevant to their specific work activities, which they chose themselves (e.g., How can the quality of our work be improved?). Participants confirmed that this type of task was a regular topic of their meetings and that it was important to work on that specific task. This guaranteed that the discussion outcomes were relevant to the groups and occurred within their natural work environment.

Functional Faultlines

Functional faultlines were calculated using the average silhouette width (ASW) method (Meyer and Glenz, 2013). The calculations were performed in R with the asw.cluster package for faultline calculation (Meyer and Glenz, 2013). Faultline strength ranges from 0 to 1, with 0 representing the minimum separation of a group into homogeneous subgroups. A value of 1 represents perfect alignment of attributes, resulting in maximum separation of a group into homogeneous subgroups. We integrated the most commonly used attributes for functional faultlines, educational level, and organizational tenure, into our measurement (Thatcher and Patel, 2012).

Meeting Interaction

For analysis of the videotaped interaction data, we used the act4teams coding scheme (e.g., Kauffeld, 2006; Kauffeld and Lehmann-Willenbrock, 2012; Meinecke and Lehmann-Willenbrock, 2015; Kauffeld et al., 2018). Utterances were unitized by sense units and subsequently coded by five trained, independent coders using Interact software (Mangold, 2010). During the coding process, each unit was assigned to one of the 44 exclusive categories of act4teams. In order to determine the quality of the coding, a subset of the videos was double coded, i.e., coded by two of the coders, to subsequently determine

the interrater reliability between all pairs of coders. The interrater reliability was excellent (Fleiss' $\kappa = 0.81$)[1]. We focused on problem-focused statements to represent information exchange and integration between group members. In the act4teams coding scheme, problem-focused communication consists of the subcodes differentiating a problem, cross-linking a problem, differentiating a solution, contributing a solution, or describing a solution, cross-linking a solution, and statements about the organization or about knowledge management. For further analyses, the absolute number of utterances coded in each observational category was enumerated per group member.

Faultline Communication Index (FCI)

Determining Intersubgroup Interaction

To determine interaction between subgroups, we turned to a method proposed by Sauer and Kauffeld (2013). They proposed a way to assess communication within team meetings as network ties. A tie between two team members is defined as a speaking turn, that is a team member's utterance following an utterance of another team member. These ties are then summed up for each communication pair (a pair of two team members). We counted all problem-focused speaking-turns (i.e., one group member makes a problem-focused utterance after another group member has spoken) for each team member and displayed the values in a "who-to-whom" matrix (see **Table 2** for an example). Column cells represent the number of problem-focused utterances each speaker gave in reaction to utterances from all other team members (i.e., team member A reacted 39 times with a problem-focused utterance to any utterance from team member C and 10 times with a problem-focused utterance to any utterance from team member D, and so on) while row cells represent the number of utterances a speaker directed to each other team member, however, our analysis only took those utterances into account that were followed by a problem-focused statement (i.e., team member A talked 26 times before team member B made a problem-focused utterance and 21 times before team member C made a problem-focused utterance, and so on). The member-to-subgroup attribution was obtained via the ASW-package in R.

Calculating the FCI for Between Subgroup Information Exchange

To calculate the FCI as a measure of between-subgroup information exchange, we employed the formulas proposed by Straube and Kauffeld (2020). Firstly, all problem-focused speaking turns between members of two different subgroups were added. This sum was then divided by the total amount of problem-focused speaking turns between all team members following this formula:

$$speaking\ turn\ ratio = \frac{number\ of\ speaking\ turns\ betw.\ subgroups}{overall\ speaking\ turns} \quad (1)$$

For the exemplary team displayed in **Table 2**, the speaking turn ratio was 201/306 = 0.66. To account for differences in group size and subgroup constellation, we further calculated the possible ties within a team (overall ties) as well as the possible ties between subgroups:

$$possible\ overall\ ties = \frac{N\ (N-1)}{2} \quad (2)$$

$$\begin{aligned} possible\ ties\ between\ subgroups = \ & N_{subgroup\ A} * N_{subgroup\ B} \\ & + N_{subgroup\ A} * N_{subgroup\ C} \\ & + N_{subgroup\ B} * N_{subgroup\ C} \end{aligned} \quad (3)$$

In the exemplary team, possible ties between the six team members were 15 and possible ties between subgroups were 2 * 4 = 8. Equations (2) and (3) were then divided to result in the so-called tie ratio, representing the ratio of possible ties within a team (overall ties) to possible ties between subgroups. This tie ratio ensures that the value of the final FCI (see Equation 5) is not biased by team size or subgroup sizes (see Straube and Kauffeld, 2020, for a development of the measure).

$$tie\ ratio = \frac{possible\ overall\ ties}{possible\ ties\ betw.\ subgroups} \quad (4)$$

The tie ratio for the exemplary team from **Table 2** was 15/8 = 1.88. The final score of intersubgroup information exchange represents problem-focused communication between subgroups controlled for overall problem-focused communication, team and subgroup size as well as subgroup constellation:

$$Faultline\ Communication\ Index\ (FCI) = speaking\ turn\ ratio * tie\ ratio \quad (5)$$

The FCI of the exemplary team was 0.66 * 1.88 = 1.24. The FCI reaches a value of 1 when communication between and within subgroups is perfectly balanced. A score below 1 indicates that less communication takes place between subgroups than within subgroups. A score above 1 indicates more communication between subgroups than within subgroups (Straube and Kauffeld, 2020).

Quality of the Action Planning

To evaluate the quality of action planning, we employed three separate measures which were then used as separate outcomes in our multivariate path model. After the meeting, the groups listed all measures that they wanted to take after their meeting in an action plan (e.g., report damages on machines, implement software trainings for workers, change material of a product to avoid defects). We employed one quantitative and two qualitative (self- and external rating) ratings to evaluate the quality of the action plan.

Firstly, we counted the number of actions. The amount of measures in the action plan were enumerated per group. In our sample, the number of measures ranged from 0 to 15.

Secondly, the quality of the measures was rated by the expert coders that analyzed the videotapes. Quality ratings ranged from 0—the measure was not mentioned during the meeting to 1—a complete action plan has been made for the respective measure during the meeting. Ratings were made on a six-point scale in

[1]Please note that the coding process was part of the larger study with meetings at several measurement points.

TABLE 2 | Example of a "who-to-whom" matrix for problem-focused communication between subgroups.

	Team member A PF (1)	Team member B PF (1)	Team member C PF (2)	Team member D PF (2)	Team member E PF (2)	Team member F PF (2)	Sum
Team member A (1)	0	26	21	10	19	5	81
Team member B (1)	39	0	7	10	6	2	64
Team member C (2)	39	13	0	6	12	2	72
Team member D (2)	10	15	4	0	4	1	34
Team member E (2)	20	18	4	5	0	0	47
Team member F (2)	5	1	1	1	0	0	8
Sum	113	73	37	32	41	10	306

Cell scores represent the frequency of responses of team members to other team members. Numbers behind team members' names indicate their subgroup. Intersubgroup communication is marked in gray. PF = problem-focused statements.

steps of 0.2. For each group, a mean rating was obtained, ranging from 0 to 1 in our sample.

Thirdly, we considered the implementation status. Six to eight weeks after the meeting, the groups indicated the status of the measures that were to be taken after the meeting with the following scale: (0) The measure has not been taken yet, (1) the implementation is in progress, or (2) the measure is implemented. We obtained a mean score for the implementation status of each group, ranging from 0 to 2 in the present sample.

Controls[2]

To be able to compare the FCI to previously employed measures to assess interactions between subgroups described before, we calculated the average cross-subgroup contacts as applied by Lau and Murnighan (2005) as well as the cross-subgroup density as applied by Ren et al. (2015). The cross-subgroup contacts were calculated as the number of problem-focused speaking turns between members of different subgroups, divided by team size. The cross-subgroup density (Borgatti et al., 1992) was calculated as problem-focused speaking turns between subgroups divided by possible ties between subgroups. We chose the problem-focused ties/contacts to ensure comparability with the FCI.

We controlled for education level diversity and tenure diversity in our analyses to evaluate the effects of faultlines strength given a team's diversity. For education level diversity, we employed the Blau Index of heterogeneity (Blau, 1977). Tenure diversity was calculated using the team-based standard deviation.

DATA ANALYSIS

We conducted path analysis with indirect effects in MPlus Version 8 (Muthén and Muthén, 2017) with 1,000 bootstrap samples. We included functional faultline strength as the predictor variable, information exchange between subgroups (FCI) as the mediating variable and quality of action plan, including number of actions, quality of actions and implementation status, as outcome variables. Education and tenure diversity were inserted as control variables.

RESULTS

Means, standard deviations, and intercorrelations for all study variables are presented in **Table 3**. Functional faultline strength ranged from 0.24 to 1.00, indicating that all teams were affected by faultlines to some extent. On average, teams had 418.34 talk-turns in their meetings ($SD = 211.37$). The mean number of problem-focused talk-turns, i.e., information exchange and integration, in teams was 163.76 ($SD = 81.30$). The FCI, representing intersubgroup information exchange, ranged from 0.40 to 2.21 with a mean of 1.03 and a standard deviation of 0.34, showing that while on average, information exchange was balanced within and between subgroups, there was variation between teams regarding the distribution of information exchange.

Table 3 further shows descriptive statistics and intercorrelations of the average cross-subgroup contacts as well as the cross-subgroup density. Both variables show moderate to strong correlations with the FCI. As opposed to the FCI, both cross-subgroup contacts as well as cross-subgroup density showed strong correlations with the overall speaking turns. In other words, the more speaking turns in a team, the higher the values for both variables. The FCI was not related to overall speaking turns. Further, cross-subgroup density showed a marginally significant negative correlation with possible overall ties, while cross-subgroup contacts showed a marginally significant positive relationship with possible ties between subgroups. We see a correlation of all three variables to the number of measures, while only the FCI is related to the quality of measures (expert rating).

Table 4 shows the results of the path analysis. The model had five degrees of freedom and showed acceptable to moderate fit to the data [root mean squared error of approximation (RMSEA) = 0.077, comparative fit index (CFI) = 0.923, standardized root mean squared residual (SRMR) = 0.086].

Functional faultline strength did not impact the FCI ($B = -0.010$, $p = 0.98$). In other words, strong functional faultlines did not hinder (nor foster) information exchange between the

[2]As noted by a recent publication (Certo et al., 2020), the use of ratios in research, as is the case in calculating the FCI, can impact the interpretability of statistical models. If sample size allows, we thus advise scholars implementing the FCI into their research to include the lower order terms (number of speaking turns between subgroups, overall speaking turns, possible overall ties, possible ties between subgroups) into their models to control for confounding effects.

TABLE 3 | Descriptive statistics and correlations among study variables.

	M	*SD*	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1. Functional faultline strength (ASW)	0.62	0.16	0.24	1.00	—	0.054	−0.164	−0.115	0.195	−0.603**	0.092	0.219	0.249	0.072	0.043	0.054	0.042	0.032	0.238	0.120
2. Intersubgroup information exchange (FCI)	1.03	0.34	0.40	2.21	0.054	—	0.415*	−0.057	0.460*	−0.122	−0.305	0.374*	0.175	0.197	0.004	0.182	−0.026	0.304	0.381*	0.520**
3. Quality of measures (expert rating)	0.79	0.26	0.00	1.00	−0.164	0.415*	—	0.369†	0.253	0.225	0.047	0.084	−0.186	0.225	0.198	0.261	0.074	0.082	−0.022	−0.078
4. Implementation status	1.61	0.56	0.00	2.00	−0.115	−0.057	0.369†	—	0.195	0.350†	−0.041	0.354†	0.156	0.070	0.431*	0.198	0.325†	−0.464*	0.270	−0.033
5. Number of measures	4.86	3.80	0.00	15.00	0.195	0.460*	0.253	0.195	—	0.019	0.106	0.594**	0.550**	0.257	0.174	0.262	−0.117	0.156	0.508**	0.417*
6. Education level diversity	0.24	0.20	0.00	0.64	−0.603**	−0.122	0.225	0.350†	0.019	—	−0.115	0.014	−0.072	0.050	0.115	0.185	0.063	−0.049	−0.069	−0.116
7. Tenure diversity	6.66	3.68	0.55	15.54	0.092	−0.305	0.047	−0.041	0.106	−0.115	—	−0.253	−0.190	0.056	−0.016	−0.032	−0.232	0.090	−0.317†	−0.397*
8. Speaking turns btw. subgroups (pf)	101.45	59.42	12	207	0.219	0.374*	0.084	0.354†	0.594**	0.014	−0.253	—	0.892**	0.454*	0.595**	0.511**	0.352†	−0.080	0.923**	0.509**
9. Overall speaking turns (pf)	163.76	81.30	38	342	0.249	0.175	−0.186	0.156	0.550**	−0.072	−0.190	0.892**	—	0.423*	0.421*	0.462*	0.110	0.124	0.819**	0.495**
10. Possible overall ties	13.07	5.55	3.00	21.00	0.072	0.197	0.225	0.070	0.257	0.050	0.056	0.454*	0.423*	—	0.791**	0.945**	0.423*	0.523**	0.134	−0.330†
11. Possible ties btw. subgroups	7.72	4.11	2.00	17.00	0.043	0.004	0.198	0.431*	0.174	0.115	−0.016	0.595**	0.421*	0.791**	—	0.779**	0.776**	−0.103	0.330†	−0.309
12. Team size	5.45	1.21	3.00	7.00	0.054	0.182	0.261	0.198	0.262	0.185	−0.032	0.511**	0.462*	0.945**	0.779**	—	0.409*	0.450*	0.176	−0.272
13. Number of subgroups	2.35	0.61	2.00	4.00	0.042	−0.026	0.074	0.325†	−0.117	0.063	−0.232	0.352†	0.110	0.423*	0.776**	0.409*	—	−0.409*	0.213	−0.282
14. Mean subgroup size	2.85	0.90	1.67	5.29	0.032	0.304	0.082	−0.464*	0.156	−0.049	0.090	−0.080	0.124	0.523**	−0.103	0.450*	−0.409*	—	−0.227	−0.085
15. Average cross-subgroup contacts (pf)	18.28	9.06	2.00	35.40	0.238	0.381*	−0.022	0.270	0.508**	−0.069	−0.317†	0.923**	0.819**	0.134	0.330†	0.176	0.213	−0.227	—	0.738**
16. Cross-subgroup density (pf)	14.31	7.40	1.33	30.67	0.120	0.520**	−0.078	−0.033	0.417*	−0.116	−0.397*	0.509**	0.495**	−0.330†	−0.309	−0.272	−0.282	−0.085	0.738**	—

ASW, average silhouette width; pf, problem-focused statements. N = 29 teams. For comparability reasons, we display three decimal places.
*†p < 0.10. *p < 0.05. **p < 0.01 (two-tailed).*

TABLE 4 | Model results for the path analysis with mediation.

	Intersubgroup information elaboration		Number of measures		Quality of measures (expert rating)		Implementation status	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Intercept	1.048***	0.271	−7.862	5.283	0.122	0.370	0.742	0.901
Functional faultline strength (ASW)	−0.010	0.450	6.363	5.457	0.070	0.334	−0.148	0.916
Tenure diversity			0.288	0.176	0.020	0.015	0.040	0.032
Educational diversity			6.143	4.947	0.463†	0.240	0.823	0.786
Intersubgroup information exchange (FCI)			5.084*	2.224	0.343*	0.156	0.411	0.359

	Effect	SE	LLCI	ULCI	Effect	SE	LLCI	ULCI	Effect	SE	LLCI	ULCI
Indirect effect of faultline strength	−0.051	2.517	−3.928	3.651	−0.003	0.176	−0.320	0.237	−0.004	0.283	−0.480	0.298

SE, Standard errors; ASW, average silhouette width. N = 29 teams. LL and UL represent the lower and upper limits of the 90% confidence interval for the indirect effect. Estimates are unstandardized. For comparability reasons, we display three decimal places.
*$^{\dagger}p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ (two-tailed).*

subgroups, refuting H1. As hypothesized, the FCI positively impacted outcomes regarding action planning. The higher the ratio of information exchange between subgroups (the FCI), the higher the external rating of the quality of the measures ($B = 0.343$, $p = 0.025$) and the higher the number of actions ($B = 5.084$, $p = 0.022$). There was no effect on the implementation status 6 to 8 weeks after the meeting ($B = 0.411$, $p = 0.252$). In other words, intersubgroup information exchange was linked to more and better measures discussed during the meeting. H2 could partially be accepted. There were no indirect effects of faultline strength on the aspects of quality of the action plan via intersubgroup information exchange ($IE = -0.051$, $p = 0.984$ for number of actions, $IE = -0.003$, $p = 0.984$ for quality of measures, $IE = -0.004$, $p = 0.988$ for implementation status). H3 had to be refuted.

DISCUSSION

In this article, we present and extend a novel approach of between subgroup communication, the FCI (Straube and Kauffeld, 2020). This measure presents an opportunity to study communication between subgroups in real life small groups that are likely varying in group size and in subgroup constellations. We further enrich the study of intersubgroup communication by integrating a behavioral process approach into the analyses. This allows a more fine-grained approach to analyzing and understanding communication between subgroups.

Our results demonstrate that the FCI is preferable to the use of cross-subgroup contacts or cross-subgroup density as a measure to intersubgroup information exchange when group constellations vary. Compared to these previously employed measures to capture interactions between subgroups, the FCI showed to be less biased by group makeup (that is, the possible overall ties within a group as well as possible ties between subgroups) and by overall speaking turns within the group.

We show how the FCI can be applied to meeting research by integrating it into a model linking faultline strength to meeting outcomes. We examined how meeting behavior—namely the information exchange between faultline-based subgroups—can mediate the negative effects of faultlines on meeting outcomes. With our study, we wanted to shed light onto "processes that are responsible for translating diversity into action" (Roberge and Van Dick, 2010, p. 298) and to examine whether faultlines come alive in micro-level interactions within team meetings. While we did not find the proposed negative effect of functional faultline strength on information exchange between subgroups, we found interesting results concerning the influence of intersubgroup communication on team outcomes. Information exchange between subgroups showed a positive impact on (a) the number of measures a group recorded after a meeting and (b) whether a measure is discussed thoroughly within a meeting.

Theoretical Implications

With our study, we contribute to the growing field of subgroups in work teams (Carton and Cummings, 2012). By integrating measures from social network analysis and a behavioral process approach, we extend existing methodology to assess processes taking place between faultline-based subgroups (e.g., Lau and Murnighan, 2005; Ren et al., 2015). As the FCI controls for different team sizes and different subgroup constellations (see **Figure 1**), it is applicable to datasets from organizational teams that show variations in their group sizes as well as number and size of subgroups. Further, the type of behavior that is shown can easily be integrated into the analyses by using behavioral codes from the act4teams coding scheme or other available coding schemes that fit the respective research questions. This is relevant to unpack the within-team processes that take place when faultlines and subgroups are present (Bonito and Sanders, 2011; Meyer et al., 2014).

Turning to the results of our empirical investigation, we can take several implications from the application of the FCI to processes in organizational groups. While some studies have carved out positive effects of functional faultlines (e.g., Gibson and Vermeulen, 2003; Bezrukova et al., 2009), faultlines have often been described as a hindering factor for communication in teams in past research (Lau and Murnighan, 2005; Meyer et al., 2011; Vora and Markóczy, 2012). Quite contrary to these results, in our study, information exchange between faultline-based subgroups was not negatively related to faultline strength, i.e., teams with a stronger functional faultline did not have a lower ratio of between-subgroup information exchange. Rather than acting as a barrier between subgroups, functional faultlines did not show a significant influence on intersubgroup information exchange in our sample. This supports the assumption that interactions within a team meeting might not only be influenced by similarities and differences between team members (Polzer et al., 2002), but pre-given by structural requirements of the organization (Lawrence, 1997). Teams with long-term history might thus already have established interaction patterns within their meetings that are not influenced by faultline strength. Existing interactions can influence how group members perceive themselves and their subgroups: When the interaction between the subgroups is positive, it can foster the exchange of different ideas and viewpoints and thus unfold the positive effects of diverse groups (Gray et al., 2005). When the interaction between the subgroups is negative, intergroup bias, and resulting conflicts might be strengthened (Labianca et al., 1998). Following this notion, intersubgroup interaction in meetings would not necessarily be influenced by faultline strength, but interaction evolving within a team might instead activate or deactivate faultlines (Ren et al., 2015).

We hypothesized that increased intersubgroup information exchange would foster the team's implementation of actions discussed during the meeting. As hypothesized, we found positive effects of between-subgroup information exchange on number of measures as well as expert quality ratings of the measures discussed in the meeting. Groups with more information exchange between functional subgroups developed more measures to be taken after the meeting, which were rated as better by external experts. This indicates that communication within a team meeting—and especially communication between faultline-based functional subgroups—plays a role in team functioning. When functional subgroups engage in a lot of information exchange, solutions they develop might be more elaborated because of the different perspectives these subgroups bring together. This deep elaboration is especially important because potential obstacles can be discussed, and alternative plans can be evaluated (De Dreu et al., 2000). The positive impact of information exchange between subgroups on the quality of the action plan further shows that even though the faultlines and resulting subgroup formation might not be salient, information sharing and elaborating between functional subgroups is still beneficial because different viewpoints as well as different strategies to solve and discuss problems are present and taken into consideration by the whole team.

Practical Implications

Team leaders as well as team members can pay closer attention to the nature of interactions between functional subgroups to foster information exchange and elaboration. Following our findings, this would lead to a greater variety and quality of action plans, likely because the teams that deeply elaborated problems and solutions, their consequences and practicability in the organization and consequently have developed a shared understanding of the team's action plan.

Our findings show the relevance of exchanging and discussing information between functional subgroups, even if the subgroups are not as strongly separated by a faultline. This indicates that even small differences between subgroups could imply a diversity in knowledge between those subgroups and a resulting importance of knowledge integration. Team managers should thus not only be aware of strong faultlines and resulting subgroup formation, but also focus on effective intersubgroup communication in teams that are seemingly not as vulnerable to subgroup separation.

Our results can support meeting leaders design more effective meetings, for example by establishing communication rules or defining cross-cut tasks, that is, tasks that are assigned to members from different subgroups to ensure intersubgroup information exchange (Rico et al., 2012). Ineffective meetings add additional costs to the already high direct expenses associated with meetings due to increased productivity (MCI Inc., 1998). Studies show that meetings also put high time constraints on employees (Rogelberg et al., 2007). To avoid these negative side effects, meeting leaders should focus on strategies to use the time spent in meetings productively. Our results show that meeting outcomes are directly linked to communication between smaller knowledge-based subgroups. Meeting leaders should make sure that all team members have a chance to speak and that no strong communication routines emerge, for example one team member only offering ideas after a member of his or her subgroup has spoken and never speaking after a member of another subgroup has spoken.

The FCI can be employed to monitor communication between subgroups that are not necessarily faultline-based. The formulas provided can be applied to any team in which a clear allocation of members to subgroups is possible. This is especially relevant in the light of the current situation related to the Covid-19 pandemic, where many organizations rely at least partly on teleworking. Teams may thus be divided into co-located subgroups which can negatively impact group processes (Polzer et al., 2006). Closely monitoring intragroup processes may further support organizations in dealing with challenges related to communicating in teams that needed to adjust their communication routines.

Limitations and Future Research

Despite the considerable insights that the study provides, there are some limitations to our research that we want to discuss and that could offer starting points for future research. The study of subgroups requires complete data sets for all team members. While simulation studies show that missing values

do not impact the calculation of faultline strength based on the ASW considerably (Glenz and Meyer, 2017), the allocation to a subgroup for each team member and the subsequent analysis of intersubgroup communication requires full data sets at least for the variables underlying the faultline calculation. We had to exclude seven teams due to incomplete data on educational level or tenure—a challenge that future studies in the organizational settings might also face, as participants might not indicate personal details due to data privacy concerns. Nevertheless, aiming for larger sample sizes when replicating our findings is commendable, especially when scholars want to integrate moderating variables into their models to further explore the proposed effects. Further, as noted above, adding the four lower order terms of the FCI as control variables in research models is advisable for mathematical reasons, but requires a certain sample size (Certo et al., 2020).

Further investigation is needed concerning the methodological properties of the FCI. Researchers could apply simulation studies to understand more closely how the FCI changes when group size and subgroup constellations vary. This could provide important insights into measures to be taken to adapt the FCI, depending on the study context and research questions at hand. Specifically, integrating configurational properties such as the number of subgroups and the variation of subgroup size into research on intersubgroup communication is relevant, as these properties will likely influence intersubgroup information exchange. As argued by research on subgroups (Carton and Cummings, 2012, 2013) the presence of more than two functional subgroups as well as a balance regarding subgroup size is beneficial for teams with functional subgroups, and is theorized to influence the consideration of knowledge in teams with functional faultlines. While this was not confirmed by our results, we still encourage future research to focus on these factors and to explore ways in which the number and balance of subgroups can be accounted for in the calculation of the FCI.

So far, we have only focused on one behavioral aspect of intersubgroup interaction when calculating the FCI: information exchange. Studies have shown that in general, negative interactions exert a greater influence on team outcomes than positive interactions (Baumeister et al., 2001; Kauffeld and Lehmann-Willenbrock, 2012). Hence, effects of negative interactions between subgroups might be especially important to outcomes such as implementation status or the quality of action planning, as they might hinder effective elaboration of task-relevant information and thus interact with the effects found in this study. Future research could further compare different aspects of communication behavior, for example comparing the FCIs of problem-focused vs. socioemotional interaction networks. The integration of behavioral codes obtained from coding schemes such as the act4teams coding scheme into the calculation of the FCI can extend our understanding of intragroup and intersubgroup processes. The interplay between different kinds of team and subgroup interactions should be considered and disentangled concisely in future studies.

Our results as well as research from other fields give rise to new research ideas that future studies could focus on. An aspect that is promising for future research is the integration of between-team communication when focusing on faultlines and subgroups (Bahmani et al., 2018). Researchers can adapt and apply the formulas used to calculate the FCI to assess communication between a set of groups within an organization. External knowledge acquisition is an important factor influencing team performance (Ancona and Caldwell, 1992). When studying teams embedded in an organization, it is likely that relations exist between individuals that do not belong to the same team. This especially relevant in the context of functional subgroups, as a strong identification with one's subgroup might strengthen team members' confidence to seek information that a subgroup needs from external sources (Cooper et al., 2013).

CONCLUSION

The present study discusses challenges and solutions to measuring communication between subgroups in the context of diversity faultlines. We present a measure of intersubgroup communication, the FCI, that can also be applied to any type of group falling into subgroups and propose a way to enrich the FCI with behavioral data. Our empirical application of the FCI extends our understanding of intersubgroup communication processes in meetings and their impact on meeting outcomes. The findings from our empirical investigation further underline the relevance of assessing intersubgroup communication. By this, we adhere to the call to integrate actual intersubgroup communication as mediating processes into research on the impact of faultlines. Our results highlight the relevance of intersubgroup information exchange for the implementation of actions that are taken within and following a meeting. Intersubgroup information exchange can be seen as an important process variable to include in future (meeting) research.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: Data protection regulations of the research project. Requests to access these datasets should be directed to Simone Kauffeld, s.kauffeld@tu-braunschweig.de.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JS conceived the original idea for this article, performed all analyses, interpreted the results, and drafted the manuscript. SK collected the data, helped designing the study, gave constructive feedback, and contributed to writing and improving the manuscript. Both authors approved the manuscript to be published.

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A Variational Approach to Scripts

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This paper proposes a formal reconstruction of the script construct by leveraging the active inference framework, a behavioral modeling framework that casts action, perception, emotions, and attention as processes of (Bayesian or variational) inference. We propose a first principles account of the script construct that integrates its different uses in the behavioral and social sciences. We begin by reviewing the recent literature that uses the script construct. We then examine the main mathematical and computational features of active inference. Finally, we leverage the resources of active inference to offer a formal model of scripts. Our integrative model accounts for the dual nature of scripts (as internal, psychological schema used by agents to make sense of event types and as constitutive behavioral categories that make up the social order) and also for the stronger and weaker conceptions of the construct (which do and do not relate to explicit action sequences, respectively).

Keywords: script theory, social scripts, variational free-energy principle, active inference, Bayesian reasoning

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INTRODUCTION

How are humans able to navigate social situations? As social agents, we take for granted that we can and do modulate our behavior as a function of what is socially acceptable in certain kinds of situations. In this paper, we are concerned with explaining social behavior that is shaped according to *social scripts*. Social agents must be able to make sense of their social predicaments, identifying event types and reacting to them appropriately, in ways that cohere with the normative standards apt for a given social or cultural group. The script concept helps.

The concept of script is valuable because it explains the (implicit and explicit) forms of social knowledge at play in social actions, and because it allows us to study the interplay between socially constructed norms and aspects of our biologically hard-wired cognition. Scripts showcase the wide variety of interpretive frames and allowable action available in a social niche. The notion of scripts helps us understand that much of what we take to be universal about human behavior is underwritten by culturally specific narratives.

The script construct has a long history spanning several disciplines. Scripts have been applied fruitfully to study human behavior in different fields, from disciplines centered on individual humans minds and their interactions, such as psychology (Ekblom and Gill, 2016), neuroscience (Allain et al., 2007), and artificial intelligence (Abelson, 1981; Tzeng, 2006), to the social sciences, where it has been used influentially in fields like sociology (Goffman, 1999, 2009; Mahardale and Lee, 2013), criminology (Ekblom and Gill, 2016), anthropology (Singleton et al., 2019), and sexology (Metts and Spitzberg, 1996; McCormick, 2010; Wiederman, 2015). Different definitions of scripts abound, with their different focuses. The concept sometimes is used under different names (action schemas, etc.) (Goddard and Wierzbicka, 2004).

The idea that motivates use of the script construct in these scientific approaches is, at its core, dramaturgical (Simpson et al., 1967; Goffman, 1999). According to its proponents, what enables social agents to act in situationally appropriate ways is a shared set of instructions or normative prescriptions for situationally appropriate behavior (Metts and Spitzberg, 1996). The implication of this view is that, in order to act as a cohesive social group in which every agent knows and enacts their role, agents must share a common body of knowledge (i.e., a script) that prescribes situationally appropriate modes of being (Abelson, 1981). This is metaphorically akin to actors sharing a dramaturgical script, hence the name of the construct. Scripts are used in scientific theories to shed light on how internalized psychological models are integrated with externalized social models, by drawing on a pool of common styles of performance and cognition through contextualized acts (e.g., speech acts) and their ensued actions driven by goals (St. Clair, 2008).

There are some issues that stand in the way of an integrated model of scripts across fields.

The first is that the concept gets implemented differently in different theories and disciplines, which throws doubt on our ability to provide a unique definition that can do justice to all the uses of the term in the literature (Abelson, 1981; Ekblom and Gill, 2016). Similarly, different terms can be used to describe very similar phenomena across domains of study, like script or schema, prepended with terms like social, cultural, or cognitive. Some authors have attempted to unify the concept (Schank and Abelson, 1977; Shore, 1998). In our view, these attempts have had a rather limited success, as the varied senses of the term suggest.

In this paper, we focus on two orthogonal distinctions that we suggest structure discussion on scripts in the literature. The first is a split between "internalist" and "externalist" readings of the construct of script. On the internalist conceptions, a script is defined as a cognitive structure that is typically internal to an agent (e.g., encoded in their brain) and that harnesses information about typified behavioral patterns that are appropriate in specific social situations (Abelson, 1981; Waters and Roisman, 2019). On the other, externalist conception, scripts are cast as the basic fabric from which social institutions are crafted. On this conception, a script is a set of highly codified practices, norms, standards, beliefs, linguistics practices, and rules that make up an institution (Heemskerk et al., 2011; Chentsova-Dutton and Ryder, 2020). Some conceptions are not as easy to split between internalist and externalist, but the way in which an agent interacts and reproduces a script does seem to bear elements of this duality nonetheless (Goddard and Wierzbicka, 2004).

The second is a split between the weak and the strong readings of script. The readings differ on how explicitly a script prescribes appropriate courses of action. On the strong reading, a script is a list of explicit instructions for situationally appropriate behavior, either neurally encoded (under the internalist reading) or implicit in conventions maintained by the institution (under the externalist reading). The strong reading dovetails with work in motor control that casts the process of motor control as the execution of a motor representation, which is cast as a list of explicit instructions for action (Tzeng, 2006). The weak reading of the script construct relaxes the assumption that a script prescribes the precise order of events that it entails. A weak script just encodes or harnesses information about the kinds of factors that an agent might encounter in a given situation type (Abelson, 1981).

Besides some early attempts in the field of artificial intelligence (e.g., Schank, 1972), there still is not an integrative formal model that is apt to do justice to all the variegated aspects and uses of the script construct. This makes it difficult to compare and see commonalities between various theories of the script.

The aim of this paper is to formalize the notion of script using the modeling resources of the active inference framework (Friston et al., 2017a). The hope is to shed light on the multifarious uses of the construct of script as it is used in the sciences that study human behavior. Active inference is relevant here because it may provide the key to formulating an integrative script construct. Active inference is an increasingly popular enactive modeling framework that is used to explain the behavioral dynamics of living creatures, i.e., their patterns of action, perception, emotions, attention, etc. (Da Costa et al., 2020; Hesp et al., 2021). Active inference casts all these processes as Bayesian inference processes. Action selection is cast as the Bayesian model selection of a preferred sequence of motor (or autonomic) movements that is informed by the likelihood of sensory observations; while the environment is cast as accumulating the traces of intentional actions left by agents acting together, thereby changing available sensory observation. Sensory perception and active modification of the environment allow active inference to explain how an ecological niche and its denizens become attuned to each other's statistical structure (Bruineberg et al., 2018; Constant et al., 2019b). Active inference is an interesting candidate framework to develop a principled, computational model of the dual nature of scripts, as internal schema, and as external social order. We will see that active inference can also accommodate both the strong and the weak reading of scripts.

The argumentative structure of this paper is as follows. In the first section, we review the internal, external, weak, and strong readings of the script construct. In the second, we introduce active inference and review the core tenets of the approach. Next, we propose a computational interpretation of the weak and strong, and the internalist and externalist readings of scripts. We show that the modeling resources of active inference can be used to derive a formal construct of script that encompasses the various readings in the literature. We conclude with remarks on the manner in which the proposed active inference model of scripts could be used to further research on human behavior.

SCRIPT THEORY: BACKGROUND

Scripts harness the knowledge involved in situationally appropriate behavior to achieve an intended social goal. Scripts are especially relevant in situations where there is uncertainty concerning the intent of the social partner. The appropriateness of a script is bound to cultural context. Take for instance flirting. The North-American middle class traditional flirting script has

been aptly described by Metts and Spitzberg (1996). The flirting script involves signaling one's intent by incrementally ensuring that similar intent is shared. This entails:

(1) Engaging in discussion on a topic.
(2) Expressing non-verbal behaviors that do not provide evidence that the agent will reach the intended goal (sexual intercourse).
(3) Moving toward topics and behavior related to the intended goal.

Steps 1 to 3 take the form of engaging in small talk; and if it is reciprocated, of choosing to ask more personal questions (e.g., moving from more distant to more personal ones) and enacting behavior (e.g., increasing closeness) that conforms to the interaction goal. If one pursues the flirting script, and starts behaving in a way that is more sexually forward, but their potential partner does not respond or enacts another script, it is safer to assume that they are not interested in engaging in a sexual encounter.

This sequencing says something about the relation between internalization of scripts and the assumption of normalcy or universality. In certain subcultures, like the swinger community (Kimberly, 2016), or gay saunas (Brown et al., 2005; Kimberly, 2016), the reality of the social scripts is equally codified (e.g., with specific locales and ways of acting), but leads to the outcome (sex) differently. Scripts speak to social goals, and communicate the enactment of these shared goals to the people around us.

Internalism: Scripts in the Behavioral Sciences (Psychology, Neuroscience) and in Artificial Intelligence

The most influential of the social script construct rendition is an internalist one that comes from its use in cognitive and social psychology (Schank and Abelson, 1977; Abelson, 1981). The construct has been used to implement the tacit knowledge that agents have of the social-cultural norms that determine the appropriateness (c.f., prior probability) of behavior in a social situation. Scripts are higher-level constructs that capture fairly general information about how certain tasks are to be accomplished.

The use of scripts by agents can be broken down into two phenomena: competence and performance (Royle, 2013). Competence is the ability of an agent to understand what each social situation entails, what scripts may be enacted, and what are the proper cues indicating when to "enter into" a script; while performance consists in acting on that capacity, leveraging the perceptual and knowledge-based aspects of the script to bring about the situationally appropriate sequence (Ekblom and Gill, 2016). Thus, a script is anchored in a specific social context, and adapts a pattern of actions to the demands of a situation.

Some features of scripts are recurrent in the literature. They must be stable in time, learned from experience and drive behavior (Mahardale and Lee, 2013; Waters and Roisman, 2019). Abelson (1981) nicely summarizes the main features of behavior driven by shared scripts:

> *"Three conditions seem necessary for scripted behavior to occur. First, the individual must have a stable cognitive representation of the particular script. Second, an evoking context for the script must be presented. Third, the individual must enter the script. This third is the critical condition at the gap between cognition and behavior. It is assumed that script entry is contingent upon satisfaction of an action rule attached to the script representation." (Abelson, 1981, p. 791, emphasis added).*

An agent must be able to navigate a social situation, and the psychological script concept gets used to explain the kind of tacit or explicit knowledge at play in the generation of appropriate actions. The first point of Abeldon's definition says that the "representations" (internal models or schema) of the action sequence to be accomplished must be stable enough to be deployed by the agent in the generation of context-sensitive behavior (Abelson, 1981; Waters et al., 2015).

The second says that agents must be able to recognize situationally specific cues that indicate the appropriateness of enacting a script now (what Abelson calls an "*action trigger*"). Agents must thus be endowed with some knowledge about what environmental cues indicate in terms of appropriate action; and this knowledge is harnessed in the script, which contains an action trigger. Using scripts, the agent may find its way in any situation by understanding which part of the event sequence she is currently in, and how to move forward (Ekblom and Gill, 2016). The enactment of a script following an action trigger assumes an action rule that defines when to partake in the script (Schank and Abelson, 1977; Abelson, 1981). These thresholds may, for instance, comprise *role* definitions. A role is entered and may be replicated in time. Inference about the role of the self, informed by the script, thus guides performance (Schank and Abelson, 1977). Similarly, observation of the actions of another agent can help an agent infer their role in a script, and predict the next actions (Ingelsböck and Schüßler, 2019).

Finally, the last point of this definition says that once the action trigger is recognized by the agent, a sequence of actions to execute must be chosen by the agent. This implies a kind of commitment to the action policy ("entering a script") by taking on a role in the script. This entails that an agent should be able to perceive possibilities for acting according to the script, and accordingly enact it via performative acts (Mahardale and Lee, 2013).

Modifying the knowledge around the script allows the agent to change their behavior in turn (Abelson, 1981). The agent learns variations of the scripts, and has some part in deciding which way to enact it. Deciding which one to pick depends on the conceptual clusters that can be found in the local environment. These clusters are created directly via analogy or conditioning (Abelson, 1981; Singleton et al., 2019).

Scripts are in this sense similar to narratives (Bouizegarene et al., 2020). Scripts emerge from interactions with relevant social others in situations with which the agent is familiar; and the proximity with narratives comes from the causal relations between events (Ingelsböck and Schüßler, 2019). Scripts harness knowledge related to contexts by specifying possible connections between event types. Scripts harness socially shared assumptions and structure inference that are allowable in a given context (Waters and Roisman, 2019).

In artificial intelligence, the script construct was employed to codify the bodies of regimented inference that are employed by agents in social contexts. The earliest conceptions of social scripts in artificial intelligence consisted in semantic networks structured into goal-oriented sequences (St. Clair, 2008). In this context, scripts were explicit conceptual representations of expected event sequences that were activated by textual triggers. These expected event sequences allow users to bridge gaps in between events because of the logical (e.g., causal) relations encoded in the event sequences (Greenberg et al., 1998; St. Clair, 2008).

In summary, in the behavioral sciences and artificial intelligence, scripts have been used to account for the accurate interaction of an agent with their context. The internalist framework in the social sciences thus focuses on the cognitive schema, permeated by contextual.

Externalism: Scripts in the Social Sciences (e.g., Sociology, Anthropology, Criminology, and Sexology)

On the alternative, externalist reading of the construct, scripts are related to the existence and maintenance of social institutions (Ingelsböck and Schüßler, 2019). Berger and Luckman compare institutions to theatrical performances, in which actions are programmed and are embodied in a set of specific *roles* that get enacted by social actors (Simpson et al., 1967). It is the enactment of these patterned roles that keeps scripts and the institutions that they compose alive (Turner and Biddle, 1981). Scripts can specify actions for more than one agent; and the various clusters of actions that can be performed by a given agent in a script is called a role.

In the externalist conception, constrain social experience by harnessing institutional norms of allowable behavior (Vanclay and Enticott, 2011). The script construct is here used in a way that emphasizes the social reality that is constituted by the enactment of cohesive, institution-specific modes of acting. Scripts are cast as the building blocks for coherent communities with shared values (Wierzbicka, 2002; Singleton et al., 2019). Scripts are higher level constructs as well on this conception, but these constructs have a social reality outside the mind of the individual.

This poses a problem. Most psychological theories would have scripts exist in the mind of individuals, but this does not explain how they are translated into material reality. By material reality, we refer to the physical properties of the world which carry social meaning. While symbols can take on a material form, not all study of symbol looks at this manifestation, and focuses rather on immaterial properties. We wanted to highlight this second side of the study of symbols. Symbols, materials and culture are intertwined in ways that make them more complex to study separately. Arguably, they can be considered different pieces of the larger social realm. Symbols act as building blocks. They allow meaning to be imbued to units. Materials are often referring to the physical reality individuals have access to, but they can be also associated to the direct ecological context an individual is embedded in. Culture is the matrix which connects and coordinates across individuals the mapping between materials and symbols. The solution starts from noticing that social structures emerge from socially organized psychological phenomena (St. Clair, 2008). The repeated enactment of scripted actions allows agents to make reliable inferences about themselves and other agents. Goffman argued that institutions can be understood as pre-negotiated inferences that find their confirmation in the reifications of practice and language. That these inferences repeat over time helps them crystallize, as it were, into a largely shared common ground (Goffman, 1999; Ingelsböck and Schüßler, 2019). The reiteration of structures does not rob agents of their agency: the agent must take part in the scripts and deal with the unexpected possibilities by interpreting the patterns accurately (Binder, 2007; Ingelsböck and Schüßler, 2019). Scripts, on this conception, are thus overarching structures that contain templates upon which agents can draw for more specific performances (Graesser et al., 1980).

Definitions of scripts in the social sciences differ in terms of the approaches to the study of cultural organization they belong to. We can distinguish between three approaches (St. Clair, 2008): the symbolic approach, the activity theory approach, and the individualistic approach. The symbolic approach (Adler et al., 1997; Ratner, 1999) casts individual agents as the main bearers of power. This power is externalized by the creation and consolidation of shared symbols. This conception accords much importance to shared meanings and concepts, and is far less concerned with the material reality of institutions. Symbols have a life of their own and allow agents to communicate with others and to develop an identity. The symbolic designations of things in the world turns them into mental objects, imbued with meanings and goals (Adler et al., 1997; Ratner, 1999; St. Clair, 2008).

The activity theory approach (Ratner, 1997, 1999) focuses on practice (praxis), and casts psychological phenomena as formed by individuals engaged in social action. This approach, influenced by Marxist theory, emphasizes the material reality of the social world, casting human agency as shaped by the pursuit of meaning and goals in a material social context. Marxist theory casts a specific importance on materialism, and the socially embedded meaning of the material reality. In Marxism, humans search for meaning through the lens of social goals. Activity theory similarly embeds the search for meaning inside the social realm, and places activity and productions as vectors for understanding individuals' relations to materiality. It is also to note that Leontiev and Vygotsky were both strongly influenced by Marxist materialism, which is perceptible in the theory's focus on material conditions as social vectors for meaning. This approach studies social phenomena as a function of how power is divided among social agents and how actions are defined by this division of power. Activity theoretic conceptions of the script emphasize individuals' interactions with the material world. By focusing on a goal, and by being constrained by linguistic tools and practice conventions (i.e., by scripts), humans achieve a stable social order (St. Clair et al., 2005).

The individualistic approach (Garey and Wikan, 1998; Ratner, 1999) maintains a duality between individuals and culture, and proposes that the individual has agency in the way that they objectify culture. Individuals confer meaning that serve their aim to elements of culture, which they will then use

to further their aims. Their cognitive life is thus shaped by cultural artifacts, which are objectified pieces of culture that they select for themselves and that they can share with other individuals. Somewhat similar to meme theory (Dawkins, 2016), this approach views culture as fractured quasi-genetic fragments that can be used, transformed and spread (Garey and Wikan, 1998; Ratner, 1999; St. Clair, 2008).

Overall, these approaches to cultural organization in social sciences allow us to portray scripts as a cultural framing. Scripts, as the order social structures, prescribe what an individual should do, given his timestep in a given pre-organized script, and the role they have chosen or was given to embody. This framing is conveyed by the individuals in a group through language and common practices. These approaches emphasize the disconnect between cognitive structures and social practices, which is bridged in language: performative externalized cognition. By performative externalized cognition, we mean that this aspect of cognition is extended to the social realm. Through linguistics, individuals can share and gather information more efficiently, without having to get the information for themselves. The interesting phenomenon at play here is the fact that this social exchange has a weight. Through communicating, individuals create the reality they seek to exchange. Their enactment of this linguistic exchange creates the reality, therefore making it performative. Existence does not happen in a silo, and all thought or action take place within a context. If the context is constituted by relevant social others, language can act as the bridge between self and the social context. This commonality frames what is possible, and anchors what is possible in a specific set of goals (St. Clair, 2008).

The Strong and Weak Conception of Scripts

Strong Scripts

The way the script construct is used in the literature is further complicated by another distinction, introduced by Abelson (1981), between a strong or weak conceptualization of the construct. The general distinction is that the strong concept entails that the script represents events and actions to be performed in a particular order, whereas the weak concept eschews any such ordinality. The strong concept of script has more to do with the links between the concepts present in the script (i.e., their ordering) than the concepts themselves; while the weak concept is more semantic, and speaks to what is typical in a kind of social situation.

A strong script refers to the sequences of structured behavioral events performed by social agents. These can be reorganized by variations, but overall maintain some similarity in structure (Leclerc and Wortley, 2013; Ekblom and Gill, 2016). It is this similarity that enables agents to make inferences about relevant social others (Berg and Hochstetler, 2016). The order of the events is paramount in strong scripts, as they are causally related (Abelson, 1981; Leclerc and Wortley, 2013). Agents are able to infer the next plausible event or course of action based on the temporal and causal connections they know to exist between two categories. The order thus matters because there is a necessary entailment of the social actions. Here, what Abelson called "event triggers" become crucial and act as floodgates, without which the rest of the script cannot or will not be enacted.

Consider for instance ordering food at a restaurant, which is covered in Schank and Abelson's famous CITE script (Schank and Abelson, 1977). The typical restaurant script in North America is something like the following: (1) Make a reservation or wait in line; (2) Be seated by the host; (3) Review the drinks menu and order drinks; (4) Review the food menu and order food; (5) Eat food; (6) Pay for services (including a 15% tip). Here, order matters. For instance, in most swanky restaurants, it would be considered inappropriate to sit at a table unless first instructed to do so by the host. In European pubs, one typically pays before eating, whereas in American bars, one pays after eating. Failure to conform leads to social friction and might also lead to penalties.

Essentially, the strong sense of scripts can be reduced to a socially coded drive toward goals that also allows agents to infer each other's goals (Ekblom and Gill, 2016). Because the scripts have common sequences that lead toward a common goal, agents can infer each other's goals, and infer the next likely actions for themselves, and by other agents. Knowledge is cached in the common practices and the expected goals. Thus, we can consider that a practical aim of scripts and their learning and transmission is to transfer practice-based knowledge. Navigating social interactions is enabled by the reiteration of practices, and optimizes communication between agents. Information is cached in the scripts, and limits how much any given agent needs to learn about optimal existence in his context (Goffman, 1999; Ekblom and Gill, 2016).

Weak Scripts

Weak scripts specify the typical features that an agent will encounter in an event type. The order of the events is not specifically important, so much as the semantic proximity and restrictions offered by the boundaries around a concept (what it does and does not contain). In this way, semantic relations are more important than the sequence of causal relations.

Consider for instance the script of going to the library. Some parts of this overall script have a strong aspect: For instance, before leaving the library with a book, one must have withdrawn it from the front desk and registered it under one's name. However, many aspects of the library script do not depend on an ordinal sequence of events. For instance, it is part of the library script that one should be silent in the library.

Weak scripts are thus, at base, clusters of associations or contingencies related to specific events. Event types do not have to be sequenced ordinally to be semantically connected in this way. In depicting what is typical in a situation type, weak scripts offer a cognitive framing related to contextual goals. They adapt the perceptual field, and make salient possible drives toward actions, and opportunities for roles for the agent (Abelson, 1981; Tzeng, 2006).

Sets of categories have overlapping characteristics which link them semantically (Tzeng, 2006). The more common ground there is between two sets of categories, the more likely two events drawing from these sets are to be in a given sequence. Thus, conceptual proximity defines the overall structure of the weak

script and defines a conceptual mapping for given situations. Conceptual mapping refers to the manifold that concepts are made of. Concepts are embedded nested structures of metonymy. They are made of layers of referents, all pointing to hierarchies of smaller or more fundamental ideas. Concepts are essentially webs of lower level semantic units. One overarching concept is the specific configuration of a semantic network, which corresponds to a specific mapping of one idea to many. These mappings for concepts can be different. This proximity structure may also help provide a restructuring effect for the strong sequencing of events in weak scripts (Abelson, 1981).

Weak scripts thus function as semantic markers of sorts, enabling an individual to infer how best to adapt to the demands of a social situation. Specifically, not all variations of a strong script are immediately translatable to a situated context. The weak script allows the agent to find the appropriate action, given the semantic field in which they are engaged. Weak scripts are integrated through practice and help agents imbue situations with meaning. When this meaning is made salient, it can help an individual navigate toward the appropriate and shared social goal (Lydon et al., 1997; Heemskerk et al., 2011).

Script Variations

As mentioned above, weak and strong scripts evince variety in the way they are integrated and performed. Scripts are polysemous (Greenhill and Fletcher, 2009). One reason for this polysemy is that *several actions that lead to the same result*. There may be more or less typical ways to achieve a given result (Abelson, 1981). Subsequently, some parts of the scripts are more important to the completion of the script, and the events in between these parts can vary. This refers to the gating of strong scripts by action trigger.

Some parts of the script are not as important, and may be at times skipped if the situation allows for it. This allows for several versions of the same overarching script to lead to similar (i.e., the more important) outcomes (Abelson, 1981). Scripts may share similar clusters, or event sequences. These may be linked into tracks or decision trees, which inflect at script gates. Script variations are partly due to the possibility that individual agents show variability in its interpretation and application. However, by considering certain parts of the event sequences to be more important, the possible permutations of scripts are limited. The conceptual "gravity" around certain concepts constrains how one may enact any given action possibility (Schank and Abelson, 1977).

Scripts can also vary because environments vary. The enactment of any given script will not always have the exact same form. There is an abstract nature to scripts that has more to do with the prototypical structure of practice (Ekblom and Gill, 2016). The same sequence may mean different things to different people based on what they previously associated to it. This intrinsic variation can have effects on practice, or it can have effects on whether or not an individual chooses to enact a script in a situation.

This concludes our review and overview of the uses of the script construct in the recent literature. We now turn to the active inference approach, which provides us with the tools to formulate an integrative and formal account of scripts.

ACTIVE INFERENCE: THE ABCs

Introduction to Active Inference

In this section, we leverage the apparatus of the active inference approach to provide a formal model of scripts that is apt to account for all the dimensions of the construct discussed above (internalist, externalist, strong, and weak readings). Active inference is an increasingly popular behavioral modeling framework that descends from older, closely related Bayesian approaches to the brain and behavior, such as predictive coding (Friston, 2010; Friston et al., 2017b). Active inference casts perception, learning, cognition, and action as forms of (Bayesian of variational) inference.

Technically, active inference says that perception, learning, cognition, and action all function to minimize an information theoretic quantity called variational free-energy (Friston et al., 2017a; Friston, 2019). This variational free-energy was first developed in the context of complex statistical inference to finesse intractable inference problems (Feynman, 1972). In this context, we aim as scientists to estimate some unknown probability distribution; however, the computation of such probability distributions often requires marginalizing over an infinite number of states, which makes inference intractable for analytic (exact) procedures. Instead of computing the distribution directly, variational inference allows us to write down a guess about this distribution (the variational or recognition model); variational inference methods to finesse this guess by changing its parameters (i.e., its shape) until it becomes close enough to the target distribution. This closeness is obtained by minimizing a variational (free-energy) bound on the evidence for our (the brain's) models or hypotheses about how (sensory) data were caused.

Generically, minimizing variational free-energy minimizes the discrepancy between the data that one would expect, given some model of how that data was generated (what is known as a "generative model"), and the data actually obtained (Feynman, 1972; Beal, 2003; Winn and Bishop, 2005). These methods were imported into neuroimaging neuroscience for various imaging modalities (functional magnetic resonance imaging, electroencephalography, and magnetoencephalography) in the 2000s (Friston et al., 2003; Kiebel et al., 2008). When minimized, the variational free energy scores the quality of the model in terms of its evidence, i.e., the probability of those data and that model. In this context, neuroscientists evaluate the probability of different models for how some neuroimaging data was generated. This is called dynamical causal modeling (Friston et al., 2003). In short, the variational free-energy is used to score the probability of each model, given the data; and the model associated with the lowest variational free-energy is the one deemed the best, or most likely to have caused our data.

Active inference applies the same strategy to modeling another kind of data: the sensory data that is generated by the activity of living creatures (Friston, 2019). In this context, the variational

free-energy construct is redeployed, now as a measure of the discrepancy between the observations the agent expected to make, and the actual sensory states encountered an agent. Active inference provides a mechanics of belief-driven action: it will look as if organisms select the actions that minimize free-energy (Ramstead et al., 2019). That is, according to the active inference approach, the dynamics (i.e., the behavior) of living systems serves to garner evidence for their existence as agents (Hohwy, 2016). Successful action in the environment generates sensory consequences that are consistent with our preferences; active inference formalizes this idea.

These expectations are harnessed in generative models, which do most of the heavy lifting in the active inference approach. A simple generative model is shown in **Figure 1** below. This generative model harnesses a number of different probabilistic beliefs: beliefs about the likelihood of observations, given the states that cause them (which are denoted A), prior beliefs about the manner in which states of the world evolve over time (denoted B), prior preferences over outcomes (C), and beliefs about states before sampling the world (denoted D).

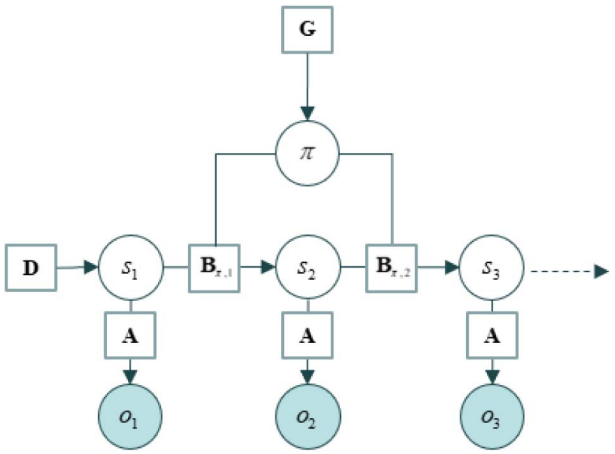

FIGURE 1 | A simple generative model for policy selection. This schematic depicts a generative model for policy selection. It represents probabilistic beliefs about how observations are related to the states that cause them (the likelihood matrix, which is denoted A), beliefs about the manner in which states of the world evolve over time (the state transition matrix, denoted B), and beliefs about states prior to sampling the world (prior beliefs, denoted D). Preferences over outcomes (C) are not depicted. From Friston et al. (2017b). For ease of visualization, we do not present the hierarchical structure of the generative process. The reader should assume that there structure of the generative process will include multiple levels. The important aspect of this schematic is to present the manner in which the generative model and the generative process interact with one another. The only reason we present multiple levels of the generative model is that two levels allows for a description of all the inner components of the script. Only one level of the generative process is needed to describe the external component (even though we should assume multiple levels of the generative process). The higher levels of a model constrain possible inference at the lower levels by unfolding over slower timescales and by setting the prior beliefs about initial states D at the lower level–that contextualize the ensuing state transitions or narratives. In such models, posterior estimates of successive states at the lower level become data or observations for inference at the level above.

A *generative model* is a statistical model of the causal process that generated the sensory data (the aptly named *generative process*). Model and process are linked at two points: the data itself, which the world generates; and the actions selected by the agent, which leave traces in the world and produce typical sensory consequences. Indeed, the main function of generative models is to mediate *policy selection* (or the selection of actions). This takes a particular form in active inference; namely, as the *realization of beliefs about action*. Policy selection is implemented as the selection of beliefs about state transitions, which reflect knowledge about the consequences of action (i.e., as the selection among a series of B matrices, each entailing a different plan of action or path into the future). The state transition beliefs are constructed to incorporate beliefs about the consequences of action; and an action is a series of such beliefs. Active inference gets its name from treating action selection as a form inference about what I must be up to: on the assumption that what I am doing minimizes variational free-energy, given my beliefs about what I might be doing and given my sensory (especially proprioceptive) data, what must I be doing? In some circles, this is akin to "planning as inference" (Attias, 2003; Botvinick and Toussaint, 2012; Millidge, 2019).

Importantly, in many applications, the generative models have a hierarchical or deep structure. Typically, the higher levels of a model constrain possible inference at the lower levels by unfolding over slower timescales and by setting the prior beliefs about initial states D at the lower level–that contextualize the ensuing state transitions or narratives. In such models, posterior estimates of successive states at the lower level become data or observations for inference at the level above.

In active inference, goals are not specified in terms of preferred states, but rather in terms of a preference distribution over outcomes (which is denoted C); that is, in terms of the preferred consequences of action. Motor control is then based not on the computation of explicit motor commands, as in optimal control theoretic formulations, but instead on feedback, in the form of prediction errors (Friston, 2011). This nicely avoids having to compute explicit motor commands in an intrinsic frame of reference (in terms of states of motor effectors, e.g., in terms of the stretching and contracting of muscle fibers); for a discussion of the implications of this for control theory, see Baltieri and Buckley (2018); Hipolito et al. (2020). In other words, the goal of an action is specified in terms of the preferred sensory consequences of action, rather than in terms of preferred states, and policies are selected that lead to these outcomes. Technically, the C vector enters into the calculation of the expected free-energy G for every policy, and defines the preferred outcomes against which actual outcomes are compared in the computation of the model evidence (negative variational-free energy).

Shared Generative Models and Sociocultural Dynamics

The active inference framework has been used to explain the emergence of coordinated group behavior. It was first shown that target patterns (e.g., morphologies) can emerge from the group behavior of components individually engaging in active

inference–on the condition that all free energy minimizing correspondents share the same generative model, that is, the same model structure with the same parameters (the A, B, C, and D matrices, etc.) (Friston and Frith, 2015; Palacios et al., 2019). When applied to large scale ensembles, such as cultural human ensembles, the convergence of behavior based on the sharing of similar enough generative models is thought to be mediated by the structure of the environment (Bruineberg et al., 2018), such as the ways in which culture is materially implemented (Constant et al., 2018). In this setting, the variational free energy minimum of the ensemble coincides with the corresponding minimum of each constituent. Because the environment is constituted by other constituents like "me" the environment and all of its denizens become mutually predictable.

On this view, a cultural or social group is a group of agents that has some common ground of shared cultural traits by virtue of sharing the same beliefs or expectations about the sensory consequences of allowable, situationally appropriate behavior. Agents acquire this body of common knowledge by the structure and parameters of their shared generative model, based on available sensory observations generated by the causal structure and processes of the environment (Constant et al., 2019a). To account for variations in culture, one needs (among other things) to account for variations in state transition narratives, leading to differentially parameterized generative models, and thus to differentially enacted policies (i.e., inference of a course of action based on the generative model). Variations in outcome sequences, in turn, result from environment-modifying actions, of both the explicit and implicit varieties (as in designing a park and leaving footprints in the snow, respectively).

Crucially for our purposes, recent work has suggested that generative models can be constructed with priors that dictate immediately which course of action to pursue upon sensing certain specific outcomes. Technically, the parameter allowing for such precisely inferred, habitised, trigger-based behavior involves a likelihood mapping between observation and policies, and a prior belief over policies forming what is known as "deontic value" (Constant et al., 2019b)" Deontic value is an attribute of the posterior of a policy. The likelihood (A) and priors (the B, C, and D) can be learned based on observations. Taken together, the standard inferential "ABCD" and deontic pathway to policy selection allows us to talk about *policy selection* in the context of cultural *group dynamics* that form via the exchange of local specific sequences of sensory observations on the basis of which a shared generative model can be learned that underwrites–and is underwritten by–a shared exchange with a common econiche. See **Figure 2**.

In **Figure 2**, Sequences of hidden states correspond to strong scripts. Action triggers (deontic cues) are represented by filled circles (blue). The ensuing architecture is defined over both internal (head icon) and external (planet icon) states. Weak and strong scripts are realized across multiple levels that span internal and external factors. From 1 to 10: (1) is the prior belief about initial state (e.g., in the flirting script, it is the categorical assumptions about the world, or specifically, the belief that there are men and women in the world, and that they will probably present themselves differently. It is combined with the likelihood (3) at that same level to infer the latent state (2). Prior beliefs about transitions at the second level (4) will contribute to determining what will be the future latent state at the second level. Here, we represent only one cycle of inference at the second level. One cycle of inference at the second level involves two (or hypothetically more) cycles of inference at first level. The inference of the latent state (2) biases the inference of the first state and subsequent states (5 s) (e.g., in the flirting script, the second level entails the belief that an agent is enacting an attractive role, being sexually interesting. They assume that their first state will be to engage the flirting with a low level of intimacy) and the action policy (6) (e.g., you should increase intimacy level with each transition, but you should start at a low level so as not to be unattractive) at level one, which themselves combine a likelihood at level one (7) (e.g., that a given event is mapped to a low level of intimacy, such as saying hello or asking about each other's name). On the side of the external world, there is only one process in play, which includes the likelihood of observation and states of the world (11) and the transition between these states (9). The agent can act on the transitions (downward thick arrow) to change the sort of outcomes generated by the world. Crucially, the outcomes (o)–that mediate the interaction between world and mind–function as deontic cues, to trigger certain plans or policies, formalized as a prior (denoted omega) biasing the inference about the first hidden state at level two of the agent's model. These outcomes form a likelihood between sensory outcomes and higher-level hidden states (e.g., the agent can thus check whether or not they have flirted accurately, based on whether or not their observation confirms that they are still attractive to their partner, and change or maintain their behavior accordingly. For instance, if the agent observes that their partner does not reciprocate their questions, and their body language does not increase in intimate proximity, the agent may infer at the second level that the interaction is not attractive and possibly not leading to sex). We also add expected free-energy (the G matrix) over the policy (6) at level one, which includes prior preferences (the C matrix).

AN ACTIVE INFERENCE ACCOUNTS OF SCRIPTS

We leverage the dual aspect of active inference (i.e., its appeal to dynamics internal and external to the agent) to dispel the tension and apparent contradiction between internalist and externalist renditions of the script construct. Active inference can accommodate all the dimensions of the script construct discussed above (i.e., the distinction between strong and weak modalities and the externalist versus internist conceptions) in a way that is both systematic and principled. Active inference can be used just as well to account for the structure and function of externally realized cognitive functions [e.g., extended cognition (Clark and Chalmers, 2010; Chalmers, 2019; Constant et al., 2019a)], as it can be used to describe the internal dynamics of agents; and it provides the requisite flexibility to accommodate the representation of both explicit scripted sequences of events (strong scripts) and typical event type features (weak scripts).

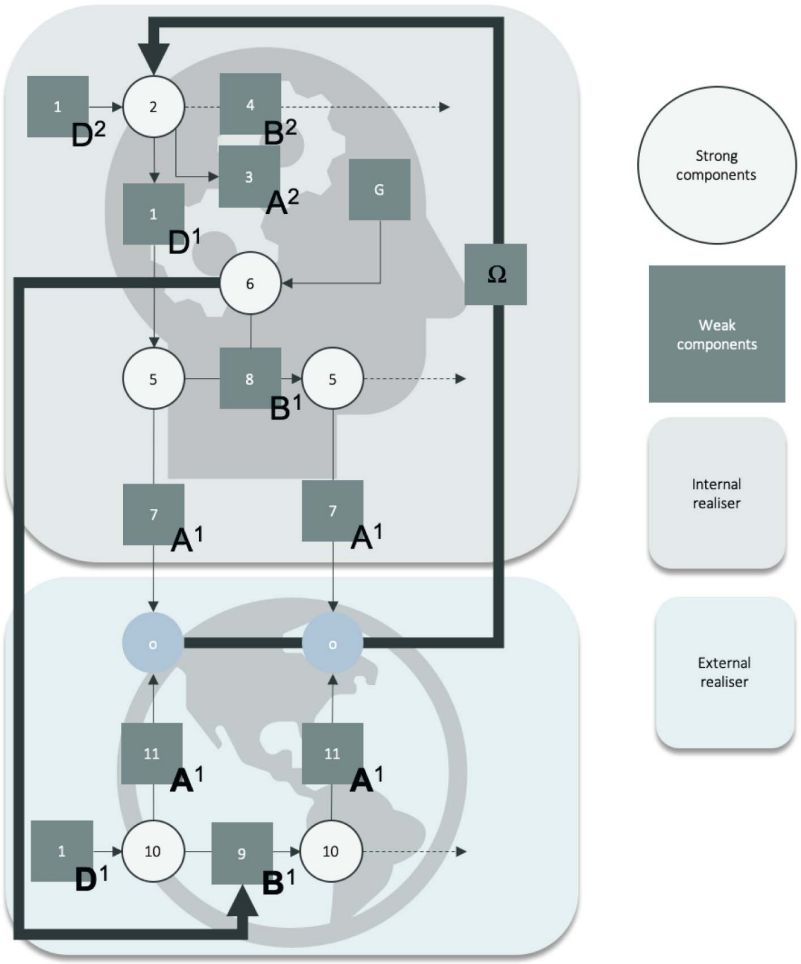

FIGURE 2 | Heuristic description of the generative model of the niche and of the agent. This schematic should be read as a heuristic "formal flowchart" of the biasing relation between priors and likelihood in generative model, rather than as a standard (probabilistic graphical) generative model. Weak scripts correspond to the knowledge about event types and their relation to sensory data available to the agent. Computationally, these correspond to priors and likelihoods (denoted as squares 1, 3, 4, 8, 7, 11, 9) that are combined to infer sequences of hidden states and the action policy (denoted as open circles 2, 5, 6, 10). Note that, for instance, "D1" in the bottom portion of the schematic is not the same as "D1" in the top section since the former is an attribute of the generative process, and the latter is an attribute of the generative model. We use the notion "D1" in both cases to help the unfamiliar reader to visualize the mirroring relation between the generative process and model.

We organize the next section as follows: we will examine the strong and weak conceptions of script under active inference, and for each, show how externalist and internalist readings can be accommodated.

Scripts as Shared Conceptual Structures About Event-Types

The most complicated aspect of the script construct to implement under active inference pertains to the weak conceptualization of the scripts. By weak scripts, we refer to semantic connections between event type concepts. Some concepts are more closely related than others, creating clusters. Some social goals are constituted as clusters. By connecting concepts more or less closely, conceptual clusters offer a cognitive framing related to contextual goals. The weak scripts are just a manifold of unordered semantics webs. They are less formal, and less easily implementable than direct strong scripts, which have a behavioral and measurable component. For example, if we come back to the earlier example of flirting, the goal of having sex entails a variety of conceptual connections. The feelings of attraction, connection, and mutuality are all connected to the flirting script. These categories can also be broken down into more concrete associations. Attraction can be connected to appearance and personality, which are related to physical attributes or behavioral traits.

Through this process of association, an agent can map observations to latent conceptual categories, which crucially include the kinds of things that one typically does in certain types of situations. Once the associations are learned, the agent

has adapted their perceptual field, and increases the salience of possible drives toward action and opportunities. By observing salience cues in the environment, the agent is driven to enact specific roles. Hence, weak scripts are closely related to direct perception and conceptual event type structures.

A conceptual mapping is a statistical probability matrix over certain sub-concepts. The manifold that forms the larger concept is a series of probabilities over other concepts. This follows the prototype theory, where some sub-concepts are more prevalent a concept, and others less so. This statistical mapping can be different across groups, and create communication breakdowns. But a niche will share the same probabilistic matrix for a given concept, making coordination easier. By defining conceptual mappings, weak scripts define the probability of certain categories being connected to certain observations, while others are not. Consequently, weak scripts increase or decrease the prior probability that certain kinds of states will be involved in a given event type. Because this mapping is shared by the niche (and indeed, might even be encoded in the physical structure of the environment), the agent can make sense of its environment, and pick up social cues from the niche. Cognition is offloaded to the niche since it reliably furnishes those statistical contingencies over time. The agent has only to pick up and interpret the cues, and does not have to try to figure out the connections between all the possible categories.

From the point of view of active inference, adopting a script allows an agent to minimize its free-energy both by enabling them to avoid spending limited resources sampling elements of the environment at random to figure out which social goal to conform to, and also by limiting the occurrence of errors when trying to achieve that social goal. Technically, scripts play the role of empirical priors that, in effect, simplify belief updating by constraining the degrees of freedom used in modeling exchanges with the (usually prosocial) econiche. Mathematically, this enables an accurate prediction of sensory exchange with minimal complexity, which precludes overfitting. In this setting, complexity is the difference between posterior and prior beliefs, i.e., the degree of belief updating incurred by observing a particular outcome. One can see that if the degrees of freedom of this belief updating are constrained by the right kind of scripts or priors, then there is less latitude for belief updating and a more efficient minimization of variational free energy. A related study by Wirkuttis and Tani (2021) has explored a similar space, related to dyadic interactions governed by active inference surprizal reduction. In their design, they had two robots interact by imitating each other, using active inference. By giving different complexity terms to the robots (tighter and softer) which in turn leads to different agency, the robots will begin to imitate accurately, and thus coordinate. Without such terms, the robots will ignore each other. This dyadic structure is interesting in the specific case of gender as it hints at hierarchical expectations. We expand on their model by offering that surprizal is already limited by existing priors contained in the niche and integrated by the actors.

The conceptual mappings at play in scripts, like those that figure in the generative models of active inference, are probabilistic. Many mappings are shared through narrative construction and practice in a niche, but the agent has a part in the interpretation of those clusters. Variations in the weak scripts of individuals occur, even when they exist in the same niche. Alternatively, individuals from different niches are exposed to different narratives, and hence adopt different conceptual mappings. This explains why some agents, adopting different scripts, do not perceive the same affordances or possibilities for action.

With this in place, it becomes possible to implement weak scripts in a generative model. We submit that weak scripts can be implemented via the likelihood mappings (A), prior beliefs (D), and sensory preferences (C) of the agent. Thus, weak scripts harness beliefs about how the expected salient social categories figure in specific situations (D) and beliefs about how they generate sensory data (A). In social situations, the relevant social categories of role and appropriate behavior can only be inferred, which requires the agent to mobilize the right kind of knowledge. An agent must infer the proper categories, the proper associations, and the proper mapping onto observations in order to navigate a social context adequately and to maximize her returns by the niche (social capital). This mapping changes in function of the context. Hence the weak script also feeds one's understanding of the context *per se*.

So far, we have only addressed the internalized aspect of the weak script. But the weak script can also be externalized and thereby provides the individual with an ecology of cues that direct their behavior in situationally appropriate ways. The niche has a double aspect: it both is the generative process that causes the agent's sensory states, and has its own generative model of the social script, physically and discursively offering patterned observations to the agent. The agent measures this against the niche and its model (whether or not other individuals share a specific mapping). For instance, in the flirting script, an agent will interact with another agent. The agent will present themselves physically to signal to other agents that they conform to some norms around attractivity, and that they are interested in a specific type of agent. Agents in the niche must be able to read these signals, and possibly also conform to those norms in order to be recognizable as possible mates by the first agent. If an individual fails to act in a way that is recognizable (i.e., inferable) by other agents, they will not achieve their goal. Other agents will not be able to map appropriate cues on their behavior, and they will either be rejected, or have to update their model, and adapt to the current context.

The niche, with its own external generative model of its denizens, produces observations, patterned in a specific way so as to be reliably interpreted by the agents of the niche. For instance, in the flirting script, showing a positive response to attempts signals that there is a higher likelihood of the flirting being mutual. On a larger scale, a bar offering free drinks to women signals that it promotes a probable heterosexual script of seduction, and that individuals presenting themselves at the bar will probably have to conform to a binary gender frame in order to be legible by one another. By enacting certain social cues that are legible by each other, agents send deontic cues to the other members of the group.

Scripts as Representations of Typified Sequence of Events

We have considered scripts as referring to clusters of categories that map onto the world, and overlap. They also refer to sequences of actions. This was previously associated with the strong sense of scripts. These sequences are causally related, which means that they are not simply habitual and dependent on practice, but that they also enable agents to make inferences based on knowledge of relations between social categories, which might be interpreted as the hidden factors of a generative model. An agent faced with having to perform the next step in a behavioral sequence will not be at a loss about what to do next precisely because they can infer the causal order of events. The information contained in the strong scripts promotes the possibility for variations, since their causal structure is not deterministic or rote, but probabilistic and open to variation.

Sequencing of the events in the scripts entails a progression over time–a narrative. The direction of this progression is prescribed to the agent by a social goal that the agent must achieve and by the allowable causal order of events. Hence, an individual must not only be in the proper state at a given time–from the inferences drawn from the observations–they must expect and enact suitable transitions as well. Agents must have a model of how events unfold under normal circumstances, but they must also be able to act accordingly, and bring about that state to move to the next causality link, in order to reach for the goal.

We can map these causal sequences in the beliefs about state transitions (B matrices) and preferences over sensory outcomes (C). Social goals are represented in terms of their typical sensory consequences, which are accumulated in the C matrix. Agents have a model of the likely transitions between states, given by the goal state. Sharing beliefs about transitions between states makes the behavior of a social agent more predictable by other agents. In response, the niche's actual transition probabilities drive the expected social responses to an agent's actions, which can be considered deontic cues. The agent must not simply predict the next state, they must also act to manifest those states. By following each other's expected scripts, agents send a signal to one another.

What Abelson called the "evoking context" or "action trigger" pertains to the strong conception of script as well, and might be implemented in active inference as *deontic cues*. The agent receives a cue from the environment as to what action will allow it to achieve its preferred state by increasing the probability of a specific, contextually appropriate policy. Hence, an agent will scaffold policy selection based on prompting and reinforcement from the deontic cues of the environment.

This allows us to understand how a niche can predict a certain pattern of behavior, and strive to provide only the relevant and salient tools. For instance, a bar or pub might provide women with free alcohol, because seduction patterns tend to happen in proximity with alcohol and pubs. The availability of alcohol for women at no cost signals to people interested in flirting with women that some will be there. It also assumes that the only customers will not be women, or else the bar would operate at significant losses; thus, the script incorporates gendered roles. And finally, it assumes that women are less likely to be motivated to enter in such places and must be motivated by an external factor, whereas men will be motivated simply by the presence of women.

This seemingly benign action has many underlying assumptions, which end up portraying two very different roles in the same flirting-at-a-pub scripts for men and women, both in a strong and weak reading. The weak modality of the script pertains to the categories (hidden factors) present in the narratives surrounding the pub context. The strong aspect of the script is suggested in the order of actions drawn from the narrative relationships between the categories, as discussed in the introduction. If the women are portrayed as less motivated, it follows that they are not expected to act overtly or take a leading role in the flirting script.

In scripted behavior, individuals can be making inferences on distinct hierarchical levels. At the first level, individuals infer categorical states from direct observations in their social environment. This state inference is used as an observation for the second level, at which they infer a role being enacted, conferring some stability in the script. The agent has to infer the most likely transition between states at the first level, which will correspond to the next likely event in a social interaction, translated in category states. At the second level, the next likely state corresponds to the continuation of the previously inferred role, or its discontinuation.

The niche both allows the individual to infer the probability of initial states by offering contextual cues, but will also offer feedback to the individual both on whether the role is enacted properly, and what the proper policy to adopt is, in order to maintain the social script.

The niche also plays a direct role. Providing condoms in bathrooms makes the usual goal of seduction very salient. Playing smoother songs by the end of the night responds to the order of the social script of seduction, where individuals will probably end their night together (as opposed to starting directly with sex, and coming back to the bar for post-coital drinks). Dimmed lights and slow music may act as deontic cues for the agents to know they are expected to have reached a certain point in the flirting script. This can be considered by the agent as a deontic cue. By responding to the scripts, the niche constrains the social possibilities of the individual by making salient certain category clusters, and promoting a sequence that, when broken, has stronger social consequences, and is made more obvious for the agent. The environment provides thus patterned regimes of attention to guide the actions of the agent.

DISCUSSION

Our model has some key differences with previously existing models, such as Gagnon and Simon's sexual script construct, or Abelson and Schank's script construct, or even Minsky's frames. Gagnon and Simon's sexual script theory addresses the multiple scales at which scripts are enacted, which is in line with out model of scripts based on active inference. Although our present account of scripts entails a model with only two layers, it can be scaled up to become more granular, such as to encompass

different time scales, and to encompass varied cultural packages. The beauty of our model is that these notions of cultural structure are no longer blurry. They can be formally deciphered and differentiated in terms of the active inference formalism, and we can study their effects over causal chains.

Another relevant difference is that we accommodate the two main dimensions of the script concept, which no other proposed construct has done heretofore. Sexual scripts are fully internal, according to Gagnon and Simon. While cultural patterns and practices act as scaffolds that enable the internalization of sexual scripts, these are fully integrated in the individual's psyche. Our model entails no such internal segregation. On our account, scripts enacted in the shared environment and the material conditions of the world fully participate in every scripted situation. Finally, while the scripts of Gagnon and Simon are restricted to the sexual realm, our model can apply to any social situation.

Abelson and Schank's model, on the other hand, is much more generally applicable. However, it mostly applies to the strong scripts, as it specifically concerns the typified sequence of events that an individual comes to expect in a given situation type. Such sequence-emphasizing theories also include schema theories, such as the gender schema theories proposed by Boston and Levy (1991), Levy and Boston (1994), which posit that individuals learn early on what kinds of behavioral sequences are expected of them based on their assigned gender. This schema theory, however, extends beyond the scripts concept, and describes psychological attributes, such as attitudes and preferences, which cannot be collapsed into scripts. While these attitudes and preferences can be scripted, they extend outside of the scope of the scripts theory *per se*. Our account of scripts does not solely focus on sequencing, however, it also does not reach out of the symbolic space that scripts occupy in the psyche.

On the other end of the spectrum, Minsky's (1975) frame theory and Bartlett and Bartlett's (1995) schema theory, followed by McClelland and Rumelhart's (1985) schematas, are more focused on the weak interpretation of scripts, as they offers a way that we reconstruct incomplete information to paint a picture and assign meaning to a given context. Minsky's frames are slightly more rigid than our conception of weak scripts in active inference. Specifically, knowledge needs to be relatively certain and re-applicable in generic ways (Minsky, 1975). Our conception of scripts instead relies on statistical probabilities. There is no need for knowledge to be classified in particular categories in order to be semantically linked. Furthermore, these theories can only account for already-known information and do not allow for an account of how new concepts are internalized. Our active inference script theory gives us an account of how knowledge about the world can be updated as the individual encounters new social dynamics. A future account will lay out more clearly how new information is learned in the weak scripts. Overall, what we can see is that our new conception can account for the various parts that the previous accounts worked through separately.

Our proposed formalization of the script construct–via active inference–allows for interesting avenues in social computing. Specifically, we can begin to make predictions about how humans react to scripts. By clearly identifying the formal role of internal and external script elements–as well as what weak scripts and strong scripts entail in a cognitive and ecological structure–we can begin to leverage the model to identify the moment-to-moment dynamics of interactions between social agents in a given context. We can identify how narratives influence expected behavior and contextual framing.

Scripts have generally been used as a framework to aid conceptual analysis. For instance, weak scripts can be used for in historical analysis to assess contextual relevance (Fleer and Robbins, 2004), or to analyze codes in literature and art under the angle of discourse (Tagg, 1992; Sun et al., 2016). Scripts allow us to frame concepts in the context of their larger associative networks to predict whether a concept will be negatively or positively framed, based on shared cultural models and narratives (Miyamoto and Ma, 2011). They have also been used to allow behavioral predictions and motivations in larger scale events, like criminology (Miyamoto and Ma, 2011; Ekblom and Gill, 2016), or epidemiology (Trostle, 2005).

Understanding cultures in those areas allows researchers to make predictions about normative sequences and the consequences of violations of shared norms. However, these models usually take a very abstract, heuristic approach to scripts, and mostly use the script construct as a template to guide analysis, rather than as a relevant prediction tool.

In criminology, the concept of script most often refers to patterns of scripted behaviors (Hayward and Young, 2004; Beauregard et al., 2007). These scripts can have an ecological dimension, but they mostly refer to the strong understanding of scripts. In our model, such scripts could be more accurately predicted, leading to preventive actions and risk limitation. But given our model's connection to weak scripts as well, working with offenders to undo thought patterns that may support such strong scripts would be made easier.

Similarly, epidemiology uses scripts theory to predict the way individual and group dynamics will influence the spread of a disease, or a problematic factor (Gibbs, 2001; Turchik et al., 2009). As we have seen with the COVID pandemic, such scripts can become vitally important. Our model can offer precise predictions as to the adoption of behaviors, and concepts for different populations, and allow us to predict what kinds of behaviors may be adopted.

For the sexological use of scripts, the ramifications of our model can have deep impacts in the way we can approach patients in therapy. Interpersonal scripts, perceptions and patterns are influenced by the ecology of the individual, and can be rearranged. Keeping these scripts in mind, erotic patterns can be woven and unwoven as they need to be for different types of pathologies.

With our formal model of scripts, we can map the direct interaction of an individual with social categories and events, as well as its concomitants in the shared niche. Those dynamics could allow not only to model how scripts come to be widespread–by simulating sensitivity to deontic cues and social coordination with interlocutors–but also how scripts may come to change when an agent is faced with a script violation, and its different ramifications. These violations may be met with

social punishment, or be embraced when they tap into previously invisible, valuable social reality. This formalism may be scaled up to simulate agents as the niche, and see how certain patterns of interactions and co-option may emerge. Finally, the model and the predicted patterns may be measured against real empirical data, and falsified or confirmed to test psychological hypotheses about adhere to scripts.

An interesting avenue, which we are now pursuing, is to test these models against the constructs used in the gender and sexuality studies, which have already used the concept of scripts with its interpretation from Simon and Gagnon (1984). Our formal treatment of sexual and gendered scripts may shed new light on this work and may allow real progress in the clinical and theoretical fields of sexology. Gender studies, rooted in feminist thought, may find new ways to critically address more biological explanations of gendered interactions and gendered differences. This is also an interesting avenue to deconstruct assumptions of the duality between the influences of nature and nurture on development, bringing human sciences into the neo-materialist era.

Future work will be concerned with formalizing the mathematical model and applying this model to simulations. These simulations could then be tested against real observed behavioral data. We can infer from these behavioral data the potential conceptual mapping that was integrated by an individual. We can also choose the alternative route of starting from a conceptual mapping, and deriving behavior, which we can then test against real data as well.

Our conceptualization of script theory accounts for different structures of information, and thus accounts for the manner in which agents flexibly adapt to new situations, learn, grow, and work out uncertainty in their script.

This paper represents the first in a multi-step process, whereby formal models are constructed. The first step is to formalize some informal notions to provide a theoretical account. We now present some speculation about what novel predictions this framework should yield. Following steps include implementing the model, at which point it becomes possible to make quantitative predictions. We can thus expect that our model will allow us to predict the ways in which information on the weak continuum maps directly to sequences, by having these representations modeled as the A matrix for the weak script, and the sequencing as the B matrix. As our model will enable an agent to decide between changing their model of the world and changing their actions, scripts will be able to evolve and integrate new information. The future directions of this research will allow us to explore how entirely new concepts get integrated as concepts. We believe that this will be related to the extent that pre-existing concepts or sub-symbolic concepts get clustered together. With these tools in hand, we should be able to predict social dynamics from large scale groups to interpersonal interactions. We will be able to untangle the ways in which an individual may be embedded in their surrounding causing some pathology and we can highlight the exact paths that lead to systemic and symbolic inequalities.

One important benefit of our model, beyond its precision, may be its computational advantages. Specifically, a lot of complexity can be smoothed out as constants at different levels of state space, which correspond to different rates of change. The interpersonal level will go much faster than the cultural level, and this cultural level, at the scale of interpersonal relationships, can essentially be cast as a prior.

CONCLUSION

The aim of this paper was to propose a formalization of the script construct using the apparatus of active inference. We hoped to propose an integrative account of the script construct that does justice to its sundry uses in the sciences that study individual and collective human behavior. First, we reviewed the recent literature that uses scripts. Then, we examined the active inference approach, a behavioral modeling framework that casts action, perception, emotions, and attention as processes of (Bayesian or variational) inference. We then leveraged active inference to provide a principled, computational model of scripts that accounted for the dual nature of scripts as internal schema and as external social order, and for the stronger and weaker conceptions of the construct (which do and do not relate to explicit action sequences, respectively).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

MA focused on social scripts theory and its active inference formulation. MR and AC adapted the active inference frameworks in terms of the social scripts theory and produced the figures for the article. KF specialized ensured that our interpretation of the model followed the appropriate mathematical formalism. All authors contributed to the article and approved the submitted version.

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Pseudomentalization as a Challenge for Therapists of Group Psychotherapy With Drug Addicted Patients

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One of the main challenges in group therapy with drug-addicted patients is collective pseudomentalization, i.e., a group discourse consisting of words and clichés that are decoupled from any inner emotional life and are poorly related to external reality. In this study, we aimed to explore the phenomenology of pseudomentalization and how it was addressed by the therapist in an outpatient group for drug-addicted patients. The group was composed of seven members, and the transcripts of eight audio-recorded sessions (one per month) were rated and studied. The interventions of the therapist were measured with the mentalization-based group therapy (MBT-G) adherence and quality scale by independent raters. Two sessions, one with the highest and one with the lowest adherence, were selected, and the clinical sequences of pseudomentalization were analyzed in a comparative way. The findings revealed that pseudomentalization does occur as a collective phenomenon, akin to "basic assumptions" of Wilfred Bion, which we reconceptualized in this study. Any pseudomentalization seemed to be reinforced by the therapist when she was presenting frequent and long interventions, when abstaining from the management of group boundaries, when providing questions focused more on content than on the mental states of the group members, and when not focusing on emotions. However, the ultimate source of collective pseudomentalization seemed to be the fear of the group members of being overwhelmed by painful emotions, mental confusion, and a loss of identity. The findings also indicated that the principles of MBT-G may be a good antidote to pseudomentalization.

Keywords: pretend mode/pseudomentalization, group therapy, drug addicted patients, micro-analysis, treatment integrity

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INTRODUCTION

Pretend mode is one of the pre-mentalizing modes of thinking that appears in the early years of the road of a child to "full" explicit mentalizing ability (Fonagy et al., 2002) and which can reoccur as a problematic non-mentalizing mode of thinking in adults, especially in individuals with a personality disorder. In this latter case, it is also referred to as "pseudomentalization"

(Bateman and Fonagy, 2010). PM is characterized by apparent awareness of mental states albeit revealing the absence of some of the essential features of mature mentalization. Indeed, it presents itself as an excessive consideration of how other people think or feel without there being any authentic interest in the other (Karterud, 2015a,b; Bateman and Fonagy, 2019). Thoughts are separated from mental reality, i.e., they lack a personal-emotional grounding in lived experience, and the narratives tend to be ruminative and overly detailed. Thus, PM can also be seen as akin to intellectualization and rationalization (Bateman and Fonagy, 2019). Patients can discuss opinions about themselves, others, and the world in a discourse filled with words with a seemingly psychological content but being devoid of any deeper emotional meaning, e.g., presenting as psychological and quasiphilosophical clichés or "empty words." This is the phenomenon that has been labeled pseudomentalization (Bateman and Fonagy, 2010).

At least three pseudomentalizing subtypes may be observed in clinical practice: (a) intrusive mentalizing, which is characterized by a certainty about mental states and a lack of any connection between thoughts and feelings; (b) overactive-inaccurate mentalizing, which consists of a preoccupation with mental states but featuring inappropriate interpretations and very little genuine curiousness about mental states; and (c) bizarre mentalizing, which refers to highly inaccurate mental state attributions and psychologically implausible mental state inferences. Globally, these three subtypes have in common a lack of any recognition of opaqueness and the developmental nature of mental states and an absence of any sociocultural contextualization of experience by reference to physical reality (Bateman and Fonagy, 2010).

Pseudomentalization poses a series of challenges for the psychotherapist. These have been described in various textbooks (e.g., Bateman and Fonagy, 2016), but empirical literature on this topic is rather scarce. In particular, in group treatment, we can frequently observe pseudomentalization, and this is a phenomenon, which it is simply impossible for group therapists. They face complex challenges since it may seem that the group members are involved in a productive reasoning, while, actually, they are avoiding an authentic mentalizing discourse. In fact, pseudomentalizing is often adopted in order to counter the emergence of strong emotions, particularly the primary emotion of fear (anxiety).

Pseudomentalization may play a temporarily defensive role in such groups. However, there is also a risk that it may become embedded in the group culture and hamper a healing mentalizing process (Fonagy et al., 2017). The emergence of strong affective content could foster a defensive stance in which the members remain focused only on the surface and neglect the possibility that the group and the other members could serve as sources of growth and change (Sierra Hernandez et al., 2015). Such a failure in the integration of affects into experiences is also highlighted in other theoretical models. For example, Multiple Code Theory (Bucci and Maskit, 2007) is a general theory of emotional information processing that highlights the fact that the referential process makes it possible to communicate the emotional experience of a person to other people and to regulate emotions through the own words of a person or words of other people. When the referential process, which links sub-symbolic experiences with images and words, is not activated in the therapeutic relationship, an expansion of the emotional aspects can occur, which can hinder a positive outcome of the intervention (Mariani and De Coro, 2013; Esposito et al., 2019).

In this study, we aimed, first, to describe the phenomenology of pseudomentalization in group therapy, in this case the so-called Moviola group therapy approach, targeted at drug-addicted patients and, secondly, to investigate the role of the therapist in its appearance and disappearance.

The Moviola Group for Drug-Addicted Patients

Several studies have demonstrated the close relationship between drug addiction and personality disorders, especially in the borderline range (Bannon et al., 2015). Accordingly, clinicians have to adopt intervention methods, which are not exclusively targeted at symptom recovery but rather at the development of psychic functions, such as mentalization (Esposito et al., 2020a), which tend to be highly compromised in the case of substance abuse. The impairment of mentalizing abilities in drug-addicted patients is also demonstrated in neuroscience (Gabbard et al., 2006), and developmental psychology has highlighted how drug addiction is related to attachment disturbances (Flores, 2004). Although there are not many empirical studies on this topic, mentalization-based treatment (MBT) for the drug-addicted patients has provided encouraging results, both in terms of improving personality functioning and of decreasing substance use (Morken et al., 2017).

Sudden failures in mentalization before and after relapse in drug and/or alcohol use can be observed in drug-addicted patients. Low levels of mentalization are also related to the habit of controlling one's own mental processes through manipulating one's own neurotransmitters by chemical means, e.g., through external, and not intersubjective, means. Often, people who habitually use substances lose their ability to recognize and reflect upon their own mental states and come to live in a mental and emotional reality that becomes more and more fictitious, strongly marked by the effect of the substance (Correale et al., 2014). These mechanisms cause an individual mistakenly to recognize herself/himself and to feel "real" when she/he is under the effect of the substance, actually when she/he is in a state of deviant emotional and behavioral activation. In this way, her/his original personality matrix becomes hidden by a false identity in which the substance fulfills the desire to escape from the frustrating company of oneself, to exit from the depths of the mind of a person, and to find a more satisfying existence in the fictitious bliss of drug-induced feelings (Correale et al., 2014).

From this premise, work on mentalization with drug-addicted patients has a fundamental value. In particular, the recognition of the opacity of mental states can be a starting point from which clients who are addicts may understand the value of exploring the mind instead of making judgments about behavior. Undertaking an activity based on mentalization means, first of all, gradually coming into contact with emotions that confuse the "thinking mind."

These premises are the basis of the Moviola Group observed in this study. This was originally a therapeutic group targeted at cocaine users, meeting in an outpatient service at a department for addictions in a city in northern Italy. At a later stage, in order to respond to new forms and types of addiction, it was decided to change the target population and the working focus of the group, taking into account two characteristics: polysubstance abuse and a younger age. For this reason, the original Cocaine Group became the Moviola Group, addressed to young adults (from 20 to 30 years old) with polysubstance abuse (a mixture of alcohol and/or drug abuse, e.g., cocaine, heroin, or cannabis), criteria which characterize an increasingly numerous range of users in modern societies. The change in the name of the group from the Cocaine Group to the Moviola Group was intended to shift the focus from the symptoms to the process. The objective of the Moviola Group is focused on *thinking together*, in the here and now, through the "slow motion" of events and situations, as narrated by the members of the group. Indeed. the term slow motion (in Italian "moviola") refers to a movement that is recreated in the narration of events in an attempt to offer the possibility of collecting the different points of view of the group members about what, in their opinion, the protagonists of the events narrated have in mind. The primary task of the group is, therefore, to recount the events, allowing different interpretations and taking into account the various points of view and experiences reported by the group members, while, at the same time, listening to the emotions of the protagonist in order to ground their own experiences. The activation of this "slow motion" process also allows the therapist to work on the interactions between the members of the group during the session and to use what happens in the here and now as an object of mentalization. The idea of slow motion as a group task was inspired by the MBT group therapy model (Karterud, 2015a), which we will now briefly describe.

Mentalization-Based Group Therapy

Group therapy has from the beginning been an integral part of MBT for personality disorders, in particular for those in the borderline spectrum (Bateman and Fonagy, 2016). The principles for the group component have been spelled out by Karterud (2015a). The primary task is to promote the understanding of the group members of their own and others' mental states, both in the context of the here and now and in the narrative context of interpersonal events narrated by patients in the group. By focusing on the emotions involved and on their attachment implications, the treatment as a whole aims at personality integration and development.

The realization of this task depends heavily on the leadership abilities of the therapist, e.g., in constructing a group structure and culture that serve as a fertile ground for the development of mentalization and affect integration and interpersonal trust (Karterud, 2015b). A group that more specifically favors experiences of a "safe base," developed by means of firm leadership, and that improves the communication of affective and mental states can constitute an important maturational ground for overcoming resistances and enhancing the reflective capacity (Black, 2019; Esposito et al., 2020b). Moreover, research on the treatment of personality disorders has shown how poorly structured interventions, favoring the emergence of unconscious content and the overcoming of repression, are particularly difficult for borderline personalities due to the deficient structuring of their inner world, e.g., presenting as vague boundaries and polarizations in their self and in other representations (Levine, 2017).

Starting from these assumptions, Mentalization-Based Group Therapy (MBT-G) advocates a therapist style that adopts an active attitude in regulating the process of the session and, at the same time, respects the principle of not-knowing (Bion, 1963) in the approach with the patients (Indrehaug and Karterud, 2015). The therapist should try to balance these different tasks, e.g., being an expert in the management of the group, in maintaining a managerial attitude in regulating the phases and in ensuring the participation of all, but, at the same time, respecting the principle of opacity of mental states when intervening and deciding when to expose their own mental states for therapeutic purposes. Overall, the therapist should encourage the patients to maintain active and exploratory attitudes and counteract passive and dependent positions in the therapeutic process.

The therapist is specifically involved in the following tasks: (1) structuring the group, (2) exploring events, (3) involving group members in the work of exploration, and (4) regulating the emotional "temperature" in the group (Karterud, 2015a). These tasks require an active, alert, and authoritative management, both toward the individual members and toward the group as a whole, while simultaneously maintaining a position of curiosity and openness to mental states.

The combination of an active authoritative management and a compliance with the not-knowing stance are two of the key elements of an MBT-G group that distinguishes this model of intervention from the classic group-analytic approach. On one hand, both models take into account the dynamics of the group and the existence of an unconscious communicational group matrix that affects the relationships between the patients, the patients and the therapist, and the group as a whole; on the other, the models differ in the conceptualization of the role of the therapist in constructing this group matrix and in facilitating the therapeutic processes (Karterud et al., 2019).

Ideally, the culture of an MBT group becomes increasingly a field of possibilities, of asking oneself and others how one feels at a given moment or in a given situation, of wondering what thoughts and emotions are present in one's own and in minds of others, and of allowing the patients to realize that they have thoughts and emotions that can be recognized and shared. In this field of possibilities, the patients can perceive a lesser sense of emptiness and deconstruction, acquiring greater intelligibility of their own mental states and those of others. The comparison with others is facilitated by the occurrence of group events that offer the possibility of understanding and communicating the mental states of a person, allowing a work of legitimizing the emotions of a person through mirroring (Pines, 1984), a process through which it is possible to see and recognize oneself through the reactions of others that are validated by the therapist and group members.

The Moviola Group Seen From the Perspective of Mentalization-Based Group Therapy

One advantage of the MBT-G approach is that it is linked to a manual (Karterud, 2015a), which includes a rating scale of adherence and competence (the MBT-G-AQS). By means of this scale, it is possible to (1) rate the interventions of the therapist for specific group sessions and thereby identify, by a scientific method, group sessions that demonstrate high, as opposed to a low, adherence and quality, and (2) assess the individual interventions by the therapist in a micro-analytic study (Karterud, 2018). Although the Moviola group observed in this study is not conducted in strict accordance with MBT-G guidelines, it is inspired by that approach, and, therefore, it seems meaningful to study its processes through an MBT-G lens. Besides, the object of our study, pseudomentalization, or PM, is a phenomenon that occurs in all groups. However, there is no other method that captures the essence of this occurrence more effectively than the MBT-G-AQS. By applying this method, we can detect phenomena and their causal connections on both micro- and macro-levels.

Objectives

In the present study, we aim to explore the challenges that drug-addicted patients pose to the therapist from a mentalizing perspective, with a specific focus on PM, and to examine the strategies adopted by the therapist in order to handle it. Specifically, our research questions are: (a) How does PM appear phenomenologically in sessions of the Moviola group? (b) Are there any differences with respect to PM between sessions, which are conducted with a high, as opposed to a low, level of integrity with respect to the MBT-G model? and (c) What is the role of the therapist in relation to the PM phenomenon and which kind of interventions seems to prevent or, alternatively, promotes, PM sequences?

MATERIALS AND METHODS

Participants

Seven patients who had attended a motivational psychological path for at least 6 months at the outpatient clinic of the addiction department were recruited: six men and one woman with an average age of 24 years. All had a diagnosis of substance addiction, particularly to cocaine and cannabis, while some had a diagnosis of alcohol addiction. Almost all had experienced a period of at least 1 month of abstention from drugs, although some continued to have periodic relapses.

The group therapy was held from January 2019 to July 2019, for a total of 28 sessions. The group was conducted by a psychotherapist with the presence, mostly silent, of a nurse.

The participants signed informed consent in accordance with the ethical principles of the Italian Association of Psychology. This informed consent allowed the collection of narrative materials and audio recordings of the sessions to be used for training and research purposes. All the data were collected in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and the Italian Law on Privacy and Data Protection 196/2003.

Therapist

The therapist was trained in group-analytic psychotherapy and had worked with patients suffering from addiction problems for 13 years. She did not have any specific training in MBT-G, but she was inspired by this model when she decided to give a new structure to the group therapy for patients who are addicts, the Moviola approach.

Methods

All 28 sessions of this group were audio-recorded and transcribed *verbatim*. Eight sessions (one per month) were selected and translated into English in order to be rated independently by one English and two Italian raters according to the MBT-G-AQS (Karterud, 2015a). After the sessions had been coded, a consensus rating was reached through discussion in the case of any disagreement and, given that one of the raters was an English-speaking coder, on the same occasion, any misunderstandings or ambiguities given by the translation were resolved. Afterward, the session with the highest treatment integrity with respect to the MBT-G model (Session 16) and the one with the lowest integrity (Session 12) were selected for further study since these sessions exemplified, respectively, good and poor handling of the pseudomentalizing sequences. Treatment integrity profiles for both these sessions were also determined. Next, in each session, we tracked the clinical sequences of pseudomentalization in order to analyze in a comparative way its phenomenology and how the therapist handled each sequence.

The MBT-G-AQS (Karterud, 2015a) was constructed in order to rate group therapist interventions in accordance with 19 items (see **Table 1**). The psychometric qualities of the MBT-G AQS have been thoroughly tested and found to be very good to excellent (Folmo et al., 2017). The first nine items are specific for the group setting and aim at evaluating the interventions with the therapist with respect to, for example, boundaries, group phases, turn-taking, exploring events, and engaging the group members in such explorations. The next 10 items refer to general MBT principles and concern, for example, interventions that promote a mentalizing stance and focus on emotions, non-mentalizing modes (including pseudomentalization), and patient-therapist relationships. All the interventions of the therapist are rated for adherence and quality. Adherence is a quantitative measure that reveals how many of the interventions of the therapist fulfil the requirements of the different items. It may range from 0 to 100%. The following items are not rated for adherence since, generally, they cannot be deduced by specific interventions but are conveyed by more general attitudes: Item 6 (care for the group), Item 7 (managing authority), Item 10 (engagement, curiosity, and warmth), Item 13 (regulating emotional arousal), and Item 15 (handling pseudomentalization). Interventions that receive an adherence rating may also be rated for quality. However, for practical purposes, the quality ratings are assessed for the total session. Quality refers to the level of skill in intervention delivery by the therapist and is rated on a Likert

scale from 0 to 7, divided into four levels: (a) not applicable (0), which is assigned when the intervention is not observed and not judged as essential; (b) low (1–3), which is assigned when the intervention is delivered with a poor quality or when relevant events in the group occurred and the therapist did not comment upon them; adequate (4), which is assigned when the intervention is delivered in a "good enough" manner; and high (5–7), when the intervention is delivered with a very good or excellent quality.

RESULTS

First, we briefly describe the integrity profiles of the two selected sessions, and, thereafter, we discuss in more detail some of the clinical sequences. Our main focus will be on the relationship between the clinical appearance of PM and the interventions of the therapist.

Integrity Profiles of the Two Selected Sessions

Session 12

In Session 12, the total number of therapist interventions was 163. In these interventions, we found 50 occurrences that were rated as compliant with the MBT-G-AQS (31%). This percentage is a good indicator of MBT adherence (Folmo et al., 2017), and, in this case, it is low.

The overall quality of the session was also rated as low (Level 3). A higher level (5) of quality was achieved only for Items 6 (care for group members) and 10 (engagement, interest, and warmth), which may suggest a more supportive, than explorative,

TABLE 1 | Definitions and examples of MBT-G-AQS (adapted from Karterud, 2015a,b).

Items	Definition	Examples
Group specific items		
1. Managing group boundaries	Management of boundary-relevant events (such as absences, new members, delay)	T: You were absent last time, C. We wonder why.
2. Regulating group phases	Active role in dynamic management of session structuring (opening, middle and closing phases)	T: Let us start with some reflections on last group meeting.
3. Initiating and fulfilling turn-taking	Facilitating mentalizing turn-taking	T: OK, let's start with C. You want to explore something with us.
4. Engaging group members in mentalizing external events	Engagement of group members in exploration of events brought up in the group	T: What do you all think about the story C told us?
5. Identifying and mentalizing events in the group	Identification of relevant events in the group and mentalize them	T: Seems like you, patient A, reacts to something here . . .
6. Caring for the group and each members	Making the group a secure base for the members	T: Unfortunately, I will be absent next time, but my colleague B, which you know, will conduct the group
7. Managing authority	Maintaining an authoritative role in leading the group	T: I know this is painful, but we cannot avoid dealing with it in the group
8. Stimulating discussion about group norms	Working on normative group-as-a-whole issues	T: Anger in groups may be difficult. How should we handle that?
9. Cooperation between co-therapists	Building a confident cooperative relationship between the co-therapists	T: I feel a bit confused. What do you think, Therapist 2?
General items		
10. Engagement, interest, and warmth	Attitude of authenticity, openness, engagement also through non-verbal signals	T: It makes me sorry to hear this, C. Hope you recover.
11. Exploration, curiosity, and not-knowing stance	Assisting group members in an exploratory process and stimulate this process	T: I am curious to know what other group members think about your reaction when your mom called you
12. Challenging unwarranted beliefs	Sensitive challenging of fixed, clichéd-like, unwarranted beliefs	T: What do you mean when you describe yourself as stupid?
13. Regulating emotional arousal	Maintaining of an ideal emotional arousal to foster mentalization	T: Just take your time, C. We can come back to this painful theme later.
14. Acknowledging good mentalization	Support and praise for members' good mentalization	T: Seems like you handled this better this time. What do you think was different?
15. Handling pretend mode	Recognizing and handling sequences of pseudomentalization	T: I must admit I have a hard time concentrating. What are we exactly talking about?
16. Handling psychic equivalence	Contrasting and handling concreteness of thought	T: You say nobody in this group likes you. Let's stop there and explore that.
17. Focus on emotions	Maintaining a focus on emotions and their mentalization	T: This was a hard blow for C. Do you feel it too and what is your thoughts about it?
18. Stop and rewind	Interruption of destructive sequences and engagement in their review to regain good level of mentalization	T: Can we stop, please? I think we need to slow down. What happened?
19. Focus on therapist-patient relationship	Mentalization of transference and countertransference	T: Seems that some of you didn't like the way I terminated the session last time.

style of leadership. Notably, the quality of handling PM was rated at Level 2 (poor).

Session 16

In Session 16, the total number of interventions of the therapist was much lower, 43. Here, we found 41 occurrences that were rated as compliant with the MBT-G-AQS (98%), indicating much higher adherence to MBT principles. In other words, the therapist intervened less often, but, when she intervened, in the majority of cases, it was in accordance with the MBT guidelines.

The overall quality of Session 16 was also high (Level 6). None of the 19 items were assigned a quality rating below adequate (Level 4). The handling of PM was rated at Level 4.

The Course of Session 12 With Special Emphasis on the PM Sequences

In what follows, we report *verbatim* transcripts of chosen clinical sequences. After each therapist intervention, we have indicated the number of the item of the MBT-G-AQS scale (A1, A2, etc., see **Table 1**) that is represented in the intervention according to the consensus of our raters. When no item is marked, it means that the intervention cannot be identified as a specific MBT-G intervention.

At this group session, 8 patients attended, although several of them were late. Patient A was missing, but he had been observed around the venue before the meeting. At the previous session, Patient A told the group that he was not able to remain abstinent, which was a requirement for group participation, and that he intended to approach a therapeutic community for more extensive help. His message stirred up diverse reactions. The therapist thought that it might have shattered the still vulnerable trust within the group.

Therapist (TP) starts the group by saying: *Well guys. . .*

Patient M: *But is anyone missing?*

TP*: No, I haven't received any message! They may be a little late, but they will arrive. In the meantime, we will begin. Let's start a little with you. How are you? I don't know, I see some.*

Patient M: *A strained week for everyone.*

TP*: Spring never brings good things, right?*

Patient NU: *Yes.*

TP: *It is always a somewhat destabilizing period. At least, I don't know, this period here is a bit difficult every year.*

Patient M*: Why do you say so? For what reason?*

TP: *Maybe the days get longer, maybe they affect people's mood a little, it's a bit of a period, it's hotter, isn't it? Temperature changes, in short, and some people are not able to take it in their stride but sometimes it affects those who are very sensitive to changes also - Hello R.! Did you see the others outside?* (**A1)**

Patient R: *Yes, there was MK and*

TP: *And why are they waiting to enter?* **(A1)**

Patient R: *MK was on the phone with his. . .*

TP: *Ah, with his wife, girlfriend*

Patient M: *MK should turn off his phone in my opinion*

Patient R: *I apologize for the delay, I arrived home late from university and then well. . .*

TP: S*omeone is ringing. . .*

Patient R: *Yes, yes, yes, yes, yes.*

TP: *Eh, sorry, but they rang, and I think it's the others.*

Patient R: *Did I miss something?*

TP: *No, no, no, we have just started, we were warming up the engines a bit, as we usually say. We were taking a warm-up tour but, in reality, I was talking about spring! The fact that it's always a bit turbulent* **(A2)**

Patient M: *For me, if it weren't for the job. . .*

Patient NU: *Me too*

Patient M: *I like the days with more sun*

TP: *Yes, it is definitely positive, but those who have a bit of . . . usually long days can stimulate craving. In short, those who have certain problems are more sensitive here*

Patient NU: *Mostly season changes are always. . .*

TP: *Here, exactly, is the phase itself.*

What we see here, right from the beginning, is a classic PM sequence. Formally, the theme is about mental states ("how are you," "people's mood," and "craving"), but what is supposed to affect these mental states is the weather and the season. We are about halfway through this sequence, and the topic of the absent member A pops up again. The group members air their frustration. However, at this point, the therapist tries to structure the session: "*No, besides A, surely we have many other problems here. Who. . . who do we want to start with?*"

No one particularly enters the scene and the topic of A surfaces again. Group Member F suggests that there is a group problem, e.g., that "*we don't see the group as a refuge, we live it like a gallows.*" There are disagreements but some realization that it is difficult to "open up" and "tell one's story." At this point, the therapist enters with a long intervention, in fact composed of 450 words. It starts like this:

> TP: *It seems to me you still are attached to this group. There is an affection—I feel it, I see it, in short. However, it is true that each group acts as a mirror in the sense that you see yourself just as you are, based on what others send you back. That is, you can also try to distract attention, emphasize only its positive aspects, but, for better or worse, then the others discover you, right? They tell you, look, I don't see you well! So, maybe, maybe finding yourself in front of your mirror is not always so positive, is it? Seeing things as they are, seeing the problems I have that I don't want to have, but that others see. It can sometimes be experienced as a gallows, can't it?*

The problem with such long interventions, although the content may be "correct" in a way, is that the therapist risks talking above the heads of the participants; the argument becomes too complex and transcends their attention span. Frequently, in this session, the therapist turns to the group, asking: "*do you understand?*" taking an authoritative stance that tends to establish principles and rules in a top-down direction as well as directing the discourse to a determined pedagogical end. Usually, people do not like to appear foolish, so, if uncertain, they will often *pretend* that they understand. Besides, the therapist is a discourse model and the participants will tend to imitate her, for better but also for worse. In this case, Patient R responds with a very long comment (330 words), which contains sentences like this:

> Patient R: . . . *Basically, the other thing is that shame is subjective. Up to now, even if I have said things that, thinking about it objectively, are not that beautiful, I have never, until now, tried,*

let's say shame. In the sense that I have more than ever acquired an awareness, which is not a rational thing, that is, it comes from within.

The content of the group discourse now moves from relationships to parents, particularly fathers, and what the therapist labels "the paternal function." The problem with this discourse is that it is dominated by *opinions*, opinions about how (ideal) parents and children should behave and what might go wrong and initiate, in the worst case, a descent into drug addiction. It is a discourse with a PM flavor and, similarly to the opening phase sequence, mostly of the intrusive subtype, lacking deeper personal emotional experiences and decoupling a psychic from external reality.

TP: *And yes, of course, the teenager continually challenges the limits*

Patient M: *The teenager but also people. not just teenagers*

Patient F: *I did what I wanted.*

Patient M: *And therefore, it takes limits, rules*

Patient F: *Eh, A must therefore also grow up at this point here.*

TP: *But even for you, growing up means being able to put these limits on yourself, without obviously having the parent to put them there. It is a paternal function that you introject, it is said, that you learn to use with yourself. For example, you yourself set limits, but everyone has to set limits in life, to be able to work, to be able to go to work in the morning, like, I have to set myself a limit, it's not that I can stay out until two in the evening at night if the next day I have to get up and come to work, do you understand? But I no longer need a parent who tells me, I learn. For living, this is a little the paternal function in a broad sense* **(A7)**

Patient M: *Being responsible for your actions*

TP: *Having limits in mind*

Patient N: *I can say that I also have limits, that is, I set limits and I achieve them, there. But if it was like two years ago, I had no limits*

Patient M: *They can be limits on money, friendships, work, schedules. They can be any kind of limits*

TP: *Exactly, yes*

Patient N: *Now I can also say, look, I do this, I don't do this*

However, some personal experiences do surface, and the therapist addresses them, although in a rather "individual therapy in group" manner. In this atmosphere, Patient S for the first time talks about his family history. He has to be pushed a little before he starts; he would prefer to do it "next time." It is a sad story about his Italian mother and African father, about the death of his mother, and his adoption by his grandmother. The story does not contain that much reflection, but it is personal and painful and indicates another type of discourse rather than PM.

After a new round of opinions about fathers, limits and drug use, Patient M talks about "*how deeply we have disappointed*. . ." our parents, and patient F responds: "*Me above all*. . . *I sold the gold*. . .." Therapist: "*Did you sell the house gold? How much? Ten thousand?*" Interestingly, the group members continued their discussion about fathers as if nothing had happened. It is as if the words of Patient F did not count, as if they were not (really) real, until the therapist invited Patient F to tell the group more, and he talked about this incident, now with the other group members listening and participating, about when he stole 10,000 euros of the family fortune and had fun for a week. Patient F added that "*He (his father) still loves me a little, but let's say he hates me so much. It also annoys him to see me. I really see that on him. He looks at me like I'm shit*. . .." All of a sudden, the group was not pretending anymore. It was filled with painful feelings, above all feelings of guilt and confusing thoughts. However, this reality is hard to cope with and, when another group member made a similar confession, that he stole 2,000 euros from his parents, the group avoided exploring it.

After a while, the therapist turned to female Patient C, and somewhat reluctantly, she entered the scene. Patient C also had a sad family story to tell, and, most importantly, she found the courage to talk about how she was sexually abused after getting drunk at a disco. After that incident, her alcohol addiction started. Again, reality fell heavily upon the group members and, with the help of the therapist, they tried as hard as possible to understand and support Patient C in her narrative of the trauma, which, previously, only her mother and best friend had known about. Patient C described how in the past she had pretended that the incident had not happened. However, in the group, the pain was palpable.

The Course of Session 16

Session 16 starts with an important premise. Group Member MK had been denied access to the previous session (15) because of an aggressive outburst in Session 14. Now, in Session 16, the therapist assumed a more authoritative leadership style, right from the beginning, in the opening phase:

TP: *Only M is missing because he is sick, but he greets you. I would also like to inform you that today A has entered the therapeutic community. Everything is going well, and we are hopeful. The last time MK was absent, he was a little under stress. Now he's back, I hope you're a little more relaxed. Then if you want to say something to the group about what happened we'll start with a little from you. Then, if I am not mistaken, there will be a bit of time to give to C who has left us in suspense with respect to some of her decisions. And I have also observed that perhaps wants to talk about the very hard days that he has had in this period. Then I don't know if even F, N and R want or need to say something.* **(A1, A2, and A3)**

To this introduction, Patient MK responds directly:

Patient MK: *First of all, I would like to apologize to the group and in particular to M (who is absent) and to R for the outburst I had last session before my absence. I don't know exactly what you perceived, but surely it was my outburst. However, I didn't want any of you to be offended, and I hope it wasn't a bad example. This might illustrate that everyone can lose their patience. It used to happen to me much more often when I was using cocaine in the past. When I got angry, it was certainly not a pretty sight. I don't know what you perceived. You can lose your patience, but you always have to keep calm and to stay focused. For me, recognizing that I'm wrong and apologizing is something new that I've never done before. After such moments of anger, you don't even remember what you said. I had a meeting with the therapist, and I revisited things a little. I was under so much stress, and it's not easy for me to hold off the fact that I do*

too many things. I always get upset when things don't go according to my plans. Even in my daily life, I tend to react with anger and to make intimidating remarks. I still have to work a lot on this.

It is useful to compare this opening of Session 16 to the opening of Session 12. There is not much pretending here. It is straightforward, honest, and highly relevant. The group then proceeded with a fine sequence that mentalized the event in the group when Patient MK lost his temper. Most of the members commented on how they perceived the event and reflected upon it with the help of rather short and direct interventions by the therapist:

TP: *But, of course, in a group you can also let off steam. That is not the problem in itself. What we reflected on together during the session that you missed is that there is a limit to what you can achieve.* **(A7, A17)**

Patient M: *I missed the situation by my own hand. I am not a superhero, it happened to me and I apologize. The important thing for me now is being able to apologize. I thought about it a lot during the days that I didn't come to the group. The important thing is to improve. I still have work to do on patience. I'm not a quiet person, I can't sit still, I still have to work on patience.*

TP: *And as you said before, also on the fact that you can't pretend to have everything under control, don't you? Does this thing stress you?* **(A17)**

Patient M: *I should take some space for myself, to unwind. Otherwise, I get too charged up with tensions. I should manage my day differently. I don't always succeed. Here it is clear that I didn't want to offend anyone, and I apologize to the group.*

Patient F: *M., I would like to tell you that in any case you have lost your patience on a difficult topic for you. You are facing your life well, but the subject was a sensitive topic for you.*

TP: *Yes F, you say something important for M., but now we are trying to evaluate the way he has managed his anger* **(A17, A4)**

Patient M: *I (turning to F) was not able to handle the anger. It was the way I took it that wasn't good. It was a useless outburst against the institutions and against that guy.*

TP: *But maybe it's how you managed it in the group, right? It is the anger that you have not managed in your relationship with the group, not so much in relation to the person you were talking about. I do not want to open up the subject of your contention with that person again, but we are talking about how you handled it here and perhaps how the group experienced your anger* **(A4, A17)**

Patient M: *At that moment, maybe I was looking for solidarity from the group, maybe I was trying to make them get as mad as me with that person and instead seeing that they didn't agree with me and were even trying to make me think, my anger increased even more at that moment. I was looking for someone to tell me revenge you are doing right, you have to take revenge.*

TP: *So, the problem is the difficulty in accepting what others tell us against our expectations?* **(A16)**

Patient R: *Yes, It is not so much what you said, it is just how you answered M. You were agitated. While M and I told you things in a low tone, you answered in another, do you understand? I'm glad you're apologizing, but this confrontation is useful to understand what happened at that moment.*

In this sequence, the therapist emerges as an expert in group dynamics rather than in the content that emerged in the discussion that led to explosion of anger of MK.

TP: *But what you call obvious may not be in the other's point of view, which is sincere at that moment one commits to tell you that thing. To you it seems obvious but the point is to respect what the other has to say. It's that sometimes we want to hear others say exactly what we expect. Isn't it?* **(A12, A16)**

The therapist highlighted the importance of respecting different points of view as an element of group therapy and also invited silent members to talk about all these incidents. This was carried out without falling into generalizations but by remaining in the event that had happened and that everyone had experienced directly. The validation of the existence of different points of view in the group seemed to allow Patient MK to reach other points of view in his own mind, related to the observation of his own behavior in the group and the diverse reactions that the different members of the group presented with respect to his anger and the content he brought. There were those who supported him and those who wanted to express a different opinion, but he recognized that what he wanted was only that his own point of view was defended, and he connected this expectation with the mental state of anger and his unwillingness to manage it at that moment: "*In particular, R and M made me crazy because they didn't support me. I was more pleased by the fact that F tried to support me, but I didn't accept any points of view different from my own at that time.*"

After this important sequence with MK, the therapist offered space to Patient S to talk about how he had been in the last few days. He shared with the group that he had relapsed but did not feel guilty about it. Some group members immediately started to declare their opinions about the feelings of Patient S prior to the relapse. The therapist stopped the ongoing inquiry: "*Sorry, but, for a moment, let's try to let him talk a little bit? I didn't understand how he felt exactly and what he wants to tell us right now. It's not clear to me.* **(A18 A11)**." When the group continued to press him, she stopped again to rewind: "*Sorry, but I still don't understand what's on his mind. S, do you want to try making hypotheses about the thoughts you had before drinking?* **(A11 A18)**." Fostering the mentalization process through "stop and rewind" (Item 18) prepares the ground for interventions by both the therapist and the participants aimed at exploration, curiosity, and not knowing. Here, we see how, unlike Session 12, the therapist did not engage in any "individual therapy in the group" but invited everyone to participate in an exploration of the underlying mental state that connected to shame and fear of Patient S that his condition as an adopted child would be highlighted by a social worker.

In fact, after some comments characterized by certainty about emotions of Patient S that pretended to depict precisely what Patient S felt or thought before his relapse, several members of the group now assisted the therapist, on her explicit invitation, in the exploration of disclosure of S, and some of them even commented on it, modeling the therapist. They stopped talking in the place of S and joined the therapist in a not-knowing and genuinely curious stance. Patient F, in fact, said: "*What did you think before drinking and drinking? Let's do the 'moviola' on this.*" Later, Patient R intervened, checking his understanding of

mental state of S, instead of stating it as a certainty: "*I'm sorry I didn't understand, you're afraid of not been seen any more as a family member if the social worker comes to talk about you with all of them. I got it right?*" In this atmosphere of curiosity and exploration elicited by the therapist, Patient S could mentalize with the group his painful and confusing thoughts about his identity and family background.

At the end of the session, Patient C, who left the room due to dizziness, rejoined the group and shared with the group members her decision to enter a residential therapeutic community. She, in fact, realized that she needed more help because she did not "*want to stay in this shit anymore,*" even though the perspective of the community is fearful, and she regretted not being able to maintain her commitment to the group. Nevertheless, the response of the group was aimed at containing her and supporting her decision.

DISCUSSION

The main findings from this study are the following:

1) Several sequences of collective PM/pseudomentalization could be identified and their phenomenology could be described.
2) PM sequences are not universal in groups. We found PM sequences in one of the group sessions studied but not in the other.
3) The group therapist seems to play a significant role in the dynamics of PM: we could identify therapeutic interventions that seemed to promote PM and others that seemed to prevent it.
4) In this case, MBT-G principles seemed to be an effective antidote to the proliferation of PM.

PM flourishes in ordinary life when we chat, play, engage in discussions, talk about all or nothing, and just get along without things being "that important." Politicians are expert at this when they can give long speeches without saying anything essential, labeled "bullshit" by the philosopher Harry Frankfurt (2005). However, in group therapy, it becomes a problem since therapeutic groups are invested with an ideal requirement for the containment and exploration of painful mental states. Accordingly, there is the need to identify PM and to counteract it.

In this study, we have identified several PM sequences. These sequences were definitely of a collective nature, and we may rightly speak about group discourse modes. They are ways of talking together that seem to be experienced by the participants as a meaningful way of being together but lack the personal and emotional commitment that the primary task of the group demands. As such, PM sequences appear to the observer as having a detached, or "as-if" quality (Bateman and Fonagy, 2019), although the content of the discourse seems to be concerned with mental states. The opening phase of Session 12, which we have described in detail, is a good illustration. In this case, PM starts immediately, but when does it end? It definitely ends after approximately half an hour, when Patient S starts to tell his sad story. During this 30 min, PM was, more or less, always present. It is like a strong undercurrent that surfaces periodically. It might be compared to the term by Wilfred Bion (1961), basic assumptions, e.g., something that undermines the primary task activity of the group from "beneath," more specifically the basic assumption of flight (Karterud, 1989). In our group, it appeared as the tendency of group members to provide solutions and banal explanations or to insist that "*you have to understand (think, do, try. . .) that. . .*," "*you did that, so you accept this,*" etc. Sometimes, they stated what the feeling of the other was like, for example, "*you felt lonely and bored!,*" "*you felt a weight,*" "*you lost confidence.*" During these sequences, the group discourse was centered around rules or guidelines on how to behave and feel in the "right way," as in intrusive pseudomentalization where the opaqueness of minds and connections with emotional experiences are lost.

Bion (1961) suggested that basic assumption phenomena surfaced when the group was afflicted by overwhelming anxieties and should be considered as a collective defense mechanism. Certainly, in this group, when the participants started to talk honestly, open, and emotionally, almost unbearable memories of death, loss, adoption, betrayal, violence, rape, and theft were revealed. We may hypothesize that approaching these memories activated emotions that were too intense for the members to regulate effectively, and that, in order to counter the emergence of these strong emotions, they fell back on the non-mentalizing mode of pseudomentalization.

The above reasoning may also be an explanation of why the therapist behaved so differently in these two sessions. During the first 30 min of Session 12, the therapist was definitely an integral part of the PM discourse. During this sequence, the name of Patient A repeatedly popped up, indicating that the group was certainly preoccupied with him. He signaled a withdrawal from the group but was observed in the surroundings. However, the theme was never discussed. Why? Does his withdrawal shake an initial idealization of the group? Does this also agitate the therapist who responds by acting out a countertransference of detachment, until she gradually assumes a more competent therapist role?

The course of Session 16 demonstrates that PM is a fluctuating phenomenon, even in this group with so much pain to bear. This fact highlights the significance of the therapist. We have already speculated that, during the first 30 min of Session 12, she was aroused by her own countertransference fear. But, more precisely, what did she do differently in the two sessions? In Session 16, we could observe that the therapist warded off very effectively any pseudomentalizing discourse and that strong emotions found their place in the group narrative. We noted that, overall, in Session 12, the therapist intervened very often and with long and sometimes complex interventions of a more pedagogical type. In contrast, in Session 16, the therapist intervened far less often, and the interventions were mostly short and simple.

There were also important differences with respect to content. In Session 12, the therapist tended to determine the content to stop and change the subject without waiting for the group. This attitude was reinforced by a frequent use of the expression "do you understand?" The therapist was caught up in formulating explanations and theories that the group members had to align with or not. The patients seemed to replicate in a way the attitude

of the therapist toward the other group members by imitating the model of intervention of the therapist. Indeed, the members formulated explanations, instead of exploring the mental states of the others, and provided solutions and rules of behavior for different contexts. In Session 16, by contrast, the therapist seemed much more focused on the process than on the content, and her interventions tended to be more supported by curiosity and doubt than by the pursuit of rational explanations. The expression "do you understand?" never appears in this session.

PM also seemed to be stimulated by the therapist, using a language of complicated words and concepts, presumably going "above heads of the members." That too seemed to be imitated by some members. A different therapeutic modeling occurred in Session 16, where the members were stimulated by the therapist to explore their own and others' mental states to focus on emotions and to engage in mentalizing external events. During this session, indeed, the therapist was more directive in orienting the group discourse toward mentalizing aims, in structuring a kind of turn-taking and in frequently stopping and rewinding the group discourse when it seemed to lose sight of mentalizing objectives.

Since PM could not be observed to any substantial degree in Session 16 and since the way of the therapist of conducting this session was more strictly in accordance with MBT-G principles, can we conclude that there is a causal relationship between these phenomena? Not in any "hard" sense. However, we will argue that these phenomena, to a significant extent, are related. After all, we have to emphasize that the principles of MBT-G were constructed in order to counteract PM and similar collective regressions. Thus, we will take the liberty of postulating an inverse relationship between PM and MBT-G treatment integrity, specifically to mention the most important interventions, when the therapist creates bridges with previous sessions, manages group boundaries, structures the group, and engages the members in mentalizing current and past events while containing and focusing on current emotions.

The good news in this story is that groups with poorly functioning patients are not doomed to remain in unproductive or destructive group discourses. When Bion (1961) formulated his basic assumptions theory, it came with a rather pessimistic therapeutic message. He could not foresee any therapeutic style that would "rescue" therapeutic groups from basic assumptions functioning. However, the way of reasoning of Bion had significant limitations. He was stuck in drive theory and the theory of Melanie Klein of early psychotic anxieties. Moreover, his phenomenology was flawed. He postulated a basic assumption of "fight/flight," supposing that "fight/flight" was a unifying concept. However, Karterud (1989) was able to demonstrate that fight and flight were different emotionalities in groups; they did not always come in one package. A modern reconceptualization of Bion's original idea is that group rationality (or mentalizing capacity) may be undermined by (contagious) primary emotions and that FEAR (as described by Panksepp, 1998) corresponds to the basic assumption of flight. Actually, what we have found in this study, as conceptualized by the more modern concepts of PM and pseudomentalization, corresponds quite well to the basic assumption of flight as identified by Karterud (1989). Flight is driven by the primary emotion of fear. So, what are the people in this group afraid of?

In the introduction, we discussed the need for individuals who are drug addicts to "distort reality" and defend the "fictitious reality" constructed by substances in the mediation of the relationship between the mind of the patient and her/his environment. When we studied this group carefully, we came across, in no more than two sessions, painful memories of death, loss, adoption, betrayal, violence, rape, and theft. The fear of being overwhelmed by these memories, with their inherent emotions complicated as they are with secondary feelings of shame and guilt, e.g., not being able to approach them and mentalize them, seems to us to be the ultimate source of PM as a defensive move. The sad destiny of many individuals who are drug addicts is not only painful traumas from early childhood but also traumas and humiliations extending into adult life under the control of an addiction lifestyle. In this study, we have found several examples of an intrusive pseudomentalizing discourse, and we may hypothesize that addiction disorders, in particular, might be victims of this subtype of non-mentalizing thinking, characterized by certainty about mental states and a disconnection between emotional experience and social cognition. This decoupling may serve as a protective/defensive factor to counter the fear of emotional turmoil, confusion, and loss of identity. Furthermore, substance abuse might allow patients who are addicts to "feel in control" of their emotional states by shutting them down when they approach consciousness. In other words, we may say that, in some way, intrusive PM imitates the effect of such substances. Moreover, a certainty about mental states may be comforting and soothing. In fact, it is less threatening to be sure of what other people are thinking than wondering what is going on inside their heads. In the same way, it is easier to chemically turn off thinking and feelings than to face and mentalize negative emotions.

LIMITATIONS

This study has several limitations. We identified a limited number of PM sequences and only from a group of drug addicts. A larger number of group sessions from diverse groups might have enriched the phenomenology and revealed more nuanced relations between therapist interventions and group processes. The study indicated a connection between the occurrence of PM and the behavior of the therapist, e.g., that certain interventions seemed to promote, and other interventions seemed to prevent PM, and that these therapist qualities could be captured by the MBT-G-AQS. Although this is in accordance with clinical literature, such a connection should be replicated. Furthermore, although we believe in the strength of the qualitative and phenomenological nature of this work, we also recognize that it could benefit from the matching of qualitative results with quantitative data with regard to the group process (such as therapeutic factors or cohesion). Moreover, it would be interesting in the future to collect and merge data from reports of therapists with evaluations of raters. This issue also has

implications in terms of outcomes. As a non-mentalizing mode, pseudomentalization is, by definition, a sign of low reflective functioning. It might be expected that patients and groups, toward the end of the treatment, would display lower levels of PM than at the beginning of the treatment. However, this has not been verified empirically.

CONCLUSION

From the study of this group of drug-addicted patients, we have verified that non-mentalizing modes of "pretending" do occur as collective phenomena, and that they are characterized as a kind of preoccupation with mental states that favors unwarranted causal claims and explanations (e.g., "seasonal qualities influence moods") rather than genuine explorations of mental states. Furthermore, the study indicates that the group therapist has a strong influence on the occurrence of PM, although the ultimate source is, probably, the fear of the participants of strong emotions, mental confusion, and loss of identity. The PM seemed to be reinforced by poor boundary regulation, frequent and long interventions, and interventions with obscure content. It was probably also influenced by countertransference. On the other hand, PM seemed to be counteracted by a therapist style that adhered more closely to MBT-G principles, specifically when the therapist provides some transformative interventions, namely when she regulates the group phases and setting, when she involves the group in the mentalization of events or when she focuses on the emotional aspects of the experience. This has been the first empirical study on PM in groups. It would be important to find out if our results also hold true for other group therapies.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The Ethic Committee for Clinical Experimentation of Padua -Italy (Comitato Etico per la Sperimentazione Clinica della provincia di Padova; CESC) reviewed and approved this study involving human participants (Deliberation n. 849). The patients provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GE, SF, and SWK designed the study and managed the literature search. GE, RP, and SWK undertook the analysis. GE, SF, RP, and SWK wrote the first draft of the manuscript and contributed to the subsequent redrafting of the manuscript. CM, VS, and SWK critically reviewed the draft of the manuscript and contributed to the interpretation of results. All authors contributed to and approved the final manuscript.

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When Teamwork Works: Examining the Relationship Between Leader-Member Exchange Differentiation and Team Creativity

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Drawing on team creativity literature and social comparison theory, we investigate how leader-member exchange (LMX) differentiation influences team creativity. Using a survey based on 91 R&D teams from Chinese companies, we observe that LMX differentiation is negatively related to team creativity ($\beta = -0.35$, $p < 0.01$). More importantly, we demonstrate that team behavioral integration mediates the relationship between LMX differentiation and team creativity (indirect effect size = −0.72, with 95% CI of −1.91, −0.13), and team emotional intelligence (TEI) moderates the relationship between LMX differentiation and team behavioral integration ($\beta = 0.23$, $p < 0.05$), such that LMX differentiation has a weaker negative influence on team behavioral integration when TEI is higher. These results provide relevant suggestions for organizational team building, management, and development.

Keywords: team creativity, team behavioral integration, LMX differentiation, team emotional intelligence, social comparison theory

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INTRODUCTION

In an increasingly changing and competitive work environment, creativity has become an essential ingredient for organizations' survival and development (Anderson et al., 2014). Defined as the product of novel and useful ideas by a group of employees working together (Shin and Zhou, 2007), team creativity has garnered a growing body of research in innovation and strategy literature. Accordingly, an increasing number of organizations are adopting teams as the primary work units to maximize creative processes (Li et al., 2010).

Although a number of researchers have explored the impact of leadership influence on team creativity (Shin and Zhou, 2007; Zhang et al., 2011; Hu et al., 2017; Mo et al., 2019), there are notable shortcomings in the current literature. First, despite the growth in literature, the potential influence of leader-member exchange (LMX) differentiation on team creativity has not been given as much attention. Among the limited present studies that have examined the direct effect of LMX differentiation on team creativity, there remains a major inconsistency in the current findings (Li et al., 2016; Matta and Van Dyne, 2020). As demonstrated by a review by Anand et al. (2015, p. 288), the "findings on the effects of LMX differentiation have been mixed at

best." Indeed, the current literature lacks insights on the mechanisms that drive differential effects (Matta and Van Dyne, 2020).

As one of the most fruitful fields in leadership research during the past few decades, LMX theory captures the notion that different relationships with leaders significantly impact employees' performance (Gerstner and Day, 1997). LMX differentiation, one major component of LMX theory, is defined as the degree to which members working with the same leader differ in terms of their relationship quality with their leaders (Ma and Qu, 2010). This varying exchange relationship quality then promotes or mitigates subordinates' performance including their self-views and employee's voice behavior (Martin et al., 2016; Matta and Van Dyne, 2020). Although some studies support LMX differentiation as having an influence on team processes and outcomes (Harris et al., 2014; Liao et al., 2017; Matta and Van Dyne, 2020), the effect of LMX differentiation on team creativity remains underexplored. With this in mind, the primary goal of this study is to examine the effects of LMX differentiation on team creativity. Social comparison theory points out that people make self-attribution comparisons both consciously and unconsciously (Festinger, 1954). The equality principle of fairness is one of the main principles within social comparison theory. High level of LMX differentiation makes team members comparison more salient, that is, team members are easy to perceive the differential treatment from leaders particularly under team context (Liden et al., 2006). Since the development of team creativity requires cooperation and information sharing among the team members, the presence of high LMX differentiation would lead to the perception of inequality, which is thought to destroy the harmony and cooperation within work teams (Liao et al., 2017), thus affecting team creativity (Camps et al., 2019; Graso et al., 2020).

The study on the context of teamwork is critical to explore how team-level constructs and their interactions influence team outcomes. We postulate that team emotional intelligence (TEI) will moderate the effect of LMX differentiation on team behavioral integration. TEI is the degree of the emotional intelligence that team members appear to use when they interact with each other. High TEI suggests that team members can better regulate their emotions and can better prioritize organizational issues (Salovey and Mayer, 1990). In this condition, team members can pay less attention to the effects of LMX differentiation and instead focus on the things that benefit the greater team(s), which can attenuate the team conflict whereby caused by LMX differentiation. Taken together, we postulate that TEI can alleviate the negative effect of LMX differentiation on team behavioral integration.

This study offers several vital contributions to the existing literature. First, building upon the existing literature on team performance research (Sui et al., 2016), we provide a more comprehensive understanding of LMX differentiation and its effect on team creativity. In this direction, we validate the effect of LMX differentiation on upper-level team creativity, which is still in its infancy stages of development (Li et al., 2016; Qu et al., 2017). We also shed new lights on the influence of LMX differentiation on team behavioral integration and help to explain why and how the team climate with high level of LMX differentiation decreases team behavioral integration. In addition, by exploring team behavioral integration as the mediator, we extend our empirical understanding of the outcomes of LMX differentiation and provide an in-depth explanation of the team member interaction process in this relationship within general teams. Last, we infer that TEI may interact with LMX differentiation to then affect team behavioral integration. This provides a new perspective to better understand how emotional intelligence works at the team level, by demonstrating when these effects occur.

The rest of the manuscript is organized along the following lines. In the subsequent section, a review of LMX differentiation and team creativity is presented. We then present the research method and analysis of the results. The final section outlines the different theoretical and practical implications of the study.

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

According to the input-process-outcome model (IPO, McGrath, 1984), LMX differentiation is the element of "input" and team creativity is element of the "output," and the "process" describes how "input" is transformed into "output," including social exchange and interaction [e.g., communication, cooperation, and information sharing (Marks et al., 2000)]. Team behavioral integration, which reflects the degree of convergence of team member interactions and demonstrates their collective behavior, is a critical construct capturing the social interaction among team members (Marks et al., 2000). Based on social comparison theory, LMX differentiation violates the social principle of equality and triggers team conflict, which could negatively affect team behavioral integration. Team behavioral integration includes team's information exchange, collaborative behavior, and joint decision-making (Simsek et al., 2005), all of which have deep influences on team creativity. Thus, we propose that team behavioral integration may be a crucial intervening process that might explain the relationship between LMX differentiation and team creativity.

Leader-Member Exchange Differentiation and Team Creativity

In recent three decades or so, many organizations have shifted from solely focusing on the individual worker or star performers to innovate to focus on cultivating and developing teams (Groysberg and Abrahams, 2006; Groysberg, 2010; Adomako et al., 2019; Amankwah-Amoah, 2020). Indeed, sole stars in organizations have been found to be a myth as individual performance is increasingly buttressed by colleagues and supporting cast (Groysberg and Abrahams, 2006; Groysberg, 2010). In the modern work environment, there are new assumptions for organizational creativity, in that creativity at work is usually conducted within team settings (van Knippenberg et al., 2011). Organizational scholars and practitioners alike have explored how to promote team creativity, a prominent indicator of team performance (Tu et al., 2019).

Team creativity is not the simple sum of individual creativity, but rather, it involves a complex team members' interaction process and can be methodologically examined using self-report, social network analysis, focus groups, and mixed method designs (Akhtar et al., 2019). Existing studies have highlighted the importance of team members' individual propensity for creativity in the team creativity process (Hülsheger et al., 2009; Kim et al., 2013). Boundary conditions of team creativity include the presence or absence of positive organizational culture, psychological safety, and team trust (Boon et al., 2016; Han et al., 2019).

Social comparison theory suggests that people make self-attributional comparisons both consciously and unconsciously and is a useful heuristic for how creativity is enacted and shared within teams (Festinger, 1954). If an individual feels as though their peers are empowered to enact creativity, they are more likely to exhibit creativity as a result (Amabile, 2018). In the organizational context, leaders, including those who enact transformational leadership behaviors, are largely the vehicles to which employees feel empowered to enact goal-directed behaviors, which also include creativity (Dong et al., 2017). Thus, if a leader is treating their subordinates differently (i.e., when LMX differentiation is high), employees are likely to become disengaged and less inclined to initiate collaborative work behavior (Roter, 2017).

Leader-member exchange differentiation suggests that within-group variability of the quality of the leader-follower relationship is different among certain employees (Liden et al., 2006; see also Dong et al., 2020). The different treatment makes team members comparison more salient and the work environment more competitive, suggesting that team members are easy to perceive the differential treatment from leaders particularly if they work together every day. This comparison can significantly influence work outcomes. Specifically, if the level of LMX differentiation within a team is high, then the perceived unfairness between team members will be likely experienced. This in turn may cause potential conflict and less cooperation, thereby harming team creativity (Li and Liao, 2014; Hopkins and Yonker, 2015). Additionally, team members may have better relationships and more interpersonal interactions with those who have similar LMX differentiation quality, and alienating those whose LMX quality is significantly different from their own (Brewer, 1999). Therefore, high LMX differentiation may lead to differences in in-group and outgroup perception. Team members in similar high- and low-quality LMX relationships will likely form coalitions, which will lead to increased interpersonal and emotional conflicts across these teams (Hooper and Martin, 2008). This process will exert negative impacts on team members' social interactions, thus mitigating team creativity.

In addition, the equality principle of fairness within social comparison theory may directly explain the negative relationship of LMX differentiation on team creativity (Camps et al., 2019; Graso et al., 2020). The development of team creativity requires cooperation and information sharing among the team members. However, the presence of high LMX differentiation would lead to the perception of inequality, which is thought to destroy the harmony and cooperation within work teams (Liao et al., 2017). Altogether, perceived inequity in the context of social comparison is harmful to team creativity. Thus, we hypothesize the following:

H1: LMX differentiation is negatively related to team creativity.

The Mediating Role of Team Behavioral Integration

The concept of "behavioral integration" was first put forth by Hambrick and Mason (1984) within the framework of Upper Echelon theory. This theory reflects the degree of convergence of team member interactions and demonstrates their collective behavior. There are three dimensions of behavioral integration: quality and quantity of team information exchange, cooperation behavior, and collective decisions. Each dimension reinforces and promotes the others and explains how a team operates and works together (Hambrick and Mason, 1984). Team behavioral integration has been linked to be a crucial process factor with great benefits for team outcomes (Bingyan et al., 2016; Tekleab et al., 2016).

We posit that LMX differentiation may have a negative effect on team behavioral integration. First, as aforementioned, LMX differentiation leads to the perception of relational boundaries in teams, which in turn makes team members form in-group and outgroup norms (Brewer, 1999; Anand et al., 2011). In-group members possess more valuable team resources, such as key positions, attention from others, and are likely to garner more promotions through the high-quality relationships with leaders (Weeks et al., 2017). This situation makes outgroup members feel higher levels of perceived unfairness and lower levels of organizational justice perceptions, therefore undermining team behavioral integration by increasing conflict (Lim and Loosemore, 2017). High LMX differentiation destroys team members' justice perception (Liao et al., 2017). Perceived unfairness makes team members disappointed, frustrated, and angry, which reduces their efforts to enact teamwork and harms team members' coordination (Hooper and Martin, 2008). In conclusion, LMX differentiation is harmful to acquire both the quality and quantity of team information exchange, cooperation behavior, and collective decisions. When teams' behavioral integration is high, members working together invest more time and energy in identifying problems, searching for more information, and putting forward effort in knowledge creation (Kim, 2010). Teams with high levels of behavioral integration are characterized by having open and timely communication of information among team members, habitual teamwork, and joint decision-making (Sousa and Van Dierendonck, 2016; Tekleab et al., 2016). When team members effectively use behavioral integration, they can obtain more valuable information, knowledge, and ideas, which in turn improves engagement in the above behavioral processes related to creativity. Moreover, a team with higher behavioral integration enables team members to collaborate with different people and experience more diverse ways of thinking, which then enriches and expands members' thinking patterns, which also contributes to team creativity (Hoever et al., 2012). Accordingly, we hypothesize the following:

H2: Team behavioral integration mediates the relationship between LMX differentiation and team creativity.

The Moderating Role of Team Emotional Intelligence

Team emotional intelligence is the capacity to understand and effectively manage our emotions, while attending to the social emotions of others (Sy et al., 2006; Mayer et al., 2016). TEI has four dimensions: awareness of own emotions, awareness of others' emotions, management of own emotions, and management of others' emotions (Jordan and Lawrence, 2009). The interaction of individual traits and complex situational factors, such as team size, industry, and job function, makes the teamwork outcome not the same as the sum of individual self-report data (Li et al., 2010). Accordingly, TEI is reflectively not the sum of individual emotional intelligence within a team, but rather, it is how team members appear to use their individual emotional intelligence when they interact with each other (Jamshed and Majeed, 2019; Lee and Wong, 2019).

In this study, we propose that TEI may weaken the negative effects of high LMX differentiation on team behavioral integration. First, teams with high levels of emotional intelligence are better at perceiving others' emotions and understanding others' attitudes, goals, and behavioral intentions more accurately (Van Kleef et al., 2009). Employees with high emotional intelligence both high and low LMX quality are better able to adjust their negative emotions that resulted from LMX differentiation. Team members with high emotional intelligence and high LMX quality can easily capture the negative emotions of low LMX quality coworkers provide them timely care, and help them to regulate their emotions. Members besides, members with high TEI have a greater propensity to focus their attention on task-relevant issues (Salovey and Mayer, 1990; Sui et al., 2016; Martin et al., 2018). Although LMX differentiation damages the fairness and may trigger relational boundary between in-group and outgroup members, both of them pay their much attention to accomplish team goals, so team members could illustrate their viewpoint, exchange information, and cooperate with each other effectively. Second, previous literature has indicated that TEI plays an important role in team members' behavioral interaction (Hopkins and Yonker, 2015), teams with low emotional intelligence which lacking of the ability to manage emotions experience more task conflict and relationship conflict (Ayoko et al., 2008), whereas teams with higher emotional intelligence have less task conflict and relationship conflict that increases the team behavioral integration (Yang and Mossholder, 2004). Jordan and Troth (2004) also examined that teams with higher levels of emotional intelligence are more likely to use an integrative conflict management style in a teamwork which focuses on the awareness of management of perceived and felt emotions both on themselves and others. TEI is an important process in which team members can adaptively shape and behave differently according to shifting environments, including the specific situation that is occurring within a team (Roberts et al., 2001). It is the process that highlights the nature of "intelligence" which is defined by Roberts et al. (2001) as "adaptation to, selection of, and shaping of the real-world environments relevant to one's life." As Elfenbein (2006) notes, "therefore, TEI is often a matter of effective interpersonal behaviors rather than unchangeable traits" (Elfenbein, 2006, p. 178). Therefore, TEI becomes an important indicator of the relationship between leader-member exchange and the successful integration of team behavior.

H3: TEI moderates the relationship between LMX differentiation and team behavioral integration, such that LMX differentiation has a weaker negative influence on team behavioral integration when TEI is higher.

Finally, combining H2 and H3, we also posit that TEI not only moderates the impact of LMX differentiation on team behavior, but will also moderate the indirect effect of LMX differentiation and team creativity, *via* team behavioral integration. When teams possess high emotional intelligence, the effect of LMX differentiation on team behavioral integration, and ultimately on team creativity, will be weaker. Conversely, in teams with low TEI, the indirect effect of LMX differentiation on team creativity through team behavioral integration will be stronger.

H4: TEI moderates the strength of the mediated relationships between LMX differentiation and team creativity via team behavioral integration, such that the mediated relationship will be weaker under high TEI than under low TEI.

Based on the above, the research model was drawn as shown in **Figure 1**.

MATERIALS AND METHODS

Participants and Procedure

In this study, we selected research and development (R&D) teams as our target subjects because this type of team requires higher levels of creativity, and employees communicate with leaders and colleagues frequently. We investigated R&D teams from eight diverse enterprises and research institutes involving machinery, electronic communication, high-speed railway, aerospace, software service, and other industries. Organizations were primarily located in Shanghai, Sichuang, and Hubei in China. We defined a team as a group of workers ranging from 3 to 10 members reporting to the same leader (Macht et al., 2019). After obtaining permission and support from relevant leaders of the surveyed enterprises, we randomly selected a total of 145 teams with each team consisting of one leader and 3–10 members.

To avoid common method variance (Podsakoff et al., 2003), data were gathered from different sources with the time lag of 1 month. At time point 1 (March 2018), employees filled out the subordinate questionnaire that included items measuring their perception of leader-member exchange and team behavioral integration, and their own level of emotional intelligence. At time point 2 (April 2018), leaders filled out the leader questionnaire that included items measuring entire teams' creativity level, and team information, such as team

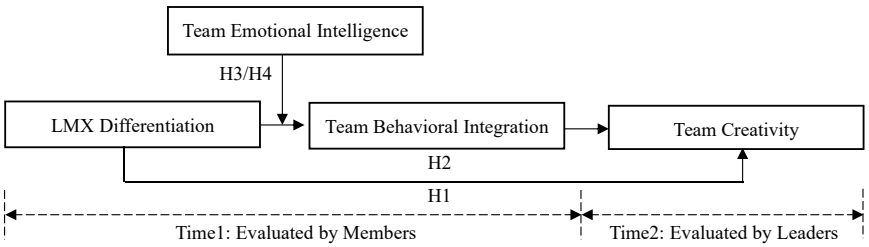

FIGURE 1 | The theoretical model.

size and task characteristics of teams (task complexity and task interdependence). Both team leaders and members self-reported their demographic information (age, gender, and education). Given that all surveys were administered during working hours, informed consent was obtained, all participants were not compensated for their involvement in the study, and all data were held confidential upon analysis.

We distributed a total of 640 questionnaires to employees at time point 1. A total of 483 surveys were returned with a response rate of 75.5%, with a final of 401 subordinate questionnaires obtained after eliminating the uncompleted and unmatched questionnaires, an effective completion rate of 62.7%. We distributed a total of 145 questionnaires to leaders at time point 2. A total of 108 surveys were returned with a response rate of 74.5%. At time point 2, a final of 91 leader questionnaires were obtained with an effective response rate of 62.8%.

Demographic characteristics of team members and team leaders were collected. Among team members, 57.8% were men and 42.2% were women; the main age groups were 26–35 years (26–30 accounting for 50.6%, 31–35 accounting for 26.8%); participants had relatively high educational levels (40.2% Bachelor's degree, 36.4% Master's degree). Among team leaders, 79% were men and 21% were women; the main age groups were above 36 years old (36–40 accounting for 21.5%, greater than or equal to 41 accounting for 65%); they have relatively high educational levels (31% Bachelor's degree, 50% Master's degree).

Measures

We designed the questionnaire based on valid scales in the existing literature. The survey was initially constructed in English, and all items were translated into Chinese by conducting back-and-forth translation procedures (Brislin, 1986) to ensure the accuracy of translation. For most items, we adopted a six-point Likert scale, ranging from "1 – strongly disagree" to "6 – strongly agree." Team creativity uses a five-point scale.

Leader-Member Exchange Differentiation

We used the 7-item scale developed by Wang et al. (2005) to measure LMX. A sample item is "my supervisor behaves in a manner thoughtful of my personal needs." The McDonald's ωfor the LMX scale is 0.91. Consistent with previous research, we aggregated the individual-level LMX scores into team-level LMX mean and measured LMX differentiation using the coefficient of variation (team LMX SD/LMX mean, Martin et al., 2018).

Team Behavioral Integration

We used the 4-item scale developed by Li and Hambrick (2005) to measure team behavioral integration. A sample item is "all team members have a voice in team decisions." The McDonald's ωfor the whole scale is 0.92. Given that team behavioral integration is a team-level construct but evaluated by individuals in this study, we aggregated these data into team-level ones by calculating the average value of team behavioral integration at the individual level in each team. We used rwg, ICC (1), and ICC (2) indicators to assess whether the measurement of this construct had sufficient intragroup consistency and intergroup heterogeneity (James et al., 1984; Bliese, 2000). The aggregation statistics were sufficient, with ICC (1) = 0.35, ICC (2) = 0.70, and mean $rwg_{(j)}$ = 0.91.

Team Emotional Intelligence

We used Wong and Law's Emotional Intelligence Scale (WLEIS) developed by Wong and Law (2002) to measure team members' emotional intelligence. It contains 16 items to measure four subscales, with four items for each subscale: Self-Emotions Appraisal (SEA), Others-Emotions Appraisal (OEA), Use of Emotion (UOE), and Regulation of Emotion (ROE). We focus on team members' whole emotional intelligence, and the McDonald'sωfor the whole scale is 0.93. The average $rwg_{(j)}$ across subjected teams was 0.85. The ICC (1) value was 0.15, and the ICC (2) value was 0.52. We aggregated the individual-level emotional intelligence scores for each team to represent the respective team-level construct.

Team Creativity

We used the 4-item scale developed by Shin and Zhou (2007) to measure team creativity. It is a 5-point scale ranging from 1 (needs much improvement) to 5 (excellent). A sample item is "How creative do you consider this team to be?" The McDonald's ω for this scale was 0.90.

Control Variables

In line with previous LMX and LMX differentiation research (e.g., Tse and Ashkanasy, 2015), we included team members' demographic information (i.e., age, gender, and education), and also team size and task characteristics as control variables in the current research.

Additionally, we used the scale developed by Dean and Snell (1991) to measure task characteristics. The scale contains three items to measure task complexity (e.g., "to what extent do the

jobs involve solving problems?") and six items to measure task interdependence (e.g., "how much do people in this team have to coordinate work with others?"). The Cronbach's α for task complexity and interdependence is 0.89 and 0.92, respectively.

RESULTS

Confirmatory Factor Analysis

We conducted a series of confirmatory factor analysis with robust maximum likelihood estimator to explore the distinctiveness of the focus four variables at individual level. As shown in **Table 1**, the hypothesized four-factor model [$X^2/_{(428)}$ = 3.73 (<5), RMSEA = 0.05 (<0.05), SRMR = 0.04 (<0.05), CFI = 0.91 (>0.90), TLI = 0.92 (>0.90)] fitted the data better than alternative models, providing support for the distinctiveness of the four constructs in this study.

Descriptive Statistics and Correlations

Table 2 shows the means, standard deviations, correlations, and reliability coefficients of the variables.

Hypotheses Testing

We used IBM SPSS 22.0 software to conduct hypotheses testing using ordinary least squares regression since our variables were the same level of analysis (team level). The results are shown in **Table 3**. The results in **Table 3** indicate that LMX differentiation is negatively related to team creativity (M4, β = −0.35, $p < 0.01$). Hypothesis 1 was thus supported.

We then examined the mediating effect of team behavioral integration between LMX differentiation and team creativity, following Baron and Kenny's (1986) recommended four conditions for establishing mediation. LMX differentiation was negatively related to team behavioral integration (M1, β = −0.24, $p < 0.05$); LMX differentiation was negatively related to team creativity (M4, β = −0.35, $p < 0.01$); team behavioral integration was positively related to team creativity (M5, β = 0.45, $p < 0.00$); when team behavioral integration was added, the relationship between LMX differentiation and team creativity was weaker, albeit still significant (M6, β = −0.26, $p < 0.01$), which suggests partial mediation. To further assess the significance of the mediation, we applied the Model 4 of PROCESS (Hayes, 2012) to test the indirect effect, the indirect effect is significant when the 95% confidence interval of sample-based Bootstrap does not contain zero. Results show that the intervening effect of team behavioral integration on the relationship between LMX differentiation and team creativity was −0.72 and the 95% confidence interval of sample-based Bootstrap (20000) was (−1.91, −0.13) (excluded zero). Taken together, Hypothesis 2, team behavioral integration mediates the relationship between LMX differentiation and team creativity, was thus supported.

H3 predicted that TEI moderates the relationship between LMX differentiation and team behavioral integration. The results in **Table 3** showed that the interaction between LMX differentiation and team EI is significantly related to team behavioral integration (M3, β = 0.23, $p < 0.05$). **Figure 2** and slope tests demonstrated that the negative relationship between LMX differentiation and team behavioral integration was significantly stronger, when team EI was at low levels (β = −0.24, $p < 0.01$) than at high levels (β = −0.09, ns), the difference is significant (Δ = 0.15, $p < 0.05$). Hypothesis 3 was thus supported.

Finally, we tested H4 which suggested that the mediation effect would be stronger under the low team EI condition. We used the Model 7 of PROCESS (Hayes, 2012) to examine this hypothesis. The results show that the conditional indirect effect of LMX differentiation on team creativity *via* team behavioral integration was non-significant [effect size = −0.18, 95% CI = (−1.10, 0.59)] in the high level of TEI, but the conditional effect was significant [effect size = −1.62, 95% CI = (−3.45, −0.59)] in the low level of TEI. Additionally, there was a significant difference in the estimates of these two mediation effects [Δ = 1.44, 95% CI excluded 0: (1.12, 3.59)]. Thus, Hypothesis 4 was supported.

TABLE 1 | Comparison of measurement models.

Models	X^2	df	X^2/df	RMSEA	SRMR	CFI	TLI
Hypothesized four-factor model: LMX, TBI, TEI, and TC	1,596.44	428	3.73	0.05	0.04	0.91	0.92
Alternative three-factor model: LMX, TBI + TEI, and TC	2,284.3	431	5.30	0.13	0.09	0.72	0.68
Alternative two-factor model: LMX + TBI + TEI and TC	2,892.44	433	6.68	0.19	0.21	0.61	0.65
Alternative single-factor model: LMX + TBI + TEI + TC	4,626.44	434	10.66	0.23	0.21	0.66	0.54

N = 401.
LMX, leader-member exchange; TBI, team behavioral integration; TEI, team emotional intelligence; TC, team creativity.
" + " represents two factors merged into one.

DISCUSSION

The goal of this study is to investigate whether, how, and when LMX differentiation influences team creativity. We introduce team behavioral integration and TEI as the mediator and moderator, respectively. Using a survey based on 91 R&D teams from Chinese companies, we confirmed that LMX differentiation is negatively related to team creativity, and team behavioral integration mediates the above relationship. In addition, TEI moderates the indirect relationship between LMX differentiation and team behavioral integration *via* team behavioral integration. Specially, our findings suggest that TEI, as an important process in which team members can adaptively shape and behave differently according to shifting environments (Roberts et al., 2001), has a potential to be an important indicator of the relationship between leader-member exchange and the successful integration of team behavior. The findings point to the importance of studying how LMX differentiation affects team creativity in R&D team settings, especially through the mediating role of team behavioral integration and moderated role of TEI.

TABLE 2 | Means, standard deviations, and correlations among variables.

Variables	*M*	SD	1	2	3	4	5	6	7	8	9	10
(1) Team Size	4.38	1.02										
(2) Age	2.37	0.73	0.04									
(3) Gender	1.59	0.25	−0.10	0.16								
(4) Education	3.89	0.90	0.19	0.24*	−0.06							
(5) Task complexity	4.53	0.63	−0.15	0.21*	0.21*	0.03						
(6) Task interdependence	3.81	0.89	0.05	0.27**	−0.09	−0.10	0.45**					
(7) LMXD	0.08	0.05	−0.35**	−0.09	0.08	−0.13	−0.03	−0.02	/			
(8) TBI	4.47	0.69	0.05	−0.16	−0.06	−0.14	0.01	0.08	−0.21*	(0.92)		
(9) EI	4.38	0.30	0.12	−0.34**	−0.04	−0.15	−0.03	0.20	0.09	0.46**	(0.93)	
(10) TC	3.40	0.52	−0.04	0.23*	0.19	0.26*	0.23*	0.06	−0.32**	0.37**	0.12	(0.90)

N = 91.
**p < 0.05; **p < 0.01.*
Reliability estimates appear in parentheses across the diagonal.
Task-c, task complexity; Task-d, task interdependence; LMXD, leader-member exchange differentiation; TBI, team behavioral integration; EI, emotional intelligence; TC, team creativity. Some control variables were coded as a dummy variable: gender (1 = female, 2 = male), age (1 = less than or equal to 25, 2 = 26–30, 3 = 31–35, 4 = 36–40, and 5 = greater than or equal to 41), education (1 = junior high school or below, 2 = high school, 3 = junior college, 4 = bachelor, 5 = master, and 6 = doctoral degree).

Theoretical Implications

This study contributes to existing team-level research in the following ways.

First, drawing on the IPO model and social comparison theory, this study is among the first to use team behavioral integration as the mechanism to explain the relationship of LMX differentiation and team creativity within organizational environments. Our findings also support prior research that LMX differentiation negatively relates to the team creativity, primarily in R&D teams (Stewart and Johnson, 2009; Liao et al., 2010; Harris et al., 2014). Although other mediators have shown to have an effect on LMX differentiation and team creativity such as relationship conflict (Zhao, 2015), we examined a different mechanism within this relationship. Results found that evidence to further support high LMX differentiation within a team creates a negative context in which team members have the perception of in-group and outgroup differentiation, primarily caused by the perception of relational boundary (Anand et al., 2011), and had injustice perception (Liao et al., 2010). We contribute by offering a better understanding of why and how team behavioral integration can be decreased by negative team climates with high levels of LMX differentiation.

Another finding in this study is that TEI moderated the negative relationship between LMX differentiation and team creativity *via* team behavioral integration. This study expands the proposed mechanisms and also offers new perspective to better understand how emotional intelligence works at the team level. Our findings build on the logic that emotional intelligence is predictive in the teamwork context, particularly in ones with high relational demands, and add more explanation on how TEI helps team members better use and manage emotions, including their own and others. In addition, this study explains how TEI improves team members' abilities to use and manage emotions effectively in work teams. This processes changes with different leadership treatment styles, more specifically, with high levels of LMX differentiation. Our study also suggests that TEI, as an important process in which team members can adaptively shape and behave differently according to shifting environments (Roberts et al., 2001), can be an important indicator of the relationship between leader-member exchange and the successful integration of team behavior, particularly in the context with high LMX differentiation.

Last, the findings establish TEI's role in facilitating team creativity. Much of current scholarship has examined emotional

TABLE 3 | Results of mediation and moderation analysis.

Variables	TBI			TC		
	M1	M2	M3	M4	M5	M6
CV						
Team size	−0.02	−0.09	−0.06	−0.17	−0.08	−0.16
Age	−0.18	0.03	0.05	0.09	0.19	0.16
Gender	−0.01	−0.05	−0.05	0.17	0.16	0.18
Education	−0.12	−0.10	−0.12	0.24	0.29**	0.28
Task-c	−0.00	0.04	0.04	0.12	0.15	0.12
Task-d	0.11	−0.07	−0.07	0.02	−0.05	−0.02
IV						
LMXD	−0.24*	−0.29**	−0.27**	−0.35**		−0.26**
Mediator						
TBI					0.45***	0.40***
Moderator						
TEI		0.50***	0.42***			
Interaction						
LMXD × TEI			0.23*			
F	1.34*	4.22***	4.52***	4.20**	6.39***	6.92***
R^2	0.10	0.29	0.33	0.26	0.35	0.40
Adjusted R^2	0.03	0.22	0.26	0.20	0.30	0.35
ΔR^2	/	0.19	0.04	/	/	0.15

N (team) = 91.
**p < 0.05; **p < 0.01; ***p < 0.001.*
All control variables were aggregated (the average value of each team). Task-c, task complexity; Task-d, task interdependence; LMXD, leader-member exchange differentiation; TBI, team behavioral integration; TEI, team emotional intelligence; TC, team creativity.

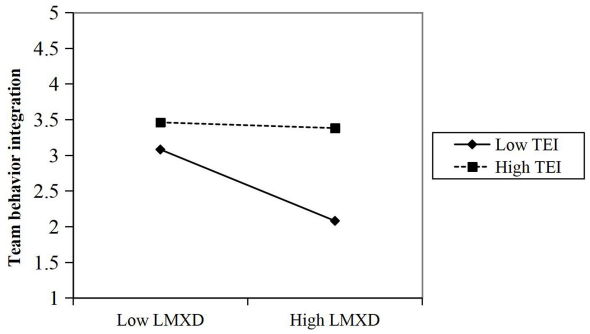

FIGURE 2 | Interaction plot.

expression as important for the overall work experience, and it has been found to be positively related to job satisfaction, job behavior, and job performance. Our findings build upon this notion further, highlighting that TEI contributes to job performance. TEI can directly improve cooperation (Yang and Mossholder, 2004) and information elaboration through its effects on cognition, namely the creative process.

Practical Implications

There are several practical contributions to this study at the team level. First, for team building, beyond using emotional intelligence as a selection tool to choose team members, human resource managers can utilize it as a development tool to help foster emotionally effective norms during the team-building process (Elfenbein, 2006; MacCann and Roberts, 2008). It will also be helpful for teams to continue to create positive work environments and organizational climates to increase trust and creativity within teams. Our findings also indicate that emotional intelligence testing may be more important for teams that need to hire more knowledge workers to produce creativity in jobs, since team members in these teams need higher degrees of information elaboration to perform their tasks (MacCann and Roberts, 2008).

Second, for team management, interventions on TEI can be used once a team has already been formed. Emotional interventions can be used in training and development programs, which may increase team members' emotional competences and skills. These programs teach employees to use emotions effectively in their work and develop more effective norms for emotional behaviors (Elfenbein, 2006). Relevant training and development programs, or coaching interventions, can be offered within organizations or by external firms. Program components include practicing mindfulness, journaling, 360° assessment, and leader gap analysis, and actively seeking direct feedback from others (Hopkins and Yonker, 2015). These coaching behaviors and interventions strengthen team members' ability to reflect on their own behaviors to be more self-aware (Hopkins and Yonker, 2015). In addition, laboratory research and initial field studies reaffirm that cognitive reappraisal interventions can also be effective in altering emotional experiences (Thory, 2013). Thus, emotional regulation strategies such as situation selection and cognitive reappraisal are recommended in teams to increase team members' emotional intelligence and to help them use and manage emotions more effectively (Parke et al., 2015).

Last, we encourage team leaders, particularly in R&D teams, to continue to invest in building high-quality relationships with their followers. Leaders who engage in LMX differentiation should carefully consider how they develop relationships with followers, as team members with high LMX may be more likely to play informal leadership roles in teams (Boies and Howell, 2006). On the one hand, informal leaders have positive influences on members and have the potential to facilitate effective coordination in teams. On the other hand, team members may perceive the unfairness as well, reducing the relational quality and team potential (Henderson et al., 2009). Therefore, team leaders should also put more effort on building high-quality relationships with followers, because it will be helpful for team members to engage in more creative, vigilant, and responsive processes while at work. Training and development programs should focus on these areas and build other interpersonal skills to facilitate deeper informal and formal mentorship relationships with followers. As aforementioned, 360° leader feedback is recommended in this capacity to help team leaders and followers develop self-awareness and perspective-taking.

Limitations and Future Research Directions

This study has some noteworthy limitations. First, we limited our analysis to R&D teams from organizations located in Shanghai and Hubei in China and in sectors such as machinery, electronic communication, high-speed railway, and aerospace. The limits the generalizability of the findings to teams in other countries and virtual teams, which might differ in the configuration. Future research can also rectify these limitations by seeking multiple countries' data and also data from virtual teams. Further, even though the aggregation results of ICC (2) supported, additional complex multilevel analysis (i.e., multilevel latent covariate approach) proposed by Lüdtke et al. (2008) is supposed to use given that aggregation may lead to measurement error if the team is small. Second, we focus on multiple industries without accounting for industry-specific effects on teams' activities. Given that multiindustry focus means that industry-specific factors such as market demand and market competitiveness which impinge on teams' activities, future studies could focus on a single sector to see whether the findings would hold. Another potential limitation is that this study only considered the degree of variation in team members' LMX quality (variation). As such, there are several other methods to measure the LMX variation from multisource indirectly, besides the coefficient of variation that was used in this study (Han and Bai, 2014). Moreover, besides variation in relationship quality between leader-follower dyads in the same work group (i.e., LMX differentiation), recent advances in LMX theory have showed that there may also be inconsistent and conflicting thoughts about the relationship within leader-follower dyads, that is, LMX ambivalence (Lee et al., 2019). Future research can further test its effect on creativity. Other properties and relevant measurements should be considered in future research to enrich the understanding of other patterns of differentiation process.

In addition, one future research direction is to consider educational level as one possible moderator in the theoretical model and explore educational effect more prominently given that the correlation results showed that it has correlated with team creativity ($\beta = 0.26$, $p < 0.05$). Another future research direction could continue to focus on team integration concepts outside of behavioral integration, such as affective integration (i.e., how teammates perceive the quality of their interpersonal relationships within the team) and cognitive integration (i.e., the amount teammates comprehend each other's interpretive frameworks; Cronin et al., 2011). Understanding how effective and cognitive integration mediates the relationships between LMX differentiation and team creativity can help expand upon the benefits of different team-focused integration concepts.

CONCLUSION

This study examined the relationship between LMX differentiation and team creativity. Drawing on social comparison theory, we conducted a survey on how LMX differentiation influences team creativity. Our findings highlighted that LMX differentiation is negatively related to team creativity, team behavioral integration mediates the relationship between LMX differentiation and team creativity, and TEI moderates the relationship between LMX differentiation and team behavioral integration. This effect then moderates the indirect relationship of LMX differentiation and team creativity *via* team behavioral integration. These results collectively enhance understanding of how team members interact with each other in the context of LMX differentiation and provide relevant suggestions for organizational team building, management, and development. Team development is an important aspect of organizational effectiveness and performance and should continue to be a priority for human resources managers, particularly in R&D teams.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JD was responsible for idea generation, manuscript writing for theoretical part, and data collection. XL was responsible for manuscript writing for theoretical part and data analysis. YC was responsible for idea generation and manuscript revision. FS was responsible for data analysis. JA-A was responsible for manuscript revision. All authors contributed to the article and approved the submitted version.

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Socioemotional Exchanges Between Men and Women in Heterosexual Relationships

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We examined affection-giving, affection-denying, respect-giving, and respect-denying behaviors among men and women in heterosexual relationships. In a pilot study (N = 106 couples), although we had expected the latent variables of affectionate and respectful behaviors to emerge from exploratory factor analyses, we obtained the latent variables of socioemotional rewards and costs instead. In the main study (initial N = 182 couples), we replicated the factor patterns of socioemotional rewards and costs in confirmatory factor analyses. Moreover, we entered (final N = 177 couples) men's and women's self-reported narcissism alongside men's and women's socioemotional rewards and costs, as reported by partners, into a dyadic model that we tested via covariance structure analyses. Results revealed that, although men and women reciprocated rewards as well as costs (and correlations between individuals' rewards and costs were negative), narcissism was not reflected in the patterns of reciprocity (men's and women's narcissism were positively related.) We discuss implications for studies of relationship processes as two-person group dynamics.

Keywords: reward, cost, relationships, exchange, narcissism

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INTRODUCTION

In an early review of the literature on close relationships, Berscheid (1985) noted that many theories within the field owe an intellectual debt to Skinner's (1938) operant reinforcement theory regarding the presumed importance of rewards and costs to individuals' maintenance vs. termination of relationships. Although the term "social exchange theories" often is invoked, such a term fails to capture the nuances that distinguish equity, exchange, and interdependence theories from each other (see also Berscheid and Reis, 1998). For example, Foa and Foa's (1974) *resource exchange theory* (which posits that partners' give-and-take of affection and respect is a hallmark of close relationships) is quite specific regarding rewards vs. costs, whereas Thibaut and Kelley's (1959) *interdependence theory* (which proposes that partners' mutual influence on each other's thoughts, feelings, and behavior is a defining feature of close relationships) is non-specific (Sprecher, 1998). Moreover, resource exchange theorists have published a survey to measure particular rewards vs. costs (e.g., the Role Behavior Test or RBT; Foa and Foa, 1974); whereas interdependence theorists have not published a comparable survey (notwithstanding one-off efforts by Rusbult, 1980, 1983; see also Rusbult et al., 1986).

Following its publication in *Societal Structures of the Mind* (Foa and Foa, 1974), the RBT rarely has been used within relationship science. For instance, when we conducted a search entering the terms "resource exchange," "Role Behavior Test," and "Foa" via PsycInfo and Academic Search

Complete (September, 2021), we uncovered two articles (Gaines, 1995; Gaines and Henderson, 2004) that had employed the RBT. Unfortunately, results of factor analyses were not reported in the book by Foa and Foa, or in the articles by Gaines (although an invitation for readers to obtain such results was offered by Gaines, 1995). Thus, we cannot be sure whether the RBT measures the constructs that it was designed to measure (i.e., affection-related and respect-related behaviors as separate, yet intercorrelated, dimensions). Consequently, without a psychometrically valid survey of affection-related and respect-related behaviors, we cannot be certain whether the basic tenets of Foa and Foa's resource exchange theory are supported by actual data on behavioral dynamics within close relationships. In the present studies, we sought to determine whether a revised version of the RBT (Gaines and Henderson, 2004) would yield affection-related and respect-related behaviors as correlated factors.

Foa and Foa's (1974) resource exchange theory identified several commodities (i.e., *money*, *goods*, *services*, *information*) in addition to affection/love and respect/status (Clark and Reis, 1988). In fact, their theory incorporates a circular or circumplex model (Turner et al., 1971) in which the six commodities are arrayed in an equidistant order around the behavioral axes of *particularism* (Y axis) and *concreteness* (X axis), such that affection ostensibly is more exclusive and less symbolic than is respect. However, results by Brinberg and Castell (1982) cast doubt upon the presumed ordering of commodities along those axes. Also, drawing upon Fiske's (1991) *relational models theory* (proposing that social tasks can be classified as *communal sharing*, *equality matching*, *authority ranking*, or *market pricing*) and the Foa and Foa resource exchange theory, Haslam (1995) found that giving affection and respect clearly denoted *communality* (i.e., closeness), whereas giving information and services denoted *equality-inequality* (i.e., authority) as well as communality (giving money and goods were too infrequent in pilot research to merit inclusion). Given that later Foa and Foa (1980) came to view affection and respect as most "intangible" *and* as most likely to be exchanged within close relationships, we limit our attention to these two resources.

Overview

In a pilot study and a main study concerning heterosexual relationships, we tested the hypothesis that (1) regarding men's and women's behavior separately, a two-factor model (i.e., affection-related and respect-related behaviors) would fit the correlational data significantly better than would a one-factor model (i.e., undifferentiated resource-related behaviors). Furthermore, in the pilot study as well as the main study, we tested the hypothesis that (2) men and women would exchange affection-related as well as respect-related behaviors at significant levels. Finally, in the main study (but not the pilot study), we tested the hypothesis that (3) among men and women alike, *narcissism* (one of the most intensively studied individual-difference influence on individuals' rewarding vs. costly behaviors in general, though not necessarily studied as an influence on the particular behaviors that we have emphasized; for a review, see Muise et al., 2018) would be a significant negative predictor of individuals' affection-related and respect-related behaviors toward their partners. Given the theme of the current special section in *Frontiers in Psychology* concerning group dynamics, we shall focus upon the potential reciprocity of affection-related and respect-related behaviors among dyads or two-person groups.

HYPOTHESES CONCERNING THE PILOT STUDY

In a pilot study, we tested the following hypothesis regarding the construct validity of a modified RBT (Gaines and Henderson, 2004), using a sample of heterosexual dyads: For men (whose behaviors are reported by their female partners) as well as women (whose behaviors are reported by their male partners), a two-factor model (with affection and respect as the underlying factors) will yield better fit to a matrix of interitem correlations compared to a one-factor (i.e., general) model. Given that we collected data from both members of each dyad and were especially interested in covariance between scores on men's and women's behaviors, we examined factor patters separately for men and women (see Berscheid, 1986, regarding the desirability of collecting and analyzing data separately when partners within each dyad can be distinguished on the basis of gender or other characteristics). We conducted exploratory factor analyses (rather than confirmatory factor analyses, given that no previously published study had entered all of the RBT items into the same factor analysis; Thompson, 2004), using the PRELIS portion of LISREL 10.2 (Joreskog and Sorbom, 2019) in tests of our hypothesis. For all of the analyses that follow, details concerning input (e.g., syntax/code) and output (e.g., tables/text) are available from the first author upon request.

Method

Participants

We obtained ethics approval from the Psychology Ethics Committee at the first author's academic institution, consistent with the British Psychological Society Code of Ethics and Conduct (British Psychological Society, 2018). We relied on a convenience sample, with dyads (i.e., pairs of participants in heterosexual relationships) recruited by our research assistants via snowball sampling. Our remit to research assistants was broad: Acquaintances and non-acquaintances of theirs could be recruited via e-mail, text, social media, face-to-face interaction, and/or other means. We tested 106 heterosexual couples (106 men, 106 women), all volunteers. Men's mean age was 27.34 years (SD = 11.49 years), and women's mean age was 25.32 years (SD = 11.12 years). A majority of participants classified themselves as White/European-descent (for men: 61.9% White/European-descent, 13.6% Asian-descent, 8.5% Black/African-descent, 4.2% "Mixed," 1.7% "Other," 10.2% unreported; for women: 62.7% White/European-descent, 16.1% Asian-descent, 10.2% Black/African-descent, 0.8% "Mixed," 10.2% unreported; further details regarding ethnic group membership of participants are available from the first author upon request, consistent with the more

specific categories that are recognized by the UK Office for National Statistics (2012). A plurality of participants did not specify their educational status, checking the box "other" (for men, 5.1% first-year undergraduate, 11.0% second-year undergraduate, 9.3% third-year undergraduate, 6.8% fourth-year undergraduate, 48.3% "other," 19.5% unreported; for women, 11.9% first-year undergraduate, 25.4% second-year undergraduate, 4.2% third-year undergraduate, 4.2% fourth-year undergraduate, 36.4% "other," 17.8% unreported). Lastly, in terms of occupation, a plurality of participants listed themselves as full-time students (for men, 22.0% professional/managerial, 22.0% clerical/sales/skilled labor, 8.5% services/unskilled labor, 0.8% homemaker, 30.5% full-time student, 5.1% retired/unemployed/job-seeking, 11% unreported; for women, 11.9% professional/managerial, 10.2% clerical/sales/skilled labor, 5.1% services/unskilled labor, 8.5% homemaker, 46.6% full-time student, 7.6% retired/unemployed/jobseeking, 10.2% unreported).

Materials and Procedure

Participants completed a 12-item, modified version of the RBT (Gaines and Henderson, 2004) along with additional social-psychological and individual-difference variables that were pertinent to another project. The modified RBT had been developed by Gaines et al. (1999) to remove "double-barreled" questions (whereby participants are required to provide one response to two mini-questions that are joined together linguistically but are distinct conceptually; Olson, 2008) prevalent in Foa and Foa's (1974) original RBT. The modified RBT was designed to measure the relative frequency with which individuals reported that their partners had given them affection (3 items), denied them affection (3 items), given them respect (3 items), and denied them respect (3 items) during the two weeks prior to taking part in the study. Sample items include: "My partner has expressed warmth toward me" (affection-giving); "My partner has withheld love from me" (affection-denying); "My partner has encouraged my personal growth" (respect-giving); and "My partner has treated me with disrespect" (respect-denying) (1 = *almost never*, 5 = *almost always*).

Results and Discussion

As Thompson (2004) pointed out, even if researchers hold *a priori* expectations regarding factor patterns, the process of establishing construct validity for a given survey ideally should include exploratory factor analyses on data from an initial sample, followed by confirmatory factor analyses on data from a subsequent sample (see also Tabachnick and Fidell, 2009). However, such a step-by-step process is not evident from published articles concerning Foa and Foa's (1974) original RBT (e.g., Gaines, 1995) or a revised version of the RBT (e.g., Gaines and Henderson, 2004). Therefore, in the pilot study, we prioritized conducting exploratory factor analyses upon data from the revised RBT. Kaiser's (1970) "little jiffy" method (whereby each factor with an eigenvalue of 1.00 of greater is retained) was applied automatically by PRELIS in an effort to identify the optimal number of factors.

Men's Interpersonal Behavior (as Reported by Women)

To determine the optimal number of factors for the items that measured men's interpersonal behavior (as reported by their female partners), we conducted an exploratory factor analysis with maximum likelihood estimation. Initially, we did not request a solution with a particular number of factors; inspection of the accompanying decision table (shown in **Table 1**) revealed that PRELIS had attempted to extract as many as three factors. However, inspection of Varimax-rotated and Promax-rotated matrices of loadings for a three-factor solution yielded uninterpretable results (i.e., Heywood cases or instances in which communalities for one or more items exceeded 1.00; Thompson, 2004). Clearly, the factor extraction procedure for men's behavior items was insufficient to produce a stable solution in the absence of an explicit specification of a lower number of factors (a not-infrequent problem in exploratory factor analysis; Tabachnick and Fidell, 2009). Subsequently, we re-ran the exploratory factor analysis, requesting a two-factor solution; unexpectedly, the resulting matrix of loadings for the Promax-rotated solution (shown in **Table 2**, taking into account the correlation between the two factors, which was −0.50) revealed that Factor 1 consisted of *rewards* (i.e., affection-giving and respect-giving behaviors), whereas Factor 2 consisted of *costs* (i.e., affection-denying and respect-denying behaviors). Unlike the Promax-rotated solution, the matrix of loadings for the Varimax-rotated solution (shown in **Table 2**, without taking into account the correlation between the two factors) did not yield a "clean" separation of items onto particular factors (i.e., for two items, absolute values for loadings were 0.32 or higher on both factors; see Tabachnick and Fidell, 2009, regarding recommended cutoff points for factor loadings).

In absolute terms, neither the one-factor solution nor the two-factor solution provided satisfactory fit to the data [i.e., chi-squares $p < 0.01$, combined with root mean square errors of approximation (RMSEA) greater than 0.10—Schumacker and Lomax, 2016]. Nevertheless, results of the exploratory factor analyses for men's interpersonal behavior (reported by women) indicated that a two-factor solution provided better fit than a one-factor solution was supported (reduction in chi-square = 238.67, reduction in degrees of freedom = 11, $p < 0.01$). Contrary to hypotheses, the content of the two-factor solution represented rewards and costs as anticipated by the original version of Thibaut and Kelley's (1959) interdependence theory—*not* affection-related and respect-related behaviors as anticipated by Foa and Foa's (1974) resource exchange theory, despite the origins of the modified RBT (Gaines and Henderson, 2004) in that theory.

Women's Interpersonal Behavior (as Reported by Men)

Subsequently, with regard to women's interpersonal behavior (as reported by their male partners), we conducted an exploratory factor analysis with maximum likelihood estimation. As was the case for men's interpersonal behavior (reported by women), we did not request a particular number of factors in our initial exploratory factor analysis of women's interpersonal behavior. However, unlike the initial exploratory factor analysis for men's

TABLE 1 | Decision tables for number of interpersonal behavior factors in the pilot study (N = 106 couples).[a]

Chi-model	MLDF	Square	*p*	RMSEA	GFI	AGFI	*df*	EP
Men's interpersonal behavior (reported by women)								
1-factor	–	461.96	<0.01	0.27	–	–	54	–
2-factor	–	223.29	<0.01	0.20	–	–	43	–
Women's interpersonal behavior (reported by men)								
1-factor	–	406.25	<0.01	0.25	–	–	54	–
2-factor	–	178.84	<0.01	0.17	–	–	43	–

[a]*MLDF, Maximum likelihood discrepancy function; RMSEA, root mean square error of approximation; GFI, goodness-of-fit index; EP, number of parameters to be estimated. Values for MLDF, GFI, AGFI, and EP are not provided by the PRELIS portion of LISREL 10 (Joreskog and Sorbom, 2019), which is relevant to exploratory factor analyses.*

interpersonal behavior, the initial exploratory factor analysis for women's interpersonal behavior produced a decision table (**Table 1**) with no more than two factors (and without any problematic Heywood cases). We did not need to specify the number of factors for women's behavior items (although, in principle, we could have used the results for men's behavior as justification for setting the number of factors at two for women's behavior). In any event, as indicated by the Promax-rotated factor loadings (**Table 2**), we replicated the unanticipated factors of socioemotional rewards and costs that we had obtained for men's interpersonal behavior (the correlation between women's rewards and costs, −0.50, was identical to the correlation that we found between men's rewards and costs). Finally, similar to what we observed for men's interpersonal behavior, results of the Varimax-rotated solution for women's interpersonal behavior (**Table 2**) did not produce a clean set of loadings on particular factors.

In absolute terms, the two-factor solution did not provide satisfactory fit to the data (i.e., significant chi-square combined with RMSEA greater than 0.10; **Table 2**). However, as was true for men's interpersonal behavior (reported by women), results of the exploratory factor analyses for women's interpersonal behavior (reported by men) indicated that a two-factor solution provided better fit than a one-factor solution was supported (reduction in chi-square = 227.41, reduction in degrees of freedom = 11, $p < 0.01$). Given the lack of absolute goodness-of-fit for the two-factor solution for women's as well as men's interpersonal behavior—in spite of the fact that the two-factor solution proved to be optimal for women's as well as men's interpersonal behavior—we wondered whether built-in limitations of exploratory factor analyses in general (requiring the calculation of loadings for all items on all factors, inability to incorporate inter-factor correlations into models) prevented us from obtaining two-factor solutions with satisfactory goodness-of-fit to the correlational data (Thompson, 2004).

Internal Consistency Coefficients and Correlations Involving Men's and Women's Behavioral Subscales

Results of reliability analyses indicated that the scales measuring men's rewards, men's costs, women's rewards, and women's costs were internally consistent, with internal consistency coefficients exceeding 0.80 for all four scales (Cronbach's alphas = 0.89 for men's rewards, 0.94 for men's costs, 0.90 for women's rewards, and 0.91 for women's costs). In addition, all of the correlations among scores on the four behavior scales (shown in **Table 3**) were significant (ps < 0.01), with the only positive correlations occurring between men's and women's rewards, and men's and women's costs. Notwithstanding the unexpected patterns of "giving" and "denying" items loading onto separate factors, the reconfigured behavior scales were low in measurement error and were intercorrelated and in directions that align with conceptualizations of rewards and costs in the original version of interdependence theory (Thibaut and Kelley, 1959).

Although we did not propose any hypotheses concerning mean differences between men's and women's socioemotional rewards or costs, we supplemented correlational analyses with paired-sample t-tests via SPSS 26.0 (IBM, 2019). Results of paired-sample t-tests indicated that men and women did not differ on rewards or costs. Details are available from the first author upon request.

Transition From Pilot Study to Main Study: (Re)Casting the Role Behavior Test as a Measure of Socioemotional Rewards and Costs That May Be Exchanged

Earlier in this article, we alluded to Haslam's (1995) results concerning affection-giving and respect-giving behavior items as loading on a single, communality/closeness factor (apparently following a principal axis factor analysis, although Haslam did not specify the type of exploratory factor analysis; Thompson, 2004). Just as Haslam and Fiske (1999) subsequently re-evaluated core assumptions of Foa and Foa's (1974) resource exchange theory concerning the usefulness of the affection-respect distinction in light of Haslam's (1995) earlier results, so too did we begin to question key assumptions of that theory concerning the utility of the affection-respect distinction when reflecting upon our own pilot study results. However, unlike Haslam and Fiske (1999), we did not discard the RBT items in favor of alternative items (e.g., items that were designed to be compatible with the relational models theory of Fiske, 1991). Instead, influenced by Kelley et al.'s (1983/2002) argument that interdependence is a defining feature of close relationships, we *re-interpreted* the RBT items from the standpoint of Thibaut and Kelley's (1959) interdependence theory (initially revised by Kelley and Thibaut, 1978, and subsequently refined by Kelley, 1979).

Given the results that we obtained for the modified RBT (Gaines and Henderson, 2004), we will refer to affection-giving, respect-giving, affection-denying, and respect-denying behaviors

henceforth as *socioemotional rewards and costs* (following Lawler and Thye, 1999). In addition to shifting our terminology, we shall shift our conceptual focus from Foa and Foa's (1974) resource exchange theory to Thibaut and Kelley's (1959) interdependence theory via Jerry Wiggins's (2003/2006) *interpersonal circumplex theory of personality and social behavior* (a theory that straddles the traditional boundary between personality psychology and social psychology). The following quote from Wiggins (1979) (p. 398), citing Foa and Foa's theory, captures our logic concisely: ". . .[I]nterpersonal events may be defined as *dyadic interactions that have relatively clear-cut social (status) and emotional (love) consequences for both participants (self and other)*" (emphasis in original). In turn, Kelley (1997) cited Wiggins's theory, suggesting that individuals will be inclined to remain in relationships to the extent that individuals are dependent upon their partners for status/respect and love/affection (though the level of dependence may not be mutual; Reis et al., 2002).

To what extent are socioemotional rewards and costs *exchanged* within heterosexual relationships? Drawing upon an early version of Wiggins's interpersonal circumplex theory of personality and social behavior (Wiggins, 1979), Kelley (1983) contended that genuine reciprocity is most likely to occur in relationships within which individuals and their partners share the perception that their relationships are equal (see also Wish et al., 1976). Under such circumstances, mutual dependence will be the behavioral norm (see also Kelley and Thibaut, 1978). Although Thibaut and Kelley's (1959) original version of interdependence theory did not prioritize the cognitive aspects of mutual dependence (Kelley, 1997), successive revisions of interdependence theory (Kelley and Thibaut, 1978; Kelley, 1979) acknowledged the role that individuals' consciously experienced, prosocial goals may play in fostering reciprocity of socioemotional rewards and costs within close relationships (including, but not limited to, heterosexual relationships; Holmes, 2000). We hasten to add that (1) individuals may pursue self-interested (rather than prosocial) goals; and (2) unilateral (rather than mutual) dependence may emerge as an alternative behavioral norm, especially in heterosexual romantic relationships (often favoring men over women; Holmes, 2002).

TABLE 2 | Loadings for men's and women's interpersonal behavior items in the pilot study (N = 106 couples)[a].

	Varimax rotation		Promax rotation	
Item	**Rewards**	**Costs**	**Rewards**	**Costs**
Men's interpersonal behavior (reported by women)				
1	0.85	−0.12	0.91	0.11
2	0.89	−0.11	0.96	0.14
3	0.75	−0.15	0.79	0.05
4	−0.26	0.69	−0.08	0.69
5	−0.34	0.72	−0.16	0.71
6	−0.23	0.77	−0.02	0.8
7	0.64	−0.32	0.62	−0.17
8	0.53	−0.36	0.48	−0.24
9	0.59	−0.28	0.57	−0.14
10	−0.1	0.91	0.17	0.99
11	−0.2	0.85	0.04	0.9
12	−0.22	0.89	0.02	0.93
Women's interpersonal behavior (reported by men)				
1	0.83	−0.12	0.89	0.1
2	0.86	−0.25	0.88	−0.03
3	0.78	−0.2	0.81	0
4	−0.24	0.65	−0.05	0.66
5	−0.36	0.79	−0.14	0.78
6	−0.38	0.74	−0.19	0.72
7	0.54	−0.29	0.51	−0.18
8	0.68	−0.27	0.67	−0.11
9	0.78	−0.2	0.8	−0.01
10	−0.06	0.76	0.18	0.83
11	−0.15	0.78	0.08	0.83
12	0.83	−0.12	0.89	0.1

[a] *1. My partner has expressed warmth toward me.*
2. My partner has shown a sense of belonging toward me.
3. My partner has shown enjoyment toward me.
4. My partner has withheld love from me.
5. My partner has failed to show tenderness toward me.
6. My partner has shown lack of closeness toward me.
7. My partner has encouraged my personal growth.
8. My partner has recognized my personal accomplishments.
9. My partner has made me feel like an important person.
10. My partner has treated me with disrespect.
11. My partner has been unappreciative of me as a unique person.
12. My partner has failed to show confidence in my abilities.

Adding Narcissism as a Potential Predictor of Socioemotional Rewards and Costs That May Be Exchanged in the Main Study

Wiggins's (1979) initial version of interpersonal circumplex theory emphasized *traits* (i.e., individuals' answer to the question, "What are you like?") as personality influences on socioemotional rewards and costs. However, Wiggins (1991) subsequently proposed an *interpersonal circumplex theory of personality and social behavior* that identified Bakan's (1966) prior dichotomy between *agency* (an intrapersonal orientation) and *communion* (an interpersonal orientation) as two overarching modalities of "being-in-the-world" that characterize the human experience (see also Wiggins, 2003/2006). Although Wiggins emphasized the agentic trait of *dominance* and the communal trait of *nurturance* (Wiggins and Broughton, 1991), Wiggins's (1997) expanded theory also includes *motives* (i.e., individuals' answer to the question, "What drives you to behave as you do?"—noting that individuals are not necessarily aware of their motives), particularly the agentic motive of *power* and the communal motive of *intimacy*. Moreover, Wiggins's expanded theory arguably encompasses *attitudes* (i.e., individuals' answer to the question, "How do you evaluate that object?"), specifically the agentic attitude of *attachment anxiety* (reverse-scored) and the communal attitude of *attachment avoidance* (reverse-scored; see also Bartholomew, 1990).

Taking on board various aspects of personality that interpersonal circumplex theorists (following Wiggins, 1991) have identified, a most promising individual-difference influence on socioemotional rewards and costs may be a construct that is not prominent within Wiggins's theory. This construct is,

TABLE 3 | Correlations among total scores on interpersonal behavior subscales in the pilot study (N = 106 couples).[a]

	Correlations			
Var.	**1**	**2**	**3**	**4**
1	1			
2	−0.47	1		
3	0.43	−0.31	1	
4	−0.35	0.65	−0.51	1

[a]*All correlations are significant (ps < 0.001 or below).*
1 = Men's socioemotional rewards (reported by women).
2 = Men's socioemotional costs (reported by women).
3 = Women's socioemotional rewards (reported by men).
4 = Women's socioemotional costs (reported by men).

narcissism, a trait that reflects both egocentric exceptionalism (beliefs on one's superiority, specialness, importance, and entitled) and social selfishness (looking down on others unempathetically and even antipathetically; Sedikides, 2021). As several authors pointed out (Sedikides et al., 2004; Krizan and Herlache, 2018; Thomaes et al., 2018), narcissism—grandiose narcissism, in particular—is consistently aligned with constructs that occupy the high agency/low communion position within circumplex models of personality, from the blended interpersonal trait of arrogant-calculating to the blended interpersonal attitude of dismissing-avoidant. In turn, high agency/low communion combinations may predispose individuals to bestow socioemotional rewards upon *themselves*, yet inflict socioemotional costs upon their partners (Hopwood and Waugh, 2020).

Does it necessarily follow that narcissism will be associated negatively with individuals' bestowal of benefits toward their *partners*, and positively with individuals' inflicting of costs upon their partners? Work by Campbell et al.'s (2000, 2002) work concerning the likely consequences of narcissism for individuals' behavior within close relationships is consistent with such a conclusion, although these authors did not explicitly refer to Wiggins's (1991) revised interpersonal circumplex theory or Kelley and Thibaut (1978) revised interdependence theory. Consistent with that conclusion is also a large literature on narcissism in relationships (Seidman, 2016; Gewirtz-Meydan, 2017; Brewer et al., 2020; for reviews, see Brunell and Campbell, 2011; Sedikides, 2021). Moreover, although a synthesis of interpersonal circumplex theory and interdependence theory (Gaines, 2016/2018) likewise would support such a conclusion, the literature on interdependence processes has been more likely to address the related construct of *self-esteem* (denoting individuals' more realistic attitude toward themselves; Brummelman et al., 2016, 2018) as a positive influence on individuals' bestowal of rewards—and a negative influence on individuals' inflicting of costs—toward partners (Machia et al., 2020). Thus, our hypotheses concerning the role of narcissism on individuals' socioemotional rewards and costs in heterosexual relationships are tentative.

In the preceding two paragraphs, we implicitly drew upon Sullivan's (1953) *interpersonal theory of personality* (which proposes that individual differences outside the domain of intelligence are best understood as enacted within the context of individuals' relationships with important others; see also Sullivan, 1954) in referring to narcissism and self-esteem. Given that echoes of Sullivan's theory reverberate through the initial versions of Thibaut and Kelley's (1959) interdependence theory, Wiggins's (1997) interpersonal circumplex theory, and even Foa and Foa's (1974) resource exchange theory, Sullivan's theory serves as a conceptual framework that allows us to integrate seemingly disparate strands of research from personality psychology and relationship science (Gaines, 2016/2018). Especially relevant to our main study is Sullivan's contention that, unlike realistically informed self-esteem (which incorporates "bad-me" as well as aspects of personality), narcissism reflects individuals' misinterpretation of "bad-me" aspects of personality as "not-me" (Ewen, 1998).

HYPOTHESES CONCERNING THE MAIN STUDY

In our main study, we tested the following revised hypothesis concerning the construct validity of the revised RBT (Gaines and Henderson, 2004), using a separate sample of heterosexual dyads: (1) For men (whose behaviors are reported by their female partners) as well as women (whose behaviors are reported by their male partners), a two-factor model (with socioemotional rewards and costs as the underlying factors) will yield better fit to a matrix of interitem correlations when the factors are allowed to be correlated, rather than uncorrelated. Additionally, we tested the following set of hypotheses regarding the criterion-related validity of the modified RBT: (2) (a) men and women will reciprocate socioemotional rewards; (b) men and women will reciprocate socioemotional costs; (c) among men and women, socioemotional rewards and costs will be negatively correlated; (d) among men and women, narcissism will be a negative predictor of socioemotional rewards; also among men and women, narcissism will be a positive predictor of socioemotional costs. Building on the results from our pilot study, we conducted confirmatory factor analyses and covariance structure analyses (Kline, 2016), using the main portion of LISREL 10.2 (Joreskog and Sorbom, 2019). Unlike exploratory factor analysis, factor rotation is a non-issue in confirmatory factor analysis (Thompson, 2004). Thus, we do not distinguish between unrotated and rotated factor solutions in the main study.

Method

Participants

The research protocol was similar to that (including ethics approval and participant recruitment) of the pilot study, consistent with the British Psychological Society Code of Ethics and Conduct (British Psychological Society, 2018). We tested 182 heterosexual couples (182 men, 182 women). Mean age for men was 34.90 years (SD = 13.67 years) and for women 33.37 years (SD = 13.36 years). Approximately half of participants classified themselves as White/European-descent

(for men: 49.0% White/European-descent, 22.5% Asian-descent, 21.9% Black/African-descent, 5.5% "Mixed," 0.5% "Other," 0.5% unreported; for women: 49.9% White/European-descent, 29.1% Asian-descent, 14.2% Black/African-descent, 3.8% "Mixed," 2.7% unreported; further details regarding ethnic group membership of participants are available from the first author upon request. A plurality of participants checked the box "other" for educational status (for men: 4.4% first-year undergraduate, 8.2% second-year undergraduate, 7.7% third-year undergraduate, 4.4% fourth-year undergraduate, 36.6% "other," 38.8% unreported; for women, 4.9% first-year undergraduate, 13.7% second-year undergraduate, 8.7% third-year undergraduate, 4.9% fourth-year undergraduate, 33.3% "other," 34.4% unreported). Lastly, in terms of occupation, a plurality of men listed themselves as professional/managerial, whereas a plurality of women listed themselves as full-time students (for men, 36.6% professional/managerial, 21.9% clerical/sales/skilled labor, 9.3% services/unskilled labor, 0.5% homemaker, 23.5% full-time student, 7.7% retired/unemployed/job-seeking, 0.5% unreported; for women, 19.7% professional/managerial, 15.8% clerical/sales/skilled labor, 7.7% services/unskilled labor, 14.8% homemaker, 32.8% full-time student, 8.7% retired/unemployed/jobseeking, 0.5% unreported).

Materials and Procedure

Socioemotional Rewards and Costs

Participants completed the aforementioned, modified 12-item version of the RBT (Gaines and Henderson, 2004).

Narcissism

Participants filled out the 40-item Narcissistic Personality Inventory (NPI; Raskin and Hall), a validated and widely used measure of grandiose narcissism (Emmons, 1984; Prifitera and Ryan, 1984; Watson et al., 1984; Raskin and Terry, 1988; for a review, see Miller and Campbell, 2011). Each item consists of a pair of statements—one narcissistic, one non-narcissistic. The number of narcissistic statements that participants endorse is their narcissism score (Cronbach's alphas = 0.90 for men and 0.88 for women). Although Rosenthal and Hooley (2010) concluded that the NPI includes several items that measure self-esteem instead of narcissism, Miller et al. (2011) did not find evidence of such a self-esteem/narcissism confounding pattern within the NPI.

Results and Discussion

Consistent with Thompson's (2004) aforementioned recommendations, having obtained socioemotional rewards and costs as the two dimensions that are measured by the revised RBT (Gaines and Henderson, 2004) via exploratory factor analyses in the pilot study, we were in a position to try and replicate that pattern of latent variables via confirmatory factor analyses in the main study (see also Tabachnick and Fidell, 2009). As was the case for the polit study, we conducted separate analyses for men's socioemotional rewards and costs (as reported by women), followed by analyses for women's socioemotional rewards and costs (as reported by men) in the main study. Details concerning all input and output information are available from the first author upon request.

Men's Socioemotional Rewards and Costs (as Reported by Women)

To test our hypothesis regarding the two-factor pattern and exclusion vs. inclusion of an interfactor correlation for men's socioemotional rewards and costs (as reported by their female partners), we conducted a pair of confirmatory factor analyses. We made the following specifications: (1) In the theta epsilon (TE, or measurement error) matrix, we freed uncorrelated measurement error terms associated with the 12 modified RBT items (Gaines and Henderson, 2004), but constrained them to be equal to each other (all correlated measurement error terms were fixed at 0.00); (2) in the lambda Y (LY, or latent-observed variable) matrix, we freed loadings for the three affection-giving items and three respect-giving items on Factor 1 (rewards), whereas we freed loadings for the three affection-denying items and three respect-denying items on Factor 2 (costs), with all other loadings fixed at 0.00; and (3) in the psi (PS, or variance-covariance) matrix, we freed the error variance terms for the reward and cost factors at 1.00 (for details regarding LISREL syntax, see Mels, 2020; Scientific Software International, 2020). We estimated all freed parameters via the maximum likelihood method, with the ridge option and ridge constant, given the problems with communalities that we had encountered when we conducted exploratory factor analyses of the RBT in the pilot study.

In the initial two-factor model, the correlation between men's reward and cost factors was fixed at 0.00. Results of a confirmatory factor analysis indicated that (as expected) the initial model did not yield satisfactory fit to the interitem correlation data (see goodness-of-fit statistics in **Table 4**). Not only was the chi-square significant ($p < 0.01$), but the maximum likelihood discrepancy function was unacceptably high (and the unadjusted as well as adjusted goodness-of-fit indices were lower than optimal; Schumacker and Lomax, 2016). Given that the orthogonal version of the two-factor model did not provide adequate fit to the data, we will not interpret factor loadings from this particular analysis.

By contrast, in the final two-factor model, we freed the correlation between men's reward and cost factors. Results of a confirmatory factor analysis indicated that (as expected) the final model yielded satisfactory fit to the interitem correlation data for men's rewards and costs (see **Table 5** regarding goodness-of-fit statistics). Not only was the chi-square non-significant, but the maximum likelihood discrepancy function was zero (and the unadjusted as well as adjusted goodness-of-fit indices were above 0.95). Also, the reduction in chi-square from the initial to final model (66.26) was significant (reduction in degrees of freedom = 1; resulting $p < 0.01$). Furthermore, all non-zero factor loadings (**Table 6**) were significant ($ps < 0.01$) and positive, exceeding 0.50 in value. Finally, the correlation between men's reward and cost factors was negative ($r = -0.80$, $p < 0.01$). The very high correlation reflected that (unlike exploratory factor

TABLE 4 | Decision tables for uncorrelated vs. correlated socioemotional reward and cost factors in the main study (initial *N* = 182 couples).[a]

Chi-model	MLDF	Square	*P*	RMSEA	GFI	AGFI	*df*	*df*
Men's socioemotional rewards and costs (reported by women)								
2 uncor. factors	0.19	99.38	<0.01	0.05	0.92	0.91	65	13
2 cor. factors	0.00	33.12	*NS*	0.00	0.97	0.96	64	14
Women's socioemotional rewards and costs (reported by men)								
2 uncor. factors	0.16	94.11	<0.01	0.05	0.93	0.91	65	13
2 cor. factors	0.00	34.37	*NS*	0.00	0.97	0.96	64	14

[a]*MLDF, Maximum likelihood discrepancy function; RMSEA, root mean square error of approximation; GFI, goodness-of-fit index; EP, number of parameters to be estimated.*

TABLE 5 | Correlations among total scores on narcissism scale and socioemotional reward and cost subscales in the main study (final *N* = 177 couples).[a]

	Correlations					
Var.	**1**	**2**	**3**	**4**	**5**	**6**
1	1					
2	0.01	1				
3	0.07	−0.7	1			
4	0.04	0.49	−0.3	1		
5	0.07	−0.47	0.44	−0.65	1	
6	0.28	0.07	0.09	0.05	0.19	1

[a]*All correlations greater than 0.15 in absolute value are significant (ps < 0.050 or below).*
1 = Men's self-reported narcissism.
2 = Men's socioemotional rewards (reported by women).
3 = Men's socioemotional costs (reported by women).
4 = Women's socioemotional rewards (reported by men).
5 = Women's socioemotional costs (reported by men).
6 = Women's self-reported narcissism.

TABLE 6 | Loadings for men's and women's socioemotional reward and cost items in the main study (initial *N* = 182 couples).[a]

Item	Rewards	Costs
Men's socioemotional rewards and costs (reported by women)		
1	0.77	0
2	0.79	0
3	0.77	0
4	0	0.71
5	0	0.85
6	0	0.83
7	0.6	0
8	0.65	0
9	0.74	0
10	0	0.74
11	0	0.7
12	0	0.64
Women's socioemotional rewards and costs (reported by men)		
1	0.68	0
2	0.73	0
3	0.74	0
4	0	0.57
5	0	0.79
6	0	0.75
7	0.61	0
8	0.73	0
9	0.75	0
10	0	0.64
11	0	0.71
12	0	0.72

[a]*1. My partner has expressed warmth toward me.*
2. My partner has shown a sense of belonging toward me.
3. My partner has shown enjoyment toward me.
4. My partner has withheld love from me.
5. My partner has failed to show tenderness toward me.
6. My partner has shown lack of closeness toward me.
7. My partner has encouraged my personal growth.
8. My partner has recognized my personal accomplishments.
9. My partner has made me feel like an important person.
10. My partner has treated me with disrespect.
11. My partner has been unappreciative of me as a unique person.
12. My partner has failed to show confidence in my abilities.

analyses) confirmatory factor analyses allow researchers to control statistically for measurement error (for an in-depth examination of confirmatory factor analysis, see Brown, 2015; cf. Onde and Alvarado, 2018).

Women's Socioemotional Rewards and Costs (as Reported by Men)

We conducted the same pair of confirmatory factor analyses on the RBT data for women's socioemotional rewards and costs (as reported by men) that we had carried out on the RBT data for men's socioemotional rewards and costs (i.e., two-factor model with uncorrelated factors, followed by two-factor model with correlated factors). Once again, we used LISREL 10.2 (Joreskog and Sorbom, 2019) to run the analyses, incorporating maximum likelihood estimation, ridge option, and ridge constant.

Results of a confirmatory factor analysis indicated that, as expected, the initial model (i.e., two uncorrelated factors) did not yield satisfactory fit to the interitem correlation data for women's rewards and costs (goodness-of-fit statistics are presented in **Table 4**). As was the case for men's rewards and costs, not only was the chi-square significant ($p < 0.01$), but the maximum likelihood discrepancy function was unacceptably high (and the unadjusted as well as adjusted goodness-of-fit indices were lower than optimal). Given that the orthogonal version of the two-factor model did not provide adequate fit to the data, we will not interpret factor loadings from this analysis.

Subsequently, results of a confirmatory factor analysis indicated that (as expected) the final model yielded satisfactory fit to the interitem correlation data for women's rewards and costs (see **Table 4** regarding goodness-of-fit statistics). As was true of the final model for men's rewards and costs, not only was the chi-square non-significant, but the maximum likelihood discrepancy function was zero (and the unadjusted as well as adjusted goodness-of-fit indices were above 0.95). Also, the reduction in chi-square from the initial to final model (59.74) was significant (reduction in degrees of freedom = 1; resulting $p < 0.01$). Furthermore, all non-zero factor loadings (shown in **Table 6**) were significant (ps < 0.01) and positive, exceeding 0.50 in value. Finally, the correlation between women's reward and cost factors was negative ($r = -0.80$, $p < 0.01$)—again, due to the ability of confirmatory factor analyses to control statistically for measurement error (Brown, 2015; cf. Onde and Alvarado, 2018).

Internal Consistency Coefficients and Correlations Involving Men's and Women's Socioemotional Rewards and Costs

As in the pilot study, results of reliability analyses indicated that the scales measuring men's rewards, men's costs, women's rewards, and women's costs in the main study were internally consistent, with internal consistency coefficients exceeding 0.80 (Cronbach's alphas = 0.86 for men's rewards, 0.89 for men's costs, 0.85 for women's rewards, and 0.85 for women's costs)—somewhat higher than we had obtained for the RBT subscales in the pilot study. Also, all of the correlations among scores on the four behavior scales were significant (ps < 0.01), with the only positive correlations occurring (1) between men's and women's rewards, and (2) between men's and women's costs. In sum, men's and women's socioemotional reward and cost scales were low in measurement error, and were intercorrelated in directions congruent with interdependence theory (Thibaut and Kelley, 1959).

Having replicated our pilot study results for internal consistencies and correlations among the RBT scales measuring men's rewards, men's costs, women's rewards, and women's costs, we concluded that we could incorporate the dynamics of men's and women's reciprocity of rewards, men's and women's reciprocity of costs, men's positive correlation between their bestowal of rewards and costs, and women's positive correlation between their bestowal of rewards and costs into the core of a covariance structure model concerning male-female interactions in the situational context of heterosexual relationships. Moreover, having measured men's and women's narcissism in the main study, we were in a position to add individual-difference variables to the model: men's narcissism as a predictor of men's rewards (negative effect) and costs (positive effect), as well as women's narcissism as a predictor of women's rewards (negative effect) and costs (positive effect). Therefore, we conducted covariance structure analyses to test the model as a whole, along with the correlations and beta coefficients that we expected.

Although we did not propose hypotheses concerning mean gender differences in narcissism, socioemotional rewards, or socioemotional costs, we supplemented our correlation analysis with a series of paired-sample t-tests via SPSS 26.0 (IBM, 2019). Results indicated that men scored higher than women on narcissism ($p < 0.01$), although men and women did not differ on socioemotional rewards or costs. Details regarding the paired-sample t-tests are available from the first author upon request.

Men's and Women's Narcissism, Socioemotional Rewards, and Socioemotional Costs: Testing the Covariance Structure Model

Among five couples, men and/or women did not respond to one or more NPI items, leaving us with a slightly reduced sample of 177 couples for testing the covariance structure model. We present in **Table 5** the matrix of correlations among total scores for (1) men's narcissism, (2) men's rewards (as reported by women), (3) men's costs (as reported by women), (4) women's rewards (as reported by men), (5) women's costs (as reported by men), and (6) women's narcissism. We entered this matrix into two covariance structure analyses with maximum likelihood estimation, ridge option, and ridge constant. Although we had planned to conduct only one covariance structure analysis, results of that initial analysis (as will become evident shortly) indicated that we should account for an unexpected, positive correlation between men's and women's narcissism in a subsequent analysis (keeping in mind that such an addition technically represents a shift from a confirmatory mode to an exploratory mode of analysis; Kline, 2016).

In an initial covariance structure analysis, we specified the following parameters: (1) in the TE matrix, we freed all uncorrelated measurement error terms for the full scales but constrained the error terms to be equal (all correlated measurement error terms were fixed at 0.00); (2) in the LY matrix, we fixed loadings for all full scales on their respective factors at 1.00; (3) in the BE (i.e., beta coefficient) matrix, we freed unidirectional paths from men's narcissism to men's rewards and costs, freed unidirectional paths from women's narcissism to women's rewards and costs, freed bidirectional (i.e., reciprocal) paths between men's and women's rewards, we freed bidirectional paths between men's and women's costs; and (4) in the PS matrix, we freed unexplained variance terms for men's rewards, men's costs, women's rewards, and women's costs; and we freed correlations between men's rewards and costs, and between women's rewards and costs (we fixed unexplained variance paths for men's narcissism and women's narcissism at 1.00). As shown in **Table 7**, the goodness-of-fit statistics indicate that the initial model provided satisfactory fit to the correlational data (chi-square was non-significant; all other goodness-of-fit

TABLE 7 | Decision tables for covariance structure model, uncorrelated vs. correlated scores for men's and women's narcissism, main study (final $N = 177$ couples).[a]

Chi-model	MLDF	Square	*p*	RMSEA	GFI	AGFI	*df*	EP
Uncor. narc.	0.00	5.22	*NS*	0.00	1.00	0.99	8	13
Cor. narc.	0.00	1.59	*NS*	0.00	1.00	1.01	7	14

[a]*MLDF, Maximum likelihood discrepancy function; RMSEA, root mean square error of approximation; GFI, goodness-of-fit index; EP, number of parameters to be estimated.*

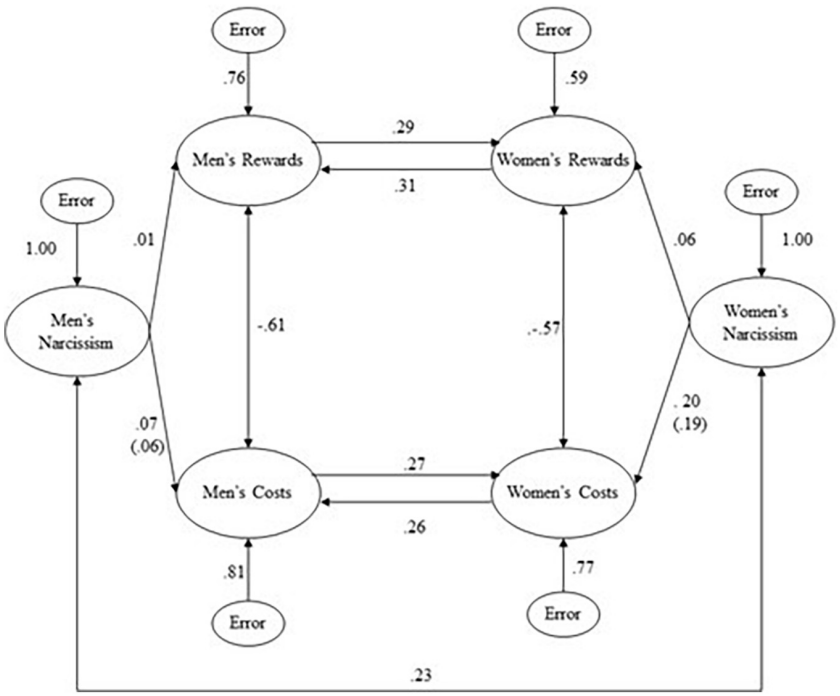

FIGURE 1 | Covariance structure model of men's and women's narcissism, rewards, and costs (final N = 177 couples). All beta coefficients and correlations with absolute values greater than 0.25 are significant (ps < 0.05 or below).

statistics were acceptable). Further inspection of the estimated parameters (**Figure 1**) revealed that, although all of the beta coefficients and correlations within the core of the covariance structure model were significant and in the expected direction (ps < 0.01), the paths from men's and women's narcissism to the reward and cost variables were non-significant. The only path that showed promise in terms of magnitude was the positive path from women's narcissism to women's costs; and the standard error for that path was so large that the resulting significance level was above 0.10 (Kline, 2016).

Inspection of maximum modification indices (Schumacker and Lomax, 2016) revealed that a correlation should be added between men's and women's narcissism. Despite the initial model yielding satisfactory fit, results of the final model indicated that, not only did it yield marginally better goodness-of fit when compared to the initial model (reduction in chi-square = 3.63; reduction in degrees of freedom = 1; resulting p < 0.10), but the correlation in particular was positive (p < 0.05). Addition of the correlation to the final model resulted in virtually no change in the magnitudes for the paths or correlations in the initial model (i.e., no change greater than 0.01 for paths; no change at all for correlations). Thus, whether the correlation between men's and women's narcissism is excluded or included, the conclusions to be drawn regarding exchanges of socioemotional rewards and costs between men and women are the same.

We note that, in the initial and final covariance structure analyses, the correlations between socioemotional rewards and costs were approximately −0.60 for each gender – significant, yet not as high as the correlations within the aforementioned confirmatory factor analyses (−0.80 for each gender) would have led us to expect. Furthermore, the magnitude of the reciprocal path coefficients linking (a) men's and women's socioemotional rewards as well as (b) men's and women's socioemotional costs did not appear to be adversely affected by potential multicollinearity between socioemotional rewards and costs within each gender (Cohen et al., 2003). Therefore, although we acknowledge concerns that regarding the interpretability of socioemotional rewards and costs as separable constructs in principle (for the Pilot Study and the Main Study), results of covariance structure analyses in the Main Study nonetheless affirmed the criterion-related validity of the separate subscales measuring socioemotional rewards and costs in practice (Nunnally and Bernstein, 1994).

Given that the chi-square for the final covariance structure model was below 2.00, it is statistically impossible for us to obtain further improvements in fit (whether significant or marginal) by adding any paths or correlations (Kline, 2016). Indeed, we are not aware of any theoretical *or* empirical rationale that would justify adding paths or correlations (Foa and Foa, 1974; Gaines, 1995; Gaines and Henderson, 2004). Therefore, we opted not to make any more changes to the model as displayed in **Figure 1**.

GENERAL DISCUSSION

We began with the assumption that the revised RBT (Gaines and Henderson, 2004) was best understood as a measure

of affectionate and respectful behaviors, consistent with the resource exchange theory of Foa and Foa (1974). However, the results of our pilot and main studies led us to abandon that assumption. Clearly, the revised RBT should be understood as measuring *socioemotional rewards and costs*, consistent with the original interdependence theory (Thibaut and Kelley, 1959). Additionally, even though our discovery regarding the content of the revised RBT led us to hypothesize that narcissism would be reflected in patterns of reciprocity involving men's and women's socioemotional rewards and costs, the main study results were inconsistent with the hypothesis. By the same token, men's and women's narcissism were positively correlated. This was an unanticipated result that raises intriguing questions concerning the extent to which partners seek kindred spirits with regard to narcissism (see also Grosz et al., 2015). We concluded that, at best, we obtained partial support for our covariance structure model.

Why did rewards and costs (rather than affection and respect) emerge as the relevant behavioral dimensions in both studies? In general, exchange theories—including the resource exchange theory (Foa and Foa, 1974) and the original interdependence theory (Thibaut and Kelley, 1959)—implicitly or explicitly acknowledge the desirability of rewards for individuals in social and personal relationships (Dindia and Canary, 1993). However, interdependence theory is distinguished by its explicit framing of rewards and costs as major antecedents of relationship satisfaction (which, in turn, is a major antecedent of relationship commitment; Rusbult and Buunk, 1993). Perhaps rewards and costs were salient in the results of our exploratory and confirmatory factor analyses of the revised RBT (Gaines and Henderson, 2004), because rewards and costs are pivotal to individuals' sense that the numerous wheels of relationship maintenance have been set into motion—a view that is consistent with findings from early tests of the *investment model* (Rusbult, 1980, 1983; Rusbult et al., 1986). In any event, our results concerning socioemotional rewards and costs complement previous findings (Carter et al., 2013) concerning the negative correlation between generic rewards and costs.

Why were men's and women's narcissism scores related positively but were unrelated to the bestowal of rewards or costs to one's partner? One reason may be that our work depicted interactions between two persons who possess comparable levels of power and can be placed along a wide continuum from high to low narcissism, with the resulting two-person groups resembling "mutual admiration societies" (Grosz et al., 2015). Among our participants, similarity in levels of narcissism was evident; the matching process had no bearing upon their reciprocity of socioemotional rewards or costs (see also Lavner et al., 2016). Perhaps our results reflect dual processes at work: (1) Narcissism matches that involve individuals evaluating each other as suitable partners (possibly reflecting an ego-driven or self-enhancement motive; Sedikides and Gregg, 2008; Wallace, 2011); and (2) reward and cost matches that involves individuals calibrating their behaviors in a manner that allows them to maintain their relationships without placing themselves at a disadvantage with regard to dependence upon each other (perhaps reflecting a data-driven or accuracy motive; Rusbult and Van Lange, 2003).

Strengths, Limitations, and Directions for Future Research

Our studies have certain strengths. For instance, to our knowledge, they are the first to progress beyond piecemeal *principal components analyses*—which are not theory-driven and do not yield estimates of latent variable scores, unlike maximum-likelihood versions of exploratory and confirmatory factor analyses (Tabachnick and Fidell, 2009)—in evaluating the psychometric properties of the revised RBT (Gaines and Henderson, 2004). Also, as far as we are aware, our main study is the first to test empirical links among men's and women's narcissism, socioemotional rewards, and socioemotional costs within a covariance structure model. Finally, the results of our main study concerning the impact of individuals' socioemotional rewards and costs upon each other's socioemotional rewards and costs *when covariance between individuals' own socioemotional rewards and costs is taken into account* are fully consistent with an interdependence theory perspective (Rusbult and Van Lange, 2003).

Our studies also have certain shortcomings. For example, it is not clear whether the original RBT (Foa and Foa, 1974; Gaines, 1995) would yield the same factor pattern (i.e., socioeconomic rewards and costs, rather than affection-related and respect-related behaviors) that we obtained with the revised RBT (Gaines and Henderson, 2004), although the presence of "double-barreled" items in the original RBT (as we noted in the Method section of our pilot study) is problematic (Olson, 2008). Also, for our pilot study in particular, the sample size-to-*number of items* ratio (9.00) was somewhat smaller than the minimum desired level (i.e., 10.00 or higher; see Costello and Osborne, 2005, regarding sample size in exploratory factor analyses), though the main study yielded a sample size-to-*number of parameters* ratio (approximately 13.00) that was somewhat higher than the minimum desired level (i.e., 10.00 or higher; see Jackson, 2003, regarding sample size in confirmatory factor analyses). Lastly, our operationalization of individuals' affection-giving, affection-denying, respect-giving, and respect-denying behaviors as words and deeds *to be reported by partners* might have impaired our ability to detect genuine effects of individuals' narcissism *as reported by the individuals themselves* upon individuals' socioemotional rewards and costs (for a broader discussion of difficulties in separating actor effects from perceiver effects within interdependence theory, see Kelley, 1997).

Regarding directions for future research, relationship scientists might wish to operationalize narcissism in terms of a circular or *circumplex model* (in the spirit of interpersonal circumplex theory; Wiggins et al., 1989), with lower-order aspects of narcissism arrayed in an equidistant manner around the psychological axes of *grandiose and vulnerable narcissism* (Miller et al., 2012). Such an innovation would

help address criticism that the NPI (Raskin and Hall, 1979; Raskin and Terry, 1988), which we used in our main study, is limited to grandiose narcissism (Jauk and Kaufman, 2018). However, such a shift in methodology would require substantially larger sample sizes than we were able to obtain in the present studies (with minimum desired *n*'s ranging from 150 to more than 300 couples, depending on the complexity of the models to be tested; see Muthen and Muthen, 2002, concerning statistical power in confirmatory factor analyses).

Implications for Therapy With Couples (and Individuals)

Despite our reconceptualization of individuals' affection-giving, affection-denying, respect-giving, and respect-denying behaviors as socioemotional rewards and costs from the vantage point of interdependence theory (Thibaut and Kelley, 1959), we acknowledge that resource exchange theory (Foa and Foa, 1974) not only is compatible with interdependence theory (as articulated by Berg et al., 1993) but also may rival interdependence theory in terms of applicability to clinical practice as well as academic research (as contended by L'Abate and Harel, 1993). Furthermore, at the time that the pioneering books on interdependence theory and resource exchange theory were published, "narcissistic personality disorder" (denoting psychologically maladaptive forms of narcissism) had not received a formal designation within the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*, or DSM (Millon, 1996), thus leading us to wonder whether results of the present studies would generalize from non-clinical to clinical populations. Although we did not have access to clinical samples, we are intrigued by the possibility that clinically narcissistic persons may instigate and reciprocate socioemotional costs toward partners (Sperry, 2003) in a confrontational manner (Black and Grant, 2014).

As Holmes (2004) observed, the social unit for interdependence theory has evolved from the *n*-person group (not necessarily defined by closeness; Thibaut and Kelley, 1959) to the two-person group (again, not necessarily defined by closeness; Kelley and Thibaut, 1978) to the relationship pair or dyad (by its nature, defined by closeness; Kelley, 1979). Results of the present studies indicate that (1) reciprocity of socioemotional rewards and (2) reciprocity of socioemotional costs are interrelated (yet separable) behavioral processes within heterosexual relationships (consistent with social exchange principles; Jacobson and Margolin, 1979). Although interdependence theorists (e.g., Kelley et al., 1983/2002) have acknowledged the widespread assessment of individual-level personality characteristics (including, but not limited to, quantitative and qualitative measures that reflect psychodynamic perspectives) within clinical practice, our results suggest that intervention may be most effective, if therapists target *couple*-level patterns of behavior (e.g., attempting to increase reciprocity of rewards and decrease reciprocity of costs, keeping in mind that it may be necessary to help some clients distinguish between short-term self-interest and long-term relationship maintenance; Kelley et al., 2003).

We note that individuals' giving vs. denial of affection and respect *to themselves*—which we did not assess in the present studies—may be important data for therapists to collect as a means toward developing intervention strategies concerning clients' *intra*personal, if not interpersonal, functioning (in line with social learning principles; Jacobson and Margolin, 1979). Also, given the over-emphasis on self-love and self-esteem that (stereo)typically characterizes persons whom therapists might diagnose as clinically narcissistic (Millon, 1996), our lack of covariance between individuals' narcissism and their socioemotional behaviors toward partners should *not* be interpreted as evidence that psychodynamic personality constructs such as narcissism are irrelevant to social exchange processes as a whole (Kelley et al., 1983/2002). Nevertheless, such self-relevant behaviors on the part of clients might be especially important to the establishment, maintenance, and termination of *client-therapist relationships* (as distinct from the dynamics of clients' relationships with significant others outside the clinical setting; Sullivan, 1956). In any event, a detailed examination of client-therapist relationships (including therapists' behavior toward clients; Foa and Foa, 1974) is beyond the scope of the present paper.

Concluding Thoughts

At the beginning of the present article, we alluded to Berscheid's (1985) review concerning reinforcement-based theories of social psychology that have been applied to close relationship processes. We are aware that some relationship scientists (e.g., Clark and Lemay, 2010) might view our exchange-based view of relationship maintenance in heterosexual relationships as incompatible with the perspective (Clark and Mills, 1979) that ongoing relationships are subject to *communal* (rather than exchange) norms. However, we do *not* assume that exchange and communal norms are inherently opposed to each other (e.g., research on conflict resolution highlights the adaptiveness of partners' refraining from engaging in *negative*, rather than positive, exchanges within close relationships; Fincham and Beach, 1999). Results of the present studies indicate that—as measured via the modified RBT (Gaines and Henderson, 2004; repurposed from Foa and Foa, 1974)—men's and women's exchanges involving socioeconomic rewards and costs constitute separate, yet related, relationship processes. In conclusion, we hope that the present article will encourage relationship scientists to (re)consider the possibility that certain aspects of social exchange can promote two-person group dynamics after all.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Psychology Ethics Committee, Brunel University London. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SG wrote the initial version of the manuscript. CS co-wrote final versions of the manuscript (with SG). Both authors contributed to the article and approved the submitted version.

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Massive Open Online Course Study Group: Interaction Patterns in Face-to-Face and Online (Facebook) Discussions

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Interaction has been regarded as a key design component in online and distance learning. In this study, we convened a student-led, blended mode (face-to-face and online/Facebook discussions) massive open online course (MOOC) study group to facilitate interactions for learning. Multiple data, including voice recordings, one-on-one interviews, video recordings, and artifacts were collected and analyzed to detect patterns of interaction in both face-to-face and online/Facebook settings, as well as student perceptions of the blended MOOC study group. Findings indicated that, overall, the blended mode MOOC study group was helpful for promoting communication, providing help, resolving problems, and exchanging ideas and information among group members. Moreover, face-to-face meetings and online discussions both might have exerted their unique strengths and functions in different learning situations for different learners. We recommend future studies continue to explore the tenability of the blended mode MOOC study group in different contexts, subject areas, and age groups, as well as examining group dynamics and interactions that transform MOOC learning into interactive, motivating, and fulfilling journeys among study group members.

Keywords: study group, MOOCs, blended learning, Facebook, college students

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INTRODUCTION

In 2012, Coursera had only about 1 million registered users (Pappano, 2012); in 2020, the total enrollment has exceeded 70 million (Coursera, 2020). Nevertheless, massive open online courses (MOOCs) have yet to fulfill their promises to deliver high-quality education to the mass (Rossi and Gnawali, 2014; Chen and Chen, 2015). Rossi and Gnawali (2014) pointed out that the quality of MOOCs could be much enhanced by incorporating social interactions into their instructional design. This claim has been supported by the study of Hew et al. (2018) wherein student reflections in 18 highly rated MOOCs were analyzed, and interaction was found to be one of the most important design characteristics of MOOCs. Other studies (e.g., Hone and El Said, 2016; Gregori et al., 2018) also identified interaction as a key factor in learners' completion of MOOCs and online courses in general.

Despite its importance, interaction remains limited in the design of MOOCs (Gamage et al., 2020). Margaryan et al. (2015) studied the interactivity of MOOCs by randomly sampling 50 xMOOCs and 26 cMOOCs for analysis. xMOOCs are usually content-based and linear online

courses, whereas cMOOCs tend to be more decentralized and allow learners to explore the content or upload feedbacks more freely. They found that the elements of interaction design (i.e., collaborative learning, collective knowledge, and instructor feedback) were quite limited. For instance, only 2% of xMOOCs and about 26% of cMOOCs had collaborative activities in design. Moreover, only 10% of xMOOCs and less than half of cMOOCs asked learners to share knowledge with others. As with learner-instructor interaction, none of the instructors in those MOOCs gave feedback to students on specific activities or assignments. Analysis of discussion threads also indicated a paucity of in-depth feedback on learners' performance.

Over the years, scholars have been exploring potentially effective tools and pedagogies to promote MOOC interactions, such as online forums (Wise, 2018), social media (Ostashewski et al., 2018; Anderson et al., 2020), and collaborative assignments (Verstegen, 2018). However, study group, particularly "study group in blended mode" (i.e., face-to-face + online) remains relatively under-researched in the MOOCs literature. In the following subsections, we will briefly introduce the concepts of the study group and blended learning in relation to MOOCs, followed by empirical studies that examine interaction patterns in the contexts of online learning and MOOCs.

Study Group

The study group has long been suggested as a means to promote interactions and learning experiences (Zevenbergen, 2004; Chen and Chen, 2015). It can be defined as a small number of learners meeting together to work on problems for the purpose of learning (Zevenbergen, 2004). Cognitively, students may share strategies such as consulting experts or searching for multiple resources to complete their course assignments. Affectively, students can support and encourage each other which stimulates motivation and engagement. Van Der Karr (1994) argued that a study group facilitates collaborative learning *via* interactions among group members. This is particularly helpful for online learning since the lack of interaction between class members had been repeatedly reported as a common cause of online students' isolation and burnout (Morgan and Tam, 1999).

In the MOOC context, Li et al. (2014) formulated 12 groups of 4–5 participants to watch course videos together. Those participants were generally satisfied with this learning approach. In addition, compared to learning by themselves, the participants maintained that learning with the group was more effective and motivating. Interestingly, the video watching styles (i.e., centralized video control and centralized display, distributed video control and centralized display, and distributed video control and distributed display) affected group interactions in terms of video-watching time, pause frequency, and the amount of speech. In another study, the Chen and Chen (2015) led a 6-week study group wherein four students met face-to-face weekly to share progress and discuss issues related to a MOOC they decided to learn together. The study group members were found to share learning strategies, broaden perspectives on the course content, and raise their cultural awareness. Furthermore, the group members increased their learning momentum and tendency to put the inner thoughts into real actions. They concluded that the MOOC study group could promote a sense of community in a group and the dynamics/effectiveness of the MOOC learning. More recently, Krasny et al. (2018) applied a study group in their MOOC design. Students, from all over the world, formulated 19 "local groups" to meet face-to-face locally and discuss the course materials, nine "bilingual groups" to meet face-to-face and/or online to overcome language barriers, and 13 "interest groups" to exchange ideas online for specific topics of interest. It was found that the study groups were helpful for students to overcome barriers of language, content, culture, technology, and time management, as well as developing strategies for cooperative learning. Notably, the social interaction that fostered cooperative and collaborative learning was identified as the key factor of the learning effects of the MOOC students. The above studies have provided support of the study group to enhance interaction and learning in the MOOC context; however, components or patterns of interaction in MOOC study groups remain under-researched and warrant further research.

Blended Learning and Massive Open Online Courses

Blended learning can be referred to as a learning mode/model that mixes online learning and face-to-face meetings (Oliver and Trigwell, 2005). More specifically, in the blended learning context, students learn partly from the content delivered *via* the Internet, and partly from instructional activities offered at brick-and-mortar locations (Staker and Horn, 2012). While online courses have the advantages of mobility, fast sharing, and flexibility in course activities to cater to students' learning needs and preferences, they have often been criticized for the lack of interaction, delayed feedback, and low completion rates (Garrison and Vaughan, 2008). On the contrary, a well-designed blended learning environment may enrich the learning materials, give access to knowledge easily and, maintain adequate social interactions and feedback at the same time (Osguthorpe and Graham, 2003). Stockwell et al. (2015) concluded that blended learning can keep the values of online learning while adding the benefits of face-to-face meetings (Alghamdi et al., 2019). Empirical studies (e.g., Cornelius et al., 2019) also found students' motivation, engagement, and satisfaction to be higher in blended learning as compared to their on-campus counterparts.

Studies have been exploring mechanisms within blended learning to promote social interactions (McCarthy, 2010). For instance, Ebner et al. (2017) found that social interactions in face-to-face sessions promoted online interactions such as forum discussions. Students got familiar and made friends with each other in face-to-face meetings, and then carried their friendships and communications over to their online activities. Furthermore, social presence was found to be another important factor in online learning (Garrison et al., 2010). According to the Community of Inquiry model (COI), the educational experience was supported by the integration of social, cognitive, and teaching presence (Majeski et al., 2018). Amemado and Manca (2017) suggested that in online learning environments where teaching presence was limited, courses should be designed to increase the

other two types of presentations to maximize the effectiveness of learning. For example, research showed that when designing appropriately, high order learning in the blended learning model could be facilitated along with the increase of cognitive presence (Akyol and Garrison, 2011). Similarly, the social presence in both virtual and face-to-face sessions aggregate together to leverage the overall social presence in blended learning. In turn, a social presence facilitates communications and a sense of community that fosters interactions and collaborations among students (Tu and McIsaac, 2002; So and Brush, 2008).

Given the benefits of blended learning to promote interactions and learning, "blended MOOCs (bMOOCs)" have arisen to integrate MOOCs with traditional university classrooms—despite that MOOCs are essentially designed as independent courses to be delivered online (Alghamdi et al., 2019). A commonly known example of this bMOOC approach is "flipped classroom," where students watch videos and other content at home and practice working through them at school. Several bMOOC modes have been proposed to illustrate the typology of bMOOC (e.g., Montgomery et al., 2015; Brannan, 2016; Alghamdi et al., 2019; Defaweux et al., 2019). Most of these frameworks categorize bMOOCs by the percentage of virtual and face-to-face time in the course. For example, Brannan (2016) introduced a continuum of MOOCs in blended learning. One end of the continuum is "Guide on the Side" (i.e., student control of learning) that all course elements are delivered online and the instructors facilitate students' learning by providing physical office hours. The other end is "Sage on the Stage" (i.e., teacher control) mode, where all course elements are delivered face-to-face in traditional classrooms, and some MOOC elements are used as supplementary content or activities. In the middle of the continuum is the "Shared Control" mode where MOOC content or activities are either supplementary or complementary. In this mode, instructors may hold face-to-face meetings and online sessions regularly. In another study, Defaweux et al. (2019) sorted three patterns of blended MOOCs, namely "Pendulum," "Sandwich," and "Tetris." In "Pendulum" blended MOOCs, classroom meetings and MOOCs were held alternatively. For example, a classroom meeting followed by a MOOC session that followed another classroom meeting. In "Sandwich" blended MOOCs, sessions of one form of meetings were arranged between the sessions of the other form. For example, the course starts with face-to-face classroom meetings for 3 weeks, followed by 3 weeks of MOOC sessions, and ends with another 3 weeks of face-to-face classroom meetings. In "Tetris" blended MOOCs, a session of a MOOC course becomes a section of different courses. For example, the week 6–week 8 sessions of a MOOC can also be used in another course as the sessions for the first 3 weeks. In all these patterns, each time slot is either scheduled for online activities or classroom meetings, but not both.

The abovementioned "bMOOCs" are simply combing traditional classroom teaching with MOOCs as opposed to incorporating face-to-face and online instructions within a single MOOC. Indeed, with few exceptions such as the Krasny et al. (2018) study mentioned earlier, it is difficult to achieve blended learning in a single MOOC, as stated by Gynther (2016), "*Blended learning is possible only in concepts that are not massive, e.g., the so-called "Little Open Online Course" (LOOC), Small Private Online Course (SPOC)..., or in concepts combining a group of enrolled students on campus with global participants*" (p. 21). Despite this limitation, the concept of blended learning in MOOCs can be supported by locally formulated Meetup groups, or what we called MOOC study groups. We contend that the effects of these study groups could be further enhanced by the blending of face-to-face meetings and online/Facebook discussions to exert their full potential. Also, we believe that the "study group" approach would be even valuable in conditions that traditional classroom contexts are not available. Next, we will discuss interaction patterns in online learning and MOOCs, then we will outline the significance of the present study.

Interaction Patterns in Online Learning

In the online learning literature, a strand of research focuses on students' interaction patterns in order to examine the structure or levels of interaction that may shed light on the design and facilitation of online courses (Michinov and Michinov, 2008; Hou et al., 2009; Philip, 2010; O'Riordan et al., 2016). Hou et al. (2009) analyzed students' online interaction patterns and found five categories of interaction, including (1) sharing/comparing information; (2) discovering and exploring dissonance or inconsistency among participants; (3) negotiating meanings/co-constructing knowledge (4) testing and modifying proposed synthesis or co-construction; and (5) agreement statement(s)/applying newly constructed meanings. Notably, 90% of the interactions in the online discussion contributed to students' knowledge construction. In the MOOC environment, Wang et al. (2017) analyzed interaction patterns in a prominent cMOOC course. Using content analysis and their Connectivist Interaction and Engagement (CIE) Framework as a reference model, they found that student interactions could generally be mapped to the four levels of CIE, namely *operation*, *wayfinding*, *sensemaking*, and *innovation*. Among the four levels, most interactions happened in wayfinding, and much fewer cases were found in the highest innovation level due to challenges of time and technology requirements. Interestingly, most wayfinding interactions were found on Twitter, while the majority of sensemaking and innovation interactions happened in blog postings. We speculated that such a difference in interaction patterns was influenced by the affordances of the communication tools that supported different types/levels of student interaction.

More recently, Tawfik et al. (2017) explored learner interaction patterns within a Chemistry MOOC on Coursera. Adopting Interaction Analysis Model (Gunawardena et al., 1997) for analysis, they found the interactions of the students (i.e., sharing and comparing information) remained at low levels in the studied MOOC. Moreover, the intensity of interaction was found to decrease over the 10 weeks of the course. They argued that the low interactions might be due to the high attrition rate and lacking high-level discourse activities. Based on these findings, they recommended a social dashboard (e.g., a webpage that provides information on post activity, popular post, peer contribution, etc.) and project-based group activities to promote social interactions among MOOC students.

Gaps, Purposes, and Questions

Several problems/gaps have been identified after a review of the literature. First of all, although interaction has been identified as a key factor of online learning and MOOCs, it remains limited in a large portion of MOOCs. Studies are warranted to investigate feasible ways such as pedagogies or learning models to leverage interactions in MOOC learning. Secondly, while blended learning is more likely to achieve better learning outcomes than online learning counterparts, it is difficult to achieve in the MOOC learning context (Gynther, 2016). As mentioned earlier, the concept of blended learning in MOOCs (bMOOCs) can be supported by locally formulated MOOC study groups *via* blending face-to-face meetings and online discussions to promote interaction, social presence, and engagement. Thirdly, although the study group approach has long been widely implemented in education, it is generally overlooked in MOOC studies. What is more, while the limited studies (e.g., Chen and Chen, 2015; Krasny et al., 2018) have verified MOOC study groups as an effective approach to promote peer interaction and learning outcomes, the patterns of interaction within MOOC study groups remained unclear. Hou et al. (2009) argued that pattern-discovery research was important because it helped educators identify situations or challenges of students, based on which more adequate guidelines could be proposed to facilitate student interactions.

In the MOOC literature, Li et al. (2014) explored students' video navigation patterns as an index of interaction; however, such "interaction" was broadly and quantitatively measured by time and frequency of operation (i.e., video-watching time, pause frequency, and the amount of speech) rather than detailed conversations, leader and member behaviors, and the discussion topics. We deem that, more detailed examinations with qualitative measures would provide even richer information about student interactions in MOOC study groups. Furthermore, examining interaction patterns in face-to-face and online settings, respectively, helps us gain a more nuanced understanding of (1) which kinds of interaction could be better supported in a single setting, and (2) how face-to-face and Facebook discussions can work together to meet students' learning needs.

To address the aforementioned gaps, we intended to perform a more nuanced analysis of the patterns of study group interaction in face-to-face and online/Facebook settings. We applied qualitative approaches (e.g., interviews and video recordings) to document group members' interactions and perceptions of face-to-face meetings and online/Facebook discussions. Three research questions were proposed to guide this study:

1. What is the pattern of MOOC study group interaction in face-to-face meetings?

2. What is the pattern of MOOC study group interaction in online/Facebook postings?

3. How do MOOC study group members perceive their experience of interactions in face-to-face and online/Facebook contexts?

It is worth noting that we adopted Facebook as the platform for online discussion. Facebook is one of the most commonly used social media around the globe. Research has shown that when properly used, Facebook can promote formal and informal learning among college students (e.g., Madge et al., 2009; Aydin, 2012; Kasket, 2012; Miller, 2013). Facebook has been found to be easy to use for sharing resources and ideas online (Wang et al., 2012), and it has become one of the most common ways to promote collaborative learning (de Villiers and Pretorius, 2013; Liu et al., 2016; de Lima and Zorrilla, 2017; Wang et al., 2017). Based on blended learning literature, we deem that face-to-face study group learners may benefit more by incorporating Facebook discussions to extend discussions and interactions. In other words, the same cohort can schedule face-to-face meetings and establish a virtual Facebook group to interact seamlessly without the constraint of time and space.

METHODOLOGY

Participants

This study adopted the qualitative case study approach (Stake, 1995; Yin, 2017) to gain perspectives of group interactions and learner perceptions within a MOOC learning context. We recruited participants from the audiences who participated in an open speech on campus about the current development of MOOCs. Those who were interested in hands-on experiences of MOOCs left their contact information to our research team. Later, we contacted the potential participants, explained the nature of this study, and invited them to join our MOOC study group. In the end, four college students, Omar, Burton, Elizabeth, and Maggie (all in pseudo names, see **Table 1** for their demographic and ethnographic profiles) volunteered to participate. An initial interview indicated that the students who participated in this study wanted to gain real experiences on MOOCs instead of merely listening to the lecture. In addition, three out of the four members were in their senior year and they were about to graduate at the end of the semester. They had flexible schedules and wanted to make good use of their time to be better prepared for the future. The following are brief descriptions of the four participants based on the researchers' observations:

The Massive Open Online Course: An Introduction to Marketing

During our first group meeting, the participants were instructed to browse available courses on Coursera to determine a course to study together. The participants were encouraged to follow their passion and choose whichever they liked. They finally picked a 9-week course entitled "***An Introduction to Marketing***" offered by the Wharton School of the University of Pennsylvania and taught

TABLE 1 | Participants' demographic profiles.

	Omar	Burton	Elizabeth	Maggie
Gender	Male	Male	Female	Female
Year of college	Senior	Senior	Senior	Junior
Study major	Engineering	Material Science	Chinese Literature	Chinese Literature

by professors Barbara Kahn, Peter Fader, and David Bell. When asked about their reasons to choose that course, the participants expressed that the course offered essential skills in the job market, which was especially helpful as three of the group members would graduate soon. A participant stated that she used to take Chinese literature courses in her own department; now she wanted to try something new. Although the MOOC had already started 2 weeks, our participants still had a chance to catch up because they had not missed any exam or assignment due dates.

According to the syllabus, the marketing course aimed to introduce the fundamental knowledge of marketing such as branding, advertising strategies, and new market entry. Major course components included video lectures, quizzes, and online discussions. The course was taught in English, and all the videos had English subtitles available. Each week, students were expected to watch six to eight lecture videos, answer small quiz questions embedded in the videos, and complete the assignments. It was estimated that 5–6 h per week were required to complete the study.

Study Group Design and Facilitation

A total of 6 weekly meetings were scheduled on Thursday evenings at 6–8 p.m. (see **Table 2** for more details). Based on our past experience, many course/platform functions would be ignored by students if the instructor failed to guide them carefully: some MOOC learners may never visit pages of the forum or even the course syllabus page. As such, in the first meeting, the researchers explained the concepts of MOOCs, helped the participants set up Coursera accounts, and walked them through the basic operations of the Coursera platform. As highlighted by Castaño-Muñoz et al. (2016), such an orientation session is crucial for equipping necessary skills and self-efficacy for subsequent online learning.

In the second face-to-face meeting, a senior who had been actively participating in a previous MOOC study group was invited to share her own learning experience. Our intention was to help the group members set reasonable expectations and then determine the goals and rules/logistics of the study group on their own. Such self-regulated learning initiatives, particularly goal setting and planning of learning are critical for ensuring MOOC learning outcomes (Kizilcec et al., 2017).

The agenda of the subsequent 4 weeks was determined by the group members themselves, as our goals were to promote participants' self-agency, as well as their commitment and responsibility. After the discussion, the group members decided to utilize the 2-h meeting time to discuss lessons and quizzes together. Upon the encouragement of the researchers, the participants also decided to take turns leading the weekly meeting, namely each person facilitated 1 week of discussion. In addition, the study group members created a Facebook group and in subsequent meetings, the researchers encouraged the participants to make good use of the Facebook group for asynchronous communications.

TABLE 2 | Schedule of weekly group meetings.

Week	Main activities	Facilitator
1	Introduction to MOOC learning	Researchers
2	MOOC learner's experience sharing; Group discussion	Researchers/invited speaker
3–6	Group discussion	Assigned member

Usually, the first 2 weeks of the MOOC course are critical for building rapport and establishing rules (Tseng et al., 2016); therefore, the researchers facilitated the MOOC study group by modeling how to lead a meeting in the first 2 weeks. The researchers consulted scaffolding strategies suggested by previous research (e.g., Lim et al., 2014; Wang C. X. et al., 2014), such as inspiring active involvement and useful roles, encouraging group communications, summarizing and clarifying the content of the discussion, and acknowledging and connecting thoughts and feelings expressed.

In subsequent meetings (Weeks 3–6), the study group members took the responsibility to manage their discussions, including the agenda and ways of interaction. As mentioned earlier, the participants took turns leading the discussion; therefore, each of them had a chance to experience the roles of both participant and leader. During this student-led stage, the researchers attended the computer lab to introduce the meeting, but for the main meeting time, the researchers and two research assistants sat at the other side of the computer lab to observe student interactions. We did not interfere with group members' discussions unless they came to ask questions or request assistance. After group members finished their meeting, the researchers spent 20–30 min leading a focus group discussion, in which we probed, summarized, and wrapped up the progress of the study group. The focus group guiding questions included, but were not limited to: "What is the focus of discussion or activities this week?" "What kinds of problems have you encountered and how did you resolve them?" "Which learning strategies have you discovered and shared?" and "What do you plan to do in the upcoming week(s)?"

In addition, the researchers took the following steps to promote communications in both online and face-to-face contexts. Firstly, we shared some personal feelings and experiences with the study group members, as past research found that facilitators' disclosure of their personal lives could enhance the connections among group members and between members and the facilitator (Holt et al., 1998). In this study, the researchers shared some personal interests such as favorite music and technology gadgets for learning, and occasionally they launched or joined the participants' informal chats about what happened at school or in society. Secondly, we facilitated connections between Facebook and face-to-face activities. For example, we took the chance to talk about what happened online when we met in person, and we also encouraged the participants to extend their discussions on Facebook by sharing information and feelings over there. Such endeavors may increase the social presence of the study group members, meanwhile promoting student learning through both online and offline interactions.

Data Collection

Data were collected *via* multiple sources, including observation notes, students' reflection journals, voice and video recordings

of study group activities, Facebook postings, student artifacts, focus group discussions, and individual interviews to enhance credibility (Yin, 2017). ***Observation notes*** were collected through participant observation (Kawulich, 2005), in which the researchers took the role of the observer to document participants' interactions in the social context. The researchers also reflected on what happened during the arrangement of time and place for meeting, their facilitation of the MOOC study group (e.g., modeling, guiding focus group discussions, and providing announcements and feedback), as well as student actions and reactions toward the above-mentioned arrangements. Moreover, two trained research assistants joined the study group observation. They specifically helped document student actions and interactions, as defined as three or more participants talking to each other during their discussion (see **Figure 1** for an example).

Each week, the participants were asked to submit their ***goal setting sheets***, as well as ***reflection journals*** that demonstrated their progress and thoughts on their MOOC study. The goal setting sheet assignment was designed to practice goal setting and planning, which were reported as highly related to MOOC learning performance (Pursel et al., 2016; Kizilcec et al., 2017). On the other hand, the weekly reflection journals had been useful not only to provide information about the participants' inner states such as motivation, aspiration, and action plans, but they were helpful for the researchers to adjust plans and facilitation of group discussion every week.

As mentioned earlier, each week after the student-led discussion, the researchers facilitated a ***focus group meeting*** that captured the current status and feedback of the group members. This could help the researchers identify the participants' instant reflections as well as their changes over time. At the end of the 6-week study group, the participants were interviewed individually for about 90 min to understand their experiences and attitudes from their personal perspectives. The interview outline included five aspects:

1. Self-evaluation of the learning process and strategies;
2. Topics/issues worked together and problems resolved;
3. Leadership experience and perceived effectiveness;
4. Group interactions and interpersonal relationships;
5. Situations and reasons to utilize face-to-face or Facebook discussions;
6. Effectiveness/barriers/suggestions about the MOOC study group.

Group meetings were video-recorded with the consent of all participants. Each session was captured by three cameras (on one notebook computer and two tablets) from different angles to record group interactions and computer operations. Recorded videos were then coded into video logs based on major events in

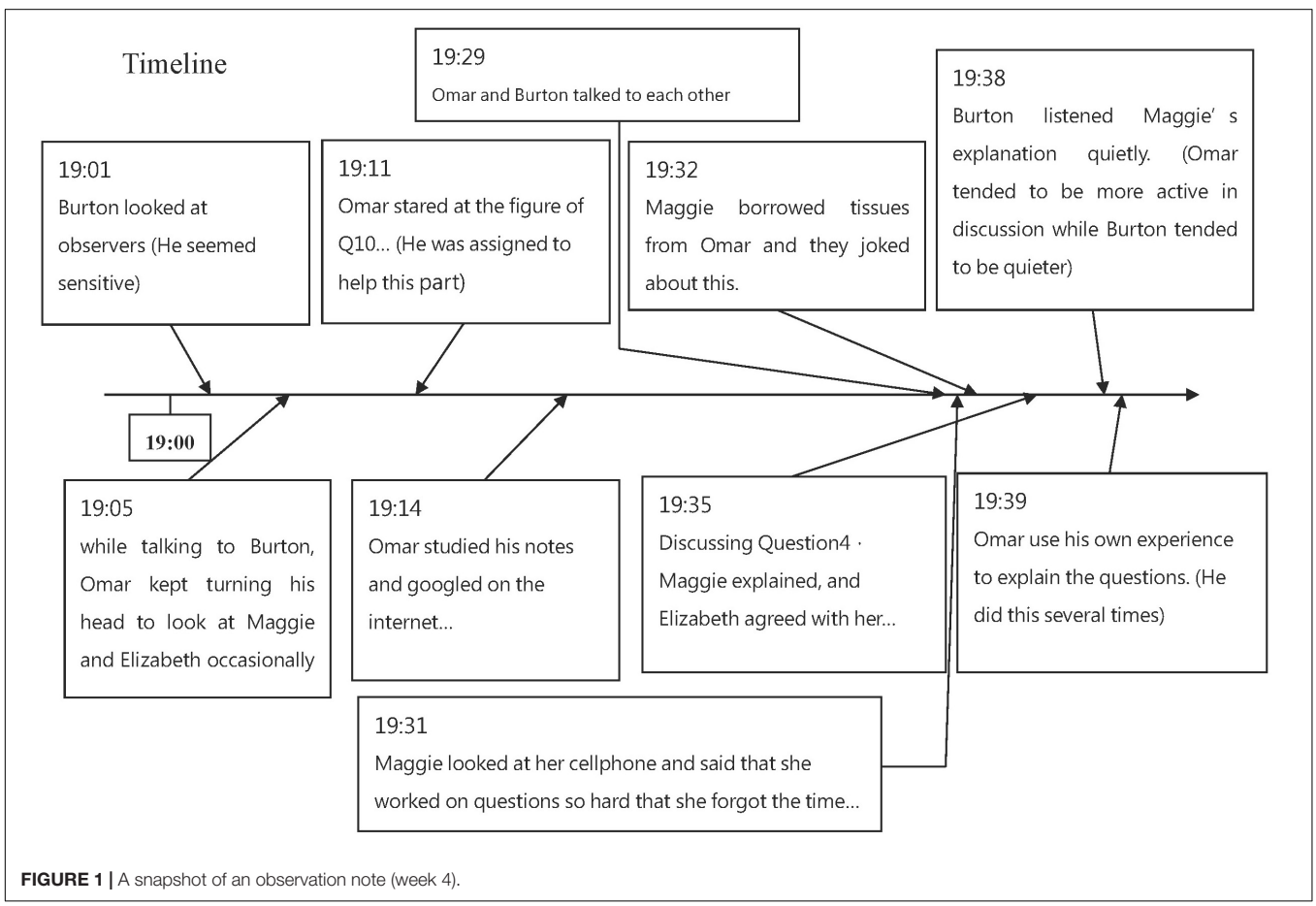

FIGURE 1 | A snapshot of an observation note (week 4).

the meetings (see **Table 3** for an example). Eventually, video logs were assembled for further analysis.

Lastly, we collected student artifacts such as study notes and PowerPoint slides shared by group members. Those artifacts were used to supplement or cross-validate results from other data sources. Furthermore, every message posted on Facebook was collected and analyzed. Together, the multiple data sources provided rich information to examine student interactions in face-to-face and online contexts, as well as participants' perceptions of the blended mode study group to learn MOOC together.

Data Analysis

Recorded interviews and focus group meetings were transcribed, and the verbatim was then processed with (Nvivo) 10. The interview and focus group discussion verbatim were analyzed with qualitative approaches (Patton, 2014). The researchers conducted the first cycle of coding, namely identifying the unit of analysis and segmenting the original texts accordingly. A structural coding (Saldaña, 2016) was performed according to the initial coding scheme, so each meaningful text segment was related to a specific research question. When the text did not fit the initial coding scheme, descriptive coding was then applied to the text, in turn, the whole coding scheme expanded to accommodate all text segments.

Two experienced research assistants joined the analysis in the second coding cycle, including free coding and focused coding. Inconsistencies between coders were resolved during regular research meetings led by the researchers. During the whole process, simultaneous coding was applied so that the same text could be coded under different labels and later be interpreted in multiple levels and by multiple perspectives (Miles and Huberman, 1994; Saldaña, 2016).

Video recordings were processed somewhat differently. Based on our research purpose, we used "*interaction*" as the unit of analysis, which was defined operationally as "three or more participants gather together to work on a certain issue." The extracted interactions were further categorized in reference to the following questions:

1. In what conditions do the group members discuss together?
2. What are the contents/issues that they work together?
3. What are the main concerns/focus during that interaction?
4. What are the results of that interaction? (e.g., when resolving a difficult problem together)?
5. What are the member roles (e.g., leader, follower, help seeker, resolver, etc.) and reactions during that interaction?

As with Facebook postings, *via* content analysis (Gerbic and Stacey, 2005), each forum thread was tagged by date, week, the name of the author, the number of replied posts, total reads, total "thumb ups," and content of posts and replies. We further used Microsoft Excel to sort those threads by a combination of tags, based on which we generated percentage tables, pie charts, and line graphs that portrayed the participants' patterns of interactions on Facebook.

Reliability and Validity

"Consistency" is commonly used as an indicator to evaluate data reliability in qualitative research (Merriam, 2002). In qualitative studies, the "inter-rater reliability" or the "degree of agreement" are calculated to signify the consistency of coding. A high percentage agreement between coders means that other trained researchers would be most likely to categorize the same data into the same codes following the same coding procedure. In this study, we ran a coding comparison query in Nvivo. The initial average of percentage agreements was 96.12%, indicating appropriate consistency/reliability in the field of computer-supported cooperative work (CSCW) (McDonald et al., 2019). All final coding was set in regular research meetings, wherein differences in coding were discussed and determined upon agreement of coders.

Validity in qualitative research often means the extent to which the results represent participants' views on the events or experiences (Creswell and Miller, 2000). Qualitative researchers employ triangulation, member check, think description, etc., to establish the validity of their studies (Denzin and Lincoln, 2011). In this study, we applied investigator triangulation and data triangulation (Golafshani, 2003) as validity procedures. For investigator triangulation, two major researchers and two research assistants worked together to collect data: the two major researchers were participant-observers while the other two research assistants observed the group from pure outsiders' perspective without involvement. This arrangement helped balance between emic and etic perspectives (Helfrich, 1999), and reduced the bias of individual researchers (Archibald, 2016). Also, the codings from different coders were cross-examined and differences in coding were solved by discussion. As with data triangulation, we collected data from multiple methods (e.g., observations, interviews, and video recordings). Data from different sources were cross-examined to find any contradictions or inconsistencies in findings (Cohen et al., 2017). Again, the

TABLE 3 | A sample video log.

Participants:	**Date**:	**Time**:	**Source**:
Omar, Burton, Elizabeth	6/5	6 min 15 s–7 min 07 s	Camera 1

Activity:	**Interaction behavior**:
Watching videos together	Participants searched for lecture videos related to Question 19 and then discussed the content while watching the videos together.

Main content: Burton operated the video player, and the others moved their seats closer to watch the video together. Maggie did not participate in this part of the discussion because her seat was too far away.

disparity of data was discussed and resolved during regular research meetings.

RESULTS AND DISCUSSION

RQ1: What Is the Pattern of Massive Open Online Course Study Group Interaction in Face-to-Face Meetings?

A total of 143 face-to-face interactions were retrieved from the recorded videos, of which six categories of interaction were further identified (see **Table 4** and **Figure 2**), including (1) Communication, (2) Help seeking, (3) Problem solving, (4) Sharing information, (5) Sharing learning progress, and (6) Watching videos, from the highest to the lowest frequency. ***Communication*** means formal and informal exchanges such as chatting, discussion of personal life, or arranging schedules for the study group, which may not be directly related to the learning materials.

Help Seeking means asking questions or giving advice to other group members. A related category is *Problem Solving*, which usually happened when the participants were working together to resolve quiz problems, for example,

Omar: Did you get the right answer to question 16?
Maggie: No, I didn't. What is the correct answer of 16?
Omar: Which one did you choose? I calculated and got the answer of 4.8, but it was wrong!
Burton: I wrote 7.3.
Elizabeth: I wrote 16 points and some more.
Omar: Ah! Then we got 13.3!
Burton: This is how it is calculated.
Omar: I was thinking that if we use 1 to divide it then it would be. . . just choose 13.3 first! 0.7 plus 2.9 times 0.29. . . so we got 0.177, it should be a 16.6 traction rate. I thought of dividing the related number, but 1 divided by 0.177 wasn't right.
Burton: 1 divide 0.177...
Elizabeth: 8.57
Omar: No! It's not correct! 0.7 divide 0.06
Burton: Then we got 16.7. . .
Omar: Yes! 16.7, 16.66 points and a little more.

(0605_193649_Samsung_11:05–14:16)

In this study, participants came from different majors and did not have much background in marketing. During discussions, they ***Shared Information*** to clarify concepts and key terms. In such open discussions, participants freely expressed their own interpretations of the concepts or shared information they

TABLE 4 | Categories of interaction in face-to-face meetings.

Types of activities	#	Percentage	Description
Communication	42	29.4%	Discussing personal life or arranging the schedule
Help seeking	39	27.3%	Asking questions or giving advice
Problem solving	28	19.6%	Explaining the concepts or working out problems together
Sharing information	20	14.0%	Providing information
Watching videos	8	5.6%	Watching/re-watching lecture videos
Sharing learning progress	6	4.2%	Sharing personal learning experience or current progress on particular questions

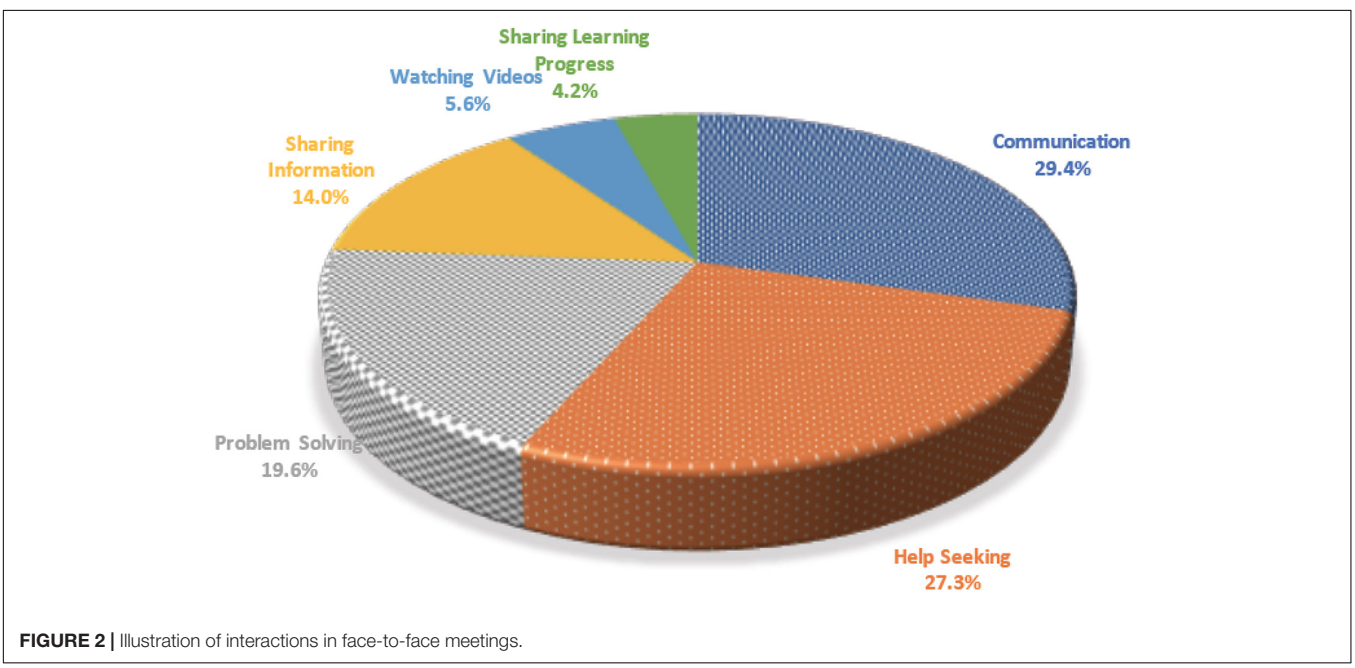

FIGURE 2 | Illustration of interactions in face-to-face meetings.

collected when they studied individually. In the following excerpt, Omar contributed what he knew about Biology and applied it to the discussion of the cycle time of the product in Marketing:

(Maggie stood up and listened)
Omar: For example, 1 divided by 0.06.
Omar: Because it's a traction rate, it means that if you want to calculate the cycle time of life, then it needs to be divided by 1, and you will get the answer of . . .I don't know how to explain it.
Omar: Just like we what we learned from Biology! You have learned that before, right? We had calculated some types of the cycle time of life.
Elizabeth: Yes, but I forgot.

(0605/NB/video2_ 18:06–19:24).

Lastly, the study group members watched videos together when someone used lecture videos on Coursera as evidence to support his or her opinion, or when they want to recall the content in the videos that might help them solve problems. During ***Video Watching*** interactions, usually, a group member retrieved a lecture video and provided interpretations, and the remaining participants offered feedback or asked further questions:

Omar: Burton, play the video for everyone, please.
(Watching the video. . .)
Omar: I will interpret it as "do you want to upgrade your car with some accessories of sports cars?" For example, the sports car's chair.
Burton: The accessories of a sports car?
Elizabeth: oh!
Omar: So, you mean you are not talking about the sports bag you just said.
21:22–26:30:
Omar: (watching the video) He said it just now... "those two numbers multiplied together result in one. . ." (feeling confused), maybe it's just an expression.
Burton: Wait a minute. . . (replaying the video and listening carefully to the video) . . . it decreases by 0.2 each year, and in five years, nothing will be left.
Omar: At the beginning, the total number is one. And it decreases by 0.2 each year, it becomes zero at the end of the fifth year.
Elizabeth: Oh, I see.
Omar: Then we don't need to watch the video all over again. Do the math- and you'll figure it out..

0605_Samsung_04:15–07:07.

According to Pursel et al. (2016), video watching behaviors were positively related to MOOC course completion. It seems that our face-to-face meetings had created a supportive environment for watching videos together with peers that can in turn contribute to students' completion of the MOOC course. Moreover, looking across the categories of face-to-face interactions, we found the categories were all related to solving problems in assignments and quizzes. More specifically, more than half (53%) of the face-to-face interactions were associated with assignment-related activities, including *Watching Video*, *Help Seeking*, and *Problem Solving*. The above instances showed that the group meeting conversations were contributive to their co-construction of knowledge. Also, many conversations reflected the process of peer scaffolding in order to work out the problems.

It is also important to note that, the seats had been changed since Week 3. In Week 2 when the study group started officially, students had no way to face each other because the seats were linearly arranged. The desks were arranged in a row, all facing to the front (see **Figure 3**). The researchers found that Maggie only talked to Elizabeth and was easily ignored during group discussions. Therefore, in Week 3 we changed the seat arrangement as illustrated in **Figure 4**. It turned out that the overall interactions among group members improved significantly, and Maggie talked more and started to seek help from others.

RQ2: What Is the Pattern of Massive Open Online Courses Study Group Interaction in Online/Facebook Postings?

At the end of the 6-week study group, a total of 32 Facebook threads (including posts and replies) were retrieved from the Facebook group. All the group members posted at least four messages on Facebook. Compared to the study of Swinnerton et al. (2017) wherein only a third of MOOC learners posted at least one comment on their course website, the online interactions in our study group seemed quite intense. It seems that compared to post messages on a larger course group, the participants may be more willing to post messages on the smaller study group which they created and experienced a sense of

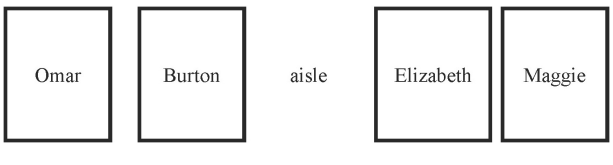

FIGURE 3 | Original seat arrangements before week 3.

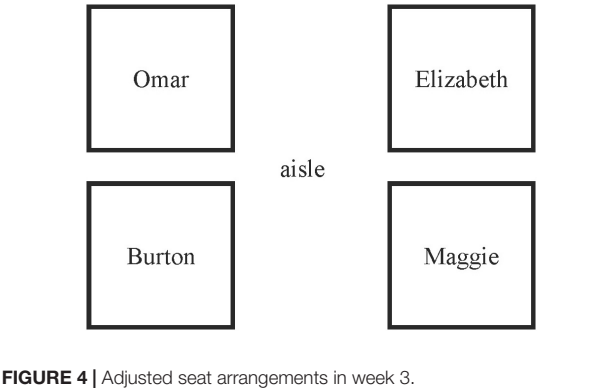

FIGURE 4 | Adjusted seat arrangements in week 3.

community. As evidenced by the study of Pursel et al. (2016), students' engagement in online postings and comments could strongly predict their MOOC completion.

Table 5 and **Figure 5** portray the four categories of online/Facebook interactions through thematic analysis, including (1) *Follow-up Discussion*, (2) *Sharing Information*, (3) *Course Logistics*, and (4) *Help Seeking and Problem Solving*, from the highest to the lowest frequency. Among the four types of interactions, *Sharing Information* usually included artifacts or supplementary learning materials. For example, some posted vocabulary lists that had been discussed in group meetings. In addition, the participants shared websites related to the topics they discussed during face-to-face meetings. Such kinds of online sharing could be regarded as the extension of their face-to-face discussions to support or defend their previous arguments. de Lima and Zorrilla (2017) found that peer sharing of information was perceived as very informative by their MOOC students. Similarly, in the Liu et al. (2016) study, more than half of the students agreed that the Facebook group was useful for their MOOC learning, and one of the most useful aspects was resources shared with the group. Interestingly, in the Liu et al. (2016) study, resource sharing was the most frequent type of online posting while in the present study it ranked second among the four types of postings.

Help Seeking and Problem Solving contained the fewest postings (3%) among the Facebook interactions. It is possible that our participants had already used the chance of face-to-face meetings to work together and help each other. Another possible reason is that, from the perspective of the Connectivist Interaction and Engagement framework (CIE, Wang Z. et al., 2014), providing help requires deeper cognitive engagement and may reduce the frequency of such postings. Follow up Discussion, which requires higher levels of cognitive engagement, contained as much as 60 percent of the Facebook postings. This could be interpreted that many discussion postings were the follow-ups of previous face-to-face discussions instead of new discussions, and to some extent, it reduces the cognitive engagement required for such postings. In the analysis of the cognitive presence of a blended mode learning community, Vaughan and Garrison (2006) reported a similar observation that cognitive discussions were less likely to be initiated in online environments. They found that the "triggering event," which was the beginning phase of the inquiry process, was more frequent in face-to-face meetings (13%) than online forum discussion (8%).

Although not all members were keen to post their ideas on the social network, most of them followed similar patterns regarding the numbers of postings across time (see **Table 6** and **Figure 6** for details). Namely, they posted more articles in the middle of the course and far less at the beginning and the end. This pattern may provide evidence that the group members were using Facebook to assist their face-to-face discussions. Another possible reason may be the rearrangement of seats in week 3. The

TABLE 5 | Categories of interaction in Facebook postings.

Types of posting	Frequency	Description	Example
Follow-up discussion	19 (60%)	Follow-up of previous topics in group meetings	"Keywords (chapter 3, week . . .)"
Sharing information	9 (28%)	Repost or post course-related information	Provide hyperlink for a related article, such as "https://www.facebook.com/useMyoops"
Course logistics	3 (9%)	Discussing meeting schedules	"Does anyone want to take another Coursera course?"
Help seeking and problem solving	1 (3%)	Ask help for assignments or discussing course materials	"How do you take notes?"

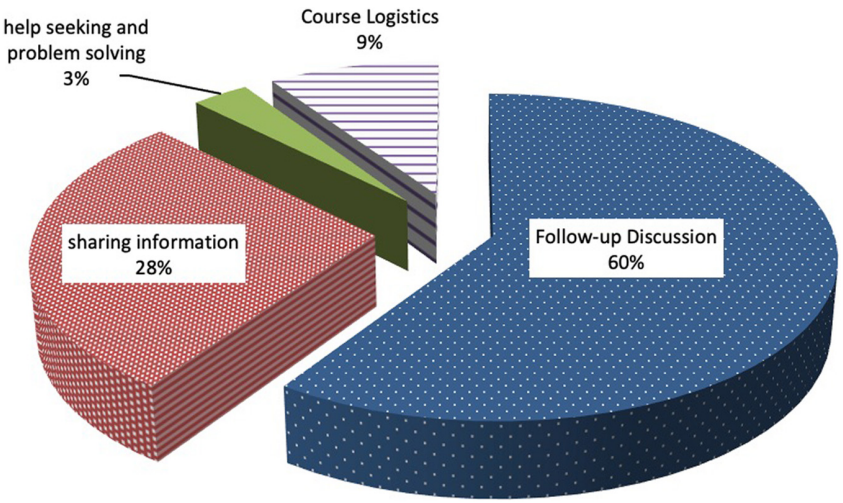

FIGURE 5 | Illustration of interactions in Facebook postings.

TABLE 6 | The frequency of weekly postings by person.

Participants	Type of posting	Week 1	2	3	4	5	6
Maggie	Follow-up discussion	0	0	2	1	1	0
	Sharing information	1	2	2	1	1	0
	Help seeking	0	0	0	1	0	0
	Course Logistics	0	0	0	0	1	1
Omar	Follow-up discussion	0	0	2	1	0	0
	Sharing information	0	0	0	0	1	0
	Help seeking	0	0	0	0	0	0
	Course Logistics	0	0	0	0	0	0
Burton	Follow-up discussion	0	0	1	3	2	0
	Sharing information	0	0	0	1	0	0
	Help seeking	0	0	0	0	0	0
	Course logistics	0	0	0	0	0	0
Elizabeth	Follow-up discussion	0	1	1	1	3	0
	Sharing information	0	0	0	0	0	0
	Help seeking	0	0	0	0	0	0
	Course Logistics	0	0	0	0	0	1
Total		1	3	8	9	9	2

participants started to discuss in a circle, facing each other, and only went back to their computers when needed. The change of seat arrangement might explain some burst of posting as they also interacted more in person.

It is worth mentioning that, each member appeared to prefer different types of posting. For example, Elizabeth only posted threads of *Course Logistics* and *Follow-up Discussion*, whereas Omar and Burton contributed to *Information Sharing* and *Follow-up Discussion*. Maggie, who engaged in Facebook discussions more than anyone else, posted threads of all kinds. It seems that the differences in postings among group members reflected the different roles they played in the MOOC study group. The difference in postings also corresponds with our previous profiling of their backgrounds, characteristics, and preferences in section Participants.

RQ3: How Do Massive Open Online Courses Study Group Members Perceive Their Experience of Interactions in the Face-to-Face and Facebook Contexts?

In this study, participants valued the opportunity to learn from each other in the study group meetings. In particular, they believed that they comprehended learning materials more easily when they watched lecture videos together during face-to-face sessions. All of them finished all required assignments and quizzes, and most of them (three out of four) earned "Statement of Accomplishment" from the course for their achievements. The participants thought that working together as a group helped them learn better. Elizabeth mentioned that, compared to listening to the instructor alone, other members could rephrase the learning materials and explain to her in ways that she could comprehend more easily. Burton elaborated this by saying ". . .it would be easier to understand those concepts when students who already understand it to explain to me in simpler and clearer ways." Another member, Omar, also agreed and said, "Sometimes you cannot grab the main ideas from the video; however, when watching videos together, some group members who understand more on the topic may give extra information to relate this. . ..then I can understand what the video is all about."

Regarding Facebook, the participants deemed it a useful tool to share information, provide timely help, and extend face-to-face communications without the limitation of time and space. According to Burton, "Facebook is a space for follow-up

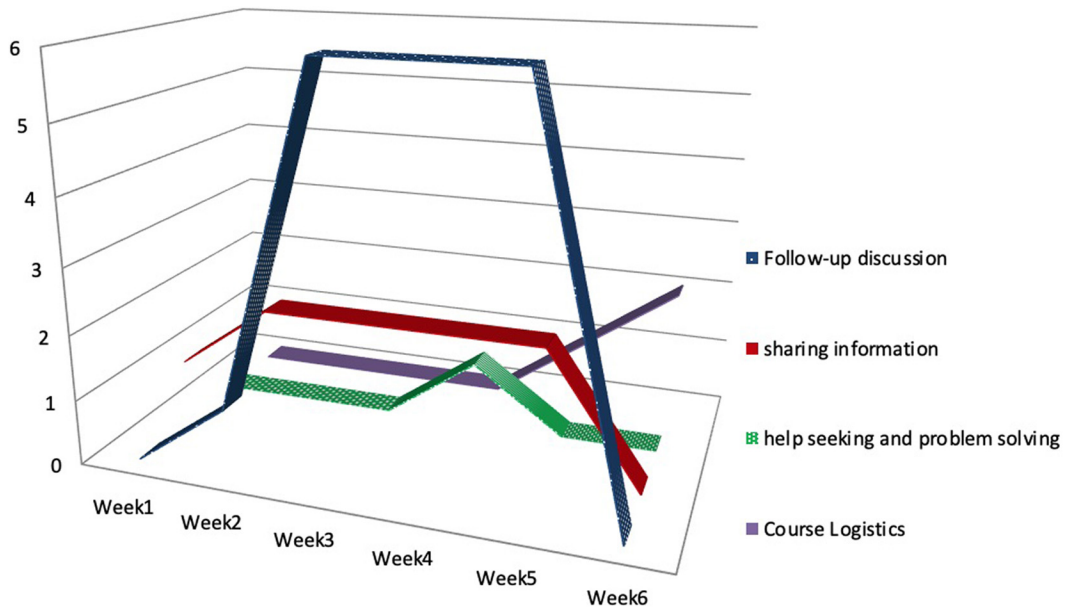

FIGURE 6 | Frequencies of Facebook postings across the 6-week session.

discussions. . .and another benefit of it is that you can upload and share files and materials with others, it's a space for sharing." Elizabeth valued Facebook for more immediate responses to resolve problems: ". . . if you have some questions you can post it on Facebook, and then someone may help you resolve the problem." Omar also said,

> ". . .it's a way to connect to each other because we only meet once a week. When you think of something that you forgot to share in face-to-face meetings, you can always share it on Facebook. So it is a place where you can share what you think, as well as catch up on what you forgot to share. Also, when you raise a question on Facebook, we can have extra discussions. I think it is nice that we have the Facebook group, a communication tool. . .because it is not very convenient to discuss over the phone. And it's free and all of us can see it!"

During the interview, one participant, Elizabeth explained the difference between discussion on Facebook and face-to-face interactions. When she was asked to identify what she would post on Facebook and what she would prefer to discuss in person, she said, ". . .for trivial matters such as meeting time, and those which did not directly relate to the course content, posting on Facebook should be just fine. . ..and the core content of the course, it would be good to discuss in person." It is also noteworthy that Facebook facilitated prolonged communications among the study group members: after the end of the 6-week study group, the participants used Facebook to communicate with each other and even scheduled a face-to-face reunion. It appears that Facebook had played an important role in maintaining the connections among study group members; also a sense of community had been escalated with the help of the Facebook group.

In this study, we examined the interaction patterns and perceptions of students in the 6-week MOOC study group. The interactions in face-to-face meetings and Facebook showed some similar patterns, as both contexts enabled *Help Seeking*, *Problem Solving*, and *Information Sharing* as categories of interaction. Although participants initiated more new issues in the face-to-face meetings, they continued with their discussions on Facebook. It seems that deep and immediate interactions were better achieved in face-to-face meetings, whereas the Facebook group offered a platform for the situation called for asynchronous interactions. In addition, problem-solving was commonly seen in face-to-face discussions, whereas more information and resource sharing were prevalent on Facebook. Newman (1995) argued that, compared to face-to-face meetings, online asynchronous discussions were less effective for problem-solving. This may explain why our participants devoted their valuable meeting time to doing assignments; otherwise, it would be much more difficult to accomplish it *via* online discussions.

Comparing group activities on Facebook and in face-to-face meetings, *Follow-up Discussion* on Facebook was essentially the extension of previous group discussions in face-to-face meetings. On the other hand, in face-to-face meetings, there were more "working together" activities in which all members participated in the same activities together at the same time and in the same place (e.g., watching videos or working on assignments together). Working together may not necessarily or directly facilitate interactions, but it generated discourse spaces and shared experiences critical for community building and knowledge co-construction.

CONCLUSION, LIMITATIONS, AND FUTURE DIRECTIONS

In Moore (1989) highlighted the criticality of interaction in distance learning. It holds true even, three decades later, in the context of MOOCs. In this study, we carried out a "blended mode," student-led MOOC study group to promote interactions and social learning. Findings indicated that, overall, the blended mode MOOC study group was helpful for promoting communication, providing help, resolving problems, and exchanging ideas and information among group members. Moreover, face-to-face meetings and online discussions both exerted their unique strengths and functions that aligned with different learning situations and learner preferences. Online study groups offered generous spaces for learners to continue their discussions initiated in their face-to-face meetings and extended their learning. As such, we would like to recommend this blended format preferably to exert the full potential of the MOOC study group. On the other hand, *self-regulated learning (SRL)* has been increasingly emphasized in higher education; for example, many universities in Taiwan are now supporting/subsidizing college students to formulate spontaneous study groups to learn something to their interest. We deem MOOCs can be an ideal target for students to learn/explore together, and our blended mode study group approach would serve as a practical, easy to implement, and effective way to promote motivation and learning of MOOCs.

This study has its limitations. First of all, this study contains only four participants, which may to some extent limit the generalizability of the study results. Despite that, from the perspective of Critical Realism, one single case may be valuable to offer unique insights (Easton, 2003), as "one talking pig is sufficient to prove that pigs can talk" (Editorial Nature Neuroscience, 2004, p.93). Research communities in Neuroscience, Management, Social Science, etc., have recognized the potential of a single case study in the research fields (Editorial Nature Neuroscience, 2004; Silverman, 2013; Mariotto et al., 2014; Ozcan et al., 2017). In any case, more studies are recommended to replicate our blended mode MOOC study group in different cultures, subject areas, age groups, etc., to establish the generalizability of the MOOC study group in a blended format. Comparisons of interaction patterns across studies are also helpful for generating insights into the design of MOOC interactions in different contexts.

Another limitation arises with the prevalence of COVID-19 when a pandemic like this has posed a threat to face-to-face encounters such as in-person study groups. In such cases, the online/Facebook portion of our MOOC study group is still useful for promoting communications and social interactions for MOOC studies. More promisingly, as COVID-19 vaccines are becoming widely available around the globe, face-to-face group discussions can be expected to resume in the foreseeable future.

We believe that the blended-mode study group may further serve as a useful methodology/pedagogy to prepare for online learning in the post-COVID-19 era.

The present study contributes to our knowledge base by supporting the tenability of MOOC study groups, portraying the utility of the study group approach to support blended learning of MOOCs, and analyzing interaction patterns that look into the structure and discourse during the study group process. It is our strong belief that continued investigation and improvement of MOOC interaction design will make MOOC learning more intriguing and fulfilling, helping us become lifelong learners in the twenty-first century.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the identities of participants may be revealed in the raw data. Requests to access the datasets should be directed to the corresponding author P-JC, pinju@mail.mcu.edu.tw.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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The role of synergistic interplay among proactive personality, leader creativity expectations, and role clarity in stimulating employee creativity

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This study investigates the interplay among proactive personality, leader creativity expectations, and role clarity in stimulating employee creativity based on the theoretical frameworks of role theory. Questionnaires were distributed to obtain 290 leader-employee dyads from China to examine hypotheses *via* conditional process analysis. The results show that proactive personality has a positive effect on employee creativity, leader creativity expectations did not play a significant moderating role on the relationship between proactive personality and employee creativity. The interaction between leader creativity expectations and role clarity has a significant moderating effect on the relationship between proactive personality and employee creativity. These findings are discussed in terms of their theoretical and practical significance.

KEYWORDS

proactive personality, leader creativity expectations, employee creativity, role clarity, role theory, Pygmalion effect of creativity

Introduction

As organizations seek to effectively navigate today's highly competitive market, they need require employees creatively solve various problems throughout the workplace (Xu and Wang, 2019). Academics broadly define "creativity" as "the ability to produce innovative and practical ideas" (Amabile, 1988). Factors influencing creativity in this context include organizational culture, job design, leadership, human resource management, and personality characteristics (Gong et al., 2009; Zhang et al., 2020, 2022). Individual factors are generally regarded as the main source of employee creativity (Shalley et al., 2004), particularly personality characteristics that may be deep, intrinsic motivations for creative work (Zhang et al., 2019).

Research have shown that proactive individuals tend to behave under stronger intrinsic motivations than those who are less proactive, and that creative behaviors can be considered a kind of "proactive action" (Ng and Feldman, 2013; Kim, 2019). Recent studies have shown that a proactive personality is extremely important in terms of

creativity, and proactive personality can be a proxy indicator of creativity among an individual's personal characteristics (Tai and Mai, 2016; Kim, 2019). Individuals with proactive personality are also predicted to perform better than those with the "Big Five" in many work situations (Marinova et al., 2015).

Although individual factors are the primary, decisive source of creativity (Shalley et al., 2004; Carmeli and Schaubroeck, 2007), a given individual may newly develop creativity due to immersion in an environment that encourages or stimulates creative behavior (Wang et al., 2022). For example, a typical case is the Pygmalion effect (Tierney and Farmer, 2004). Despite extant studies offer valuable contributions to the literature regarding contextual factors such as work environment, leadership, and colleague relationships that may occur simultaneously and affect the relationship between proactive personality and individual creativity (Shalley et al., 2004; Kim et al., 2010; Wang et al., 2014; Chen et al., 2016; Kim, 2019; Mubarak et al., 2021), the effect of role expectations on the relationship between proactive personality and creativity is not yet well understood.

One with a proactive personality has a "stable tendency that is relatively free of environmental constraints and can influence the surrounding environment by taking active actions" (Bateman and Crant, 1993). This definition of the proactive personality, however, not necessarily includes self-orientation, namely, the expectations of creativity under which the individual operates. Such expectations are important to consider, however, as the orientation of individual behavior is shaped largely by the environment. As one of the key environmental factors in the workplace, the leadership factor is highly influential (Joo et al., 2013; Chen and Hou, 2016; Hughes et al., 2018). Scholars have previously explored the influence of leaders' expectations on employees' creative work (Qu et al., 2015a). Leaders' expectations of creativity can be considered as an external motivator for promoting (or hindering) their employees' independent innovation abilities in different situations (Zhao and Guo, 2019). Based on the theory of role theory (Anglin et al., 2022), the interaction between individual internal and contextual factors can deepen our understanding of the Pygmalion effect of creativity.

In this study, we first focus on the possible influence of leader creativity expectations by determining whether such influence plays a moderating role between proactive personality and employee creativity. Previous researchers have tended to focus on the manner in which leaders shape their employees' creative behavior by their expectations, but generally ignore the response of employees to such creativity expectations (Qu et al., 2015b; Jiang and Gu, 2017; Xu and Wang, 2019). However, in practice, employees tend to respond strongly to support and encouragement from others. Their work—including creative work—is also influenced by the roles they are given by their supervisors (Eden, 1992; Jada et al., 2019). Considering only the role expectations placed on employees does not comprehensively reveal the potential to improve their creative performance (Väänänen et al., 2005).

Role indicates the expectations and desires of the individual and organization from each other (Adil et al., 2021). According to role theory (Anglin et al., 2022), we instead focus on the bidirectional nature of role expectations in regard to employee creativity. The content of one's work, beyond leaders' expectations, is also an important factor in the environment in which that work takes place. The influence of work content on employee creativity has been given relatively little research attention. Creativity is a high-level cognitive process; producing innovative, high-quality solutions necessitates "creative thinking" (Xu and Wang, 2019). Novelty, complexity, and ambiguity act differently on different people as they attempt to problem-solve. Problems requiring creative thinking in the field of physical sciences markedly differ from those requiring creative thinking in the humanities field (Baer, 2003). Role clarity indicates the extent to which employees acquire and understand the information or data required to complete their work (Kelly and Richard, 1980; Adil et al., 2021). Employees who are short on role clarity often cannot maintain progress or positivity; they tend to not feel encouraged or supported by their superiors, which is a known predictive factor of deviant behavior (Judge et al., 2006; Bang et al., 2022; Orgambídez et al., 2022).

Sawyer (1992) defines "role clarity" from two dimensions. The first is "goal clarity," namely, the degree to which employees clearly understand the purposes of their work and the responsibilities relevant to those purposes. The second is "process clarity," which refers to the employees' understanding of the operations necessary to achieve these goals. Employees with higher role clarity understand the expectations placed upon them as well as the methods and processes they should adopt to achieve their goals. A clearer understanding of the core aspects of their work allows employees to communicate effectively with leaders to achieve goals as a team. Individuals' perceptions of their job responsibilities may determine the extent to which they understand the creativity expected of them by their leaders.

This research aims to answer a theoretically relevant question of when and how interactions of three types of antecedents (proactive personality, leader creativity expectations, and role clarity) lead to varying levels of employee creativity. While investigating the influence of proactive personality on employee creativity, we explore the bidirectional support of leader creativity expectations and role clarity. By simultaneously considering the influence of both leader creativity expectations and employee role clarity, we seek to investigate the role proactive personality has in shaping creative performance based on a role shaping perspective. Our hypothesized model is shown in Figure 1.

Literature review and hypothesis statements

Proactive personality and employee creativity

Proactive behaviors mainly include prediction, change orientation, and self-motivation (McCormick et al., 2019). Innovation behavior is closely related to proactivity. A proactive

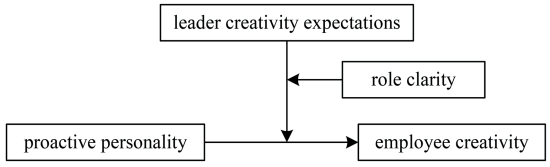

FIGURE 1
Hypothesized model.

personality is considered an important antecedent of a variety of individually proactive behaviors. Individuals with proactive personalities are usually more sensitive in their work than non-proactive individuals; they more actively seize work-related opportunities (Alikaj et al., 2021). Positive, proactive behaviors tend to be driven by high intrinsic motivations to obtain praise, encouragement, or promotions (Antonacopoulou, 2000; Tolentino et al., 2014).

In general, there is a positive correlation between proactive personality, self-learning orientation, and self-efficacy of learning in employees. Proactive employees are more likely to improve their own work-related abilities and gain knowledge and skills related to their work field on their own volition, thereby showing a stronger tendency to innovate (Kim, 2019). Employees with proactive personalities tend to be self-created, future-oriented, and transformation-oriented, which may also support the generation of creativity (Parker et al., 2010; Jiang and Gu, 2015). Studies have shown that employees with proactive personalities manage pressure effectively, allowing them to utilize the knowledge and skills they have gained to creatively solve problems at work (Vignoli and Depolo, 2019; Mubarak et al., 2021).

The active expression of personal ideas is another important characteristic related to a proactive personality. To this effect, proactive employees may have stronger communication abilities than non-proactive employees. By communicating with colleagues, these employees can gain support for their ideas among both peers and higher-level individuals, accelerating the creativity of the entire organization (Thompson, 2005). As per the social exchange theory, proactive employees may become more efficient after other individuals show trust, encouragement, or other actively supportive feedback, thereby actively engaging in further proactive behaviors. This feedback process continually improves creativity (Gong et al., 2012). Employees with low proactivity, conversely, may be more inclined to make passive responses to workplace situations, be less likely to gain knowledge and skills in the work field on their own, and struggle to identify opportunities in the workplace, thus experiencing less motivation for independent creative behaviors (Mubarak et al., 2021). Although the relationship between proactive personality and employee creativity is not the focus of this study, we still propose the following hypothesis for the sake of research integrity:

> *H1*: Proactive personality positively related to employee creativity.

Leader expectations for creativity

Although individual personality characteristics are the main source of and key factor in creativity, a proactive personality does not necessarily relate to the expectations for creative behaviors placed upon the individual by his or her supervisor. The behavior orientation of subordinates largely depends on the influence of leaders (Xu and Wang, 2019). Further, leaders are often considered to be representatives of organizations (Bysted and Jespersen, 2014). Subordinates tend to closely focus on the traits and behaviors of their leaders (Zhang et al., 2020).

Leaders tend to be the initiators of innovation (Xu and Wang, 2019). Innovation invariably accompanies risk. Risk, and other changes brought on by employees' creative ideas and behaviors, can challenge established work objectives, working methods, task relationships, and informal norms (Bysted and Jespersen, 2014). These challenges create turbulence and place pressure on executive leadership. In this sense, innovation is driven from the top down; employee creativity thus requires specific signals sent by leaders (Bysted and Jespersen, 2014). When discussing the manner in which leadership behavior motivates innovation, it is important to emphasize that for the vast majority of employees, innovation is deemed as an extra-role behavior (Qu et al., 2015b). As behavioral practices within the organization usually refer to the successful experiences of the past, employees tend to use known solutions to solve similar problems at work rather than seeking new solutions (Ford, 1996). Creative problem-solving carries higher risk, as it requires employees to believe that innovative, new behaviors will be successful. In the absence of this belief, employees will not take the risks to perform beyond their own duties. The attitude of leadership toward innovation is crucial, as employees may depend on top-down motivations for creativity (Xu and Wang, 2019).

Under the "Pygmalion effect," an individual's expectations or predictions based on their perception of a certain situation allow them to adapt. Thus, a leader's expectations are likely to facilitate followers generate creativity. Role expectations can clearly indicate the work that employees should undertake, which plays an important role in shaping role behavior (Dierdorff and Morgeson, 2007). As an important external motivation, leader creativity expectations can significantly influence creative behavior (Qu et al., 2015b; Jiang and Gu, 2017; Nabi et al., 2022). Leaders have an important legal position in the organization as well as the control over their employees' work, including task allocation, performance appraisals, salaries, personnel transfers, and promotions (Xu and Wang, 2019). Employees thus observe and deduce the expectations of their leaders and respond in kind. When leaders prioritize creativity, and set clear expectations for creativity, their followers are more likely to be creative.

Employees with proactive personalities tend to excel at finding opportunities to enhance their current work, and to take positive actions to continuously influence their surrounding environment (Bateman and Crant, 1993; Crant, 2000). Innovative or creative activities may be more time-consuming and riskier

than existing practices (Dewett, 2006), so leaders with creativity expectations should provide greater external support. Creative work also requires high-level cognitive ability and occupies a large amount of resources (Shalley et al., 2009), so leaders with creativity expectations should be mindful of this and timely replenish the resources consumed. Leader creativity expectations can indicate the value of creativity and encouragement of creativity to a certain extent within their organization (Jaussi and Dionne, 2003; Carmeli and Schaubroeck, 2007; Kark and Carmeli, 2009). Further, in individuals with higher self-efficacy (Zhao and Guo, 2019), their perceived leader creativity expectations are directly proportional to their engagement with creative work. When employees' high proactive personalities sense that their leaders expect them to be creative, they will search out and seize opportunities to do so. However, not all employees sense such implications. Those with non-proactive personalities may regard the leader's creativity expectations as external pressure under which they will adopt passive behavior or rebellious attitudes.

Based on the above theoretical analysis and empirical evidence, we find that when the leaders clearly express expectations for innovation, proactive employees will see these expectations as opportunities to engage in creative work. They will respond autonomously, generating creativity that is then fed back into the organization in a cyclical manner. We developed the following hypothesis accordingly:

> *H2*: Leader creativity expectations positively moderate the relationship between proactive personality and employee creativity.

Role clarity

Early researchers tended to emphasize the positive role of leaders in shaping employee behavior, where subordinates are generally conceptualized as passive recipients (Väänänen et al., 2005). The "Pygmalion effect" does not always hold, and it is affected by various factors. For example, the influence of "Pygmalion effect" on female leaders is less than that of male leaders; it also has less influence on existing subordinate groups than newcomers (White and Locke, 2000). In recent years, researchers have begun to focus on the bidirectional nature of social support. There are indeed advantages to both giving and accepting support (Du et al., 2016).

Role indicates the expectations and desires of the individual and organization from each other (Adil et al., 2021). Hence, considering only the role expectations of employees set by their supervisors does not fully reflect the potential for innovation. Employees' cognition of their role (namely, their role clarity) may play the same critical role in the effects of leader creativity expectations. As creativity cannot be separated from the specific content of an employee's work or the environment in which that work is performed (Baer, 2003). Role clarity indicates the extent to which employees acquire and understand the information or data required to complete their work (Kelly and Richard, 1980; Adil et al., 2021). The novelty, complexity, and ambiguity of problems differ among the different people who solve them and the problems that require creative thinking in a certain environment may not translate directly to other environments. Objectives, responsibilities, and rules of behavior also may differ depending on the employee's position, which affect his or her role clarity (Stinglhamber and Vandenberghe, 2004; Panaccio and Vandenberghe, 2011; Orgambídez et al., 2022).

Role clarity, as mentioned above, refers to the extent to which employees believe they have clear guidance for the expected behavior relevant to their job (Jada et al., 2019). Intuitively, role clarity gives employees clear expectations for their performance. Studies have shown that the employees with high role clarity work under an appropriate amount of pressure (Gilboa et al., 2008), less physical fatigue and psychological discomfort (Cenzig et al., 2021; Orgambídez et al., 2022), and have relatively high psychological empowerment (Hall, 2008), which support them in conducting work-related activities independently and creatively. Employees with role clarity report a stronger sense of support from their leaders, which encourages them to take their duties more seriously (Eisenberger et al., 1990; Stinglhamber and Vandenberghe, 2004; Newman et al., 2015). Employees with higher role clarity also tend to have the resources and psychological support necessary to explore and innovate within the parameters of their work responsibilities (Gkorezis, 2016). Employees with low role clarity tend to feel more stress and anxiety at work; an ambiguous environment leaves individuals unable to understand the expectations of the company or leaders regarding their performance (Newman et al., 2015), which is also fed back into the organization and can weaken the effects of any existing leader creativity expectations.

For employees with proactive personalities who perform innovative activities, timely feedback between their leaders' expectations of creativity and role clarity can further strengthen the connection between proactive personality and creativity. We propose the following hypothesis:

> *H3*: The interaction between role clarity and leader creativity expectations influences the relationship between proactive personality and employee creativity; the positive relationship between proactive personality and employee creativity is strongest when both role clarity and leader creativity expectations are high.

Materials and methods

Participants

We issued questionnaires to the innovation teams of several subsidiaries of China XD Group in early December 2020. As one

of the largest state-owned enterprises in China, XD Group's business includes real estate development, new materials engineering, and healthcare. There were relatively active levels of formal and informal exchanges among members of the group. Therefore, supervisors were able to easily obtain information about subordinate actions, and every supervisor who had the opportunity to observe their employees' creative behavior was invited to finish the scoring task. Most of the respondents (87.2%) are engaged in new product development, with only a small number of human resources personnel and manager supporters. Therefore, the sample is suitable for hypothesis testing and the selection bias in this study is low. Table 1 presents the relevant information of participants.

To prevent common method bias to the maximum extent, we adopted a matching "supervisor-subordinate" sample. The respondents were ordinary employees and their direct supervisors within the company. The leader provided corresponding evaluations (A) to the direct subordinate regarding creativity. The employee evaluated his or her leader's creativity expectations, their own proactive personalities, and their role clarity (B) All participants provided personal information in completing the questionnaire, which was kept confidential. A total of 565 pairs of questionnaires were issued in the survey, among which 290 "supervisor-subordinate" pairs were matched. The overall effective recovery rate of the questionnaires was 51.33%. The reason for the low response rate may be that people in the Confucian cultural background characteristics by collectivism and high power distance are unwilling to express their views easily in many cases, especially employees from state-owned enterprises.

Among them, male employees account for 59.7% and female employees for 40.3%. The overall age structure of employees is relatively young, with a minimum age of 21 years and a maximum of 35 years. Up to 73.1% of the total, 212 of the employees, hold a Bachelor's degree; 136 have Master's degrees, accounting for 46.9% of the total; and 17 employees (5.9%) hold PhDs. Leaders and employees had worked together for an average of 3.25 years at the time of their participation, so the data obtained from the questionnaire can be regarded as based on a mutual understanding between them. The employees are considered to have a relatively clear understanding of their own abilities with a certain level of objectivity and accuracy.

Procedure

Before administering the questionnaire, we informed all department heads, supervisors, and volunteers of the purpose and process of this study, and of their privacy rights in participating. Our coordinator gave respondents detailed instructions on the procedures for completing the investigation and the purpose of the study. Additionally, we attached a survey description to each questionnaire that guaranteed the confidentiality of our investigation, with the corresponding certificate number of the supervisor and subordinates displayed in advance in order to match the reply of each interviewee. Furthermore, we prepared a small gift for all participants. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments.

Considering the complexity of paired sampling and the sensitivity of mutual ratings, we have carefully designed the steps of the research and prepared the materials that need to be used. To avoid common method biases and potential biases, we made a separate questionnaire for each subordinate and their direct supervisor. We also used the upper and lower pairing method to obtain relevant data, distributed it to upper and lower staff, and asked each supervisor to complete a questionnaire for only one subordinate. Specifically, the team leader completes the leadership questionnaire, evaluates the creativity of their direct subordinate, and fills in the personal information. The direct subordinate of the team leader then completes the employee questionnaire (including the proactive personality and leader creativity expectations, role clarity), and fills in the personal information.

The scales were translated and re-translated by three doctoral students familiar with both Chinese and English (Brislin, 1980).

TABLE 1 Means, standard deviations, and correlations.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1 Employee age	26.86	3.236									
2 Gender	0.60	0.491	−0.009								
3 Tenure	2.02	0.834	0.676**	0.076							
4 Job type	0.37	0.483	−0.081	0.498**	−0.059						
5 Prosocial motivation	3.01	0.860	−0.003	−0.020	0.014	0.013					
6 Proactive personality	3.16	0.782	−0.022	0.113	0.028	0.083	−0.055	(0.76)			
7 Leader creativity expectations	2.98	0.870	0.005	−0.016	−0.114	0.040	0.037	0.029	(0.75)		
8 Role clarity	3.09	0.979	0.015	0.109	0.028	0.159**	0.023	0.470**	−0.144*	(0.84)	
9 Employee creativity	3.26	0.898	0.008	−0.025	−0.001	0.061	0.117*	0.317**	0.174**	0.207**	(0.84)

$N = 290$. *$p < 0.05$ and **$p < 0.01$.

AVE values are on the diagonal in parentheses.

All items were measured using the Likert 5-point scale (from 1 = strongly disagree or not at all, to 5 = strongly agree or a great deal). In the first wave, with the assistance of department heads and supervisors, we invited employees to participate in answering the corresponding questions. In the second wave, we invited department heads/supervisors to complete the evaluation of employee creativity.

These samples are divided into two groups according to the type of industry using to the method proposed by Frazier et al. (2009) for purpose of examining the non-response bias. The *t*-test results of these two different groups' samples showed no significant difference. Therefore, non-response bias is not a factor that needs to be particularly concerned in this study. In addition, Harman's one-factor test is also be applied to examine common method bias in our study (Frazier et al., 2009). The results show that the first principal component explains for 36.58% of the variance, demonstrating that no single factor exists to account for most of the variance, which further signifies that the common method bias is not serious.

Measure

The scale used in this study was adapted from international mainstream journals, please refer to the Appendix for details. We followed the standard procedure of literal translation and back-translation to ensure that each item's content was accurately maintained after translation. We used a five-level Likert scale to measure the items, where "1" represents "strongly disagree" and "5" represents "strongly agree."

Proactive personality

We measured the employees' proactive personality on 10 items developed by Seibert et al. (1999), including "I have been looking for new ways to improve [my] life," "no matter where I am, I am always the important force to make constructive changes." Cronbach's α for this scale was 0.97.

Employee creativity

We measured employee creativity level on the four items developed by Farmer et al. (2003), including "[I] will first try new ideas or methods" and "[I] will find new… methods when solving problems." The Cronbach's α value is 0.96.

Leader creativity expectations

We measured leader creativity expectations on the four items developed by Carmeli and Schaubroeck (2007). The employees reported their perceived expectations of their direct subordinate leaders for innovation, including "My direct [superior] expects me to be creative at work" and "My direct [superior] expects me to creatively finish [my] work." The Cronbach's α value is 0.92.

Role clarity

We measured role clarity based on a five-item scale from Rizzo et al. (1970) sample items included "I feel certain about how much authority I have" and "There are clear, planned goals and objectives for my job." The Cronbach's α value is 0.96.

Control variables

We control for variables including age, gender, tenure, and job type, which have been found to be significantly related to employee creative performance (Zhang and Bartol, 2010; Harris et al., 2014). Specifically, age is measured in years. Gender is manipulated as a dichotomous variable coded as 0 for females and 1 for males. Tenure is measured as the number of years that an employee had been with an enterprise (Code: 1 for "< 1 year," 2 for "1 to <3 years," 3 for "3 to <10 years," and 4 for "10 to <20 years"). Job type is also manipulated as a dichotomous variable, where 0 represents employees working in R&D departments and 1 represents employees working in non-R&D departments (such as employees working in strategic marketing and functional departments). Furthermore, we control employees' prosocial motivation since employees with highly prosocial behavior may spontaneously engage in creative actions within norms. The scale consists of four items, and a sample item is "I care about benefiting others through my work." The Cronbach's α value is 0.93.

Results

Therefore testing our model, we first analyzed the reliability and validity of the scale. The Cronbach's Alpha is greater than 0.7 with the factor load over 0.7 and AVE over 0.6, indicating that the scale has good reliability and validity. The proposed four-factor model (proactive personality, leader creativity expectations, role clarity, and employee creativity) exhibited an adequate fit with the data ($\chi^2/df = 1.986$, $\chi^2 = 444.929$, $df = 224$, CFI = 0.969, NFI = 0.940, RMSEA = 0.058). The mean value, standard deviation, correlativity values, and AVE values, as shown in Table 1, indicate that all the major variables are significantly correlated with employee creativity. The results of confirmatory factor analysis are shown in Figure 2. The correlation among variables provides preliminary support for verifying our hypotheses.

To verify our hypotheses more exactly, we conducted two-step regression analysis by SPSS PROCESS 3.3 through Model 1 and Model 3. The results are showed in Tables 2 and 3. As shown in Table 2, we can see that the regression coefficient of proactive personality and employee creativity is 0.368 ($p < 0.001$), namely, proactive personality has a positive and significant effect on employee creativity, thus H1 was supported.

We next verified H2. As the results shown in Table 2, the regression coefficient of the interaction term on employee creativity between proactive personality and leader creativity expectations is −0.060 ($p > 0.1$), namely, leader creativity expectations do not significantly moderate the relationship between proactive personality and employee creativity. Higher expectations do not strengthen the relationship over lower expectations, so H2 was not supported.

Table 3 shows that the interaction between leader creativity expectations and role clarity has a significant moderating effect on the relationship between proactive personality and employee creativity ($\beta = 0.148$, $p < 0.001$). Besides, the results of conditional effects of the focal predictor at values of the moderator(s) show that when both role clarity and leader creativity expectations are high (M + 1SD), the positive correlation between proactive personality and creativity is strongest ($\beta = 0.510$, $p < 0.001$). Referring to Cohen et al. (2013), we plot the simple slopes to uncover the nature of the significant three-way interactions by conventional procedures for high (M + 1SD) and low (M-1SD) focal variables. Figure 3 clearly shows that the significant three-way interaction effects of proactive personality, leader creativity expectations, and role clarity on follower creativity. As shown in Figure 3, the positive relationship between proactive personality and employee creativity is significantly proven for high leader creativity expectations—high role clarity (slope 1, $\beta = 0.510$, $p < 0.001$) and high leader creativity expectations—low role clarity (slope 2, $\beta = -0.018$, $p > 0.1$), while the relationships between proactive personality and employee creativity are still significantly proven for low leader creativity expectations—high role clarity (slope 3, $\beta = 0.428$, $p < 0.001$) and low leader creativity expectations—low role clarity (slope 4, $\beta = 0.405$, $p < 0.01$), which means that proactive personality has the most positive effect on employee creativity only when both leader creativity expectations and role clarity are high. Hence, H3 was supported.

Discussion

This study examined the interactive role of synergistic interplay among proactive personality, leader creativity expectations, and role clarity on employee creativity. We investigated the joint moderating effect between leader creativity expectations and role clarity to reveal the function of

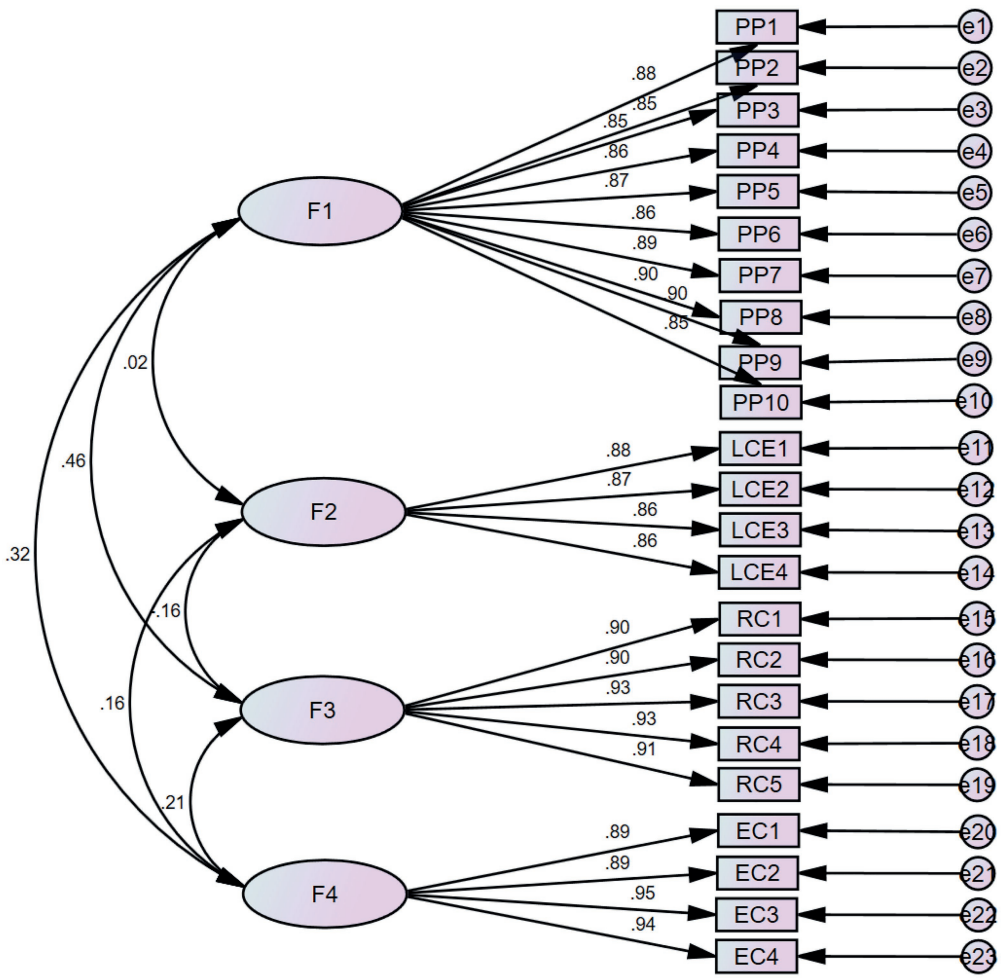

FIGURE 2
Confirmatory factor analysis.

TABLE 2 Hierarchical regression results of Model 1.

	Standardized coefficient	SE	*t*	*p*	95%CI	
					LL	UL
Outcome variable: employee creativity						
constant	2.723	0.507	5.367	0.000	1.724	3.722
Proactive personality	0.368	0.064	5.782	0.000	0.243	0.494
Leader creativity expectations	0.166	0.058	2.878	0.004	0.053	0.279
Int_1	−0.060	0.064	−0.931	0.353	−0.186	0.067
Employee age	0.004	0.021	0.209	0.835	−0.037	0.045
Gender	−0.163	0.117	−1.387	0.166	−0.394	0.068
Tenure	0.016	0.082	0.200	0.842	−0.145	0.178
Job type	0.144	0.119	1.219	0.224	−0.089	0.378
Prosocial motivation	0.142	0.058	2.456	0.015	0.028	0.255
Model summary						
R	R^2	MSE	*F*	df_1	df_2	*p*
0.3963	0.157	0.699	6.544	8	281	0.000

N = 290; Product terms key: Int_1: Proactive personality x Leader creativity expectations.

role shaping in the process of creative problem-solving as affected by personal proactive personality.

We did find a positive correlation between proactive personality and creativity; however, we did not find that the leader creativity expectations moderate the relationship between proactive personality and employee creativity. Though proactive personality is a key factor in enhancing intrinsic motivation (Horng et al., 2016; Mubarak et al., 2021), the process of activating such motivation may be influenced by the external environment (Joo and Lim, 2009; Liao, 2022). According to self-determination theory, once an individual feels that he or she is influenced by external circumstances to take action, any "autonomous" motivations otherwise felt will be significantly reduced. Extremely strong leader creativity expectations may be perceived as a job requirement (Montag et al., 2012; Zhao and Guo, 2019), in which case employees may perform creative behaviors at the behest of their supervisors rather than autonomously (Shin et al., 2017). Creativity expectations can thus be regarded as a form of controlled motivation (Gagné and Deci, 2005).

Controlled motivation refers to the motivation of an individual beyond his or her voluntary will or free choices to engage in a certain behavior under internal (e.g., guilt) or external (e.g., demands of others) pressure. The degree of autonomy over an individual's behavior is relatively weak. Some researchers believe that controlled motivation functions negatively in terms of hindering individual behavior (Deci and Ryan, 2000; Baumeister and Vohs, 2007). Grant et al. (2011) further pointed out that the co-occurrence of autonomic motivation and controlled motivation may result in ineffective behaviors. Namely, controlled motivation may inhibit creativity in work situations or other situations that require innovation. When leader creativity expectations are regarded as controlled motivation, the employee may lose his or her enthusiasm for otherwise highly autonomous and proactive behaviors (Zhao and Guo, 2019).

After considering the individual contingency factor of role clarity, we found that the interaction between leader creativity expectations and role clarity significantly enhances the above relationship, playing a positive moderating role between proactive personality and employee creativity. It is possible that when facing even very high leader creativity expectations, as long as the employee has strong role clarity, he or she can effectively prioritize creativity in regard to the current responsibilities and scope of his or her position. In such cases, leader creativity expectations may not be regarded as a type of controlled motivation as innovation is a "responsibility" rather than "additional work." Thus, employees with strong proactive personalities are more likely to show higher creativity when the creative activities are regarded as a part of their job.

Theoretical significance

We identified a significant positive role of synergistic interplay among proactive personality, leader creativity expectations, and role clarity in stimulating employee creativity, which may enrich relevant research on the Pygmalion effect of creativity. Previous studies have shown that proactive personality can perform as a key antecedent variable for employee creativity (Tai and Mai, 2016; Kim, 2019; Wang et al., 2022; Zhang et al., 2022), and this study further confirms the relationship between proactive personality and employee creativity. This result may be due to the great emphasis that Confucian societies place collectivism. Confucian collectivism urges people to sacrifice individual interests for collective interests in many cases, although the changes brought by proactive personality will challenge the established work objectives, working methods, task relationships, and informal norms (Bysted and Jespersen, 2014).

TABLE 3 Hierarchical regression results of Model 3.

	Standardized coefficient	SE	*t*	*p*	95%CI	
					LL	UL
Outcome variable: employee creativity						
constant	2.801	0.488	5.736	0.000	1.840	3.763
Proactive personality	0.331	0.071	4.666	0.000	0.191	0.471
Leader creativity expectations	0.116	0.062	1.865	0.063	−0.007	0.238
Int_1	−0.098	0.072	−1.361	0.175	−0.239	0.044
Role clarity	0.042	0.058	0.718	0.474	−0.073	0.156
Int_2	0.141	0.050	2.843	0.0048	0.043	0.238
Int_3	0.101	0.054	1.859	0.064	−0.006	0.208
Int_4	0.148	0.044	3.392	0.0008	0.062	0.234
Employee age	−0.002	0.020	−0.108	0.914	−0.042	0.037
Gender	−0.165	0.113	−1.466	0.144	−0.387	0.057
Tenure	0.041	0.079	0.514	0.608	−0.115	0.196
Job type	0.127	0.115	1.103	0.271	−0.100	0.353
Prosocial motivation	0.150	0.056	2.704	0.007	0.041	0.259
Conditional effects of the focal predictor at values of the moderator(s)						
Leader creativity expectations	Role clarity	Effect	SE	t	*p*	
−0.870	−0.979	0.405	0.124	3.268	0.0012	
−0.870	0.000	0.416	0.096	4.331	0.0000	
−0.870	0.979	0.428	0.104	4.129	0.0000	
0.000	−0.979	0.193	0.092	2.112	0.0356	
0.000	0.000	0.331	0.071	4.666	0.0000	
0.000	0.979	0.469	0.080	5.866	0.0000	
0.870	−0.979	−0.018	0.108	−0.170	0.8655	
0.870	0.000	0.246	0.093	2.641	0.0087	
0.870	0.979	0.510	0.114	4.455	0.0000	
Model summary						
R	R^2	MSE	F	df_1	df_2	p
0.485	0.235	0.644	7.103	12	277	0.000

N = 290; Product terms key: Int_1: Proactive personality × Leader creativity expectations; Int_2: Proactive personality × Role clarity; Int_3: Leader creativity expectations × Role clarity; and Int_4: Proactive personality × Leader creativity expectations × Role clarity.

Secondly, this research helps deepen our understanding of the Pygmalion effect of creativity. Even for employees with proactive personalities, leader creativity expectations may not necessarily be effective in enhancing employee creative performance. This result supports the finding of Zhao and Guo (2019) to a certain extent, and also indicates that employee with proactive personality has stronger intrinsic motivation rather than controlled motivation (Ng and Feldman, 2013; Horng et al., 2016; Kim, 2019; Mubarak et al., 2021). Besides, we found that although leader creativity expectations do not significantly enhance the relationship between proactive personality and employee creativity, once role clarity (a "contingency factor") is considered, the interaction between leader creativity expectations and role clarity does positively moderate the relationship between proactive personality and employee creativity. Under the conditions of both extremely high leader creativity expectations and role clarity, there is a strong positive correlation between proactive personality and creativity. This finding enriches our empirical understanding of the connotations of role shaping. According to the role theory (Anglin et al., 2022), role shaping should not only rely on leader role expectations, but more importantly, employees' own role cognition and role-related learning. Role clarity indicates the extent to which employees acquire and understand the information or data required to complete their work (Kelly and Richard, 1980; Adil et al., 2021). Role clarity can create "mutual matching" between individual factors and contextual factors. Shalley et al. (2004) also found that matching between individual personality characteristics and situations can make employees more creative, which supports the conclusions we reached in the present study.

Practical significance

Our results may have significance in terms of managerial practices. Organizations may enhance their overall creativity by selecting employees with specific personality traits (Zhang et al., 2020). Proactive employees are relatively more creative,

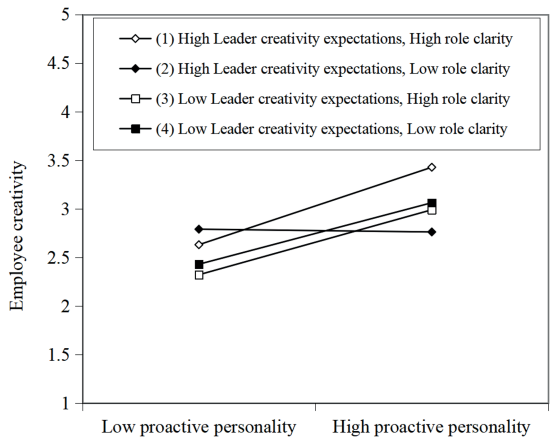

FIGURE 3
Three-way interaction effects of proactive personality, leader creativity expectations, and role clarity on employee creativity.

so hiring or promoting those with stronger proactive personalities may be useful—especially for positions that explicitly require creative problem-solving. Organizations should also understand the key role of leaders, particularly in regard to establishing and enforcing creativity expectations as well as providing role clarity. Leader creativity expectations at a certain level can damage the sense of self-determination in employees with stronger proactive personalities, thereby damaging their creativity, so administrators should dynamically adjust the expectations assigned to different types of employees' creative behaviors. The organization should help employees to clearly understand their roles, clearly communicate the specific duties of their positions and relevant tasks, strengthen job training specific to certain roles, and encourage leadership. The results of this study also prove that mutual matching between individual factors and situational factors stimulates employee creativity to the greatest extent possible. When an organization intends to stimulate the overall creativity, it would benefit from matching appropriate team leaders to employees based on their individual personal characteristics.

Limitations and future research

Although the vector relationships explored in our hypotheses are consistent with previous studies, cross-sectional data did not serve as an ideal design for establishing the causal order between the proposed relationships. Future work may use multi-wave time-lagged research to provide more accurate inferences. The second limitation of the study is that role clarity is in fact "perceived role clarity" as the actual role clarity is not measured, only the perceived. Future research can adopt indicators of specific work demands that can objectively reflect the level of role clarity. Third, we did not examine the possible mediating effects between the three-way interaction and employee creativity. It is of great significance to investigate the mediating mechanism, as it will help reveal the method by which proactive personality is related to employee creativity.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

XW, MW, and FX jointly designed the general idea and outline of the manuscript. FX and XW created a first draft. FX and MW revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Appendix

Proactive personality
I have been looking for new ways to improve [my] life.
No matter where I am, I am always the important force to make constructive changes.
Nothing is more exciting than seeing my ideas turn into reality.
If I see something I do not like, I fix it.
No matter what the odds, if I believe in something I will make it happen.
I love being a champion for my ideas, even against others' opposition.
I excel at identifying opportunities.
I am always looking for better ways to do things.
If I believe in an idea, no obstacle will prevent me from making it happen.
I can spot a good opportunity long before others can.
Employee creativity
I will first try new ideas or methods.
I will find new ideas and methods when solving problems.
I will Generates ground-breaking ideas related to the field.
I am a good role model for creativity.
Leader creativity expectations
My direct [superior] expects me to creatively finish [my] work.
My supervisor thinks that creativity is important to me.
My direct [superior] expects me to be creative at work.
My supervisor would probably be disappointed in me if I was not creative.
Role clarity
I feel certain about how much authority I have.
There are clear, planned goals and objectives for my job.
I know exactly what is expected of me.
I know what my responsibilities are.
I know that I have divided my time properly.

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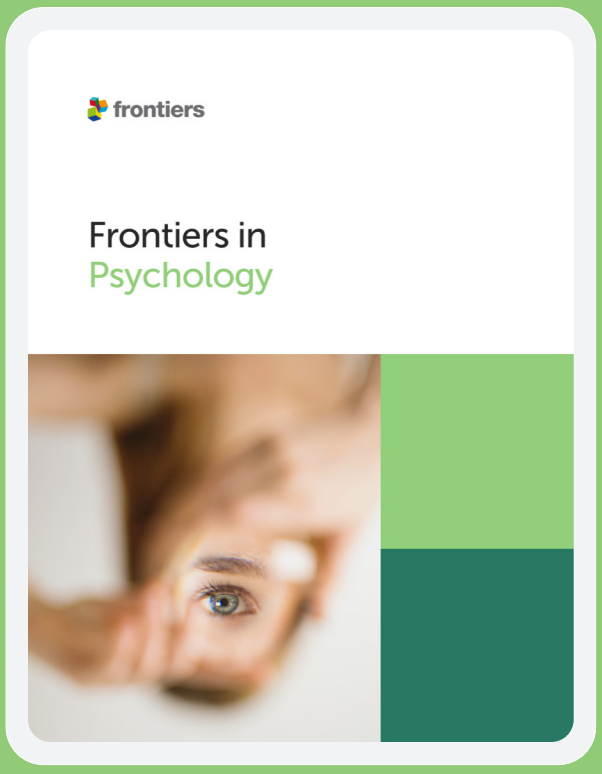

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