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Assessments and measures in psychotherapy research: Going beyond self-report data

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Assessments and measures in psychotherapy research: Going beyond self-report data

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Editorial: Assessments and measures in psychotherapy research: going beyond self-report data

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Editorial on the Research Topic
Assessments and measures in psychotherapy research: going beyond self-report data

Introduction

Good clinical decision-making during case conceptualization, treatment selection, and the adjustment of the therapeutic strategy over the course of treatment can improve the effectiveness of psychotherapy. To support therapists making such decisions, measurement-based and data-informed psychological therapy, which relies on prediction algorithms, can be implemented (1). In recent decades, the statistical methods used to create these algorithms have improved rapidly, e.g., with the introduction of machine learning (ML) into psychotherapy research (2). However, these advanced methods quickly reach their limits when the data base is insufficient to realize their full potential to predict outcomes and derive clinical recommendations. Indeed, psychotherapeutic processes are rich on various channels, including verbal and nonverbal exchanges between patients and therapists, emotional expressions, somatic-motor activity, and physiological processes. These different modalities convey important information about patients' mental states, thoughts, and emotions and can lead to a more in-depth understanding of psychotherapy processes and outcomes. However, most measurement-based prediction algorithms have been calculated based on self-report data. Although they are the cornerstone of psychotherapy research, standardized subjective self-report measures have critical shortcomings, including limited patient self-insight, response tendencies, and cognitive biases (e.g., memory bias) (3, 4). To better support therapists with the most accurate models and recommendations, we must go beyond self-report questionnaires. In the following sections, we will summarize assessments and measures in psychotherapy research that can capture important information about patients and treatment in addition to and beyond self-report questionnaires, thus providing novel data for evidence-based and data-informed psychotherapy.

Video and observer-based data

With advancing technology and digitization, video recordings can provide more objective information about the patient, therapist, and treatment non-invasively and with high temporal resolution. Observation methods can be applied to video recordings to capture verbal information and behavior (e.g., therapeutic interventions) (5), as well as non-verbal cues, such as movement (e.g., movement-based attunement) (6), gestures, and facial expressions. Methodological studies evaluating the validity of these measures are crucial to gain insight into what we are assessing (7). Three papers in the Research Topic examine video- and observer-based methods. Maaß et al. validated a brief rating scale to reliably and applicably assess basic psychotherapeutic communication skills in clinical training. Diaz et al. applied an observational coding system measuring relationship-building behaviors between therapist and clients and modeled affective dynamics within the dyads. Terhürne et al. introduce a video-analysis system for automated emotion recognition and examined associations between system ratings of emotional valence and arousal and self-reports, change processes, and symptoms.

Audio and text data

Each video recording also provides one or more audio tracks containing verbal and paraverbal information. Linguistic expressions in a session reveal patient and therapist thoughts and emotions and provide information about the dyadic interaction, which can be extracted and analyzed via natural language processing. Speech content is transcribed either manually by human raters or automatically and thus transferred into text form. These texts can be evaluated by qualitative linguistic analyses or according to predefined categories such as sentiments (8). Paraverbal parameters, e.g., speech rate, speech frequency, and vocal arousal, can be extracted from the audio files to examine intra- and interpersonal emotion dynamics and other therapeutic processes (9, 10). Four papers in this Research Topic analyze verbal or paraverbal features. Broadbent et al. identified clients at risk of suicide using natural language processing on data from a text-based crisis encounter and mobile tipline app. Egozi et al. applied observational measures of attachment and therapeutic distance to transcripts of video-recorded patient and therapist narratives about their therapeutic relationship. Lee et al. examined transcribed session recordings regarding the use of discourse particles, which indicate the formality in language, and its association with observer-rated therapist empathy. Opladen et al. validated fundamental frequency $f0$, which is a commonly used index for emotional activation, as a marker of arousal, valence, and distress during a body exposure session.

Physiological data

Considering the close association between psychological and physical processes, biological and physiological variables can offer further useful information. Variables such as heart rate variability (HRV) or electrodermal activity (EDA) allow an objective and continuous recording of stress or emotional arousal during the therapy session. Additionally, patient and therapist co-activate and co-regulate their physiological responses (11). The availability of smartwatches and other wearable devices means that these measurements no longer represent a noticeable intrusion into the therapeutic setting (12). Three papers in this Research Topic rely mainly on data from physiological measures. Andorfer et al. assessed the psychophysiological stress response during a social-evaluative speaking task via HRV, heart rate, and blood pressure to evaluate the effectiveness of a mindfulness-based intervention. Nyman-Salonen et al. provide a narrative review of opportunities and challenges associated with measuring embodied variables in psychotherapy, which focuses on the sympathetic nervous system and body movements. Looking to the future, Hollandt et al. present the protocol of a pilot study planning to examine the dyadic synchrony of heart rate, EDA, and electroencephalogram via wearable devices during two experimental emotion-processing tasks.

Experimental tasks

The measures discussed above can be collected passively before, during, and after treatment. Patients do not have to do anything other than participate in the regular course of therapy, meaning that these assessments often involve less effort for patients than self-report questionnaires. However, additional information about patients can also be obtained via more active assessment methods such as experimental tasks. Psychological tasks can, for example, include implicit association tests as an indirect measure of pathological attitudes and cognitions or change processes such as outcome expectations (13). In this Research Topic, one paper applied an experimental task. Amano et al. assessed reaction times and the ratio of the number of responses for positive valence in the future thinking task as potential objective measures of treatment process and outcome.

Conclusion

This Research Topic highlights the range of possible assessments and measures in psychotherapy that go beyond self-reports. The 11 studies aimed at validating these measures as well as measuring and predicting treatment processes and outcomes. The next step must involve the multimodal and multimethod assessment of patient and treatment information. Some studies included here have already collected measures from varying channels (e.g., Opladen et al.), and introduce methods to integrate information from different modalities (e.g., Nyman-Salonen et al.). With the advancing digitization and technologization of psychotherapeutic settings, the implementation of these measures into routine care is becoming more feasible. Nevertheless, it requires time, resources, and improved scientific training for practitioners to be able and feel

confident making clinical decisions supported by these new sources of data (1).

Author contributions

BS: Conceptualization, Writing—original draft, Writing—review and editing. JU: Writing—review and editing. DA-S: Writing—review and editing.

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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.

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The concise measurement of clinical communication skills: Validation of a short scale

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Objective: There is a lack of brief rating scales for the reliable assessment of psychotherapeutic skills, which do not require intensive rater training and/or a high level of expertise. Thus, the objective is to validate a 14-item version of the Clinical Communication Skills Scale (CCSS-S).

Methods: Using a sample of N = 690 video-based ratings of role-plays with simulated patients, we calculated a confirmatory factor analysis and an exploratory structural equation modeling (ESEM), assessed convergent validities, determined inter-rater reliabilities and compared these with those who were either psychology students, advanced psychotherapy trainees, or experts.

Results: Correlations with other competence rating scales were high ($rs > 0.86–0.89$). The intraclass correlations ranged between moderate and good [$ICC_{(2,\ 2)} = 0.65–0.80$], with student raters yielding the lowest scores. The one-factor model only marginally replicated the data, but the internal consistencies were excellent ($\alpha = 0.91–95$). The ESEM yielded a two-factor solution (*Collaboration* and *Structuring and Exploration Skills*).

Conclusion: The CCSS-S is a brief and valid rating scale that reliably assesses basic communication skills, which is particularly useful for psychotherapy training using standardized role-plays. To ensure good inter-rater reliabilities, it is still advisable to employ raters with at least some clinical experience. Future studies should further investigate the one- or two-factor structure of the instrument.

KEYWORDS

standardized patient, treatment integrity, measurement, therapist competence, role-play, psychotherapy process

Introduction

One of the main goals of psychotherapy training is to improve trainees' skills (1, 2). In order to identify these skills and monitor their changes as recommended by several authors (3, 4), valid and reliable measurement methods are needed (5, 6). Such measurements should be suitable for a number of different training contexts, for example, for the use in role-plays with simulated patients—a training approach that is becoming increasingly important in psychotherapy training (7–11).

Role-plays are particularly appropriate for assessing "therapist competency" in the narrower sense, that is, the demonstration of therapeutic skills in controlled conditions. By contrast, the assessment of competences in real therapy sessions and of treatment delivery refers to "therapy quality" (11–14). Ottman et al. note that "the need for reliable, standardized methods to assess therapist competency prior to treating clients remains a significant gap in the literature" (p. 10). Although role-plays offer a number of benefits, such as fair competence tests and targeted training for difficult situations (8), it is not easy to evaluate those skills that only come into play during the course of therapy or against the background of a specific treatment strategy (e.g., case conceptualization, repairing relationship ruptures etc.). The measurement of competencies in role-plays is therefore either limited to very specific skills that are necessary for the particular simulated scenario (e.g., performing an exposure) or focuses on general skills that are observable across situations. These common skills are often referred to as common therapy factors and include such skills as interpersonal skills or communication (15). Consequently, most competence measures include at least one item relating to such common factors (11, 16). There is evidence emphasizing the relevance of communication skills in particular for the improvement of client outcomes in therapy (17–19). However, so far, there is a lack of reliable instruments assessing communication skills that can be applied to different role-play scenarios across situations. For example, Ottman et al. (11) found only eight studies (out of 43) that measured competencies in standardized role-plays, whereas most instruments were applied to the assessment of real therapy sessions.

For cognitive behavioral therapies (CBT), two of the most prominent competence rating scales are the Cognitive Therapy Scale (CTS) (20) and its revised version (CTS-R) (21). The CTS-R consists of 12 items, which use a comprehensive 7-point rating scale. While some items might be appropriate for assessment in role plays, such as "interpersonal effectiveness," other items relate to overarching skills or very specific ones that are not observable in all situations, such as "agenda setting," "homework setting," or "conceptual integration." In addition, the CTS and CTS-R have been criticized for having a number of limitations, for example, unclear definitions of the behavioral basis underlying each item, low content validity, item overlap, and concept overlap within items (6, 13).

Another newly developed rating instrument is the Assessment of Core CBT Skills Scale (ACCS) (22), which comprises 22 items with a 4-point anchored rating scale. The authors' intention was to address some of the criticisms of the CTS-R, for example, by developing clearer behavioral anchors to reduce the evaluators' room for interpretation. However, in terms of usability for competence assessment in role-plays, the measurement also includes too many situation-specific items (e.g., homework, assessing change, CBT interventions).

Both the CTS/CTS-R and ACCS have also been criticized for their time-consuming application and the costly training of raters that is needed to achieve high rating reliabilities (16, 23). However, high levels of inter-rater reliability are not always accomplished across studies (5, 11). One reason might be the varying degree of rater expertise. In line with that, Wu et al. (24) suggested that expert ratings should serve as a standard for adherence ratings. This might also be true for competence ratings. For example, Weck et al. (25) found that, while novice raters achieved satisfactory ICCs without significant differences to the ratings of experts, the concordance between expert and novice raters was only moderate. In addition, Kühne et al. (26) reported that raters with both more clinical experience and experience in using the corresponding rating scale achieved higher ICCs.

Thus, while the commonly used competence rating scales (e.g., CTS/CTS-R, ACCSS) are well validated, they also display some general limitations (i.e., heterogeneity in ICCs, high training and completion effort, high expertise level required) and specific restrictions (i.e., focus on specific CBT techniques rather than on common factors) for the application across different situations (e.g., in role-plays).

For these reasons, Kühne et al. (23) developed a competence rating scale, the Clinical Communication Skills Scale (CCSS), which is easy and quick to complete and covers basic counseling techniques. The CCSS examines basic psychotherapeutic communication skills such as, asking open-ended questions, expressing empathy, or exploring cognitions, emotions, and behaviors. It is an observation-based assessment of general and cognitive-behavioral skills in both real and simulated patient situations, and includes 37 items and a 4-point rating scale. It thereby focuses on common factors rather than specific CBT techniques. In contrast to the CTS/CTS-R and ACCS, the CCSS does not deploy a comprehensive rating scale with behavioral anchors. Instead, the items are short and behavior-based. Examples of items that demonstrate the behavior orientation are "gives the patient time to talk and to ask questions" or "summarizes interim results."

In a sample of $N = 209$ lay-persons and psychology students, the CCSS revealed a unidimensional one-factor structure with an excellent internal consistency ($\alpha = 0.94$). The instrument achieved moderate to high convergent validity with established rating instruments (e.g., communication item of the CTS: $r = 0.59$, empathy: $r = 0.68$) and a good differentiation between high and low levels of competence of the therapists being rated (23).

Thus, the CCSS is a promising instrument for application in training with standardized role-plays in particular. It assesses clinical communication skills which is seen not only as an important basic skill that therapists have to acquire in their training (1), but also as a common factor of most competence measurements (11) and a predictor of therapy success (19). However, the original validation of the CCSS has not yet provided inter-rater reliabilities. Furthermore, the high internal consistency justifies the reduction of the item number, which will in turn decrease the time raters need to complete the scale. Especially in contexts like research, supervision and training, shorter scales are often needed due to time restrictions. Generally, short scales are advantageous, because they ensure the representativeness of the construct of interest without content repetition (27) and do not tend to overestimate the internal consistency (28).

Consequently, the objective of this present study is to validate a short version of the CCSS (23) in the context of standardized role-plays. Furthermore, as an extension to the original study, we will calculate inter-rater reliabilities (i.e., intraclass correlations, ICCs) based on video recordings of therapists behavior in simulated therapy session segments (i.e., standardized role-plays). Finally, we evaluate the impact of rater expertise by comparing the ICCs of trained psychology students, advanced psychotherapy trainees, and licensed psychotherapists with each other.

Research questions and hypotheses

Our research questions were: (1) What are the psychometric properties of a short version of the German (CCSS-S)? (2) Do the inter-rater reliabilities for the CCSS-S differ significantly between the expertise levels of raters (i.e., psychology students, advanced psychotherapy trainees, licensed psychotherapists)?

We assumed that the one-factor structure of the original CCSS, the internal consistency, and its nomological network associations could be replicated for the CCSS-S (23). In addition, we examined the influence of rater expertise on the ICCs. Based on previous results, one would assume that expert raters achieve higher ICCs. However, previous studies were based on comprehensive rating scales (CTS) (24), ACCS (25), while the CCSS was developed to be useful without intensive training. Thus, one could also argue that there should be equivalent results between different levels of rater expertise. For this reason, we conducted an exploratory comparison of the ICCs between psychology students, advanced psychotherapy trainees, and licensed psychotherapists.

Materials and methods

We preregistered the methods and statistical analyses on the Open Science Framework[1] and indicated when we deviated from the procedure described therein.

Validation procedure for the clinical communication skills scale - short version

We analyzed four data sets that have recently been collected as part of three different studies (7, 23, 29). The data sets have not been analyzed before for the purpose of validating the CCSS-S. The validation was conducted in three parts (see text footnote 1 for a detailed description). (1) *Item Selection*: We analyzed the original data for the CCSS (data set 1, see below) to select the best items for a short version. (2) *Validation of the CCSS-S*: We analyzed three additional data sets (data sets 2–4, see below) to determine the validities (i.e., construct and convergent) and reliabilities (i.e., internal consistencies, intraclass correlations) for rater-based data. (3) *Exploratory analyses*: We compared the intra-class-correlations (ICCs) across different rater perspectives (psychology students, advanced psychotherapy trainees, licensed psychotherapists).

Participants in the original studies

Data set 1 originates from a cross-sectional online study of which the main objective was to validate the CCSS (23). We selected the items for the CCSS-S based on an analysis of a subsample ($N = 154$) which evaluated the competences of a therapist in a video of a simulated therapy session (8 min). Data sets 2–4 were used for the validation of the CCSS-S. The data originate from two randomized controlled trials comparing different training methods for psychotherapists (7, 29). In each study, two trained raters watched videos of simulated therapy sessions (20 min) and evaluated the competences of $N = 69$ psychology students, in the roles of therapists across several measurement points. The raters were female and had different degrees of psychotherapy expertise: two licensed psychotherapists (data set 2), two psychology students (Master's degree, data set 3), and two advanced

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psychotherapy trainees (data set 4). For the detailed design and sample descriptions, refer to the original studies (7, 23, 29).

Ethics approval and consent to participate

Ethical approval for the original studies was obtained from the University of Potsdam Ethics Committee with the reference numbers 9/2018 (7), 01/2019 (23), and 60/2021 (29).

Measurements

For the nomological network analysis, we examined (a) therapist competence with the German version of the Cognitive Therapy Scale (CTS) (20, 30), (b) therapist empathy with the German Empathy Scale (ES) (31), and (c) therapeutic alliance with the German Helping Alliance Questionnaire (32). All measurements are observer-based rating (ES and HAQ were originally developed as self-report instruments (33, 34), but we used the observer-based versions (for details on the measures, see **Supplementary material 1**).

Statistical analyses

Item selection

The process of item selection is described in more detail in the pre-registration (see text footnote 1). A group of five experts (i.e., the study authors: three licensed psychotherapists, two psychologists with advanced psychotherapy training) selected and discussed those 20 items of the CCSS that best represented "clinical communication skills" (35). Statistical properties were also considered to ensure a balance between good representation of the construct, item difficulties (20–80%), and high item-total correlations (0.40–0.70) (36). Factor loadings ranged between 0.42 (Item 14) and 0.73 (Item 13), item difficulties ranged between 70 (Item 25) and 80% (Item 15), and item-total correlations ranged between 0.39 (Item 14) and 0.68 (Item 13). Finally, we selected 14 items for the CCSS-S (see **Supplementary material 2**). The CCSS-S needs approximately 2 min to complete.

Validation of the clinical communication skills scale - short version

The validation included a confirmatory factor analysis, a nomological network analysis, and a determination of the internal consistency and intraclass correlations (ICCs). Except for the ICCs, the rater scores were averaged across both raters per data set. All outcome variables were analyzed using mean scores. Analyses were conducted with R (37); Version 2021.09.1 + 372), including the packages lavaan (38) and psych (39).

Structural validity

Confirmatory factor analysis

In accordance with previous data on the CCSS (23), we specified a one-factor model using robust maximum likelihood estimation, and evaluated the model fit following the standard recommendations for the CFI, RMSEA, and SRMR fit indices (40): CFI $\geq$ 0.95, RMSEA $\leq$ 0.05– $\leq$ 0.06, SRMR $\leq$ 0.05– $\leq$ 0.08.

Nomological network analysis

We calculated bi-variate correlations for both the CCSS and the CCSS-S with the corresponding convergent measures. In the area of therapist competence, it is not easy to identify clear convergent and discriminant measures, because professional communication, empathy, and working alliance capture unique aspects but are still considered part of therapist competence (41). As already shown by other studies (23, 42), the intercorrelation between these variables is relatively high. Also, the performance of specific CBT techniques, as captured by the more global competency scales CTS or ACSS, cannot be separated from *the way* they are delivered (e.g., in what way and how emphatically they are communicated). Therefore, although we consider ES and HAQ to be conceptually discriminant measures for the CCSS-S in this study, we still expect moderate to high correlations. This is also suggested by the results of other studies (43, 44). To compare the nomological networks between the CCSS and the CCSS-S, we determined vector correlations based on the quantifying construct validity procedure (45), which "quantifies the match between a set of validity correlations and a set of hypotheses regarding convergent and discriminant validity" (p. 2). We interpreted the following two indicators in order to examine the degree of correspondence between the correlations of the CCSS and CCSS-S. Higher values (i.e., > 0.79) of the indicator $r_{alerting-CV}$ indicate that the "degree to which the strongest (vs. weakest) predicted correlations are, in fact, the strongest (vs. weakest) actual correlations" (p. 6). In addition, higher values (i.e., > 0.71) of the indicator $r_{contrast-CV}$ demonstrate "the degree to which the actual correlations are well differentiated (i.e., differ from each other) and are ordered (from high to low) in a way that parallels the predicted correlations." (p. 7).

Reliability indices

We calculated the internal consistencies for the CCSS and CCSS-S using Cronbach's alpha. In addition, we determined $ICCs_{(2,\ 2)}$ (46) for each group of rater pairs (i.e., psychology students, advanced psychotherapy trainees, licensed psychotherapists). We interpreted values less than 0.5 as "poor," between 0.5 and 0.75 as "moderate," between 0.75 and 0.9 as "good," and greater than 0.90 as "excellent" (47).

Exploratory analyses: Rater-perspective comparison of intra-class-correlations

We compared the stability of the ICCs for the CCSS-S across different expertise levels of the raters (i.e., psychology students, advanced psychotherapy trainees, licensed psychotherapists). We concluded that ICCs were largely comparable across the various levels of expertise if the 95% CIs overlapped (48, 49).

Sample size and power

The power calculations are described in detail in the pre-registration. We combined the data from the first two measurement points of data sets 2–4, leading to a sufficiently powered sample size of N = 690 competence ratings (see **Supplementary material 3** for an overview of the sample sizes per data set).

Deviations from the preregistration

We differed from the original pre-registration in the following ways: (1) Before conducting the analyses, we decided to refrain from using the Authenticity of Patient Demonstrations (50) as a discriminant measurement, because it is not related to therapist behavior but to the performance of simulated patients. (2) We analyzed N = 690 instead of N = 414 videos, as indicated in the pre-registration, because therapists in data sets 2 and 3 produced two videos (instead of one) per measurement point, due to there being two different tasks in the corresponding study (7). (3) We used Finn's r as an additional inter-rater reliability coefficient, because, during the test of pre-requisites for using ICCs, we discovered that the data were skewed. In such cases, Finn's r for ordinal data is recommended, because it is not influenced by low variances (51, 52); interpretation according to Pearson's correlation) (4). Due to an unexpectedly poor model fit, we decided to calculate an exploratory structural equation modeling (ESEM) in addition to a confirmatory factor analysis (CFA).

Results

The descriptive statistics and correlations for the CCSS and CCSS-S can be found in **Table 1**.

Factor structure

The one-factor CFA for the CCSS-S resulted in a borderline model fit, CFI = 0.90, RMSEA = 0.11, and SRMR = 0.05. Therefore, we decided to perform an additional exploratory analysis to better understand the factorial structure. We used exploratory structural equation modeling (ESEM) (53), which is intended to result in a more realistic representation of the data, because cross-loadings between items are allowed, just as in exploratory factor analysis, but not in CFA (54). To avoid bias that results from multiple analyses of the same data, we used a partly new data set for this analysis, namely the full data sets 2 and 3 including all three measurement points (N = 718 ratings; see **Supplementary material 3**).

Based on the procedure described by Silvestrin (55), ESEM starts with an exploratory factor analysis with oblique rotation, followed by an CFA-like model that implements cross-loadings, fixed factor variances, EFA loadings as starting points, and one anchor per factor (high loadings on one factor and low loadings on the others). The EFA yielded a two-factor solution (explained variance: Factor 1 = 22.5%, Factor 2 = 21.7%). The ESEM confirmed this structure, as indicated by an excellent model fit: CFI = 0.95, RMSEA = 0.07, and SRMR = 0.04. Factor 1 included 8 items (**Supplementary material 4**) with unstandardized loadings ranging from 0.39 (Item 1) to 0.84 (Item 3). This factor could be best described as *Collaboration Skills*. Factor 2 contained 6 items (**Supplementary material 4**) with loadings ranging from 0.46 (Item 4) to 0.96 (Item 5). This factor could be best described as *Structuring and Exploration Skills*. It is worth noting that there were relatively high cross-loadings, given that only five items loaded on their designated factor above 0.60. For example, Item 11 ("Works through content together with the patient") in particular, had almost equal loadings on both factors (0.44 and 0.52). The two factors were significantly correlated (r = 0.67, $p < 0.001$). Because of the exploratory nature of this analysis, we did not use the two factors in the proceeding analyses.

Nomological network analysis

Overall, there were high correlations between the CCSS-S and the other measurements (r = 0.80–0.88; **Table 1**). The vector correlations were $r_{\text{alerting}-CV}$ = 0.80, indicating high similarity between the correlations of the original CCSS and the CCSS-S. The second vector index was very low, $r_{contrast-CV}$ = 0.22, 95% CI [0.15, 0.30], $p < 0.001$. However, this is probably due to the restricted variance across the correlations, as we did not include discriminant measurements with low or only moderate correlations.

Reliability and rater-perspective comparison

The reliability indices are displayed in **Table 2**. The internal consistencies of the CCSS-S were high (> 0.90). The ICCs ranged between moderate (data set 3, students), and good (data sets 2, experts, and 4, advanced trainees). In addition to the ICCs, we calculated Finn's r for each item of the CCSS, because as **Supplementary material 5** shows, the variance of

TABLE 1 Means, standard deviations, and correlations (N = 690).

Variable	*M*	*SD*	1	2	3	4
1. CCSS	2.93	0.44	–			
2. CCSS-S	2.88	0.47	0.97 (0.97, 0.98)	–		
3. CTS	2.55	0.87	0.82 (0.80, 0.85)	0.86 (0.84, 0.88)	–	
4. HAQ	3.20	0.71	0.89 (0.87, 0.90)	0.88 (0.86, 0.90)	0.82 (0.80, 0.85)	–
5. ES[a]	3.35	0.41	0.82 (0.79, 0.84)	0.80 (0.77, 0.83)	0.65 (0.60, 0.70)	0.82 (0.79, 0.85)

CCSS, Clinical Communication Skills Scale (original version); CCSS-S, Clinical Communication Skills Scale Short Version; CTS, Cognitive Therapy Scale; HAQ, Helping Alliance Questionnaire; ES, Empathy Scale; Values in brackets indicate the 95% confidence interval for each correlation. All values are significant at $p < 0.001$. [a]n = 586 due to missing values.

CCSS scores was restricted and the data did not follow a normal distribution (except data set 4). For the CCSS-S items, Finn's r ranged from 0.50 to 0.94, indicating good inter-rater reliability (**Supplementary material 6**). Although the student raters achieved the lowest ICC scores, the confidence intervals for the ICCs overlapped with experts and advanced trainees.

Discussion

The purpose of the study was to validate the short version of the CCSS (23), the CCSS-S, which is an observer-based rating scale for the assessment of basic therapist skills, with a focus on communication. We pursued a transparent and structured approach to selecting appropriate items for the CCSS-S, following recommendations for constructing short scales (35). By analyzing a sufficiently large sample size (i.e., N = 690 video-based ratings of simulated therapy sessions), the results show that the CCSS-S is a feasible short scale that demonstrates comparable reliabilities and validity with the original scale.

The convergent correlations with other competence measurements (i.e., CTS, HAQ, ES) were high (rs > 0.86–0.89). The values demonstrate that each measurement can be subsumed under the construct of "therapist competence," but still assesses certain unique aspects. While the HAQ focuses on the trusting relationship between patient and therapist, the ES focuses even more on the expression of empathy by the therapist. The CCSS-S also partially captures variables of empathy and therapeutic collaboration, for example with items such as "reacts with empathy to the feelings of the patient" and "works through the content together with the patient." Similarly, the CTS includes items for assessing the alliance and empathy (i.e., interpersonal effectiveness), and also communication skills (i.e., guided discovery, clarity of communication, use of summaries). The high correlations among those measurements are in line with a recent meta-analysis of 53 studies, which found that the therapeutic alliance was significantly associated with therapist empathy (r = 0.50) (41). Furthermore, a longitudinal study demonstrated that the use of common factor skills, such as active listening, are associated with higher ratings of the alliance, and vice versa (56). Nevertheless, the description of the nomological network of "therapist competence" deserves further investigation, especially with regard to the discriminant variables. It has not yet been conclusively clarified whether different measurements with different competence foci are necessary, or whether it is simply very likely that competent therapists generally achieve high scores on different competence aspects [e.g., (16)].

The internal consistency of the CCSS-S (α = 0.91–95) was excellent and the inter-rater reliabilities in this study ranged between moderate to good [i.e., $ICC_{(2,\ 2)}$ = 0.65–0.80 at mean level, Finn's r: 0.50–0.94 at item level]. In general, inter-rater reliabilities are lower when the variance of ratings is restricted (51), which was the case in the sample of this study. One explanation for this could be the standardized setting, in which the tasks for all participants were the same (e.g., in the student and expert rater data sets), the participants were mostly therapy beginners and thus had a similar skills level. In addition, raters were encouraged to consider the background knowledge of the participants. Future studies should examine the inter-rater reliabilities of the CCSS-S in real clinical situations, where a higher variance in skills can be expected.

One aim of the development of the instrument was not to afford a comprehensive rater training, because the items are behavior-based (23). Although the CCSS-S is in fact easy to administer, it might not be completely independent of the rater's expertise. The ICCs between the different raters were comparable (as judged by their overlapping confidence intervals), however, the absolute ICCs were somewhat lower for the student raters. Future studies need to investigate this difference further. At the moment, it seems advisable to apply raters with at least some clinical experience to achieve good inter-rater reliabilities. However, if personal resources are limited, student raters are also a feasible option. In this case, close monitoring and additional training can improve the inter-rater reliabilities (57). This includes a shared understanding of the items and how to interpret behavioral indicators. All raters should be taught that competent communication involves a structured conversation in which one remains non-judgmental, speaks clearly and understandably, and works with the patient rather than giving him or her instructions.

Although the exploratory factor analysis of the original scale suggested a simple one factor model (23), the model fit of

TABLE 2 Inter-rater reliabilities (ICCs) across the different rater perspectives.

	CCSS			CCSS-S		
Rater	**$ICC_{(2,2)}$**	**95% CI**	**α**	**$ICC_{(2,2)}$**	**95% CI**	**α**
Students[a]	0.70	(0.58, 0.78)	0.95	0.65	(0.51, 0.74)	0.92
Advanced Trainees[b]	0.80	(0.65, 0.88)	0.95	0.77	(0.65, 0.85)	0.91
Experts[a]	0.78	(0.71, 0.83)	0.97	0.75	(0.69, 0.81)	0.95

[a]$N = 276$, [b]$N = 138$.

the CFA for the CCSS-S in this study was rather weak. It is quite likely that the restricted variance in the scores might have contributed to rather poor fit indices of the CFA. For this reason, we conducted an additional ESEM, resulting in a two-factor solution that represented the data very well. The two factors were labeled *Collaboration Skills* and *Structuring/Exploration Skills*. Such subscales are generally in line with other research conceptualizing CBT as an interplay between techniques and relationship skills [e.g., (58)]. Also, in analyzing the structure of the CTS, several authors suggested distinguishing similar factors, among others, that refer to structuring skills (e.g., agenda setting) and relationship skills [e.g., communication skills; (16, 59)]. However, the cross-loadings in the ESEM model were still relatively high for many items compared to the factor loadings. On the one hand, this might call into question the differentiation between the factors obtained. On the other hand, those cross loadings might simply display the conceptually logical interplay between most therapist skills; and ESEM models might thus be particularly useful to apply in the field of therapist competence. For example, therapists can't structure the session without working collaboratively with patients. Therefore, only few items are unique indicators of the factors (i.e., Items 3, 10, and 14, giving time to speak, empathy, and clarifying as indicators of Collaboration; Items 5 and 6, summarizing and logic running through as indicators of *Structuring and Exploration*), whereas most skills have cross loading. Overall, the analysis of a more diverse therapist sample is desirable, before drawing final conclusions about the most appropriate factor structure of clinical communication skills as assessed with the CCSS-S.

Limitations

The most important limitation is dependency within the data sets. To achieve the necessary power, we combined data from different studies and measurement points, some of which were based on assessment of the same participants (e.g., licensed psychotherapists in data set 2 and psychology students in data set 3 assessed the same participants). Although this procedure might bias the results, we are confident that the general correlational patterns will not be affected, because each video that is rated presents a new therapeutic situation. Thus, the factor structure of the CCSS-S and its correlations with other rating scales should not change. However, future research is needed to confirm the results obtained from this study with a larger data set of independent ratings. Another limitation is the lack of a suitable discriminant measurement to fully establish the validity of the CCSS-S. Future studies might include variables such as treatment adherence or behavior-based ratings of personality traits, such as extraversion (23). Fourth, the current validation relates to competence assessment in standardized role-play scenarios. Even though the authors of the original studies achieved a high level of authenticity in patient presentations, as measured *via* the rating scale for authentic patient demonstration (50), future studies should expand the validation and application of the CCSS-S to real therapy situations. Finally, measurements for alliance skills and empathy were based on scales that were originally used as self-reports, but observer-based versions are also available (32). Future studies should examine the convergent validities of the CCSS-S when it is also used as a self-report instrument, for example, when trainees are asked to self-assess their skills.

Implications for training and research

The CCSS-S can be used for education and training purposes, and also in competence research. In the context of training, role plays are particularly suitable for assessing the communication skills of beginners using the CCSS-S. Our results suggest that advanced raters achieve higher levels of inter-rater reliabilities. However, given time and financial resources, it also seems appropriate to use student or peer raters to gain an impression of trainees' skills. Nevertheless, all participants should familiarize themselves in advance, with the items of the scale. The CCSS-S might also be used as a self-assessment and reflection tool (29, 60). This way, the progress of trainees, their strengths and weaknesses in professional communication, could be monitored efficiently, for example, during the supervision process (3). There is also a growing interest in developing practical exams in which trainees demonstrate their skills in standardized role-plays, for example, the objective structured clinical examination (OSCE) is quite common in medical education (61). Although the CCSS-S has not yet been tested for creating summative assessments, we are confident that the scale can also be used for this purpose.

In addition to its application in education, we believe that the CCSS-S is also a useful tool for research, for example, as an efficient tool in longitudinal studies on therapist development.

However, since reliability is particularly crucial for research purposes, we recommend the use of advanced raters over student raters. The training of these raters should follow the common recommendations for achieving high inter-rater reliabilities (57). Furthermore, the question of optimal training time is worth studying. The CCSS-S would prove particularly valuable if the time required not only to complete the scale but also to train raters could be reduced. This is also important for rater selection. For example, it might be reasonable to select clinically less experienced trainers who require more intensive training but are more affordable. In contrast, for some research questions, it might be important to use clinical experts as raters, who are more expensive but require less training effort to apply the CCSS-S.

Another important task for the field of competence research is the examination of associations between competence and patient outcomes. In their systematic review, Ottman et al. (11) noted that a positive relationship between competency and client outcomes was more prominent when common therapy factors (e.g., empathy) were used, in comparison to the assessment of specific CBT skills. Thus, future studies might also examine the associations between CCSS-S scores and client outcomes. In general, the next step for the research of competence assessment will be the application of the CCSS-S in real world conditions, that is, in real therapy situations (13). In addition, although the CCSS-S was developed as an instrument for general counseling and CBT skills (23), suitability for non-CBT contexts (e.g., psychodynamic therapies, acceptance, and commitment therapy) needs to be explored. Finally, the CCSS-S might also help in gaining a deeper understanding of deviations between self-reports and observer-based judgments (62).

Conclusion

All in all, the CCSS-S is particularly useful for psychotherapy training using standardized role-plays, or general situations in which (a) general skills with a focus on communication skills are of interest, independent of specific CBT techniques, (b) when time resources are limited, and (c) when segments of therapy sessions should be evaluated. To ensure good inter-rater reliabilities for research contexts, we recommend employing raters with at least some clinical experience. For other contexts, such as peer evaluations, student raters achieve sufficient inter-rater reliabilities.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s. The scripts of analysis are available at osf.io/xbeqa.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Potsdam Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

Author contributions

UM, FK, and FW conceived the study. UM wrote the study protocol and was responsible for the data analysis and for drafting the manuscript. All authors initiated and implemented the design, read, and agreed to the final manuscript.

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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

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.977324/full#supplementary-material

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Validation and application of the Non-Verbal Behavior Analyzer: An automated tool to assess non-verbal emotional expressions in psychotherapy

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Background: Emotions play a key role in psychotherapy. However, a problem with examining emotional states via self-report questionnaires is that the assessment usually takes place after the actual emotion has been experienced which might lead to biases and continuous human ratings are time and cost intensive. Using the AI-based software package Non-Verbal Behavior Analyzer (NOVA), video-based emotion recognition of arousal and valence can be applied in naturalistic psychotherapeutic settings. In this study, four emotion recognition models (ERM) each based on specific feature sets (facial: OpenFace, OpenFace-Aureg; body: OpenPose-Activation, OpenPose-Energy) were developed and compared in their ability to predict arousal and valence scores correlated to PANAS emotion scores and processes of change (interpersonal experience, coping experience, affective experience) as well as symptoms (depression and anxiety in HSCL-11).

Materials and methods: A total of 183 patient therapy videos were divided into a training sample (55 patients), a test sample (50 patients), and a holdout sample (78 patients). The best ERM was selected for further analyses. Then, ERM based arousal and valence scores were correlated with patient and therapist estimates of emotions and processes of change. Furthermore, using regression models arousal and valence were examined as predictors of symptom severity in depression and anxiety.

Results: The ERM based on OpenFace produced the best agreement to the human coder rating. Arousal and valence correlated significantly with therapists' ratings of sadness, shame, anxiety, and relaxation, but not with the patient ratings of their own emotions. Furthermore, a significant negative correlation indicates that negative valence was associated with higher affective experience. Negative valence was found to significantly predict higher anxiety but not depression scores.

Conclusion: This study shows that emotion recognition with NOVA can be used to generate ERMs associated with patient emotions, affective experiences and symptoms. Nevertheless, limitations were obvious. It seems necessary to improve the ERMs using larger databases of sessions and the validity of ERMs needs to be further investigated in different samples and different applications. Furthermore, future research should take ERMs to identify emotional synchrony between patient and therapists into account.

KEYWORDS

emotion recognition, process-outcome, video analyses, prediction, facial coding, software validation, software application

Introduction

Emotions are a central component of human communication, form the basis of interpersonal relationships, indicate how we feel, provide feedback about internal states, and prepare impulses for action (1). Most mental disorders are characterized by some form of emotional impairment. Dysfunctional behaviors often result from difficulties in dealing with unpleasant feelings (2). Especially emotional disorders (e.g., depression) are characterized by frequent and intense negative emotions, a diminished sense of control and negative appraisal of specific emotions, as well as efforts to avoid emotions (3). Beyond that, patients with mental disorders seem to have problems expressing their emotions adequately. For instance, their facial activity is reduced and their ability to imitate emotional expressions is impaired, which makes it harder for them to establish healthy relationships (4–7). Therefore, focusing on emotions is transdiagnostically relevant to the therapeutic process and outcome over nearly all psychotherapeutic modalities (8).

In a meta-analysis including 42 studies, an averaged weighted effect size of $r = 0.40$ between patients' emotional expressions and treatment outcome was found (9) indicating that stronger expressions of affect were associated with better outcomes. However, the authors point out that direct evidence of causality cannot be demonstrated with this correlational approach. Further findings suggest that emotions contain information about a patient's underlying needs and motives (10) and that emotional empathy fosters the therapeutic relationship, which is associated with better treatment outcomes (11). Additionally, the affective experience during therapy which is a predictor of symptom reduction (12) has been shown to be characterized by negative valence and high arousal (13).

Since emotions are a central element of human interaction, emotion research has a long tradition. Wundt (14) was one of the first to distinguish between the two different aspects of valence (ranging from feeling pleasant to unpleasant) and arousal (ranging from feeling quiet to active). Many other definitions of significant emotion features followed, which differ primarily in the number of dimensions and their labeling (15). The circumplex model of emotions (16) is one of the most established theoretical models and describes emotions as a specific combination of the dimensions arousal and valence. These two dimensions are arranged orthogonally, resulting in a coordinate system in which emotions can be mapped. This model integrates non-verbal information multimodally, allowing easy determination of emotional expressions (17).

Besides these theoretical considerations of emotion classifications, there is a great variety of methods to assess emotions (e.g., self-reports, physiological measures, external observations of salient emotional cues). Regarding patients' emotions–and their change over the course of therapy–research has so far been based mainly on subjective self-reports. Here, evidence for the association between patient emotions and treatment success was found (18–20). However, a problem with examining emotional states via self-report questionnaires is that the assessment usually takes place after the actual emotion has been experienced which might lead to biases. For a detailed review of possible reasons for faulty memories of emotional experiences, see Levine et al. (21). Their findings suggest that diagnostic and experimental tests based on self-reports of past emotions, and testimony concerning the emotional impact of past events, should be interpreted with caution, particularly when an individual's report follows major changes in his or her goals and beliefs. Moreover, during the therapy session, emotions are usually expressed non-verbally and determined based on salient non-verbal cues. In particular, facial expression has proven to be a helpful indicator for emotion recognition (22). Manual external observational ratings of emotional expressions yielded results superior to self-report ratings [for an overview see (15)], however, they have to be considered a time-consuming procedure (23).

In this context, modern automated external observational methods such as artificial intelligence (AI) video analysis software seem a promising way to examine emotions. They are less time-consuming and less expensive than manual ratings,

more objective than patients' self-report ratings, and they can provide continuous ratings with a high number of measurement time points for the entire length of a psychotherapy session. Due to the high temporal resolution, the application of AI video analysis software supplies new opportunities to examine emotions in the context of psychotherapy. Moreover, AI video analysis software allows the analysis of psychotherapy processes without having to implement additional equipment (e.g., electrodes) in the psychotherapeutic setting. This makes it possible to recognize emotions in a naturalistic setting without influencing the therapeutic process. Furthermore, with the help of video analysis tools, it is possible to examine expressions of emotion without the previously mentioned possible distortions in human ratings. Accordingly, once a suitable emotion recognition model (ERM) for software-based examination has been trained, it can be applied to an unlimited number of later recorded therapy sessions. Candra et al. (24), for example, proposed to use automated emotion recognition tools give feedback to psychotherapists and thus enable them to pay more attention on contemplation of emotions in the reflection of the sessions. Available software varies with regard to the quality of emotion recognition (25, 26). However, in a review of deep-learning approaches, recognition accuracy averaged 72% (27). Real-life applications of software solutions for an automated and continuous emotion recognition still remain an open challenge as most software's reliability is limited in naturalistic settings (28). There are only a few first studies which use AI-based ERMs in the field of psychotherapy (17). However, first promising findings indicated high levels of accuracy for automated continuous emotion recognition and significant consistency with manual ratings in psychotherapy (17, 24).

To address the challenges of assessing emotions in naturalistic settings, the open-source software *Non-Verbal Behavior Analyzer* [NOVA; (29–32)] has been adapted to psychotherapy research because it does not interfere with the therapeutic process. NOVA is a software originally developed as an interview analysis tool within the EU FP-7 project TARDIS [2012–2015, (33)]. It was extended to include interactive machine learning capabilities as part of the ARIA-VALUSA Horizon project [2015–2018, (34)]. NOVA is an open-source tool and available on GitHub[1]. In a pilot study, it was applied to 72 therapy sessions of a test anxiety treatment (29). NOVA was evaluated as intuitive and ergonomic by trained human raters. Furthermore, they highlighted the wide range of functions and its good usability.

In summary, the progressive advancement of AI-based software solutions enables new assessment methods and fields of investigation. Continuous video-based emotion recognition can now be applied resource-efficiently and non-invasively in naturalistic psychotherapeutic settings. Therefore, this study aimed to apply NOVA to psychotherapy research and evaluate the validity of this method for assessing emotional expressions. For this purpose, the associations between the average arousal and valence of the patient per session determined by means of NOVA on the one hand, and the emotion assessment by the patient and therapist as well as symptom severity and the established process variables emotional, interpersonal and coping experiences (12), which are based on Grawe's (35) process variables, on the other hand were to be examined. Therefore, we investigated the following hypotheses:

1. Emotion recognition models comparison: Valence and arousal estimated by the ERM correlate positively with human coders' ratings. ERMs using different feature sets differ in terms of the strength of their correlation with human ratings of arousal and valence. The best ERM with the highest positive correlation can be identified.
2. The patients' emotions (identified using the superior ERM in NOVA) are related to the patient and therapist ratings of the patients' emotions at the end of the session using the PANAS. We expected higher negative valence to be correlated with more sadness, shame, anxiety, and anger. Accordingly, we expected higher positive valence to be associated with more satisfaction, energy, and relaxation. Furthermore, we expected higher arousal to be correlated with more anger, satisfaction, and energy. Lower arousal was expected to be correlated with more relaxation and sadness.
3. The patients' emotions (identified using the superior ERM in NOVA) are related to the three process variables affective experience, interpersonal experience, and coping experience. We expected stronger affective experiences to be associated with higher arousal and more negative valence. Furthermore, we expected stronger interpersonal and coping experiences to be associated with more positive valence.
4. Emotion recognition models-rated arousal and valence are predictors of patient symptom severity in the respective session and the two following sessions (comprising a period of around 2 weeks). More arousal and more negative valence are associated with higher symptom severity.

Materials and methods

Participants and treatment

All patients in this study were treated with integrative cognitive-behavioral therapy (CBT) between 2017 and 2019 at an outpatient clinic in southwest Germany. The following inclusion criteria had to be met: (1) At least ten therapy sessions, and (2) patients older than 16 years. Exclusion criteria

1 https://github.com/hcmlab/nova

were: (1) Organic, including symptomatic mental disorders (ICD-10: F00-F09), (2) primary diagnosis of schizophrenia, schizotypal, or delusional disorders (ICD-10: F20-F29) because of expected problems during coding due to the peculiarities of the affective processing of these disorders (36), (3) physical limitations that interfere with the expression of emotions (e.g., paralysis, prostheses, amputations, dystonia, rigidity, burn, and disfigurement), and (4) patient transfer to a different therapist during the course of therapy. In total, videos of 183 patients (one session/video per patient) were used in this study. Videos were selected randomly from a sample with high video quality. One video per patient from a randomly varying session was included in this study. The training sample consisted of 55 videos, which were coded twice by different coders. The test sample consisted of further 50 patients who were not part of the training sample. The final application sample consisted of the 50 sessions from the test sample plus 78 additional patients (see **Figure 1**). Patients in the application sample had on average 35.68 (*SD* = 18.47) sessions of psychotherapy. They were between 18 and 72 years old with a mean of 34.72 years (*SD* = 12.77) and 70 (54.7%) of them were female. Detailed sample characteristics of the training, test, and evaluation samples can be found in **Table 1**. All therapists participated in a 3-year (full-time) or 5-year (part-time) postgraduate training program with a CBT focus and had received at least 1 year of training before beginning to see patients. They were supervised by a senior therapist every fourth session and were supported by a feedback system monitoring patient outcomes on a session-by-session basis (37). Therapists were trained in an integrative CBT approach including interpersonal and emotion-focused elements (35, 38, 39). All therapists were familiar with various disorder-specific CBT manuals but individually adapted their approach depending on patients' characteristics. Psychometric feedback was provided to therapists after each session [for a detailed description of the treatment setting see (40)]. Research data were routinely collected via a range of instruments and all therapy sessions were videotaped. The patients were informed in writing when they registered for therapy and in person during the first therapy session about the continuous video recording as well as the collection of psychometric data. They were also informed about the evaluation of the video and psychometric data and the anonymized publication. Patients were informed about their right to withdraw their consent. All patients gave their written informed consent. This procedure was approved by the Ethics Committee of the German Psychological Society (DGPs, 2020-03-20VADM).

Patients were diagnosed based on the Structured Clinical Interview for DSM-IV Axis I Disorders [SCID-I; (41)] conducted by intensively trained independent clinicians before actual therapy began. The interviews were videotaped and subsequently interviews and diagnoses were discussed in expert consensus teams comprised of four senior clinicians. Final diagnoses were determined by the consensual agreement of at least 75% of the team members. For the diagnosis of personality disorders, the International Diagnostic Checklist for Personality Disorders [IDCL-P; (42)] was conducted in the first sessions by the therapist.

Automated emotion recognition using Non-Verbal Behavior Analyzer

Video processing

As a matter of routine, all therapy sessions were video recorded in the outpatient clinic. A sketch of the setting can be found in **Figure 2**. The therapist and patient were recorded separately by two different cameras. In this study, only the patient videos were considered. To ensure that the analyzed material covers the therapeutic interaction only, videos were checked, and additional video time was cut out. Afterward, video resolution was standardized to a scaled size of 640:480 and 25 frames per second and converted to mp4 format.

Software

The central instrument for assessing arousal and valence was the NOVA software (29, 32). With the help of NOVA, arousal and valence were measured continuously between −1 and +1 with up to 16 decimal places. On the arousal dimension, −1 represents a drowsy state and +1 a state of strong agitation. On the valence dimension, −1 represents a very negative valence and +1 a very positive state. Both dimensions were then aggregated separately to generate mean values of arousal and valence per session. Without any additional training, NOVA is able to extract defined features of multiple modalities, such as the face and the body, so-called feature streams. In this study, different feature streams are used: OpenFace (43), a feature set that contains facial landmarks, head orientation as well as 17 actions units, OpenPose (44), a 2D skeleton tracking algorithm, as well as calculated features on the skeleton data such as the overall activation and the energy of the movements (31). An impression of the user interface of NOVA is given in **Figure 3**.

Rater training

To improve NOVA's recognition performance, the algorithms were trained with manually rated videos (human coder ratings). The arousal and valence dimensions were scaled so that the values ranged from −1 to +1. All four raters (two female, two male) have graduated in psychology and underwent 30 h of training (consisting of technical instructions, information on common emotional theories with a special focus on the circumplex model, as well as video training material to train coding skills). Monthly supervision sessions were held with a licensed psychotherapist. Raters did not start rating in the project until their agreement in the example material was at least Cronbach's $\alpha = 0.70$.

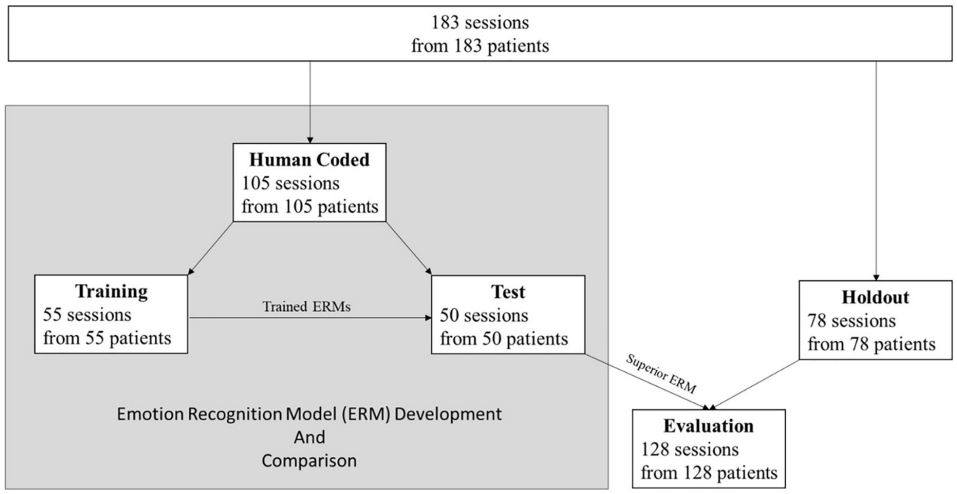

FIGURE 1
Flowchart of the sample distribution.

TABLE 1 Sample characteristics of the training, test, and evaluation sample.

	Training (n = 55)		Test (n = 50)		Evaluation (n = 128)	
	Mean (*SD*) or %	Range or *N*	Mean (*SD*) or %	Range or *N*	Mean (*SD*) or %	Range or *N*
Patient age (years)	32.88 (13.34)	18–69	34.64 (13.42)	18–65	34.72 (12.77)	18–72
Patient sex (female)	65.45	36	44	22	54.7	70
Therapy duration (sessions)	34.70 (36)	10–90	30.65 (13.86)	10–68	35.68 (18.47)	10–86
Drop-out rate	16.36	9	10	5	11.7	15
Comorbidity	52.73	29	44	22	39.8	51
Primary diagnosis						
Affective disorder	45.45	25	46	23	45.3	58
Anxiety disorder	10.91	6	8	4	10.3	13
Adjustment disorder	14.55	8	16	8	10.2	13
PTSD	9.09	5	8	4	7.8	10
Personality disorder	3.64	2	2	1	0.8	1
Other	16.36	9	20	10	25.6	33

Therapy duration refers to the complete length of the therapies from which the analyzed sessions originate.

Psychometric questionnaires

Hopkins Symptom Checklist-11

The Hopkins Symptom Checklist-11 (HSCL-11) (41) is a short questionnaire based on the HSCL-25 (45), which is a short version of the Symptom Checklist-90 (46). It contains items from the subscales depression and anxiety. The HSCL-11 is a self-report questionnaire, which consists of 11 items, all structured as a 4-point Likert scale ranging from 1 (*not at all*) to 4 (*very*). In this study, the mean score for the whole questionnaire and scores for the subscales anxiety and depression were used. The internal consistency of the HSCL-11 (Cronbach's alpha) was $\alpha = 0.85$ (47). The mean of the 11 items is highly correlated with the Global Severity Index (GSI) of the Brief Symptom Inventory [BSI; $r = 0.91$; (12)]. Furthermore, psychometric properties are comparable to the BSI (45).

Subjective emotion rating

As a subjective emotion rating, an adaptation of the Positive and Negative Affect Schedule [PANAS, (48)] was carried out at the end of each session. The patient and therapist had to rate on a scale from 0 (*not at all*) to 100 (*extremely*) how sad, ashamed, frightened, angry, satisfied, energetic, and at ease the patient felt during the therapy session.

Session Report

At the end of each session, a short form of the Session Report (SR) (49–51) was administered. Patients assessed the

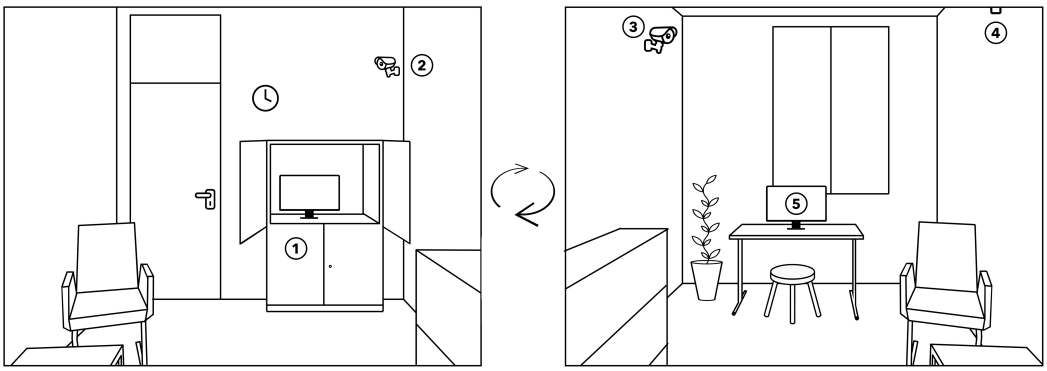

FIGURE 2
Sketch of the structure of a therapy room from two different angles. 1 = video and audio recording equipment (hidden in a cupboard), 2 = camera that focuses on the therapist, 3 = camera that focuses on the patient, 4 = microphone, and 5 = touchscreen for assessment of the session reports.

subjectively perceived realization of process variables during the session. Three subscales, each ranging from −3 (*not at all*) to +3 (*yes, exactly*), were created from the 12-item version by averaging items of a scale: coping experiences (6 items), interpersonal experiences (4 items), and affective experiences (2 items; for more details see Rubel et al. (12)). The internal consistency (Cronbach's alpha) was shown to be $\alpha = 0.89$ for coping experiences, $\alpha = 0.90$ for interpersonal experiences, and $\alpha = 0.85$ for affective experiences (12).

Data analytic strategy

> *Hypothesis 1: ERM comparison – Identifying the best NOVA ERM*

The human and automated codings each resulted in continuous time series. In the first step, several ERMs were trained in the training data. Then, they were tested in the training as well as in the test data for their agreement with human ratings by correlating automatic (via NOVA) and human ratings for each session. Correlation coefficients were averaged over all sessions. Furthermore, the model fit indices mean squared error (MSE) and root mean square rrror (RMSE) were considered. The best performing ERM in training and test data was then applied to the application sample.

> *Hypotheses 2–4: Evaluating the best NOVA ERM*

In the application sample, session scores for arousal and valence were calculated by taking a mean per session for each of the two emotion dimensions. Following hypothesis 2, Pearson correlations between the mean values of arousal and valence in NOVA and the subjective assessment of the patients' emotions were carried out. Afterward, following hypothesis 3, mean session scores for arousal and valence were correlated with the patient assessment of the three process variables coping experiences, interpersonal experiences, and affective experiences using Pearson correlations. Furthermore, the predictive value of arousal and valence was tested using linear regression. Here, the dependent variable HSCL-11 (mean session scores as repeated measures of symptom severity) at session t, t+1, and t+2 was regressed on arousal and valence at session t as predictors (hypothesis 4).

Results

Human ratings' reliability and test assumptions

The human coder ratings that were used to train the ERMs showed acceptable to excellent agreements on average for both arousal (Cronbach's $\alpha = 0.73$, ranging from $\alpha = 0.61$ to $\alpha = 0.89$) and valence (Cronbach's $\alpha = 0.74$, ranging from $\alpha = 0.60$ to $\alpha = 0.90$). Curves estimations indicated linearity of the data (all linear terms $p < 0.05$, all other terms $p > 0.10$). The Durbin Watson value of 1.774 for valence and 1.745 for arousal showed no evidence of autocorrelation of the predictor. The Shapiro–Wilk test showed that the residuals were normally distributed (valence: $p = 0.302$, arousal: $p = 0.159$). Homogeneity of variances was asserted using Levene's test, which showed that equal variances could be assumed (all $p > 0.10$).

> **Hypothesis 1: Valence and arousal estimated by the ERM correlate with human coders ratings. A best ERM can be identified.**

Different models based on different feature sets were evaluated. As expected, there were differences in the chosen models regarding their fit to the human codings. The model comparison showed that in both the training and test samples,

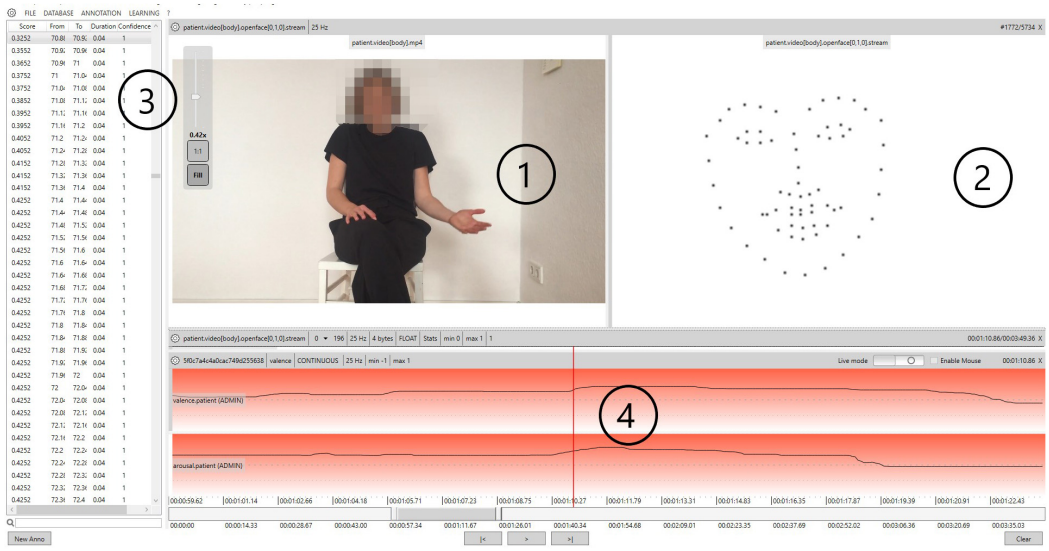

FIGURE 3
Exemplary representation of therapy videos in Non-Verbal Behavior Analyzer (NOVA). 1 = original video, 2 = schematic representation of the OpenFace feature points (not shown to raters during rating), 3 = time series for arousal/valence, and 4 = graphical representation of the arousal and valence characteristics/graphical interface for the rating of arousal/valence.

the OpenFace model produced a higher agreement (training sample: $r_{valence} = 0.26$, $r_{arousal} = 0.38$; test sample: $r_{valence} = 0.37$, $r_{arousal} = 0.44$) to the human rating than the other models (see Table 2). Only in the test sample was a slightly higher agreement for valence ($r = 0.42$) for the OpenFace-Aureg ERM than for the OpenFace ERM ($r = 0.37$). However, the performance of the OpenFace ERM was close to the agreement for valence of the OpenFace-Aureg ERM and the OpenFace ERM outperformed all other models in assessing arousal. Therefore, this ERM was considered the best performing model.

> **Hypothesis 2: The patients' emotions (identified using the superior ERM in NOVA) are related to the patient and therapist ratings of the patients' emotions at the end of the session.**

No significant correlations were found between the patient rating of his/her own emotions and the emotions recognized with the help of ERM. The therapist ratings of their patients' emotions were significantly correlated with ERM-rated valence for sadness ($r = -0.18$, $p < 0.049$), shame ($r = -0.23$, $p = 0.011$), and anxiety ($r = -0.21$, $p = 0.023$), indicating that more positive ERM-coded emotions were associated with less sadness, less shame, and less anxiety of the patient rated by the therapist. Furthermore, ERM-rated arousal was significantly associated with the therapists' assessment of their patients relaxation ($r = -0.19$, $p = 0.039$).

> **Hypothesis 3: The patients' emotions (identified using the superior ERM in NOVA) are related to the three process variables affective experience, interpersonal experience, and coping experience in the same and the two following sessions.**

In the third step, we examined the correlation between automatically recognized ERM-rated arousal and valence and the three processes of change interpersonal experiences, coping experiences, and emotional experiences. Significant associations could be found between valence and affective experience ($r = -0.23$, $p = 0.010$) and arousal and affective experience ($r = 0.18$, $p = 0.044$), indicating that more negative emotions and higher emotional arousal during the session were correlated with a higher level of emotional experience. Further results can be found in Table 3.

> **Hypothesis 4: ERM-rated arousal and valence are predictors of patient symptom severity in the respective session and the two following sessions (comprising a time period of around 2 weeks).**

In the last step, the predictive value of ERM-recognized arousal and valence for symptom severity in the same (t) and the two following (t+1 and t+2) sessions was examined. There was no significant predictive effect for the HSCL-11 mean score measured at sessions t and t+2. There was a significant effect indicating that positive valence at session t predicted lower symptom severity in the following session (t+1; $b = -5.38$, $\beta = -1.98$, $SE = 2.72$, $t_{(126)} = 1.98$, $p = 0.046$). Valence and arousal did not predict symptom severity on the HSCL-11 subscale depression at any of the three time points. However, valence proofed as a stable predictor for the symptom severity

TABLE 2 Emotion recognition model (ERM) comparison for the emotion dimensions arousal and valence based on different feature streams.

	Pearson CC	MSE	RMSE
Valence			
OpenFace	0.26	**<0.01**	**0.07**
	0.37	**<0.01**	**0.06**
OpenFace-aureg	0.26	<0.01	0.08
	0.42	<0.01	0.06
Openpose-activation	0.05	<0.01	0.09
	0.05	<0.01	0.07
Openpose-energy	<0.01	<0.01	0.09
	−0.03	<0.01	0.07
Arousal			
OpenFace	**0.38**	**<0.01**	**0.10**
	0.44	**0.01**	**0.11**
OpenFace-aureg	0.34	<0.01	0.10
	0.10	0.02	0.13
Openpose-activation	0.05	0.01	0.11
	0.31	0.02	0.13
Openpose-energy	0.17	0.01	0.11
	0.20	0.01	0.12

The first line indicates the correlation between human rating and Non-Verbal Behavior Analyzer (NOVA) in the training sample. The second line indicates the correlation between human rating and NOVA in the test sample. Due to the large number of data points, *p*-values are not shown. Pearson CC, Pearson correlation coefficient; MSE, mean squared error; RMSE, root mean square error. Bold values indicate the best performing ERM.

on the HSCL-11 subscale anxiety over all three sessions (session t: $b = -4.97$, $\beta = -0.20$, $SE = 2.39$, $t_{(126)} = -2.08$, $p = 0.038$; t+1: $b = -5.32$, $\beta = -0.18$, $SE = 2.88$, $t_{(113)} = -1.85$, $p = 0.066$; t+2: $b = -5.94$, $SE = 0.27$, $\beta = -0.21$, $t_{(109)} = -2.20$, $p = 0.026$). Arousal did not predict the HSCL-11-score on the subscale anxiety to any of the three time points.

Discussion

The automated recognition of emotions in psychotherapy enables novel insights into psychotherapy processes beyond self-report questionnaire data. AI-assisted emotion recognition allows for a cost-effective and time-saving emotion recognition over the course of entire naturalistic psychotherapy sessions. The present study demonstrated a potential application of the NOVA software and its contribution to expanding our understanding of mental processes and their correlates. In a first step (hypothesis 1), it could be shown that the ERM which was based on the whole OpenFace stream was best performing in the training and test sample except for valence in the test sample where the OpenFace-Aureg ERM performed slightly better. There was no noteworthy difference in performance of ERM between arousal and valence. All in all, the benefits of the OpenFace stream for emotion recognition, which have already been shown in several earlier studies (52–54) were confirmed.

Additionally, this study has shown the benefit of continuous recognition of arousal and valence in a naturalistic psychotherapy setting. Although there were no significant correlations between the patients' ratings of their own emotions and the automated recognized dimensions of arousal and valence, arousal and valence correlated significantly with therapists' ratings of sadness, shame, anxiety, and relaxation (hypothesis 2). This implies that the assessment of emotions using the NOVA software is most closely related to the external assessment of emotions, which is also consistent with the results of a previous study (55). This result was expected, as NOVA was trained with the help of external ratings and so reflects an external emotion recognition. Furthermore, it is known from previous studies that patients with mental disorders in particular find it difficult to adequately perceive, assess, and reflect emotions (4, 5, 7, 56). This might lead to limited results when it comes to self-report measurements. It is therefore questionable to what extent patient self-assessments can be used to validate the ERMs and we rather argue that what the AI-based ERMs assess goes beyond self-report data. Furthermore, it is noticeable that the emotions associated with the NOVA-rated valence all have negative connotations. One reason might be that the OpenFace ERM works well, especially with strong negative emotions. However, emotions such as joy, expressed rather reservedly in psychotherapy, are not yet adequately recognized. These findings should be a reason to further improve existing ERMs in NOVA. Another reason might be that human raters reacted more sensitive to strong negative emotions during the training process. Here, a further refinement of the training process for the recognition of positive valence could also contribute to the improvement of the ERMs.

Related to hypothesis 3, a significantly negative correlation between valence and the affective experience as well as a significantly positive association between arousal and the

TABLE 3 Correlation between automatically recognized emotion dimensions and processes of change.

	Valence	Arousal	Interpersonal experience	Coping experience	Affective experience
Valence		0.24**	0.10	0.01	−0.23*
Arousal	0.24**		0.11	0.02	0.18*
Interpersonal experience	0.10	0.11		0.42**	0.21*
Coping experience	0.01	0.02	0.42**		0.13
Affective experience	−0.23*	0.18*	0.21*	0.13	

$N = 128$; *$p \leq 0.05$, **$p \leq 0.01$.

affective experience was found. These findings correspond to earlier results (13). They further support the interpretation that affective experience takes place when the patients' problem is addressed in an affectively engaging way, resulting in high emotional involvement (12). At the same time, the ERM used in NOVA seems able to capture the affective experience as a combination of high arousal and negative valence which supports the validity of the used software and OpenFace ERM.

The predictive value of valence determined with NOVA for symptom severity could be shown for the anxiety subscale of the HSCL-11 over the respective and the two following sessions. This result shows that emotion recognition using NOVA has a predictive benefit for symptom severity that goes beyond the session itself. In particular, the anxiety scale of the HSCL-11 is associated with feeling strong emotions that are also expressed externally. It stands to reason that there is a correlation to this scale in particular. The depression scale, which is more associated with a reserved expression of emotions, shows no correlations with the emotion dimensions determined by NOVA. Therefore, NOVA could be used to assess and predict anxiety symptomatology based on the emotional expressions in patients' faces only.

Limitations

The results indicate that the used ERM should be improved. Therefore, it seems reasonable to increase the data sets used to develop and test the models. So far, it is not clear to what extent an overlap between human and machine ratings can be achieved since both might measure slightly different components of emotional expressions. The determination of the best ERM is based on descriptive differences between model fits, in particular due to the large number of data points. In future studies, the formulation of critical differences between correlation coefficients could be useful (57). It is possible that ERMs might capture emotions in a different way than human raters (hypothesis 1) or patients themselves (hypothesis 2).

Furthermore, it remains unclear whether it is more beneficial to train generalizable models in large heterogeneous multi-site samples or to train them on more selective homogeneous samples for each new population. While this study controlled for some diagnoses, some diagnostic heterogeneity was not avoidable. There could be certainly an effect of different diagnoses of interest that was not possible to examine in this feasibility sample. Furthermore, there might be differences in different psychotherapeutic settings. Therefore, in future studies, other settings like inpatient settings or online interventions could be an interesting field of application. This study has focused on between-patients statistics rather than within-patients statistics, which does not allow an assessment of individual changes or the computation of intra-individual effects. It was found that the level of group average compared to individuals can even lead to opposite relationships (e.g., relationship between self-efficacy and performance), showing that considering only group statistics can lead to wrong conclusions about the process that takes place within the individual (58–60). Hence, it might be helpful to investigate within-patients effects over the time of therapy to differentiate between time-varying effects and stable personality traits such as the individual expression of emotional states. The individual change in emotion during a therapy might be an important information correlated to outcome or therapeutic interventions. Finally, the present study does not consider interpersonal events between the two interaction partners. It is conceivable that, in addition to the intrapersonal emotional events of the patient, the interpersonal emotional fit between patient and therapist plays an important role in the therapeutic process and thus also for clinical improvements.

Conclusion and future directions

Overall, this study can be seen as a step into a promising, innovative field of research in which methods of computer science can be used in naturalistic settings of psychotherapy. Further adaptations and validations of the underlying algorithms should take place. For this purpose, it may certainly be useful to combine data from different research institutions worldwide. For further validation, other constructs such as the recording of arousal via skin conductance could be used in future studies. Nowadays, physiological data can easily be collected with the help of a smartwatch, so that it is also possible to collect data in a natural therapy setting without any disturbing wiring (61). In addition to emotional facial expressions, para-verbal and verbal features from speech and text analysis (62, 63) as well as body movement data (64) might improve the accuracy and validity of emotion detection.

In the future, further validation studies should also be conducted to examine the different quality of EMRs in heterogeneous and homogeneous patient samples. It is possible that the correlation between ERMs coded emotional experience and treatment outcome varies as a function of the diagnostic group and initial symptom severity. From studies on therapist effects it is known that differences between therapists in their patients' treatment outcome are dependent on initial impairment (65). Therapist effects have been shown to be larger for highly impaired patients compared to less impaired patients. Similarly, emotion expression might have a higher predictive value for more severely distressed patients, for whom the effectiveness of treatment may vary more than for less distressed patients.

Following the growing research in the field of interpersonal synchrony (64, 66–71), future research should go beyond the isolated consideration of patient emotions and instead compare time series of arousal and valence of the two dyadic partners,

patient and therapist. Synchrony between patient and therapist, and its relation to therapeutic outcome and process variables has already been shown for movements (67, 72, 73), speech content and prosodic features (62, 74) as well as physiological measures (70, 75). Regarding emotions, it can also be assumed that it might be beneficial if patient and therapist are attuned to each other. At least, interpersonal emotional synchrony may provide important further insight into therapeutic processes.

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 German Society for Psychology (DGPs). The patients/participants provided their written informed consent to participate in this study.

Author contributions

PT, BS, TB, WL, and EA contributed to the conception and design of the study. PT, TB, DS, and EA organized the application of the NOVA software. PT and BS performed the statistical analyses. PT wrote the first draft of the manuscript. PT, TB, and BS wrote the sections of the manuscript. SE created illustrations. PT, BS, and SE were supported in the preparation of the revision by the co-authors. All authors participated in proofreading of the manuscript and read 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.

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Challenges and added value of measuring embodied variables in psychotherapy

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Research on embodied aspects of clinical encounters is growing, but discussion on the premises of including embodied variables in empirical research is scarce. Studies have repeatedly demonstrated that embodied aspects of psychotherapy interaction are vital in developing a therapeutic alliance, and these should be considered to better understand the change process in psychotherapy. However, the field is still debating which methods should be used and which features of the embodied aspects are relevant in the clinical context. The field lacks methodological consistency as well as a theoretical model. In the Relational Mind research project, we have studied the embodied aspects of interaction in the context of couple therapy for almost a decade and have gained experience with the positive and negative aspects of studying embodied variables in quantitative and qualitative studies. We have set out to develop the methodology (or procedures) for studying embodied variables in a multiperson setting, concentrating on interpersonal synchrony of sympathetic nervous system responses and movements, and we have strived to create methods for integrating information from different embodied modalities. In this narrative review, we share our experiences of the challenges and added value of studying embodied aspects in psychotherapy. The research field urgently needs an ongoing discussion of what researchers should take into consideration when studying the embodied aspects of interaction. We urge researchers to collaborate between research groups to jointly decide on the basic parameters of studies on the different embodied modalities of the research so that the individual researcher can become more aware of the impact the methodological choices have on their studies, results, and interpretations. We also see the use of embodied variables as having added value in the clinical work of psychotherapists, since it not only deepens our understanding about what is helpful in psychotherapy but will enable fine-tuning therapy processes to better suit clients who are verbally less fluent.

KEYWORDS

embodiment, psychotherapy, synchrony, nonverbal synchrony, electrodermal activity, methodology, crossmodal, embodied variables

Introduction

Recently, there has been growing interest in studying the embodied aspects of psychotherapy to investigate how they are related to the change process of psychotherapy and its outcome. Embodied aspects have been suggested as one of the common factors (1) shared among psychotherapy approaches that account for the effectiveness of the treatment (2, 3).

Research has concentrated on the nonverbal aspects of communication in clinical contexts (4, 5), such as patients' autonomic activation during clinical interaction [for a review, see (6)], blood pressure during suppressed emotions (7), how the client's nonverbal behavior during clinical interactions can be related to diagnostics (8), and how general practitioners and psychiatrists differ in their embodied implicit mentalization strategies (9). In this paper, we claim that research on embodied factors in the clinical context is still in its creative exploratory phase, during which researchers try out different methods and variables. To develop the research field further, we as researchers need to be aware of how our methodological choices, e.g., the operationalizations, the choice of data analysis units, and analysis methods impact the results of our studies, and how the context impacts the meaning and possible interpretations that can be made from the results. We will use our experience from the research project *Relational Mind in Events of Change in Multiactor Therapeutic Dialogues* (10, 11) to illustrate the difficulties researchers face when studying embodied variables, and what aspects a researcher needs to take into account while designing the study, collecting the data, and analyzing and interpreting the results. This article is a narrative review of research conducted in this area and aims to enhance readers' understanding of using embodied variables in clinical research.

Research on embodiment

In research in the psychotherapeutic context, studies on embodiment have mainly been conducted using three research approaches: (i) Qualitative studies on the verbal dialogue in psychotherapy sessions have added embodied aspects of the interaction to the discourse analysis (12–14); (ii) quantitative studies using larger sample sizes have extracted specific embodied variables from psychotherapy sessions, such as movement energy by the participants, and calculated synchrony between the client and therapist based on these (15–17); and (iii) autonomic reactions, such as skin conductance, heart rate, breathing, or movements of the participants in the therapy sessions, have been recorded using wearable trackers [cf. (18–22)]. The study of interpersonal synchrony is a growing field of research. In psychotherapy, synchrony between client and therapist has been found in several modalities: in movements (15, 16, 23), in physiological variables, such as skin conductance (21, 24, 25), heart rate and heart rate variability (26), and even respiration (18). Although research on the embodied aspects of psychotherapy or other clinical contexts has been increasing, articles discussing the challenges and added value of studying embodied variables in psychotherapy are lacking. The aim of this narrative review is to examine different aspects of conducting research on embodied variables in psychotherapy.

This paper is inspired by our experience from the Relational Mind research project (10), in which we have conducted research on the embodied aspects of couple therapy interactions. It is important to stress, that we have not made experimental research, but gathered data from natural interactions in couple therapy.

We will first present the Relational Mind research project and the research field which studies embodied variables in natural settings. After that we will dwell into different aspects that need to be considered when conducting research on embodied variables, such as how to gather, process and analyze data originating from different modalities of interaction. After this we address the complexity of studying embodied data, its idiosyncrasy and context dependent nature. Relevant issues regarding synchrony studies are addressed as well, since we have in the Relational Mind research project studied synchrony between participants in different embodied modalities. Relevant issues regarding synchrony calculations and inferences made based on the findings are addressed.

We have also strived to integrate information from different modalities and will disclose our research strategies on how this could be done, with a hope to develop the research field further. Finally, we will discuss the added values of using embodied variables, as well as make some recommendations for researchers in the field. We have in our studies used several different methods but find that discussion about methodology is scarce. We hope that this paper will start a scientific discussion on the premises of studying embodied variables in psychotherapy.

The Relational Mind research project

The Relational Mind research project (2013–present) conducted at the Psychotherapy Training and Research Centre of the Department of Psychology at the University of Jyväskylä has focused on embodied aspects and especially interactional synchrony in couple therapy (10, 11). The premise of the Relational Mind (hereafter RM) project was to study how the participants' mutual attunement is formed by clients and therapists in couple therapy. The multimodal design, which uses couple therapy as a "natural laboratory," provides access to verbal, nonverbal, physiological, and experiential levels of therapy interactions. The rationale and the design of the study has been described in detail in Seikkula et al. (10, 11), and the findings of the study have been reported in several empirical publications (all RM studies are listed in the Appendix). The RM

design was novel and innovative in 2013, and even today, it is rare in psychotherapy process research. In RM couple therapy was conducted in a usual manner, but the sessions were video-recorded and the participants' (both clients' and therapists') autonomic nervous system responses (electrodermal activity, heart rate, and respiration) were recorded in two measurement sessions, one at the beginning of the therapy process and the other toward the end of the process. After the measurement sessions, individual stimulated recall interviews (hereafter SRIs) were conducted, for which the researcher had chosen four episodes from the therapy session, and the participants were asked to recall what thoughts, feelings, and bodily sensations they recall having at that time in the session. The data comprise 12 couple therapy processes, including 150 h of therapy sessions video-recorded with six cameras, 23 sessions during which clients' and therapists' psychophysiological responses were measured, and 92 individual video-assisted interviews. Moreover, in each session, alliance and outcome measures were used. Detailed information on the research design and participants can be found in Karvonen (27), and for an interested reader the theoretical background of the design is described in Seikkula et al. (11).

To analyze the data, a wide range of methodological approaches and tools, including qualitative conversational and observational approaches as well as mixed methods and computational and statistical approaches, were used. The embodied side of the interaction was included in the analysis of all the studies.

We discovered that even though research on embodied aspects is vital to obtaining a more complete picture of what occurs during clinical interactions, this type of research has proven to be very complex. The reason for this is at least 3-fold: (i) There is no preexisting common methodology for studying the embodied aspects of psychotherapy interventions. Studies use different methods, which is seen through the entire research process: in the variety of research designs, in the differences in selecting the data analysis unit, and the differences in interpreting the results. This makes the research field scattered and hinders the comparison of the studies. We found that we needed to separately define or develop (or tailor-make) a data analysis method for each study that could best answer the research questions. (ii) The use of different methods is related to the lack of a common theory that could connect the findings from different studies on embodiment in clinical encounters. Embodied cognition [cf. (28)], which sees all cognitive processes to be grounded in the body's interactions with the world, has been suggested as one of the theories, as well as complexity science [cf. (29–31)], but these are still too abstract to be easily applicable to studies in clinical contexts. (iii) The embodied variables often prove to be context dependent, with the meaning of the same behavior (such as synchrony) changing from one situation to the other. Embodied variables are often idiosyncratic, meaning that, for instance, people use their bodies in individual ways, and embodied aspects influence persons in idiosyncratic ways, which leads to difficulty in interpreting the results. This was found in our study on nonverbal synchrony in couple therapy, where we discovered that the associations between, for instance, synchrony and the alliance changed depending on the role of the participant (client or therapist) or even gender (23). This aspect has been most profoundly manifested in qualitative RM studies that have concentrated on shorter episodes of the dialogue combining embodied variables into the analysis, which have demonstrated that the participants interpret the situations individually (32, 33). These aspects make it difficult to compare different studies. Thus, insufficient information has accumulated for us to form a common theory.

As we tried to grasp the various aspects of embodied research, it became important to consider the development of the research field in its historical context. We compared research on embodied variables to brain research, which has a long tradition of methodological development, starting from feature extraction (e.g., figuring out what signals were relevant) to considerations of how the information obtained should be processed to obtain the key aspects of the signal in relation to the research question. When inspecting research on embodied aspects, it became evident that, in this research area, we are still in the early phases of research, trying to figure out which features are relevant and what kind of feature detection methods we should use. This phase of research has taken almost a century and is still an ongoing process. One reason for this is that the term *embodied* is an umbrella term covering many aspects of interaction, from visible features such as nonverbal behavior to invisible behavior such as electrodermal activity, heart rate, and breathing frequency. Due to this, the research field is very large, and the various embodied variables require the development of methods to extract and process them. To make research even more complex, the variables of the different modalities can be used or operationalized in various ways, ranging from specific nonverbal behaviors such as head nods (34) to head movement synchrony (35) or psychophysiological arousal (36) to synchrony of electrodermal activity (EDA synchrony) (37). While meta-analyses of research on only visible nonverbal behaviors in the clinical context have repeatedly concluded that it is important to study these behaviors but that research has not enhanced much in recent decades (38, 39), it is not surprising that the vast field of studying embodied variables suffers from similar difficulties.

Based on these observations, we suggest that the field is still in its creative exploratory phase, during which we try different methods to extract features such as EDA synchrony [for an excellent discussion in this regard to dyadic interpersonal synchrony, see (40)]. Different algorithms for calculating synchrony have been used, from the concordance index (24) to windowed cross-lagged correlations (18) and recurrence quantification analysis (41). Often, studies are simultaneously trying out a specific algorithm and studying how the embodied

variable (such as EDA synchrony) is related to a specific phenomenon (such as the therapeutic alliance or empathy). The same method can also be used in different contexts; windowed cross-lagged correlations (42) have been used in individual psychotherapy (15) and in couple therapy (23). To summarize, we are still making "fishing expedition research," that is, attempting to discover new information and generate new knowledge. In the long run, the aim is to come to a common understanding of which features are relevant to extract, and to understand how information from the different embodied variables could be integrated. Hopefully, this will lead to a common theory of the importance of embodied aspects in clinical interactions. Some theoretical suggestions have been developed on, for instance, the relationship between movement synchrony and the therapeutic alliance by Koole and Tschacher (43). They suggested that synchrony is related to this therapeutic alliance by enabling access to another's internal states via interbrain coupling, which over time may improve emotional regulation and thus the therapy outcome. The difficulty is that the theoretical model has not yet been tested empirically.

During the RM project, we learned that the design was feasible and useful in detailing the roles of body language and interpersonal synchrony as healing mechanisms of couple therapy. Even though research on synchrony in a multiperson context, such as couple therapy, is more complex than in dyadic contexts, we found that statistically significant interpersonal synchrony in sympathetic activity (20) and movement synchrony (23) occurs during couple therapy sessions. In successful therapies, sympathetic synchrony increased between the spouses toward the end of the therapy (25), whereas movement synchrony was related to the spouses' well-being and the therapeutic alliance (23). We developed computational tools for analyzing and visualizing the peaks and synchronies in psychophysiological signals and integrated these into qualitative analyses of conversations (10, 13, 32, 44).

For examples of how the embodied variables can be visualized for use in subsequent analyses, see Figures 1, 2. Figure 1 presents analyses on a session level, and Figure 2 presents a microanalytic study of the dialogue. In Figure 1A, the conversational structure between four participants demonstrates that it may vary in different topical episodes (which are episodes of the dialogue that have been separated manually by their thematic contents); verbal exchange may occur only in one dyad, in a triad, in rapidly changing dyads and triads, and also in the quartet. In couple therapy with two therapists, it is common for one or two participants to be outside the verbal exchange for several minutes time until the conversational structure changes (13). Figures 1B,C represent visualizations of each participants' skin conductance responses (panel B) and observed posture and movement synchrony of the co-therapists (panel C) in the topical episodes of one couple therapy session. The information from these pictures was used together with information from the other modalities to analyze the couple therapy session, integrating embodied variables and the dialogue. Figures 2A,B present how we used the embodied variables in relation to the verbal dialogue. Synchrony of the SCR peaks was found between the two dyads in this particular extract. During the RM research process, we discovered important aspects that the researcher must consider when studying embodied variables; we will review them next.

Gathering and processing the embodied data

One of the most important aspects when gathering data simultaneously from different modalities is that the data are synchronized in a timely manner [see, for instance (46), who describe in detail the choices that the researchers made during the development of a study using wearable equipment to record multimodal data]. Unfortunately, data are still largely synchronized manually; furthermore, there is a lack of providers that enable gathering data from several modalities simultaneously and automatically providing synchronized data. Currently, wearable trackers are still in a developmental phase, but in the future, we hope to see systems that would be easy to use outside laboratory settings in ecologically valid situations, such as psychotherapy clinics. We further hope that the systems would, as stated previously, enable gathering data from different modalities simultaneously within the same system and that the data would be synchronized automatically.

One important aspect to consider when gathering data is its storage. As we have studied clinical material, such as psychotherapy sessions, there are ethical considerations that need to be taken into account in the storage of the data. Many machine learning and deep learning algorithms, which could be suited for analyzing embodied data, use artificial intelligence-based on cloud-based storage. It is possible to store unidentifiable and anonymous data in clouds, but as we have studied the embodied aspects of psychotherapy, we often use video recordings of the actual sessions in our analyses. Even though new ethical guidelines for using artificial intelligence have been developed (47), we need a thorough discussion in the scientific community about how confidential and highly sensitive material, such as psychotherapy videos, which cannot be anonymized, could be used in machine learning applications.

During the research process, we understood that one of the core aspects when studying embodied variables was to consider the properties of the variables of each specific modality separately to thoroughly understand how the data are usually processed and how this affects the information that can be obtained from that modality. For instance, EDA is one of the oldest psychophysiological measures for recording the activity of the autonomic nervous system and its sympathetic nervous system activity. Sympathetic nervous system activity prepares

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A

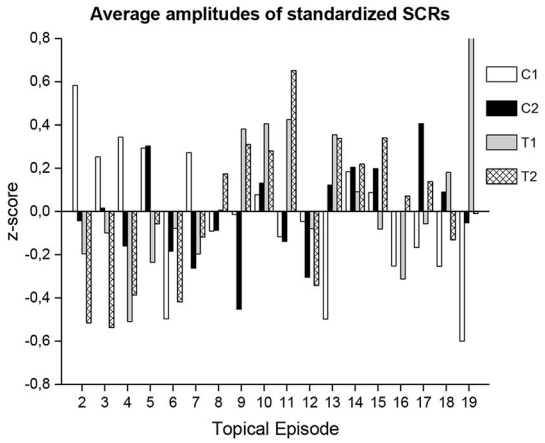
Conservational Complexity in one therapy session

TE	2	3	4	5	6	7	8	9	10
CCS	2	4	4	4	1	4	3	3	4

TE	11	12	13	14	15	16	17	18	19
CCS	4	4	4	4	4	4	3	2	3

Conversational Complexity Scale (CCS):
1= Conversation occurs mainly in one dyad
2= Conversation occurs mainly in one triad
3= Conversation occurs in changing constellations,
one participant is always outside the verbal exchange
4= Conversation in changing constellations, all four participate.

B



C

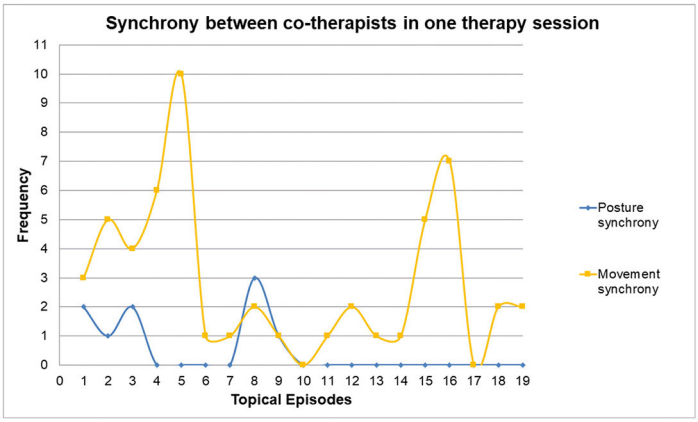
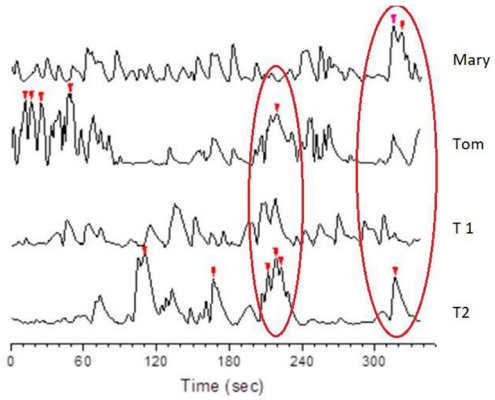


FIGURE 1
Visualizations of different variables from one couple therapy session. **(A)** For each topical episode (TE) Conversational complexity (CCS) was observed and rated. **(B)** The average arousal levels as standardized Skin Conductance Responses (SCRs); measured = represented = indexed for each topical episode. C1 = client 1, C2 = client 2, T1 = therapist 1, T2 = therapist 2. The panel **(B)** has previously been published in (45). **(C)** The frequency of the co-therapists' posture and movement synchrony per topical episode. **(A)** presents coding of Conversational Complexity for shorter thematic segments (Topical Episodes), and **(B,C)** visualize the embodied variables per topical episode.

the body for action and is also related to emotions, motivations, attention, and stress (48). EDA is most commonly represented by skin conductance responses (SCR), which are phasic responses to specific stimuli, whereas the skin conductance level (SCL) represents a tonic or slowly changing level of EDA. We used SCRs because of our interest in looking at the participants' reactions in relation to a particular stimulus, namely to what happened in the psychotherapy session (33,

A



B

MARY: every so often (.) when he was away at work and I was just like at home (.) and that like phew (3)
TOM: made a difference
MARY: yea it did make a **°difference°**
TOM: well I think you felt such a burden
T2: mm
MARY: mm
TOM: **°with the care°** that you've given the care **°and stuff like that°**
T2: mm
MARY: yea mm mm (2) I think a lot of the **guilt** also that maybe is still there for me is just (.) and I we talked about this last time like the discourse around you know how **(Mary's & T2's SCR peaks occur at the same time)** "oh it's just wonderful you have this baby and you just fall in love with it and *la la la*

FIGURE 2
Visualization of the embodied recordings and a transcript of the dialogue during the SCR peaks. **(A)** The synchronization of the participants' SCR peaks during a short segment of dialogue. The peaks marked with red triangles are the SCRs that were >2 SD of the participant's mean. The left red oval depicts synchrony between Tom and therapist 2 and the right oval depicts synchrony between Mary and therapist 2. **(B)** The dialogue occurring at the moment of Mary's and therapist 2's highest SCR peaks (right red oval in **A**). Both panels present a microanalytic study on moments in couple therapy during which there were several SCR peaks between participants. The embodied variables were used together with the transcript of the moment. T1, therapist 1; T2, therapist 2.

44, 45). The temporal properties of SCR are such that the response happens 1 s after the stimulus and lasts for ∼2 s. This is important to consider when analyzing the data. SCRs are temporally exact and thus suitable to use in combination with spoken dialogue in real time—as it is happening. Heart rate variability (HRV), on the other hand, is calculated (and extracted) in longer windows of 15 s (18) and sometimes in intervals of 2–5 min (49). This makes HRV a less time-accurate measure. However, one important aspect is that through the processing of the data, temporal exactness can be affected.

For instance, it is quite common to calculate the peak points of the embodied variable responses (see Figure 2A); however, different ways to calculate the peaks exist. We used two different methods to calculate the peaks in different modalities. The absolute stress vectors (ASVs) were calculated based on the heart rate, the high-frequency power, the low-frequency power, and respiratory variables (50). The ASVs were used to identify the most stressful situations for each participant when the dialogues were studied in couple therapy sessions (10, 32). We also used EDA peaks, which were extracted from the SCRs. The SCRs were first standardized for each participant, and peak detection was then applied. Peaks that were two or more standard deviations above the individual's session mean were selected as statistically significant SCRs (44). In the analyses, the peaks were integrated with what happened in the conversation. Päivinen et al. (44) found EDA peaks in most of the participants in interactions during which one spouse's identity was blamed, i.e., who you are as a person.

As there are multiple ways to extract and process data, the researcher needs to understand the process and how

it affects what the information obtained could reflect. For instance, ASV and EDA peak detection are both thought to reflect the activation of the sympathetic nervous system, but ASV is calculated based on heart rate and EDA from sweat secretion in the palms. As the gathering and processing of the data from different modalities require different knowledge and understanding of the data, our research group has designated specific researchers to work on specific modalities, thereby enabling them to acquire expertise on the properties of their specific modality.

Data analysis strategy

When selecting how to analyze the data, it is important to consider the temporal aspects of each modality. Are the specific variable and the way the data have been extracted and processed best suited for an analysis in which the data analysis unit is temporally very precise, such as combining the embodied variable with a microanalytic qualitative analysis of a transcript (13, 44)? Or is the variable and how it is operationalized better suited for studying longer intervals? We have, for instance, also used SCRs in relation to case studies in which the psychotherapy session was split into topical episodes during which one specific topic was discussed (see Figure 1B). Topical episodes could vary in time, ranging from 2.5 to over 7 min (33, 45). In the qualitative analysis of multimodal data, the researcher needs to consider multiple temporalities, referring to the fact that there are several non-linear overlapping sequences of action in the different modalities, as well as multiactivity, where one or more participants engage in multiple activities at the same time (51).

In qualitative studies, the transcripts of conversations are often used as an automatic part of the analysis process. One innovative methodological suggestion on how to use transcripts in a more embodied way was put forward by Chadwick (52), who emphasized the importance of embodiment by altering the way transcripts were written to include rhythm or embodiment. In the qualitative studies, we mainly used the transcripts of the sessions and included the embodied variables in them.

In quantitative studies on synchrony, for instance, the temporal structure most commonly covers the entire therapy session, as the embodied variables usually display the mean of synchrony in the entire therapy session (20, 23, 25); however, discussions of whether to study session-level synchrony or momentary synchrony are emerging.

The meaning of the embodied responses

Throughout our research in the RM project, we held one key aspect of studying embodied variables in clinical settings to be what hypotheses the researcher formed regarding the meaning of the responses by a specific variable. For instance, EDA arousal has been related to emotional arousal (53), but also to cognitive load or movement (54). In clinical encounters, EDA arousal has been related to situations in which the therapist is empathic toward the client (55), when there are moments of confrontation (56), when one's identity is blamed (44), and in relation to reflection (45). In a case study, ASV was observed both in the client and in the therapist at an important moment of change, which was thought to relate to both the emotional importance and the psychological importance of the moment (32). In the individual SRIs, both the client and the therapist confirmed the importance of this moment to the client's therapy. This finding is in line with del Piccolo and Finset's (6) suggestion that arousal could be a sign of active emotional engagement. More than anything else, these studies demonstrate the creative exploratory phase of studying embodied variables in clinical settings. We do not yet have the answers to questions such as what EDA or HRV are related to in the clinical context but are slowly accumulating study results. We hope that future research will develop a theory on how arousal is related to the therapeutic process and therapy outcome.

It is also important to form a hypothesis about how context influences embodied responses. Psychotherapy is a specific context that has its own conventions that differ from ordinary interactions. This affects the interpretation of the embodied responses [cf. (57)]. Some of the important aspects that can affect the embodied variables are the behavior and overt responses of all participants that can be related to the topics discussed. At the same time, however, the implicit level is always present. The participants might not be aware of this, but it might still affect the embodied variables. In the RM research project, we used individual interviews (SRIs) to provide additional information about the participants' experiences of the interaction. The SRI can provide access to participants' thoughts, feelings, and bodily sensations during the therapy interactions, but also invite new reflections and insight (58). One instance in which the therapist's feelings were present in the embodied patterns occurred when one of the therapists reported in the SRI that he had felt empathetic toward the client (whereas the other therapist did not), and in the session, he was repeatedly imitating the client's postures and movements (13). In the SRI, participants sometimes commented on their bodily responses and/or emotional behaviors while watching the video clips from the session, e.g., "*Now I'm holding my breath*," or "*I did not notice myself feeling bitterness during the session, but when I see and hear myself, this looks and sounds like bitterness*," or "*I was trying not to weep; I often try to hide my feelings*."

However, in the context of psychotherapy, one of the most important aspects is the relationship between the participants. Synchrony studies have focused on this aspect, but the relationship might also influence individual embodied variables. For instance, relational tension between therapist and client has

been reported as physiological arousal (59). There is also the possibility that a defense mechanism, such as suppression, affects the expression of the emotion, but the embodied responses might remain intact (60). It is a complex task to interpret the causes of the embodied responses based on the video material alone. Along with the SRI, these issues can be addressed systematically using self-ratings.

Methods for calculating synchrony

Our quantitative studies on RM have focused on interpersonal synchrony in the sympathetic nervous system (20, 25) and movements and postures [by two separate methods: (23, 61)]. As the synchrony of a certain embodied variable is studied, this brings forth other important aspects. As previously mentioned, practices on how to calculate synchrony differ from one modality to another, but also within one modality, several methods have been used. The choice of algorithm is often guided by common practice in previous studies of the specific modality. For instance, EDA synchrony has been calculated by the concordance index (18, 20, 21, 24, 25), but also using the windowed cross-lagged correlations (WCLC) (18). Movement synchrony is usually calculated using WCLC (15), but specifics on how the time series are divided into smaller segments (non-overlapping or overlapping windows) and how synchrony is calculated within them also vary. In synchrony algorithms, either z-transformed correlations or concordance indexes have been used as an index of synchrony (62). The statistical significance of the synchrony is determined by shuffling methods using either individual client–therapist or client–client pairs or using a pool of all pairs included in the study (63).

Comparisons of the different methods are scarce. Tschacher and Meier (18) compared the concordance index and the WCLC on EDA synchrony data and found differences between the results obtained by different algorithms. Schoenherr et al. (64) compared the different algorithms used to calculate movement synchrony and demonstrated that different algorithms yielded different results and thus portrayed different kinds of synchrony. Schoenherr et al.'s (64) article is the first methodological study to aim at understanding how the differently calculated synchronies convey different aspects of the same embodied variable. Recently, Altmann et al. (65) compared different algorithms and recommended standardization efforts for synchrony computations. We find that it is important, and sometimes required, for a researcher to understand all the finesses of calculating synchrony; it is vital to thoroughly understand what the calculated synchrony is for the researcher to be able to make valid interpretations of the results.

With regard to understanding synchrony calculations, another fascinating aspect of studying synchrony is that, even though it has been studied a great deal, little is known about the function synchrony has in psychotherapy. In our view, it is important that the researcher forms a hypothesis about what the synchrony of certain embodied responses is thought to reflect. Studies with larger data sets have proven that movement synchrony is related to therapeutic alliance and outcome in individual psychotherapy (15, 16). However, as research has accumulated, a more diverse picture emerges. High movement synchrony has been related to non-improving clients dropping out of therapy (66) as well as better outcomes and faster improvements for clients suffering from interpersonal difficulties (67), therapy sessions during which there was not much improvement (68), and confrontational alliance ruptures (69).

The research on physiological synchrony has also been seen as scattered (70). Sympathetic nervous system arousal and EDA synchrony has been related to empathy between therapist and client (21, 24, 37). Palumbo et al. (70) list the main problems in the research field related to inconsistency in terminology and physiological variables used, as well as methodological and statistical inconsistencies. The same applies to movement synchrony, although there is no existing review on the subject. In the research field, there is still an underlying assumption that more synchrony is better, even though research has repeatedly reported that this is not the case. Mayo and Gordon (71) initiated a discussion on the importance of considering two separate tendencies of synchrony: to synchronize or adapt to the other and to desynchronize or act independently.

As we have studied synchrony in the context of couple therapy, it has become evident that the meaning of synchrony differs if it occurs between spouses, between co-therapists, or between client–therapist dyads [cf. (23, 25)]. In couple therapy, the assumption that more synchrony is always better might not apply, either. In mother–infant studies, too much synchrony has been related to attachment insecurity (72, 73), and between spouses to relationship dissatisfaction and conflict (74). In couple therapy, too much synchrony between spouses could reflect an enmeshment between the spouses—a lack of individuality, leading to dissatisfaction. Another study revealing the complexity of synchrony in couple therapy was a finding that decreased physiological synchrony between therapist and client in a case study was related to a positive therapy outcome (75). For movement synchrony, a similar finding was that too much synchrony led to a reduction in emotional regulation (76).

All studies point to synchrony as a multifaceted phenomenon; differences based on roles have been shown in RM. Another aspect was put forward by Butler (77), who pointed out that synchrony can be seen as something occurring between two persons or as two persons being synchronized to an outside event. As we studied synchrony in couple therapy, we discovered that the therapists were mostly synchronized in both the sympathetic nervous system (20) and their movements (23). This could possibly reflect the two therapists being synchronized to an "outside event," the spouses' narratives, which are the focus of the therapy.

Integration of information from different modalities

From the beginning of the RM project, we aimed to integrate information from the various modalities to form a more complete picture of the embodied variables in the therapeutic process. We have systematically developed ways to conduct multimethod, multimodal studies to fully utilize the possibilities offered by this rich and unique data. In multimodal research, several problems need to be solved. Since modality-specific measures operate on different time scales, observations from a single variable can have several meanings, each of which may be relevant to the interaction to a greater or lesser degree. We have tackled these problems with two main strategies: (a) through multimodal case studies, and (b) by using statistical modeling to analyze synchronies in more than one modality simultaneously.

In qualitative case studies, we aimed to integrate information from separate modalities. This was evident from our first study [(10), p. 713], in which we concluded, "*It is evident that it is not enough to look only at the ANS information, or at any other single source of data. We need to integrate … all measured information if we are to make more precise hypotheses and observations on the ways in which the therapist and the client synchronize their embodied reactions in dialog.*" In a microanalytic study on alliance formations in couple therapy (13), which concentrated on an extract of dialogue, we included posture and movement synchrony and EDA peaks in the analysis. The study demonstrated that the different modalities have separate but complementary tasks in couple therapy. When there were clear markers of alliance in a dyad in verbal exchange, there were also markers of synchrony in one or more nonverbal modalities. In addition, when a dyad was outside conversational exchange, markers of nonverbal alliance in the form of bodily synchrony were often observed in the same dyad. In another case study, we combined the dialogue and the average SCR arousal, and posture and movement synchrony to clarify the variables' relationships to each other within the couple therapy session (33). We discovered that the different modalities often told different stories of the same important moment. The naïve assumption, that one modality would represent one aspect of interaction (for instance, EDA arousal reflecting emotions or movement synchrony reflecting rapport) did not receive support. It seems that the responses from the different embodied modalities were highly related to both the context (what was talked about), the emotions, and the participants' individual thoughts, responses, and even defenses.

Qualitative case studies reveal that couple therapy sessions are temporally interesting and vary in unpredictable patterns concerning the dialogue, who talks and who listens, and the embodied variables. These studies questioned the use of session-level variables of embodied variables. Yet, quantitative studies on embodied aspects in psychotherapy often use session-level averages to describe, for instance, synchrony between participants.

Quantitative studies on the relationship between synchronies in different modalities are almost non-existent. In a recent study, we investigated how physiological synchrony, movement synchrony, and speech patterns were associated in couple therapy (78). EDA synchrony and movement synchrony correlated with each other on the entire sample level, especially in the client–therapist dyad. This supports the assumption that the role of the participant can influence synchrony patterns. Contrary to our hypothesis, movement synchrony was negatively correlated with the amount of speech. This study is one of the first attempts to clarify the relationship between synchrony in different modalities and in relation to speech, which is often seen as the key ingredient of therapy.

In the exploratory phase, new methods are created for solving existing methodological problems, such as the new multivariate form of a synchrony algorithm [mv-SUSY (79)], which enables calculating synchrony between multiple participants. Until now, synchrony has been studied mainly in dyadic constellations, even though couple therapy provides an opportunity to study triadic or quadratic synchrony (61). It remains to be seen how this will change studies on synchrony and what new information it will bring about.

One of the aspects that a researcher encounters when studying embodied variables is the mind-body issue, which we have not addressed in RM. As we have studied the multimodality of interaction, it has become apparent that we make inferences of what occurs in the mind of the participant based on the information from the embodied variables. But it is evident that reducing the mind into a simplistic model is not making justice to the complexity of the human mind. The question of how the responses of the body (the embodied variables) are connected to the experiences and processes in the human mind is a classical philosophical question for any researcher in empirical psychology. In the RM, we have tried to approach this dilemma by using the SRIs, wherein we have asked the participants to recall their embodied responses and explicate them to the researcher [cf. (33)]. This methodological endeavor does not, however, answer the question of how the mind and body are connected, for which multi-disciplinary collaboration with for instance philosophers would be both critical and fruitful.

The added values of using embodied variables

Thus far, we have mainly addressed the challenges of studying the embodied aspects of psychotherapy. Next, we would like to discuss our notions of what the added values are. One of the main advantages is that it enables a new embodied aspect of the interaction to become "visible" and thus increases awareness of the impact the embodied variables have

on the clinical interaction. The importance of considering the embodied aspect of the interaction during the psychotherapeutic encounter has been stressed (1, 4, 80–82), since by concentrating solely on the verbal discourse, a narrow view of psychotherapy is constructed. It is our view that taking the embodied variables into account broadens our understanding of the process of change in psychotherapy since our assumption is that a notable part of the change occurs through the embodied connection between therapist(s) and client(s). Actually, this is not a new idea in psychotherapy since the psychoanalytic school of psychotherapy emphasizes making the implicit realm more explicit by giving words to our (embodied) experiences. It is important that some aspects of interactions are most commonly expressed only nonverbally, such as crying/weeping as a sign of sorrow or engagement in the interaction by gazing intently at one's interaction partner.

Our research team has noted that including the embodied side has expanded the view of who benefits from therapy. By observing the interactions in our data set, we noticed that while male clients are sometimes unable to verbalize their experiences, they convey much information through the embodied channels. Hopefully, there will be more embodied ways of evaluating outcomes for psychotherapy in the future. Marci and Riess (83) suggested that studying psychophysiology in psychotherapy (as a marker of empathy) could serve as a potential bridge between psychotherapy research and the theory and practice of psychotherapy, which was also suggested over 60 years ago (84).

We would also like to put forth an interesting development in the feasibility of using embodied data in psychotherapy sessions. Including biofeedback in psychotherapy is not a new concept; it has been around for at least 50 years [cf. (85)]. As embodied trackers have become available and affordable to the average client, they offer new opportunities for psychotherapists to include embodied variables in the psychotherapy process. Information from the embodied trackers can be seen as a more objective form of information that could inform the therapist and client about the progress of therapy or important factors contributing to the client's well-being. In her psychotherapy practice, the first author has used information from her client's well-being trackers of sleep quality, HRV, and respiratory rate. The data have revealed important aspects of clients' lives that might otherwise be omitted from awareness and dialogue. Sometimes, clients might not be aware of what stressors they have in their daily lives, and through tracking their embodied variables, they learn to recognize formerly implicit stressors. It goes without saying that it is also interesting for the psychotherapist to wear a tracker and, after each session, to view whether it was a stressful or a relaxing session. Another added value can be seen in using trackers with clients who suffer from psychosomatic disorders. It might be that through discussing the embodied metrics of the client—who is usually very interested in the metrics—the working alliance is slowly developing in a less threatening way. The embodied variables can help in creating the bond between therapist and client. Sometimes, the trackers can reveal important aspects of relational bonding in the embodied metrics, which we haven't symbolized previously. Kleinbub et al. (82) suggested that including biofeedback in psychotherapy could inform important aspects of the interpersonal relationship, which could be used when monitoring the psychotherapy process.

Of course, it is important that the psychotherapist knows what the specific embodied metrics are related to, is curious about using them in their own private practice and is also aware of the benefits and risks of using trackers.

Recommendations

As studies on the subject already exist, we find it important that researchers familiarize themselves with previous studies so that they do not invent new methodologies if preexisting methods are available. For a researcher considering a broader view of what aspects need to be considered in the research, we refer to Spatz (86). For a more theoretical way of defining research on embodiment, we refer to Brown et al. (87).

We urge more collaboration between researchers to avoid the pitfall of reinventing the wheel. An ongoing dialogue and more effective networking between experts of the different modalities from separate research groups would increase our in-depth understanding of the various modalities and their interrelations in the context of psychotherapy. It is important to create recurring meetings, such as summer schools or international seminars and data seminars, for psychotherapy researchers who include embodied variables in their research. This would help to develop the field and enable us to start making joint decisions on what analysis units to use, which calculation methods for synchrony would be best suited to our research aims, and which parameters to choose. This could, in turn, help make the various studies more comparable, and information would start to accumulate on the different aspects of embodiment in psychotherapy.

Another important development would be to define the context of psychotherapy, to create a model based on the common factors of change in psychotherapy, and to clarify how psychotherapy interaction differs from everyday interactions. Ideally, there would be a dialogue between researchers studying embodied variables in in non-clinical institutional contexts, everyday interactions and psychotherapy researchers. Obtaining information from the principles of how the embodied variables react during interaction would be important information for psychotherapy and basic research.

The same would apply to synchronization studies in the context of embodiment; self-organized meetings of

researchers of human interaction with invited experts on engineering, statistics, and computer science could be arranged to develop models for gathering structured data of the experimental and clinical sessions. It would be useful to define, for example, the number of participants, length of sessions, equipment for gathering data on autonomic nervous activity, movements, and speech, protocols for synchronizing the recordings, defining the data structure, and protocols for making the data open access in a safe and ethical manner. In addition, preferred methods for extracting essential features of the data and statistical methods revealing the synchronization of participants based on those features would be defined. Then, strictly defined large datasets would allow the use of deep learning artificial intelligence to dig out the essential features of the bodily, experiential, and cognitive dimensions of the interaction. Furthermore, methods of complexity science could be used to develop, for example, multidimensional complexity models to explain and predict emergent behavioral changes in single person and couple therapy. Based on our research, we would like to suggest that candidate attractor states promoting and/or helping to sustain behavioral change would be, for example, SCR peaks, silent movements in discussion, changes in breathing patterns, and posture changes.

We find that during this phase of the research, it is important to implement both qualitative and quantitative studies, and that researchers in their reports emphasize and reveal their conclusions behind their methodological choices. This would help other researchers develop the research further.

By qualitative studies, the meaning of the underlying embodied variables can be deciphered, and various hypotheses can be developed for further use in quantitative studies. Qualitative studies can aid in developing theories on the relations between embodied variables and various contexts. For qualitative studies, it is important that the embodied variables are not used as proof of bodily influence, but to use them alongside qualitative analyses to explore how the embodied side of the interaction is a constitutive part of social interaction (88).

In quantitative studies, it is vital to further develop the methods, scrutinize the meaning of the differently operationalized embodied variables, and critically evaluate how to interpret the results obtained in different contexts. It is important to develop theoretically informed hypotheses regarding the embodied variables studied and their relationships to other variables. We urge the researcher to question the meaning of the variables and to consider the idiosyncrasy and context dependency of the embodied variables.

It has been suggested that a large part of the success of the clinical encounter has to do with the embodied variables in the interaction (43, 81, 89) and that clinical reasoning by therapists is often grounded in the embodied domain (90). We have discovered that studying embodied variables is vital to understanding how the change process in psychotherapy occurs, and that including embodied variables in the designs enables us to create a more multidimensional and ecologically valid picture of what is truly going on in the psychotherapy process.

Author contributions

PN-S had the main responsibility of writing and editing the manuscript and figures. V-LK and MP contributed to the writing process and the figures. All authors contributed equally to the substance of the article, revised the article critically for important intellectual content, and approved the submitted version to be published.

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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.

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Supplementary material

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Formality in psychotherapy: How are therapists' and clients' use of discourse particles related to therapist empathy?

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Introduction: Previous studies explored the preferences for therapists' attire and office setting based on initial impressions as a reference for the formality in psychotherapy. This study examines the formality of psychotherapy by investigating therapists' and clients' use of discourse particles, the linguistic marker and quantifier of the formality in speech, in relation to therapist empathy in different stages of psychotherapy.

Methods: Four psychotherapy sessions (representing early, mid, and late stages) each from 39 therapist-client dyads were analyzed. Trained observers rated therapist empathy in each session using the Therapist Empathy Scale.

Results: Results of multilevel modeling show that synchrony in particle usage, hence synchrony in formality, between clients and therapists is not associated with therapist empathy. Therapists' use of particles (i.e., absolute formality of therapists) was also not associated with therapist empathy. In contrast, the relative formality of therapists plays significant roles: therapist empathy is generally observed when therapists are relatively more formal than the clients (i.e., lower relative usage of particles by the therapists when compared to the clients). However, for clients who speak formally with few particles, therapist casualness (i.e., higher relative usage of particles than the clients) at the beginning of therapy may be interpreted as therapist empathy as therapists help these clients ease into the therapeutic relationships.

Discussion: Our results suggest that the examination of therapists' and clients' use of particles across different stages of treatment may illuminate dynamic interactional styles that facilitate or hinder the psychotherapy process.

KEYWORDS

discourse particle, therapist empathy, formality, psychotherapy, linguistic feature, synchrony

1 Introduction

This study explores the formality of psychotherapy by investigating therapists' and clients' use of discourse particles in relation to therapist empathy.

The formality of psychotherapy is an area that is not commonly explored by researchers. Previous research mainly explored therapists' attire, which may reflect people's preferences on the formality of therapists. Participants were asked to rate the therapists after being presented with photos of therapists wearing different attire or having a short interaction with therapists. Their results were generally equivocal: therapists with formal/professional attire were perceived as higher in expertness and credibility, whereas those with casual attire were perceived as lower in expertness (1–3). However, the participants of these studies were undergraduate students and not real clients, so their results may not be representative of clients in psychotherapy setting. Stillman and Resnick (4) also conducted a similar study in 1972 by asking 50 male students to rate 5 male trainee therapists after a 20-min initial interaction, but they found no significant effects of therapists' attire on participants' disclosure or perception of therapists' attractiveness. However, as Halmagyi (5) argued, their study was conducted in early 1970s with all male therapists and participants, which may not be generalized to present times when female dominate psychotherapy and related professions. In addition, a recent qualitative study interviewed and surveyed current clients of psychotherapy and showed that clients generally perceived therapists dressed in professional/formal attire as having a more professional attitude (6).

Hubble and Gelso (7) was another study that asked about clients' preferences in the formality of therapists' attire. They asked 54 female undergraduate students who have real personal problems which they wanted to discuss with a therapist to engage in a 45-min interview with male therapists with three levels of attires: formal (coat and tie), casual (sport shirt and slacks), and highly casual (sweatshirt and jeans). Being undergraduate students, the clients dressed either casually or highly casually. Their results showed that clients who dressed casually preferred therapists dressing more formal than themselves with formal attire, and clients who dressed highly casually preferred therapists dressing relatively more formal than themselves with casual attire but not formal attire. In contrast to other studies that were based on forced options of *absolute formality* (i.e., binary: formal vs. casual), their findings shed light on the importance of *relative formality* (i.e., therapists being relatively more formal or more casual than their clients). Also, they were aware of the heterogeneity in the level of formality/casualness among clients, and that clients' preference may depend on their own level formality.

Three studies surveyed psychiatric patients about their preferences on their medical practitioners, but they showed equivocal results. First, psychiatric patients perceived nurses in uniform as more of benevolent autocrat than nurses in street clothes (8). Second, Gledhill et al. (9) found that psychiatric patients preferred psychiatrists wearing formal attire [e.g., long-sleeved shirts with formal trousers and ties (male) and blouses and skirts (female)] with white coats, which were perceived as more competent and understanding. Third, conversely, most (96%) psychiatric patients in the study of Nihalani et al. (10) preferred psychiatrists not wearing white coats, and the majority of their participants preferred psychiatrists wearing casual shirts and pants/skirts.

Apart from the formality of therapists' attire, few studies investigated the formality of the office setting of psychotherapy. Bloom et al. (11) asked 144 undergraduate students to sit at two settings of psychotherapy (traditional vs. humanistic) and rated therapists of different sexes based on their initial impression. Traditional office looked more formal, which included therapists sitting behind the desks (around 183 cm apart from the clients) with a five-drawer file cabinet next to the desks, and the walls of the office were decorated with four diplomas. In contrast, therapists sat face-to-face with the clients (around 89 cm apart from the clients) in humanistic office with a small end table between them. The walls were decorated with several posters with some poignant sayings. In general, humanistic office looked less formal than the traditional office. They found that participants perceived female therapists in the traditional office setting as significantly more credible than female therapists in the humanistic office setting. In contrast, participants perceived male therapists in the humanistic office as significantly more credible than male therapists in the traditional office. Later, Gass (12) asked 233 undergraduate students to listen to some audio recordings of psychotherapy while being presented with photos of therapists with formal or casual attire in two office settings: behind desk (more formal) vs. without desk (less formal). Based on participants' initial impression, therapists with casual attire were perceived as more personally attractive when seated without desk. Findings of these two studies on the formality of office setting suggested that informality/casualness can sometimes be perceived positively as an initial impression; however, participants of both studies were only undergraduate students, so their results may not be representative of real clients of psychotherapy. Also, their results may only be indicative of initial impression, which may not be generalized to later stages of psychotherapy.

The above literature review has shown confounds in the preference for the formality of psychotherapy in terms of therapists' attire and office setting. Halmagyi (5), a recent qualitative study that interviewed therapists, concluded that therapists' attire is an area that is absent in formal mentioning in training and is believed to be a common assumption in the field; however, common agreement and awareness on attire are both lacking, not to mention the formality of psychotherapy. Therapists dressing formally (casually) and having a formal (casual) office setting do not imply therapists

conducting psychotherapy formally (casually), especially since attires and office settings are fixed variables in psychotherapy, but there can be dynamical changes in the therapist-client relationship where the formality of psychotherapy changes throughout the course of psychotherapy. A preference on the formality of psychotherapy based on initial interaction may not be representative of that in later stages of psychotherapy. Moreover, formality exists over a spectrum/continuum, rather than dichotomously (5). Fixed variables such as attire and office setting may qualify the measurements of formality to few dichotomous/binary categories (e.g., formal vs. casual).

Furthermore, even though attire and office setting contribute to the perception of formality, a crucial component of formality is constituted by the way people speak (i.e., the use of language) (13). Language, as a tool and method of information delivery, does not only encode the message itself, but also the paralanguage and metacommunication of the speakers, such as speakers' emotions, attitudes, intentions, and nuanced meanings. From a pragmatic point of view, a dialogue is a communication activity between parties that involves the interplay between speakers, rather than a mere summation of independent monologs. For example, the English fillers (e.g., *um*, *uh*, etc.) and discourse markers (e.g., *you know*, *I mean*, etc.) are analogs to the "traffic lights" in a conversation, signaling a deceleration of conversation, changing topic, or turn taking to the interlocutors (14–16). A recent study by Jin and Tay (17) pioneered in investigating the occurrence of Mandarin particles *ou* and turn-construction-units (TCU) in clinical contexts. They found that non-TCU-final *ou* occurred mainly in the patient speech to mark newsworthiness and call for the doctor's attention, while TCU-final *ou* occurred in both the doctor and the patient speech serving various functions. This demonstrates how "subtle" use of particles can facilitate relationship building in conversational activities. In short, pragmatically speaking, language encode paralinguistic and metacommuncative information. As psychotherapy is primarily a speech-oriented activity, it is thus believed that linguistic/pragmatic analysis is crucial for capturing the dynamics of formality in psychotherapy. For instance, the changes in formality in the psychotherapeutic interaction can be reflected by the formality in the speech of therapists and clients.

In linguistics, *discourse particles* are argued to be the speech markers of formality. In contrast to grammatical particles (e.g., *up* and *down* in phrasal verbs and infinitival *to* in English), discourse particles (e.g., *well*, *now*, sentence-final *huh?*, and sentence-final *man!* in English) are defined as particles that express speakers' attitudes, including their emotions, expectations, intentions, and assumptions, which are crucial to steer the flow and interaction of a dialogue (18, 19). Their meanings and pragmatic functions are so abstract and idiosyncratic that are often described as "untranslatable"; nevertheless, their frequency in ordinary speech is high. The communicative competence is considered drastically impaired if learners of language cannot master the use of particles (18, 20). The following examples demonstrate how discourse particles encode speakers' attitudes in Cantonese, the language used in the psychotherapy sessions of the current study. Cantonese discourse particles are also known as sentence-final particles and utterance-final particles, for they typically appear at the end of sentences. The sentence-final particles in examples (1–3)[1] convey different pragmatic meanings and discourse functions using the same sentence body *keoidei taisyu* ("they read books"): *me* in (1) transforms the statement into a rhetorical question; *gwaa* in (2) signals speculation; and *lo* in (3) expresses obviousness.

(1) *Keoidei taisyu* ***me?***
they read.book particle
"Do they really read books?" [Rhetorical question]

(2) *Keoidei taisyu* ***gwaa***.
they read.book particle
"I guess they read books." [Speculation]

(3) *Keoidei taisyu* ***lo***.
they read.book particle
"It is needless to say that they read books." [Obviousness]

Since Cantonese particles typically occur at the end of sentences, they are argued to be employed for recalibrating and finalizing speaker's epistemic stance, including reaffirming and modulating (upgrading or downgrading). For instance, *gwaa* in (2) is a particle indicating speaker's uncertainty, and *lo* in (3) is a particle indicating speaker's certainty. It is worth noting that language often has multiple strategies to encode similar discourse functions, and the methods can interact with each other. For instance, Chor (21) argued that Cantonese particles are used to recalibrate the epistemic stance of the speakers laid down by other strategies, including epistemic adverbials (e.g., *probably*, *certainly*, etc.), modals (e.g., *must*, *may*, etc.), and epistemic phrases (e.g., *I think*, *I believe*, etc.). However, pragmatically, nuances of formality are incidentally encoded by different strategies. For instance, both the adverbial "obviously" and the Cantonese particle *lo* encode obviousness. While adverbials are mostly emotionally neutral, the use of particles always brings in additional speaker's emotions/attitudes and subjective mood, and the exudation of personal emotions is often considered more causal in terms of formality than staying emotionally neutral. In other words, to avoid personal emotions

1 First line of each example is the *Jyutping* romanization of Cantonese characters (108). Second line is the gloss. Third line is the English translation of the whole sentence.

and mood, formal speech tends to reduce the use of particles and employ other more neutral strategies, say adverbials (19, 22–28).

Cross-linguistically, linguists are able to find corresponding "redundant" adverbials to particles in different languages that encode very similar semantic/pragmatic meanings. Such a correspondence system in syntax-discourse mapping is argued to be universally true in all languages (22, 25–29). It is also widely observed that particles in different languages generally encode semantic/pragmatic meanings with higher casualness, and higher usage of particles is cross-linguistically observed in casual/colloquial speech (e.g., conversation with close friends and relatives) (22, 30–35). Syntactically speaking, discourse particles do not belong to the argument structure in syntax. They are "optional elements" in sentences (vis-à-vis obligatory elements: subjects, verbs, and objects). Given such optionality, particles are reduced to the minimum to preserve a high degree of formality in formal speech (e.g., reporting speech) (22, 30–35). Thus, the usage of particles in speech has been an effective quantifier of the formality of the discourse: the more casual the discourse, the higher the usage of particles. For instance, based on naturalistic data of Cantonese, Leung (32) reported that particles took up 0–6% of utterances in reporting speech (e.g., news report, weather report, transportation report, etc.), 29–33% of utterances in radio/television commentary and interviews, and 62–71% of utterances in chit-chat and daily conversation. Based on the varying use of particles across Cantonese speeches that vary in formality and the cross-linguistic observation on the relationships between particles and formality, we hypothesize that the use of particles as a quantifier of the formality of a discourse, including the formality of psychotherapy sessions: the more casual the discourse, the higher the usage of particles.

Formal speech is generally characterized by the neutrality of speakers' emotions/mood. In psychotherapy, neutrality as a therapeutic stance originated within psychoanalysis and was viewed as one of the most effective viable therapist stances for many decades (36). In essence, psychoanalysts' neutrality helps to maintain the therapeutic boundary, and prevent the therapists' values and feelings from interfering with clients' exploration and the therapeutic process (37–39). However, psychoanalysts are also aware of the importance of empathy and engagement in a real relationship with patients, noting that the gratification of patients' needs for affection and dependency (among other needs) should be provided at times to motivate them to continue to work on understanding themselves in deeper ways (36, 40–43). In other words, there needs to be a balance between neutrality of emotions and the exudation of emotions/empathy in classical psychoanalysis (36, 39, 42).

Later, it is similarly proposed in other therapeutic approaches, such as psychodynamic, humanistic, and integrative approaches, that therapeutic *neutrality* should be enacted within the context of *empathic atmosphere* to be effective (36, 44–47). The empathic atmosphere first involves the therapists to experience empathy (i.e., entering the patients' inner worlds, intellectually grasping the worlds, and to an extent affectively experiencing them). At the same time, the therapists do not lose themselves in the clients' worlds, but instead maintain their separate identities. Most importantly, the therapists are able to communicate their empathy via their verbal responses to facilitate patients' inner experiencing and emotional expression in the here and now, without pulling clients to experience more affect than what they are ready for through excessive warmth (36, 40, 41).

In summary, therapists' verbal response of empathy to clients involves both neutrality/refrainment and the exudation of personal affect/warmth. Whether the therapists are expressing neutrality vs. warmth can be reflected in the therapists' speech, for examples, the pragmatic and paralinguistic/metacommunicative aspects of speech encodes speakers' emotions and attitudes. These aspects may in turn reflect in the formality of the speaker. The current study aims to investigate the linguistic elements in speech that can capture, pragmatically, the formality in psychotherapy. As a first step, we explore how these linguistic elements reflecting the speakers' formality relates to clients' experience of therapist empathy.

Clients' experience of therapist empathy has long been hypothesized to be a key process in psychotherapy contributing to client change (47, 48). It can be defined broadly as "the therapist's sensitive ability and willingness to understand the client's thoughts, feelings and struggles from the client's point of view" (49). A recent meta-analysis on 82 independent samples and 6,138 clients has shown that empathy is a moderately strong predictor of therapy outcome (48). Linguistically, both intonation (the pitch pattern of a sentence) and particles perform similar pragmatic functions of encoding speakers' emotions and attitudes (19, 22–24, 29, 34, 50–54) and are linguistic features that are pertinent to empathy. It is argued that all languages use a combination of intonation and particles for expressing connotative meaning, and they form a continuum in world languages: languages that use more intonation tend to use fewer particles, and vice versa. For example, languages that primarily have larger inventories of intonation, such as English and French (e.g., *hein?*), have fewer discourse particles. In contrast, languages that use a large number of particles, such as Cantonese, German (e.g., *doch*, *eben*, *ja*, etc.), Japanese (e.g., *ka*, *ne*, *yo*, etc.), Mandarin (e.g., *ba*, *le*, *ma*, etc.), and Vietnamese (e.g., *à*, *hả*, *nhỉ*, etc.), have smaller repertoires of intonation (19, 32, 55, 56). However, previous studies on psychotherapy only investigated intonation, but the role of particles is left unexplored. For example, the use of intonation by therapists was annotated in the transcript excerpts of psychotherapy sessions in studies of conversation analysis, but intonation was not the center of their discussion and the intonation mentioned was mostly certain one-off instances in speech (57–59). Weiste and Peräkylä (60) was the first study that investigated the systematic use of intonation by the therapists in psychotherapy. They

concluded that therapists tend to continue the intonation of clients with a lower pitch and softer voice when they validate clients' opinions and change to using a higher pitch and louder voice when they challenge clients' views. Since then, more studies investigated the use of continuity of clients' intonation by the therapists in psychotherapy (61–63).

Such a concept of continuity resembles the notion of synchrony in the studies of empathy and psychotherapy. First, empathy has been conceptualized as a general process that involves mirroring, which depends on a process of synchrony and imitation (64). Second, there has been a history of studying interpersonal synchrony, which is argued to promote cooperative behavior, affiliation, and compassion. The alignments can occur in levels of neural, perceptual, affective, physiological, and behavioral responses during social interaction (65–69). Specifically in psychotherapy, since therapists assist clients through verbal interactions, previous studies showed relationships between dyadic synchrony and the quality of interpersonal interactions in therapist-client dyads in psychotherapy. For example, higher synchrony between therapists' and clients' body movements was associated with higher ratings of relationship quality and treatment outcome (70). Higher synchrony in physiological signals, such as skin conductance, between dyads was associated with better therapist empathy (71, 72). In terms of language use, linguistic synchrony between the therapists and clients are hypothesized to be beneficial to the treatment outcome therapists and clients may attain synchrony by developing "common language" by mutual adaptation to each other's linguistic behaviors (73). For instance, synchrony in language style between dyads was found to be associated with higher therapist empathy and better treatment outcome (74, 75). Also, Imel et al. (76) found that synchrony in vocally encoded arousal (measured by mean fundamental frequency) between dyad members was higher in sessions with high empathy ratings; however, Gaume et al. (77) failed to replicate their results. They attributed the failure of replication to three major reasons. First, Imel et al. investigated standardized patients (i.e., actors portraying generic patients) who may amplify a hypothesized synchrony effect. Second, the clinicians in the study of Imel et al. were recently exposed to training of Motivational Interviewing and might be particularly attentive to empathic reflection of patient emotions. Third, there are differences in language and culture. The sessions of Gaume et al. were held in French-speaking Switzerland, while those of Imel et al. were held in English-speaking United States. Paralinguistically, Americans tend to speak more loudly than Europeans, and English has more fluctuating prosody and pitch than French, so English may show synchrony in prosody more easily.

Unfortunately, existing approaches to linguistic synchrony tend to be methodologically divided—either quantitative or qualitative approach (78). Quantitatively, automated text analytic software like Linguistic Inquiry and Word Count (LIWC) (79) is widely employed to analyze the frequency count of content words and grammatical words in overall sessions, which claims to reflect analytical thinking, clout, authenticity, and emotional tone of the speakers. In general, mixed-effects modeling and cluster analysis are proposed to be the common statistical analytics (78–86). However, discourse particles are not considered in the calculation LIWC. Qualitatively, conversation analysis is a common method to investigate the turn-by-turn linguistic features between the therapists and clients (14, 15, 17, 60, 63, 78, 86–90). Tay and Qiu (78) and Qiu and Tay (86) thus proposed that mixed methods of both quantitative and qualitative approaches should be employed in the linguistic analysis of psychotherapy to capture both the generalizable patterns in higher levels (e.g., session level) and lower levels (e.g., turn level). We follow Qiu and Tay (86) in applying mixed-effects modeling in our subsequent analysis of discourse particles, followed by qualitative conversation analysis of examples in our data.

The current study explores how the use of particles, an indicator of the formality of speech in psychotherapy, is related to ratings of therapist empathy. Based on the findings of the previous studies, we can hypothesize at least three relationships between the use of particles, hence the formality of psychotherapy, and therapist empathy. First, from the perspective of synchrony of features, previous studies have shown that higher synchrony in linguistic features and other non-verbal features is associated with higher therapist empathy and better treatment outcome (64, 70–72, 74–76). This predicts that synchrony of particle usage (and hence formality) between clients and therapists is associated with higher therapist empathy.

Second, from the perspective of formality, most studies based on binary options of absolute formality suggested that clients prefer formality over casualness in psychotherapy settings and the therapists' attire (1–3, 6). In addition, although particle use may have interactional component and be dependent on their interlocuters, particle use can also be a characteristic of each individual (91). If these findings also apply to the formality of psychotherapy speech, it predicts that, regardless of the formality or casualness of the clients, the lower the usage of particles by the therapists (i.e., therapists being more formal), the higher the therapist empathy.

Third, by contrast, relative formality (instead of absolute formality) of psychotherapy can be important to clients' perception (7). If findings about relative formality prevails in psychotherapy speech, it predicts that fewer use of particles by the therapists than their clients, hence indicating higher therapist formality than their clients, predict higher therapist empathy. Also, clients can have different degree of formality/casualness (7), and some studies suggested that therapist casualness may play a role in the initial impressions (11, 12). Preference for therapist formality may thus differ

between clients of different degree of formality and across different stages of psychotherapy.

2 Materials and methods

2.1 Setting

Data were collected from a department training clinic in a university in Hong Kong, where master's level trainees complete their first 20-weeks counseling practicum as part of the degree requirement. They also participated in individual and group supervision as part of training. As such, the data represented the therapists' work with one of their first few clients. They had one year of counseling training prior to starting the counseling practicum. Their training was based on Hill's (92) three-stage model of helping. Based on this model, counselors learned to use basic helping skills from client-centered, psychodynamic, and cognitive-behavioral orientations in the counseling sessions.

The clinic provided low-fee psychotherapy for adults living in the community, and sessions were conducted weekly over the practicum period. The therapists and clients were mainly matched by availability, although sometimes the therapist can indicate their interest to work with specific clients based on the clients' issues that they indicated at screening. Using the standard of Bloom et al. (11), the setting of the counseling rooms in the clinic was all identically humanistic: therapists sat face-to-face with clients with a small end table between them.

2.2 Participants

Thirty-nine (29 women, 10 men) clients were included in this study. Clients' age ranged from 18 to 57 years (mean = 34.67, *SD* = 10.85). Thirty-nine (31 women, 8 men; mean age = 34.25, *SD* = 8.01) therapists provided counseling to the 39 clients, thus forming 39 unique therapist-client dyads. All therapists and clients were Asians, and the counseling sessions were conducted in Cantonese.

2.3 Measures

The Therapist Empathy Scale (TES) (93) is a nine-item observer-rated measure of therapist empathy. The items cover the cognitive, affective, attitudinal, and attunement aspects of empathy. Each item is rated on a seven-point scale from 1 = *not at all* to 7 = *extremely*, and a score is given to each item after observers complete watching a videotaped counseling session. A sample item is "Expressiveness: A therapist's voice demonstrates expressiveness when the therapist speaks with energy and varies the pitch of his or her voice to accommodate the mood or disposition of the client." The total score (range from 9 to 63) is used in this study, with a higher score indicating higher observer-rated therapist empathy. The TES has excellent psychometric properties in the scale development sample (93), and its internal consistency for the current sample is high ($\alpha = 0.96$).

In the present study, eight raters were first trained on the TES using eight videotaped counseling sessions unrelated to the study sample but were collected from the same setting. Based on these sessions, the intraclass coefficient (ICC) for the eight raters was 0.79. Using Cicchetti (94)'s guidelines on interrater reliability, where ICCs < 0.40 are poor, 0.40–0.59 are fair, 0.60–0.74 are good, and > 0.75 are excellent, the raters are considered to have excellent interrater reliability. The raters then proceeded to rate counseling sessions from the study. As a reliability check, about 40% (61 sessions) of the videotapes were rated by two raters. The ICC based on a mean-rating ($k = 2$), consistency, two-way random effects model was 0.90, indicating excellent interrater reliability beyond the training phase. No outliers were detected in our sample as the scores all fall within $\pm$ 3.29 SD (95), which indicates that there were not very unempathic therapists in our data.

2.4 Procedures

Potential clients learned about the clinic through website listings, flyers, and word-of-mouth. The clients reported a range of issues that they sought counseling for during initial screening intake, including mood difficulties, stress, personal growth, family issues, interpersonal problems, academic/work-related problems, and marital/romantic relationship issues.

Following Flückiger et al. (96), four sessions (representing early, mid, and late stages of psychotherapy) were randomly selected from the 12 sessions of each dyad (i.e., a total of 156 session) for the research purpose of this study. Different tasks were involved in different stages of the therapy in this convention of dividing therapy stages. Typically, emphasis was given in the early stage to establish the working alliance between the therapists and the clients. The middle stage involved deeper work on the clients' issues, and the late stage involved helping the clients look forward to life independent from the therapists and getting the clients ready to part from the therapists.

All analyzed sessions were videotaped and voice recorded. Trained observers completed the TES after watching the videotapes of the sessions.

In addition, the videotapes and voice recordings of all sessions were manually transcribed by university undergraduate students, who were native speakers of Cantonese. They adopted the same convention of transcription, including the delimitation of utterances and speaker turns based on native judgments. After that, all transcripts were cross-checked with voice recordings by native adult speakers of Cantonese who were trained in

Cantonese phonetics. They focused on the accuracy of the transcription of particles with reference to the lists of Cantonese discourse particles compiled by Tang (22) and Sybesma and Li (52). The usage of particles by the clients and therapists in each session was calculated by the percentage of utterances produced with particles by the clients or therapists = (number of utterances produced with particles by the client or therapist in a specific session/total number of utterances produced by the client or therapist in the specific session) × 100%. The same delimitation of utterances and speaker turns was previously employed by Lee et al. (97) in their linguistic analysis of discourse boundaries.

Based on the obtained particle usage data, we first calculated the synchrony of the use of particles by obtaining the absolute value (i.e., ignoring directions of subtraction) of the pairwise subtraction between clients' and therapists' percentage usage of particles in each session. The closer the value is to zero, the higher the synchrony of the use of particles by the dyad, hence having higher synchrony in formality. Second, we calculated the relative usage of particles by the therapists by pairwise subtraction of clients' percentage usage of particles from therapists' percentage usage of particles in each session. The higher (more positive) the relative usage by the therapists is, the more particles the therapists use than the clients, hence having higher casualness than their clients.

2.5 Multilevel modeling

Descriptive and bivariate statistical analyses were conducted using R (98). In addition, session-level data were nested within the client-level data, but there was no further nesting within therapist-level data since the therapist-client dyads are all unique. Multilevel modeling was performed on our data using *lme4* package (99) in R with TES as the dependent variables of three multilevel models. Model 1 investigated the synchronized use of particles, which included predictors of the synchrony of the use of particles between the therapists and clients and session number. Model 2 investigated the usage of particles by the therapists regardless clients' usage (i.e., absolute formality in psychotherapy), which included predictors of the usage of particles by the therapists and session number. Model 3 investigated the relative use of particles (i.e., relative formality in psychotherapy), which included predictors of usage of particles by the clients, relative usage of particles by the therapists, and session number. We also included random slopes of clients [equivalent to unique therapist-client dyads (100–103)] for the (absolute/relative) usage of particles in each model. As measures of effect size, both the proportion reduction in error resulting from adding predictors (104) and f^2 adjusted for multilevel models (105) were computed. The f^2 for multilevel models can be interpreted as follows: $\geq$ 0.02 are small, $\geq$ 0.15 are medium, and $\geq$ 0.35 are large (106).

2.6 Qualitative conversation analysis

Following the convention of mixed methods study in psychotherapy (78, 86), we analyzed two qualitative examples in our data to elaborate specific examples at turn level based on our quantitative findings at a more "global" session level.

3 Results

3.1 Descriptive statistics and intercorrelations

Table 1 reports the session-level means, standard deviation, range, and the bivariate correlations among the synchrony of the use of particles, usage of particles by the clients, usage of particles by the therapists, relative usage of particles by the therapists, and TES. Although the usage of particles by the therapists is correlated positively with that by the clients (r = 0.44) and negatively with TES (r = −0.18), there is no correlation between synchrony of the use of particles and TES. In contrast, relative usage of particles by the therapists correlates with both TES (r = −0.02) and clients' usage of particles (r = −0.46), which allows for further interaction analyses.

3.2 Multilevel models

3.2.1 Model 1

Results of Model 1 show that there are neither significant main effects of the synchrony of the use of particles [B = 22.36, SE = 25.90, t(114.34) = 0.86, p = 0.39] and session number [B = 1.23, SE = 0.69, t(107.05) = 1.77, p = 0.08], nor significant interaction effects between the two predictors [B = −7.27, SE = 8.89, t(105.50) = −0.82, p = 0.42], on TES. This indicates that therapist empathy is not predicted by the synchrony in particle usage between clients and therapists, and hence the synchrony in formality, and time in therapy. As measures of effect size, the proportion reduction in error resulting from adding predictors in Model 1 is 2.30%, and the f^2 is 0.04, indicating a small effect size of the predictors.

3.2.2 Model 2

Similarly, results of Model 2 show that there are neither significant main effects of the usage of particles by the therapists [B = −0.38, SE = 13.65, t(24.45) = −0.03, p = 0.98] and session number [B = 2.34, SE = 1.28, t(70.75) = 1.83, p = 0.07], nor significant interaction effects between the two predictors [B = −6.08, SE = 4.68, t(71.47) = −1.30, p = 0.20], on TES. This indicates that therapist empathy is not predicted by the usage of particles by the therapists, hence the absolute formality in psychotherapy, and time in therapy. As measures of effect size, the proportion reduction in error resulting from adding

TABLE 1 Session-level mean, standard deviation, range, and intercorrelations of study variables.

Variable	*N*	Mean	*SD*	Min.	Max.	1	2	3	4	5
1. Synchrony of the use of particles (|therapists' % usage of particles—clients' % usage of particles|)	156	7.01	5.00	0.02	20.89	–				
2. Usage of particles by the therapists (% of particles/total utterances produced)	156	26.27	8.47	2.29	49.78	0.08	–			
3. Usage of particles by the clients (% of particles/total utterances produced)	156	27.00	7.72	1.67	50.00	0.15	0.44***	–		
4. Relative usage of particles by the therapists (therapists' % usage of particles—clients' % usage of particles)	156	−0.73	8.59	−18.81	20.89	−0.06	0.59***	−0.46***	–	
5. Therapist Empathy Scale (TES)	156	38.80	7.89	18.00	56.50	−0.01	−0.18*	0.03	−0.02*	–

*$p < 0.05$, ***$p < 0.001$.

predictors in Model 2 is 3.25%, and the f^2 is 0.04, indicating a small effect size of the predictors.

3.2.3 Model 3

By contrast, results of Model 3 show that there are significant main effects of the relative usage of particles by therapists, $B = 123.54$, $SE = 44.06$, $t(118.97) = 2.80$, $p = 0.006$, on TES. Using the R package *sjmisc* (107), **Figure 1A** shows that the lower (more negative) the relative usage of particles by the therapists compared to their clients, the higher the predicted TES. This indicates that therapists who are more formal than their clients are perceived to have higher therapist empathy.

Second, there are significant interaction effects between the relative usage of particles by the therapists and session number on TES, $B = -49.53$, $SE = 17.38$, $t(116.91) = -2.85$, $p = 0.005$. Specifically, in early sessions (e.g., session 1; red line in **Figure 1B**), the higher the relative usage of particles by the therapists (i.e., therapists being more casual than the clients), the higher the predicted TES. On the contrary, in the middle and later sessions (e.g., sessions 2, 3, and 4; blue, green, and purple lines in **Figure 1B**), the lower the relative usage of particles by the therapists (i.e., therapists being more formal than the clients), the higher the predicted TES.

Third, there are significant interaction effects between the relative usage of particles by the therapists and the usage of particles by the clients on TES, $B = -397.22$, $SE = 145.93$, $t(118.36) = -2.72$, $p = 0.007$. **Figure 1C** shows an overall negative relationship between relative usage of particles and the predicted TES, regardless of the usage of particles by the clients, for all curves have negative slopes. The lower the relative usage of particles by the therapists (i.e., therapists being more formal than the clients), the higher the predicted TES. In addition, the slope becomes steeper when clients used more particles [red line: client particle usage at 1 *SD* below the mean (19.27%); blue line: client particle usage at the mean level (27.00%); green line: client particle usage at 1 *SD* above the mean (34.72%)]. In other words, the same unit of increment in the relative usage of particles by the therapists results in a greater decrease in TES scores as clients' usage of particles increases (i.e., when clients are more casual).

Fourth, there are significant interaction effects between relative usage of particles by the therapists, the usage of particles by the clients, and session number, $B = 141.17$, $SE = 60.00$, $t(117.48) = 2.35$, $p = 0.02$, on TES. **Figure 1D** shows the results of the 3-way interactions.

For clients having high usage of particles (green lines, usage 1 *SD* above mean = 34.72%), the lower the relative usage of particles by the therapists, the higher the predicted TES across all sessions. In contrast, for clients having low usage of particles (red lines, usage 1 *SD* below mean = 19.28%), therapists' lower relative usage of particles is associated with higher predicted TES only in the later sessions (sessions 3 and 4); therapists' higher relative usage of particles is associated with higher predicted TES in the earlier sessions (sessions 1 and 2). In general, the slopes of clients having high usage of particles (green lines, usage 1 *SD* above mean = 34.72%) are consistently negative across sessions, whereas the slopes of clients having low usage (red lines, usage 1 *SD* below mean = 19.28%) and average usage (blue lines, mean usage = 27.00%) of particles become more negative as therapy proceeds. Specifically, the slopes of clients having low usage (red lines) change from positive in earlier sessions (sessions 1 and 2) to negative in later sessions (sessions 3 and 4). The slope of clients having average usage (blue lines) is initially positive in early session (session 1) but turns negative in later sessions (sessions 2–4). The interaction analyses suggest that if clients are casual, therapists are predicted to have higher empathy ratings if they speak more formally in all stages of psychotherapy. In contrast, if clients are formal (i.e., use fewer particles), therapists are predicted to have higher empathy ratings if they speak more *casually* than the clients in the early stage of psychotherapy; however, in the later stages of psychotherapy, therapists are predicted to have higher empathy ratings if they speak more formally than the clients.

There are no significant main effects of the clients' usage of particles [$B = -17.50$, $SE = 14.88$, $t(102.76) = -1.18$, $p = 0.24$]

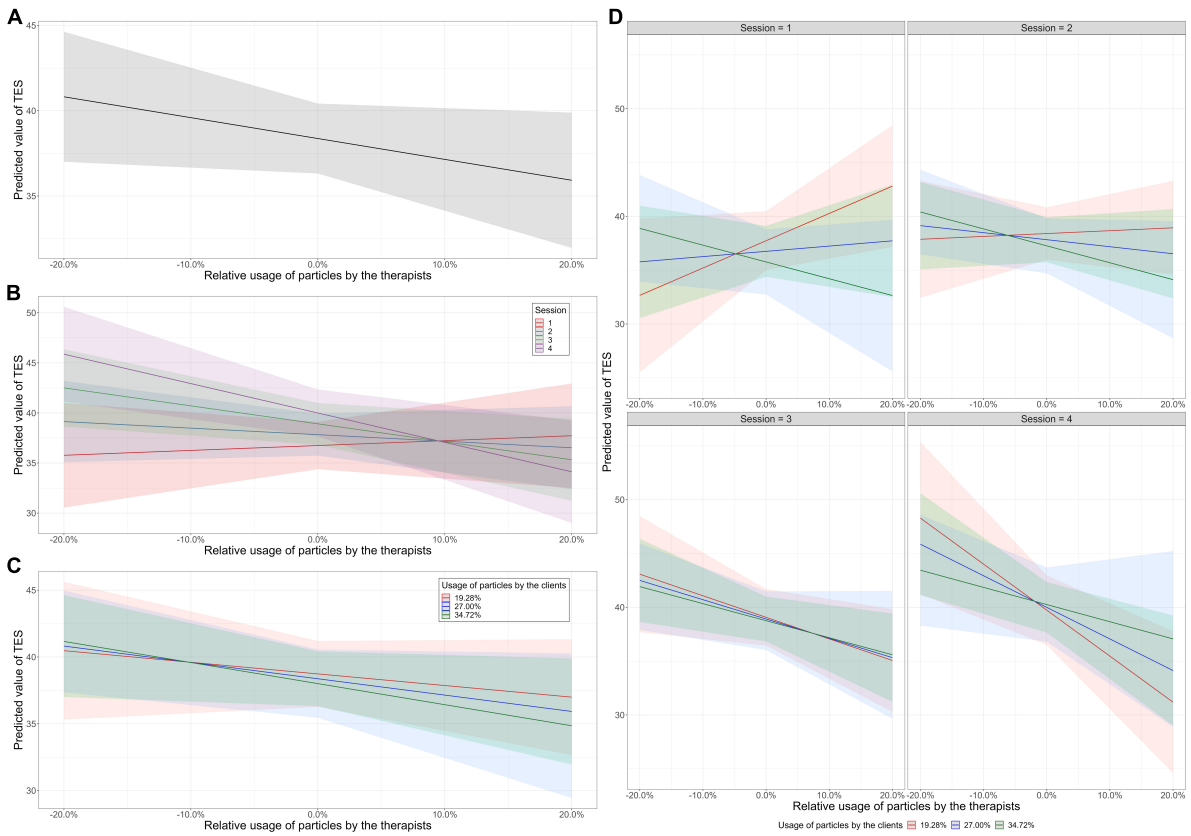

FIGURE 1
Results of multilevel modeling (Model 3). **(A)** Main effects of relative usage of particles by the therapists on TES scores. **(B)** Interaction effects between the relative usage of particles by the therapists and session number on TES scores. **(C)** Interaction effects between the relative usage of particles by the therapists and the usage of particles by the clients on TES scores. **(D)** Interaction effects between relative usage of particles by the therapists, the usage of particles by the clients, and session number on TES scores.

and session number [$B = -0.32$, $SE = 1.63$, $t(113.95) = -0.20$, $p = 0.85$] on TES. The interaction effects between the usage of particles by the clients and session number on TES are also found non-significant, $B = 5.19$, $SE = 6.13$, $t(115.25) = 0.85$, $p = 0.40$.

As measures of effect size, the proportion reduction in error resulting from adding predictors in Model 3 is 9.32%, and the f^2 of the model is 0.16, indicating a medium effect size of the predictors.

3.3 Qualitative conversation analysis

3.3.1 Excerpt 1

Excerpt 1 is taken from a psychotherapy session at the mid stage, which discussed financial issues with client's family members. Both the therapist (age: 38 years) and the client (age: 23 years) are male. The observer-rated TES of this session is 23 (possible TES ranges from 9 to 63; mean = 38.80, $SD = 7.89$). The session was conducted in Cantonese. We translated the transcript into English, while retaining Cantonese particles in Jyutping romanization (108) in bold font at the place where they were used with a bracket indicating the functions of the particles according to description in Tang (22) and Sybesma and Li (52).

1. Therapist: After listening to you, you have actually not received any money from them ***gaa wo*** [surprise].
2. Client: No ***aa*** [emotion softener], absolutely, except that I may have got several red pockets from them during the Chinese New Year.
3. Therapist: Yes ***lo*** [obviousness]. So, there is nothing about being realistic or not, isn't it ***aa*** [emotion softener]?

Both the therapist and the client talked similarly casually with almost all utterances carrying particles. In fact, the sentences are still well-formed and grammatical even if all particles are removed. The addition of particles characterizes the mood of the speakers and adjust their emotions. For example, the use of *gaa wo* by the therapist in the first turn shows the therapist's emotion of being surprised by new information that differs from his original epistemic stance. The *lo* the therapist

used in the third turn expressed obviousness with a negative mood of looking down on the situation. Pragmatically, the whole sentence "Yes *lo*" can be translated as "it is needless to say that it is what I have predicted." If we remove *gaa wo* and *lo* from the two sentences, the two sentences will become more emotionally neutral (i.e., without therapist's subjective emotion and mood). The sentence in the first turn would then become a neutral description of the financial fact, and the "yes" phrase in third turn would be a genuine agreement.

3.3.2 Excerpt 2

Excerpt 2 is taken from a psychotherapy session at the early stage. The therapist (age: 58 years) was male, and the client (age: 45 years) was female. The observer-rated TES of this session is 21. This therapist was observed with abundant use of compound particles, such as *aamaa*, which marked high casualness and speaker's subjectivity and should be generally avoided in psychotherapy. In this session, the therapists produced 35 tokens of *aamaa*, while other therapists in our data produced an average of 0.67 token of *aamaa* in one session.

1. Client: So, he is arranged to sit with a student with dyslexia. That student. . . um. . . is not an able student. The teacher is kind to ask my son to teach and help the student.
2. Therapist: Your son is smart ***aamaa*** [obviousness]. That's why the teacher asks him to help the student with dyslexia.
3. Client: But my son is not patient.

In turn 1, the client brought up the concern that his son was arranged to sit with a student with dyslexia. The therapist was unempathic to detect the anxiety of the client and assumed the client would be happy about her son being arranged to help with the neighboring student. The therapist used the particle *aamaa* in turn 2, which is carries even stronger subjective mood than *lo* in excerpt 1. In this case, it means that the therapist is certain that the client should have known that her son is smart, but the client is not aware of this, which carries a sense of irony and casualness (19, 22, 54). However, the client was actually unhappy about the seating arrangement at all, because she thought that her son was not patient enough to help other students (turn 3).

The overuse of the compound particles reflects high casualness in the therapist, and it is not an appropriate occasion to talk casually when the client was anxious about various aspects of her son in the early stage of psychotherapy (i.e., the therapist and client were not familiar with each other). The casualness in speech can be perceived as being unempathic. A component of empathy is communicative attunement, defined as "an active effort to stay attuned on a moment-to-moment basis with the client's communications and unfolding experience" (48). Part of this attunement process involves being responsive to the clients' preference for formality or casualness in the interaction. In other words, the client's experience of therapist empathy probably includes how well their therapist responds to their preferred therapist demeanor (i.e., more or less formal). In the above scenario of a formal discussion about client's son in an early stage of psychotherapy, talking casually can be perceived as disrespectful and playful, which may affect the perception of empathy. The therapist subjectively assumed the client was happy about the seating arrangement; however, the clients raised disagreement, which is believed that the use of compound particles in the excerpt helped little the client to reflect about her belief. The examples illustrate how the use of particles between turns, hence the formality of speech, may affect the perception of empathy.

4 Discussion

This study is the first study to explore the formality in the speech of psychotherapy by investigating therapists' and clients' use of discourse particles in relation to therapist empathy. Previous studies on psychotherapy mainly explored the formality of therapists' attire and office setting using stimulated scenarios, which are fixed variables that may not capture the changes in formality throughout the course of actual psychotherapy. This study has explored a novel linguistic feature, the use of particles, which is the speech markers of the formality of discourse and can quantify the spectrum/continuum of formality.

First, in contrast to the previous findings on the association between synchrony of linguistic or non-verbal features and therapist empathy (64, 70–72, 74–76), our results (Model 1) suggested that the synchrony in the use of particles, hence the synchrony in formality, between clients and therapists is not associated with therapist empathy. These findings are in line with Gaume et al. (77) who failed to replicate the results of Imel et al. (76), which found that synchrony in vocally encoded arousal between dyad members was higher in sessions with high empathy ratings. Similar to Gaume et al.'s study, we used real clients rather than standardized clients, who were used in Imel et al. Real clients' synchrony effects in linguistic features may not be as conspicuous as those in standardized patients (51). In addition, there can be cultural and paralinguistic differences in the use of particles across different languages that may have contributed to differences in findings across studies that deserve further her inquiry in future research. Second, our results (Models 2 and 3) cast doubt on clients' preference for absolute formality of therapists (i.e., therapists being formal regardless of the formality or casualness of their clients). Results suggested that therapist empathy is generally observed when therapists are *relatively* more formal than the clients (i.e., lower relative usage of particles by the therapists), which echo the findings of Hubble and Gelso (7) based on therapists' attire. The fact that casualness is generally not preferred can be attributed to the fact that formality of therapists is often perceived as credibility and expertness (1–3, 5–7).

Third, while previous studies on the formality of psychotherapy were based on initial interaction or first impression, which may not be representative of later stages of psychotherapy, our study has explored the dynamics of formality across different stages of psychotherapy and among clients of different degree of formality/casualness. In general, the lower the relative usage of particles by the therapists (i.e., therapists being more formal than their clients), the higher the predicted TES, and this negative association gets stronger over the course of therapy (**Figure 1B**). However, as **Figure 1D** shows, when clients used few particles and thus more formal, *higher* relative usage of particles by the therapists was associated with *higher* therapist empathy in the early stages of psychotherapy. Taken together, therapist casualness may be interpreted as therapist empathy as therapists help clients who speak formally with few particles ease into the therapeutic relationship. As therapy progresses, the expectation of therapist formality relative to the client may have led observers to rate therapist as more empathic when they speak with fewer particles than their clients, regardless of clients' level of formality/casualness. Our results suggest that the examination of therapists' and clients' use of particles across different stages of treatment may illuminate dynamic interactional styles that facilitate or hinder the psychotherapy process. Our methods of using linguistic features such as particles to quantify the spectrum/continuum of formality advances previous research that examined formality in a dichotomously way (e.g., formal vs. casual).

Linguistically, apart from being the speech marker of formality of discourse, particles also perform pragmatic functions of encoding speakers' emotions and attitudes similar to intonation (19, 22–24, 29, 34, 50–54). Previous studies only explored the use of intonation in psychotherapy (57–63). This study is the first study that explores the relationships between particles and empathy in psychotherapy. Compared to intonation, particles are more stable and reliable substitutes in linguistic analysis. The lack of invariance problem, which refers to the absence of reliable connections between phonemes (mental representations of sounds) and their highly varying acoustic signals attested in actual speech (109, 110), has been a hard problem in speech perception; of which, intonation is particularly notorious because its acoustic measures are often unreliable and incomparable between utterances (24, 111). There are also copious factors that influence speech sounds, such as physiological state, level of vocal effort, process of production, and individuals' characteristics (112). The analysis of intonation cannot only rely on acoustic measurements but on the subjective judgments of native speakers which are highly labor-intensive, so many previous studies on psychotherapy could only remark one-off instances of intonation used by the therapists (57–59).

Unlike intonation, particles are words with fixed combinations of consonants and vowels (i.e., syllables) that can be unequivocally identified, quantified, and analyzed based on transcriptions. Thus, particles may serve as an alternative feature to intonation for linguistic analysis of human emotions and attitudes. A next step would be to investigate how the formality in relation to therapist empathy changes within a session as a session also comprises many stages (e.g., warming up, supportive therapy, intervention, conclusions, etc.). While we recognize how the quantitative aspect of the usage of particles can be indicative of the formality in speech, which is not easily represented by other linguistic elements, there is also a qualitative aspect of the usage of particles (i.e., different types/categories of particles). Each particle encodes specific semantic and pragmatic functions, which are representative of the mood, emotions, attitudes, intonation, expectations, and assumptions of the speakers. It is worthy for future examination on how the different types of particles (e.g., interrogative particles, imperative particles, declarative particles, particles with other pragmatic functions, etc.) being used and/or synchronized in different conversation topics, backgrounds, and cultures of psychotherapy. Furthermore, particles are words in speech that can be recognized automatically by machines and analyzed computationally, which can be a favorable feature for cutting-edge big data analysis in psychotherapy/psychology.

Clinically, this study has implications for therapists' use of language and formality that can be applied to practice. As a matter of choice of words, therapists can attend to their use of particles in relation to clients' usage and adjust the use of particles in psychotherapy by training efforts. This study also raises the awareness of the correlates of therapists' formality across different stages of psychotherapy, which is not often mentioned in therapist training.

There are certain complications in the formality of the psychotherapy setting of the current study. We collected data from a department training clinic in a university in Hong Kong, where master's level trainees complete their counseling practicum as part of the degree requirement. First, even though Hong Kong has been has historically received influence from the West that the overall sociocultural relationships may be more egalitarian than typical Asian cultures, studies found that traditional Chinese values and hierarchical collectivism are still deep rooted in the mentality of Hong Kong clients (113, 114). Although therapists are generally positioned as more superior than their clients in Asian psychotherapy setting (113–115), trainee therapists are not experts, which may affect the formality/casualness of the psychotherapy as a power differential rooted in Asian hierarchical culture. In the present study, the clients knew that the therapists were trainees, which might lower the perception of the therapists' authority; however, the clinic was a low-fee clinic serving clients from less advantaged socioeconomic background, which might elevate the "status" of the therapists, especially when the clinic was housed in a prestigious local university. Furthermore, the sex and age of the therapists and the clients could also matter, but we had relatively few male

therapists and clients in the sample and an almost equivalent mean age between therapists and clients for specific sub-group analyses. Further studies can explore how age, sex, professional status of the therapists and clients may affect the formality of psychotherapy.

The therapists in this study were all trainees in their first counseling practicum, and all psychotherapy sessions were conducted in Cantonese, which may limit the generalizability of this study. Despite this, future studies can explore the differences in formality between trainee therapists and experienced therapists as trainee therapists tend to be more formal, or sometimes overly formal, than experienced therapists. Since the empathy ratings in the study were given by observers in the session level, which may not be ideal to reflect moment-by-moment change in the perception of empathy. Based on the current findings, future works can ideally work on clients' statement-by-statement basis, so that the direct use of formality is examined. As such, the formality/casualness in critical events can also be independently investigated, which may be another important topic in the study of formality in psychotherapy.

The sample size of therapist-client dyads of the current study is small, which limits our ability to look at therapist-level predictors. The sample size in the level of the series of sessions is also small, which may have weaker statistical inference than that drawn from all sessions. However, we believe that our study serves as a much needed preliminary investigation into the formality of psychotherapeutic speech and the roles of particles in psychotherapy. Besides, since particles exist in most, if not all, languages, this study can be replicated in psychotherapy settings of other languages and cultural backgrounds in future investigation. However, there is a potential limitation that measurement of formality based on linguistic features can be language dependent. In addition, formality and its expression are embedded in cultural contexts. Other sociocultural relationships factors, such as age, gender, professional status, etc., can affect the meaning of formality. Formality out of discourse or sociocultural context can mean not formality, but creating interpersonal boundaries, such as coldness in personality or aloofness in response.

Data availability statement

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

Author contributions

JL, HC, TL, and SL contributed to the conception and design of the study. JL performed the statistical analysis and wrote the first draft of the manuscript. HC wrote sections of the manuscript. DT and NL organized the database and extracted transcription data. All authors contributed to the manuscript revision, read, 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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The effect of cognitive behavioral therapy on future thinking in patients with major depressive disorder: A randomized controlled trial

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Background: Pessimistic thinking about the future is one of the cardinal symptoms of major depression. Few studies have assessed changes in pessimistic thinking after undergoing cognitive behavioral therapy (CBT). A randomized clinical trial (RCT) was conducted with patients diagnosed with major depressive disorder (MDD) to determine whether receiving a course of CBT affects pessimistic future thinking using a future thinking task.

Methods: Thirty-one patients with MDD were randomly assigned to either CBT ($n = 16$) or a talking control (TC) ($n = 15$) for a 16-week intervention. The main outcomes were the change in response time (RT) and the ratio of the responses for positive valence, measured by the future thinking task. Secondary outcomes included the GRID-Hamilton Depression Rating Scale, the Beck Depression Inventory-Second Edition (BDI-II), the Dysfunctional Attitude Scale (DAS), and the word fluency test (WFT).

Results: Regarding the main outcomes, the CBT group showed reduced RT for the positive valence (within-group Cohen's $d = 0.7$, $p = 0.012$) and negative valence (within-group Cohen's $d = 0.6$, $p = 0.03$) in the distant future condition. The ratio of positive valence responses in both groups for all temporal conditions except for the distant past condition increased within group (distant future: CBT: Cohen's $d = 0.5$, $p = 0.04$; TC: Cohen's $d = 0.8$, $p = 0.008$; near future: CBT: Cohen's $d = 1.0$, $p < 0.001$; TC: Cohen's $d = 1.1$, $p = 0.001$; near past: CBT: Cohen's $d = 0.8$, $p = 0.005$; TC: Cohen's $d = 1.0$, $p = 0.002$). As for secondary outcomes, the CBT group showed greater improvement than the TC group regarding the need for social approval as measured by the DAS ($p = 0.012$).

Conclusion: Patients with MDD who received CBT showed a reduced RT for the positive and negative valence in the distant future condition. RT in the future

thinking task for depressed patients may be a potential objective measure for the CBT treatment process. Because the present RCT is positioned as a pilot RCT, a confirmatory trial with a larger number of patients is warranted to elucidate the CBT treatment process that influences future thinking.

Clinical trial registration: https://center6.umin.ac.jp/cgi-open-bin/icdr_e/ctr_view.cgi?recptno=R000021028, identifier UMIN000018155.

KEYWORDS

future thinking, cognitive behavioral therapy, major depressive disorder, future thinking task, response time

1. Introduction

Patients suffering from major depressive disorder (MDD) commonly demonstrate pessimistic and negative views toward the future. Pessimistic thinking about the future is one of the cardinal symptoms of MDD and an essential domain of the psychopathology of depression (1, 2). Beck's cognitive theory of depression is a widely known stress-vulnerability model explaining negative-biased views of the future as well as oneself and the world (*the negative triad*) that posits a major role in the onset, maintenance, and recurrence of depression. Beck asserted that this negative triad is based on the automatically activated dysfunctional self-schema, a fundamental cognitive structure that processes information about oneself through screening, differentiating, and coding (2). Patients with depression generally show a limited adaptive cognitive style, which is characterized by abstract and over-generalized processing linked to a poor evaluation of possible futures, which develops hopelessness. Hopelessness has been associated with suicidal behavior (3), for which cognitive behavioral therapy (CBT) has potential effect (4). Further, depressed patients have a diminished ability to imagine a positive future (5).

Diminished ability to imagine a positive future is a specific feature of future thinking (6). Depressed individuals anticipate fewer positive events than healthy individuals (7). Bjärehed et al. (8) reported a decrease in positive expectations among depressed individuals but no increase in negative expectations based on the future thinking task (FTT), a measure of future thinking based on the verbal fluency paradigm (9). Kosnes et al. (10) indicated a decrease in positive expectations for the future based on the explicit FTT, and the implicit FTT was more pronounced as measured by response time. Our previous study reported that the FTT response time for the positive valence responses in the distant future condition was prolonged in patients with MDD (11). Thus, future thinking in depression may be characterized as a diminished ability of positive anticipation. Perhaps patients with MDD experience difficulty in imagining their positive distant future, which may lead to engaging more frequently with pessimistic thinking. Although future thinking has been extensively studied (12) and several studies have reported that verbal fluency tasks, verbal fluency paradigms and response times using verbal fluency paradigms are associated with hopelessness and suicidal behavior (5, 10, 13). Few studies have examined changes after CBT) for patients with depression. One study found that depressed patients engaged in more positive future thinking after administration of CBT (14), and this was not observed among those who received routine medication treatment (5). In another study, FTT index scores for negative events were reduced after CBT, and change scores for the FTT negative events correlated with depression symptoms (15). Thus, alleviating pessimistic future thinking through improving positive anticipation may help depressed patients imagine their positive distant future and specifically reduce the response time of the distant future condition on the FTT.

Few studies have evaluated the change in future thinking among patients with MDD who received a course of CBT. The present study was conducted at a tertiary care hospital where MDD patients have been visiting and seeking care because they had not responded adequately to initial antidepressant treatment. Therefore, a randomized clinical trial (RCT) was conducted with patients diagnosed with moderate to severe MDD to determine whether receiving a course of CBT affects the response time and percentage of positive recall responses to four temporal conditions in the FTT differently than talking control (TC). We also explored the relationship between the changes in future thinking and the dysfunctional schema.

2. Materials and methods

2.1. Study design

The present study was a 16-week RCT of two parallel groups with a 12-month follow-up. The full RCT protocol has been published elsewhere (16). This study was registered with the UMIN Clinical Trials Registry (identifier: UMIN000018155) and approved by the Ethical Review Committee of Keio University School of Medicine (reference No. 20150070). The neural change and functional connectivity outcomes have been reported elsewhere (17); this article focuses on the behavioral outcomes.

2.2. Patients

From July 2015 to October 2019, patients were recruited from a university teaching hospital located in Tokyo, Japan. Those who agreed to participate were asked to provide written informed consent prior to initiating any study procedure.

Eligible participants were outpatients aged 20–69 years, had a diagnosis of MDD as defined by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (18), either single or recurrent episodes, and without psychotic features. They were assessed by trained psychiatrists using the DSM-IV Structured Clinical Interview (19), with a total score of 16 or higher

on the 17-item GRID-Hamilton Depression Rating Scale (GRID-HAMD17) (20).

2.3. Interventions

Patients received a course of either CBT or TC sessions with therapists and routine psychiatric clinical management. Patients were randomized 1:1 to CBT or TC after the baseline assessment. Allocation was concealed with the use of a computer-generated random allocation system.

2.3.1. Cognitive behavioral therapy (CBT)

Patients allocated to the CBT group were offered 16 individual 50-min sessions, scheduled weekly, with up to four additional sessions if deemed clinically appropriate by the therapist. Therapists followed the procedures outlined in the CBT Manual for Depression (available at the Japanese Ministry of Health, Labour and Welfare website[1]). This manual is based on Beck's original treatment manual (2), with some adaptions designed to address the cultural characteristics of Japanese patients (21). Six therapists, a psychiatrist ($n = 1$), a psychiatric nurse ($n = 1$), or masters- or doctoral-level clinical psychologists ($n = 4$) provided CBT. They had practiced CBT for a mean of 5.5 (SD = 4.1) years and had used CBT to treat a mean of 15.7 (SD = 13.9) patients prior to this study. All received CBT training, including a 2-day intensive workshop plus weekly 1-h on-site group supervision sessions with a skilled CBT supervisor (AN), with thorough review of the cases and detailed feedback to maintain adherence to CBT protocols and competence throughout the study period.

2.3.2. Talking control (TC)

Participants allocated to the TC group were offered a talking control based on the manual of Serfaty et al. (22). TC is an unstructured supportive therapy to encourage patients to talk about their daily experiences and offer empathy without trying to solve problems or teaching new skills. Clearly defined criteria for the TC group were used to prevent CBT from being delivered. TC was also delivered by the same six therapists who provided the CBT in line with previous studies (23). All therapists had practiced psychotherapy including supportive therapy for a mean of 4.5 (SD = 1.7) years and had sufficient clinical experience and training in the elements of supportive therapy. The therapists received TC training, including a 1-day intensive workshop, and practiced delivering the TC in 3-h role plays with the supervisor so that difficult questions could be addressed. One hour of group supervision was then conducted every week, and audiotapes of therapy sessions were evaluated using a fidelity checklist to maintain adherence to TC protocols and competence during the study.

2.4. Outcome Measures

Our main outcomes were the change in response time (RT) and the ratio of the number of responses for positive valence using the FTT at 16 weeks. Valence indicated the emotional value that was associated with events or situations (24). Positive valence refers to responses in a positive context, and negative valence refers to responses in a negative context. Secondary outcomes were the change in scores for depression symptoms as measured by the GRID-HAMD17 and the Beck Depression Inventory-Second Edition (BDI-II), dysfunctional schemas as measured by the Dysfunctional Attitude Scale (DAS), and neurocognitive function as measured by the word fluency test (WFT).

2.4.1. Main outcomes

A schema of an example trial is shown in **Figure 1**. Based on the Future Thinking Implicit Relations Assessment Procedure (10), we used the FTT contextualized and adapted to the Japanese context (11, 25). The FTT consisted of four temporal conditions, which were categorized into two groups relating to temporal directions (past/future) and two groups relating to distance (near/distant). Each trial began with a description of the temporal words (e.g., "in the future") and their primary context (e.g., "your dream"). Participants were asked to imagine events in the distant or near future or to remember events in the distant or near past. When presenting a complete sentence (e.g., "in the future, your dream will come true"), patients were required to press a button to respond "yes" or "no" after judging whether the content was congruent with what they were thinking. The FTT included 64 trials, which took the time ranging from 21.6 to 25.0 min. Stimuli were presented using SuperLab software (version 5.0; Cedrus Corp., San Pedro, CA, USA), and the respondent's RT and answer were collected.

All patient responses indicated a positive or negative valence to each temporal condition. The change in the ratio of the number of responses for positive valence in each temporal condition was calculated to assess the severity of negative future thinking. RT was measured from when the whole sentence was shown to when the patient pushed the button to respond. The ratio of the number of responses for positive valence in each temporal distance condition was calculated to assess differences between the groups. All stimuli were presented in black text on a light white background and projected on a screen viewed by participants on a mirror in the MRI.

2.4.2. Secondary outcomes

Outcomes were collected at baseline and 16 weeks. Alleviation of depressive symptoms was measured by the change in the GRID-HAMD17 score and patient-reported measures of depressive symptoms using the BDI-II (26). Improvement of dysfunctional schema was measured by a change in the DAS (27) total score and three subscale scores (Achievement, Self-Control, and Need for Social Approval) (28). Assessment of the levels of word fluency was carried out by the WFT (29). All assessors received extensive GRID-HAMD17 training, exhibiting excellent interrater reliability with an intraclass correlation coefficient of 0.94–0.98.

All GRID-HAMD17 assessors were masked to the allocated treatment. Considering the percentage of agreement and κ coefficients between the actual allocation and the allocation guessed through asking the masked assessors at the post-treatment visit (at 16 weeks) were 54.0% and 0.093 (95% confidence interval [CI]: −0.36 to 0.36), respectively, the masking was successful.

2.5. Sample size estimation

Because this trial was a pilot RCT with a behavioral experiment conducted under MRI, the sample size was determined primarily

1 http://www.mhlw.go.jp/bunya/shougaihoken/kokoro/dl/01.pdf

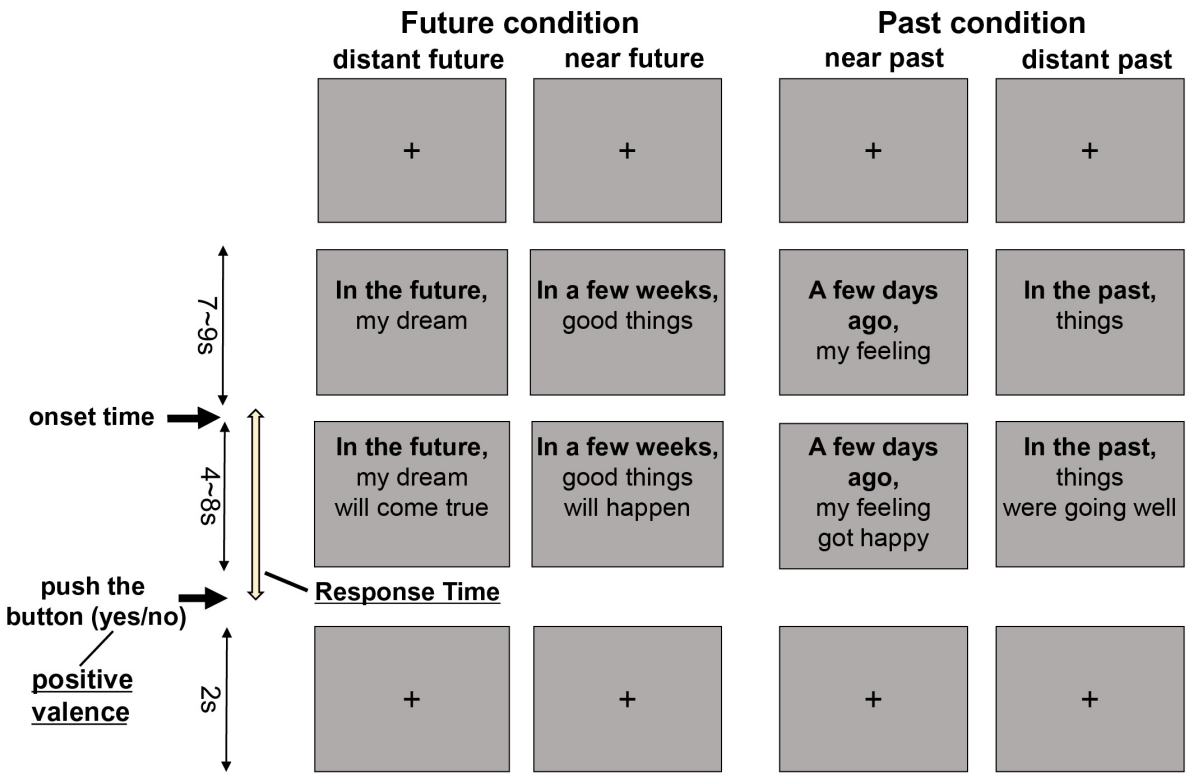

FIGURE 1
Future thinking task. Example trials for four different conditions are shown. Participants were asked to imagine the future or recall the past when presented with a temporal word on a slide. Once the sentence was complete, participants pushed a button to indicate a response of yes or no.

based on feasibility considerations. Therefore, we set a target number of 19 participants per group (38 total). The details are reported elsewhere (17).

2.6. Statistical analysis

Demographic factors and patients' baseline characteristics were summarized by each treatment group. Data were presented with mean ± standard deviation. Analyses were performed in the per-protocol sample, including participants completing the future thinking task. Treatment effects on the FTT were evaluated with the *t*-test for mean change from baseline between groups and paired *t*-test (null hypothesis: mean change = 0) for the pre and post values within groups. Clinical and neurocognitive variables were evaluated with the *t*-test for mean change from baseline in outcomes. Pearson's correlation coefficients between change in a variable in the FTT and change in DAS were calculated. For all analyses, the significance level was set at 0.05 (two-sided). All statistical analyses were performed using SPSS (version 27.0).

3. Results

3.1. Patient characteristics

Figure 2 shows the flow of the patients from screening to post-treatment (16 weeks). Thirty-eight patients were randomized to receive CBT (n = 19) or TC (n = 19). Of those randomized, 17 in the CBT group and 18 in the TC group completed a 16-week intervention. Of the 35 post-treatment assessment completers, 31 (CBT = 16, TC = 15) completed the future thinking task. Table 1 shows the baseline demographic and clinical characteristics of the treatment groups. Typically, patients were in their 30–40s, had two previous depression episodes, had been in the current episode for nearly 5 years, and were severe to moderately depressed. None of the patients experienced serious adverse events during the intervention period.

3.2. Main outcomes

The results of the RT assessed using the FTT are presented in Figures 3A, B and Supplementary Table 1. Between groups, no significant change from baseline for the RT both of positive and negative valences was observed for any of the temporal conditions. Within-group effects were large in the RTs for both positive (Cohen's $d = 0.7$, $p = 0.012$) and negative valence (Cohen's $d = 0.6$, $p = 0.03$) for the distant future condition in the CBT group. There was a reduction of RTs for positive valence for the near future condition (Cohen's $d = 0.7$, $p = 0.017$) and near past condition (Cohen's $d = 0.7$, $p = 0.02$) in the CBT group.

The mean ratios of the positive valence responses for each temporal distance are shown in Figure 4 and Supplementary Table 2. Between groups, no significant change from baseline for the ratio of positive valence responses was observed for any of the temporal conditions. Within-group effects were increased in terms of the ratio

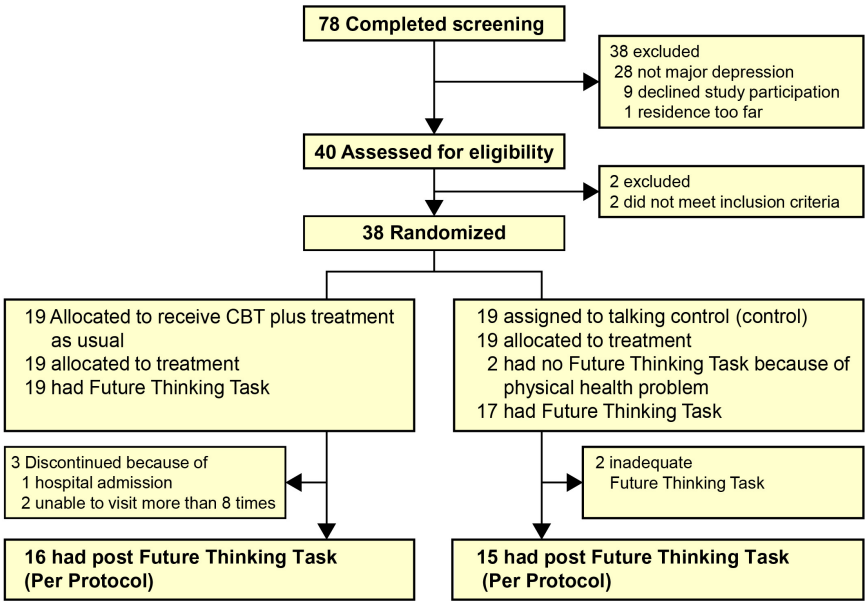

FIGURE 2
CONSORT diagram of the participant flow of the study. CBT, cognitive behavioral therapy.

of positive valence responses for all temporal conditions except for the distant past condition in both groups [distant future condition: CBT: Cohen's $d = 0.5$, $p = 0.04$; TC: Cohen's $d = 0.8$, $p = 0.008$; near future condition: CBT: Cohen's $d = 1.0$, $p < 0.001$; TC: Cohen's $d = 1.1$, $p = 0.001$, and near past condition (CBT: Cohen's $d = 0.8$, $p = 0.005$; TC: Cohen's $d = 1.0$, $p = 0.002$)].

3.3. Secondary outcomes

The results of the clinical assessments are presented in Table 2. Between groups, the patients who received CBT showed greater reductions from baseline for the need for social approval as measured by the DAS ($p = 0.012$) compared to those who received TC. Within-group effects were lower in terms of the means of depression severity (GRID-HAMD17: within-group CBT: $p < 0.001$; TC: $p < 0.001$, BDI-II: within-group CBT: $p < 0.001$; TC: $p < 0.001$) and dysfunctional schema (DAS total score: within-group CBT: $p < 0.001$; TC: $p = 0.001$) after treatment in both groups. Within-group effect was increased in terms of the levels of word fluency in the TC group (WFT initial words: within-group TC: $p = 0.004$).

3.4. Exploratory analysis of correlations between RT for the positive valence of the future and the DAS

We explored whether the changes in RTs for positive valence in the future condition are associated with the changes in scores on the DAS in the CBT and TC groups. In only the CBT group, there was a significant correlation between reduction in RTs in the distant future condition and the DAS Need for Social Approval subscale scores ($r = -0.6$, $p = 0.01$) but not in the TC group ($r = -0.05$, $p = 0.8$). In addition, in only the CBT group, there was a significant correlation between reduction in RTs in the near future condition and the DAS Need for Social Approval subscale scores ($r = -0.7$, $p = 0.003$), but not in the TC group ($r = -0.05$, $p = 0.8$) (Table 3).

4. Discussion

Patients with MDD who received a course of CBT showed a reduction in RT in the distant future condition, although no significant difference was observed in terms of the change from baseline for RT or the ratio of the number of responses for positive valence between groups. In addition, MDD patients who received CBT showed a decrease in RT in the near future condition for positive valence. Moreover, the ratio of the number of responses for positive valence in the near and distant future condition increased after the intervention in both the CBT and TC groups. In terms of clinical and neurocognitive change, the dysfunctional schema related with need for approval as measured by the DAS Need for Social Approval subscale was found to improve to a greater degree in the CBT group than in the TC group. Furthermore, among the participants in the CBT group, the improvement in terms of dysfunctional schemas related to the need for approval correlated with a reduction in RT for positive valence in the distant and near future condition.

In our samples, RTs decreased in the CBT group for both the positive and negative valence in the distant future condition. This finding is compatible with our previous study that showed that maladaptive activation in the frontopolar cortex (BA10) was associated with pessimistic future thinking during distant future thinking (11) and decreased after a course of CBT (17). Prior research has shown that depressed patients generally experience a form of thinking through abstract and overly general processing (30), that events imagined to occur in the distant future are experienced ambiguously (31), and that such patients are less likely to make concrete assessments about the future (32). In our study, when patients who completed CBT were asked to qualitatively describe

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TABLE 1 Participant characteristics at baseline.

Characteristics	CBT ($N = 19$)		TC ($N = 19$)	
Demographic characteristics				
	Mean	SD	Mean	SD
Age (years)	38.0	7.4	36.9	10.1
Education (years)	16.3	2.1	15.5	1.4
	N	%	*N*	%
Male gender	9	47.4	9	47.4
Unemployed	0	0	2	10.5
Absences from work	13	68.4	11	57.9
Marital status				
Married	10	52.6	9	47.4
Separated, divorced, widowed	2	10.5	0	0
Single	7	36.8	10	52.6
Cohabiting (yes)	15	78.9	18	94.7
Smoking habit (yes)	5	26.3	3	15.8
Alcohol habit (yes)	10	52.6	11	57.9
Clinical characteristics				
Previous hospitalization	1	5.3	1	5.3
Previous suicide attempts	1	5.3	3	15
Self-reported childhood abuse	2	10	0	0
Self-reported experience of childhood bullying	3	15	7	36
Family history of psychiatric disorders (first-degree)	10	52	5	26
Specifiers of index episode (DSM-IV)				
Chronic (≥2 years from index episode)	10	52.6	10	52.6
Melancholic features	3	15	2	10
Atypical features	0	0	1	5.3
Comorbid DSM-IV Axis I diagnosis				
Panic disorder (with agoraphobia)	1	5.3	2	10.5
Social anxiety disorder	1	5.3	0	0
Obsessive-compulsive disorder	0	0	0	0
Generalized anxiety disorder	1	5.3	0	0
Dysthymic disorder	0	0	1	5.3
	Mean	SD	Mean	SD
Total number of depression episodes	2.0	0.94	2.2	1.6
Duration of index depression episode (months)	67.5	74.5	63.9	86.7
DDD of antidepressant medications prescribed at baseline	1.1	0.49	1.1	0.63
Depression severity				
GRID-HAMD$_{17}$	20.0	4.0	21.3	5.6
BDI-II	29.3	8.0	28.9	9.9
Dysfunctional cognition				
DAS	117.2	23.0	104.7	18.1
Neurocognitive function				
Word fluency				
Initial words	25.5	5.6	26.8	8.0
Category	42.2	7.7	43.2	7.7

CBT, cognitive behavioral therapy; TC, talking control; MDD, major depressive disorder; DDD, defined daily dose; GRID-HAMD$_{17}$, 17-item GRID-Hamilton Depression Rating Scale; BDI-II, Beck Depression Inventory-II; DAS, Dysfunctional Attitude Scale.

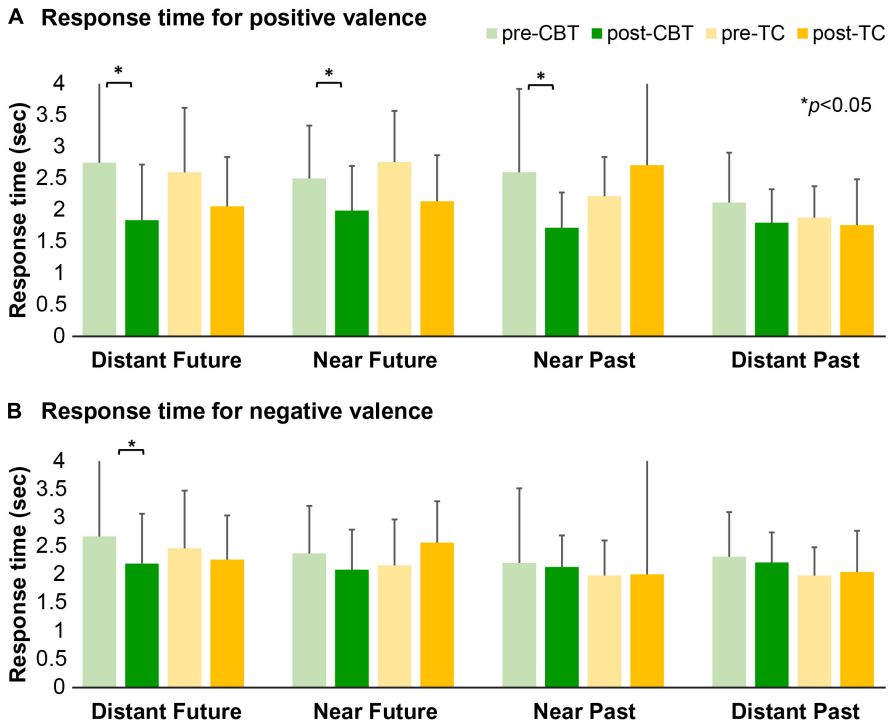

FIGURE 3
The response time for the future thinking task. Mean RTs for positive **(A)** and negative valence **(B)** across the four different conditions for the CBT and TC groups before and after treatment. CBT, cognitive behavioral therapy; TC, talking control; RT, response time. **(A)** Greater reductions in RTs for both positive valence in the distant future condition ($p = 0.012$), near future condition ($p = 0.017$), and near past condition ($p = 0.02$) in the CBT group. **(B)** A significant reduction in RT for negative valence in the distant future condition in the CBT group ($p = 0.03$).

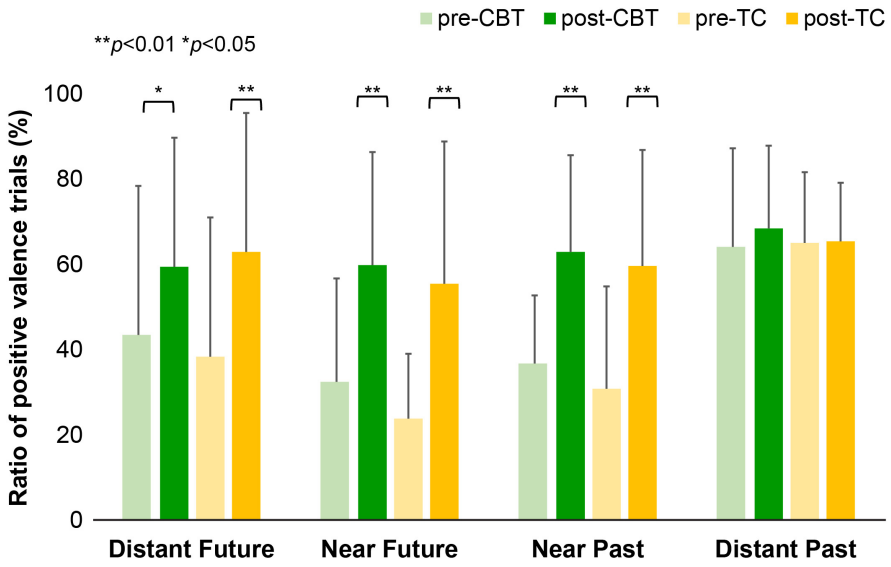

FIGURE 4
The ratio of positive valence trial in the future thinking task. Mean ratio of positive valence across the four different conditions for the CBT group and TC group before and after treatment. A paired *t*-test shows that the ratio of positive valence responses increased after treatment in both groups in the distant future condition (CBT: $p = 0.04$; TC: $p = 0.008$), near future condition (CBT: $p = 0.001$; TC: $p = 0.001$), and near past condition (CBT: $p = 0.005$; TC: $p = 0.002$). CBT, cognitive behavioral therapy; TC, talking control.

what they had learned about CBT, they commented that they were satisfied with the CBT they had experienced and that it helped them think more concretely about the future (33). CBT has a future-oriented treatment structure, such as training clients in goal setting and planning strategies and using behavioral activation to enable patients to schedule enjoyable and fulfilling future experiences (34). Therefore, these findings may suggest that depressed patients were able to smoothly and concretely evaluate the distant future. A further future possibility is that CBT with a future-oriented treatment structure may not only benefit depression but also those suffering

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TABLE 2 Secondary outcomes for patients receiving cognitive behavioral therapy and talking control.

Measures	Cognitive behavioral therapy (n = 16)								Talking control (n = 15)								Between groups[‡]	
	Pre		Post		Change (post-pre)		Within groups[†]		Pre		Post		Change (post-pre)		Within groups[†]			
	Mean	SD	Mean	SD	Mean	SD	t	p	Mean	SD	Mean	SD	Mean	SD	t	p	t	p
Depression severity																		
GRID-HAMD17	20.6	4.38	11.4	6.7	−9.2	5.2	7.0	**<0.001**	22.1	5.5	11.2	7.5	−10.9	2.2	5.0	**<0.001**	0.7	0.5
BDI-II SCORE	30.4	7.34	18.9	12.3	−11.4	9.8	4.7	**<0.001**	32.3	9.7	18.5	12.0	−13.9	2.8	5.0	**<0.001**	0.7	0.5
Dysfunctional schema																		
DAS Total Score	119.5	20.2	102.4	18.9	−17.1	15.8	4.3	**<0.001**	104.3	17.5	93.9	17.7	−10.5	10.3	3.9	**0.001**	−1.4	0.9
DAS Achievement	51.3	11.5	44.1	13.2	−7.1	10.9	2.6	**0.019**	44.1	10.3	40.6	9.2	−3.5	7.8	1.7	0.1	−1.1	0.3
DAS Self-control	28.2	5.1	25.3	4.8	−2.9	3.9	3.0	**0.01**	24.4	6.5	21.6	6.1	−2.8	5.0	2.2	0.05	−0.04	0.9
DAS Need for social approval	28.8	4.5	19.8	3.2	−8.0	3.6	8.8	**<0.001**	23.2	5.0	20.1	3.3	−3.1	6.3	1.9	0.08	−2.7	**0.012**
Neurocognitive test																		
WF-initial words	25.0	5.5	26.6	7.0	1.6	5.5	−1.1	0.3	28.1	8.4	34.1	11.6	5.9	6.6	−3.5	**0.004**	−2.0	0.05
WF-category	41.6	8.1	42.1	9.3	0.4	9.9	−0.2	0.9	44.9	8.3	48.3	11.1	3.3	9.2	−1.4	0.2	−0.8	0.4

Bold items are significant at $p < 0.05$. [†]Paired t-test. [‡]Independent t-test; SD, standard deviation; GRID-HAMD$_{17}$, 17-item GRID-Hamilton Depression Rating Scale; BDI-II, Beck Depression Inventory-II; DAS, Dysfunctional Attitude Scale; WF, word fluency test.

from another psychological construct called demoralization, linked to negative future cognitions and consequent suicide (35, 36).

In the near future condition, MDD patients who received CBT showed a reduction in RT for positive valence. Decreased positive RT in the near future may reflect the treatment effects by CBT because CBT focuses on "here and now" problems and positive planning for the near future (37). Furthermore, behavioral activation schedules rewarding behaviors into a patient's routines (38), which may facilitate near future thinking.

Interestingly, improvement of the depressive symptoms and an increase in the ratio of the number of responses for positive valence after the intervention was similar between CBT and TC. These results are in line with a meta-analysis reported by Cuijpers et al. (39) that showed no differences in efficacy among the modalities of psychotherapies for depression. RTs were shortened after the intervention only in the CBT participants in our sample. Summing up these findings, it appears that RT does not reflect an improvement in depressive symptoms.

In our sample, the greater reductions in RTs in the future condition were inversely correlated with the degree of the dysfunctional schema in the CBT group. This finding adds to previous studies (40) that showed that CBT improved dysfunctional schemas and that the improvement of dysfunctional schemas from the use of CBT coincided with the reduction of RT in the future condition. In a previous study investigating information processing associated with DAS responses, healthy individuals showed slowing in RT with agreement with dysfunctional schemas (41). The literature reveals that dysfunctional schemas affect information processing (42), and schema-based information processing is a crucial determinant of the depressed state (43–46).

Interestingly, depressed patients who received CBT were found to show improvements in their need for social approval, as measured by the Social Approval Needs subscale of the DAS. The DAS Need for Social Approval subscale is a measure of interpersonal personality vulnerability (47) and the belief that one's happiness and self-worth are dependent on the receipt of approval, support, and love from others (48). These findings are consistent with previous studies showing that interpersonal personality vulnerability improved over the course of CBT treatment (47–49).

TABLE 3 Spearman's correlation coefficient between RT for the positive valence of the future and DAS total and subscale score.

	CBT		TC	
RT-distant future	r	p	r	p
DAS Total score	0.06	0.8	0.09	0.8
DAS Achievement	0.1	0.7	0.2	0.6
DAS Self-control	−0.04	0.9	0.3	0.3
DAS Need for Social Approval	−0.6	0.01*	−0.05	0.8
RT-near future				
DAS Total score	0.02	0.9	0.2	0.8
DAS Achievement	0.1	0.7	0.3	0.7
DAS Self-control	0.05	0.9	0.04	0.3
DAS Need for Social Approval	−0.7	0.003*	−0.05	0.8

*Statistically significant after Bonferroni correction. RT-distant future, Change in response time for the positive valence of the distant future; RT-near future, Change in response time for the positive valence of the near future; DAS, Change in dysfunctional attitude scale; CBT, cognitive behavioral therapy; TC, talking control.

Strengths of the present study include the use of a rigorous RCT design with a TC as the control group, an FTT to assess changes in future thinking before and after psychotherapy, and a focus on behavioral assessment. While many psychotherapy studies have been based solely on clinical questionnaires (50), the current study was significant because it took a different approach to outcome assessment. In addition, the focus on dysfunctional attitudes suggests that FTT response time captures not only a post-treatment outcome but also the treating process of CBT. However, this study has limitations that should be considered when interpreting the results. First, we had a relatively limited sample size. The lack of significant differences in change pre- and post-intervention between the groups could be due to the effect of the small sample size. Second, participants were recruited from a university teaching hospital, thus limiting generalizability. Third, the FTT may have a potential confounding issue because some aspects of content (e.g., conceptual words or physical-state-related words) were not controlled for. Fourth, most patients in our study received pharmacotherapy for treatment of depression. Therefore, the possibility of medication effects could not be ruled out. Fifth, since the FTT was performed twice, test-retest bias may occur within evaluation periods.

In conclusion, patients with MDD who received a course of CBT experienced reduced RTs in the distant future condition. Therefore, response time to a future-thinking task in depressed patients may contribute as an objective measure for a CBT treatment process. As the present RCT is positioned as a pilot RCT, future research is necessary to further validate the results in a fully powered trial using a larger number of patients and to elucidate the cognitive behavior therapy treatment process that influences future thinking.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the Ethical Review Committee of Keio University School of Medicine (reference no. 20150070). The patients/participants provided their written informed consent to participate in this study.

Author contributions

MA and NK: conceptualization, visualization, project administration, formal analysis, resources, data curation, and writing—review and editing. SU, YT, HT, and TK: investigation, methodology, and writing—review and editing. TA: methodology, formal analysis, and writing—review and editing. MM: project administration, resources, and writing—review and editing. AN: conceptualization, visualization, formal analysis, supervision, project administration, resources, and writing—review and editing. All authors critically reviewed the manuscript for content and approved the final version.

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Conflict of interest

AN received royalties from Igaku-Shoin and Kongo-Shuppan publishers for CBT textbooks and developed and wrote the Japanese CBT manual for depression and is involved in the Japanese National CBT Training Project funded by the Japanese Ministry of Health, Labour and Welfare.

The remaining 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

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.997154/full#supplementary-material

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A machine learning approach to identifying suicide risk among text-based crisis counseling encounters

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Introduction: With the increasing utilization of text-based suicide crisis counseling, new means of identifying at risk clients must be explored. Natural language processing (NLP) holds promise for evaluating the content of crisis counseling; here we use a data-driven approach to evaluate NLP methods in identifying client suicide risk.

Methods: De-identified crisis counseling data from a regional text-based crisis encounter and mobile tipline application were used to evaluate two modeling approaches in classifying client suicide risk levels. A manual evaluation of model errors and system behavior was conducted.

Results: The neural model outperformed a term frequency-inverse document frequency (tf-idf) model in the false-negative rate. While 75% of the neural model's false negative encounters had some discussion of suicidality, 62.5% saw a resolution of the client's initial concerns. Similarly, the neural model detected signals of suicidality in 60.6% of false-positive encounters.

Discussion: The neural model demonstrated greater sensitivity in the detection of client suicide risk. A manual assessment of errors and model performance reflected these same findings, detecting higher levels of risk in many of the false-positive encounters and lower levels of risk in many of the false negatives. NLP-based models can detect the suicide risk of text-based crisis encounters from the encounter's content.

KEYWORDS

machine learning, suicide, crisis text-line, text content, natural language processing

1. Introduction

Suicide and crisis hotlines can be an effective, inexpensive, and accessible resource for people in crisis in need of confidential support (1, 2). These interventions can help deescalate and reduce feelings of distress and hopelessness (2, 3) as well as decrease the likelihood of attempting suicide (4, 5). In the last decade, text-messaging has become a dominant form of communication generally and in mental health care, especially among youth who

may prefer text-messaging as a more immediate, private, and familiar modality (2, 6–12). As such, text-based crisis counseling has begun to supplement phone-based conversations with tens of thousands of crisis messages sent each day (13). While the reach of text messaging is impressive, this volume of care places a tremendous burden on crisis systems to train and support counselors who are in short supply and at risk of burnout (14–19). Ensuring the consistent provision of high-quality crisis services is critical to their effectiveness (20, 21), and one such way to support this is through accurate and consistent evaluation of the level of risk in a given crisis conversation.

Current guidelines on crisis counseling and suicide risk assessment suggest a minimum of three questions to evaluate risk of suicide (20, 21). However, the consistency in following these guidelines in crisis services can vary dramatically, with some studies showing that crisis clients are often not asked about suicidal ideation (3, 22), and one study in particular finding no assessment of suicide risk in over half of all telephone crisis calls (23). However, it should be noted that counselors in crisis settings, especially text-based crisis settings, are often navigating these complex conversations with multiple clients simultaneously. While counselors, who often have relatively minimal training, are expected to report on risk after a conversation as a means of quality assurance, counselors are navigating many conflicting demands (e.g., responding to the next texter promptly and empathically vs. generating thorough documentation). Given broad concerns about the accuracy of documentation in medical records (24), it is possible they may overlook risk in a conversation or may simply forget to document risk in the midst of other competing tasks. It is imperative we explore new means of supporting counselors in the identification of at-risk clients.

Natural language processing (NLP) is one tool that holds significant promise for developing scalable methods for evaluating the content of crisis counseling (25). A subfield of artificial intelligence and linguistics, NLP methods enable a computerized approach to the learning, interpretation, processing, and analysis of human language in written or spoken form (26–28). Modern NLP methods rely on a family of machine learning models called neural networks that are trained to encode linguistic information from input text data for a specific task such as text classification, text summarization, and text translation (29–31). There have been notable efforts in recent years to deploy NLP methods in psychotherapy and mental health research (32, 33), with numerous studies showing potential success in identifying and predicting instances of suicidality across a variety of text-based sources including clinical records, discharge notes, patient-therapist dialogues, and social media posts (34–40). While this evidence suggests risk in text-based mental health counseling can be estimated using NLP-methods, research evaluating risk from clinical dialogues has focused on general asynchronous counseling environments where the risk of suicide is lower than in crisis counseling (33). Most recently, one study used domain knowledge to encode the content of the conversations for risk assessment (41). This work is promising but relies on the necessarily incomplete theoretical frameworks of experts, rather than a data-driven approach to learning associations between text and suicide risk, likely reducing generalizability and performance. There is no published application of modern transformer-based language models to risk identification in crisis counseling.

TABLE 1 Data summary of crisis counseling encounters.

Encounter measure	Minimum	Median	Mean (SD)	Maximum
Duration (minutes)	0.014	0.950	1.106 (0.776)	9.605
Number of counselors	1	1	1.404 (0.574)	5
Counselor messages	1	17	20.973 (14.568)	159
Client messages	1	20	24.840 (19.427)	287

In this study, we build upon recent advancements in NLP using a data-driven approach to train and test NLP-methods on naturalistic crisis counseling data in identifying the presence of suicide risk. Specifically, we present a modern transformer-based neural architecture powered by state-of-the-art Robustly Optimized BERT Pre-training Approach (RoBERTa) embeddings trained over large, labeled crisis conversations from a regional crisis counseling app (42). It is possible for neural network models to learn spurious correlations based on artifacts of data collected (43, 44). Accordingly, we also conducted a thorough analysis of model errors and system behavior including a manual evaluation of encounters associated with model errors and cumulative risk throughout a crisis counseling dialogue.

2. Materials and methods

2.1. Data

This retrospective study utilized de-identified data from 5,992 crisis counseling encounters (totaling 273,804 messages) collected from SafeUT, a regional text-based crisis encounter and mobile tip line app (see Table 1 for a data summary). The SafeUT counselors are licensed or license-eligible clinical social workers with a background in crisis counseling. SafeUT counselors receive additional training in suicide risk assessment and safety planning. The study sample included crisis encounters from clients of any age located in Utah, Idaho, and Nevada who utilized the service between June 2020–April 2021. Mobile tips, a system for notifying schools and educators about potentially at-risk student peers, were excluded from the study sample. Institutional Review Board (IRB) approval was obtained for this study. SafeUT does not systematically collect potentially identifiable information and text messages were scrubbed of incidental identifying information prior to analysis.

2.2. Measure

Dispositions of each crisis counseling encounter, labeled by the SafeUT counselors, were used to measure the level of client risk. Counselor-generated dispositions cover a range of topics discussed, services provided, type and level of action needed, client perceptions of crisis counseling interaction, as well as the degree of client suicide risk perceived by the counselor. For the latter, counselors are asked to follow the Suicide Risk Assessment Standards of the National Suicide Prevention Lifeline (45). This

guideline, recommends crisis workers to a minimum number of suicide status prompt questions (see **Supplementary Appendix I** for more details). Importantly, crisis workers are instructed to mark the degree of risk in a way that reflects the whole encounter in aggregate.

Counselors assign suicide risk labels (i.e., dispositions) to each crisis counseling encounter, with options ranging from low-risk, moderate-risk, high-risk, and emergency referral (mobile crisis outreach team response, active rescue by law enforcement or paramedics, school contact). Counselors evaluate suicide risk level, based on clients' self-report, using their clinical judgment with respect to the intensity of reported suicidal ideation and other clinical risk factors (such as access to lethal means) that are endorsed by the client. Overall, 85.3% of all crisis counseling encounters were categorized as "lower risk," followed by 9.25% as moderate-risk encounters, 3.47% as high-risk encounters, and 1.95% as emergency-referral encounters. For the purposes of this study, we collapsed these ratings into a binary label classifying risk as either "lower risk" or "higher risk" to form more even groups based on sample size and to allow for a logistic regression analysis (where "higher risk" included all other categories except low-risk). Overall, 85.3% of all crisis counseling encounters were categorized as "lower risk," followed by 9.25% as moderate-risk encounters, 3.47% as high-risk encounters, and 1.95% as emergency-referral encounters (resulting in 14.67% of all encounters categorized as having "higher risk;" **Table 2**).

2.3. Model training and analysis

Two modeling approaches were evaluated for the classification of risk level in crisis encounters, a neural network model and a term frequency-inverse document frequency (tf-idf) weighted logistic regression model for a baseline comparison. Existing counseling-generated risk dispositions were used to train both models in classifying the level of risk for each crisis counseling encounter. Both models were evaluated using the receiver operating characteristic area under the curve (ROC AUC). The higher the AUC score the better the model classification, with an AUC of 1 suggesting a perfect (but likely over-fitted) classifier, an AUC of 0.5 suggesting a random-chance classifier, and an AUC of 0.8 or higher suggesting a good classifier (46). Other evaluation measures included sensitivity, proportion of higher risk encounters correctly classified by the model; specificity, proportion of lower risk encounters correctly classified by the model; precision, proportion of correct higher risk predictions of the model; false-negative rate (1-sensitivity), and false-positive rate (1-specificity).

Both the neural network model and tf-idf model received a crisis counseling encounter as input and output a probability distribution for "lower risk" vs. "higher risk." An 80/20 train-test split was used, with model training on 80% of the data and two hold-out (test) sets, each corresponding to 10% of the remaining data, for development and testing, respectively. This partition was done maintaining the same distribution of the labels across the three datasets.

TABLE 2 Categories of risk.

Category		*n*	%
Lower risk		5,113	85.3
Higher risk*	Moderate risk	554	9.25
	High risk	208	3.47
	Emergency referral	117	1.95

*n = 879 (14.6% of all crisis counseling encounters).

2.4. Neural network

The neural network model utilized a machine learning transformer architecture. Transformers are a family of neural networks designed to process sequential data using self-attention, a mechanism allowing the network to extract and use information from arbitrarily large input contexts efficiently (47). The initial component in the transformer architecture (i.e., encoder) is particularly useful in natural language processing as it takes a string of text (sequence of words) and returns a sequence of numerical representations of the input corresponding to each word in the input text (47). These numerical representations (i.e., word embeddings) contain the semantic and grammatical meaning learned from context through the transformer's self-attention process (47). Current state-of-the-art approaches in many NLP-tasks are based on RoBERTa embeddings, which are contextualized word embeddings obtained from stacking multiple transformer encoder blocks or layers pre-trained on large corpora of text (42, 48).

In this study, RoBERTa word embeddings were aggregated into a single sentence embedding for each message in each crisis counseling encounter.[1] Importantly, to adapt the original general-purpose RoBERTa embeddings to the domain of crisis counseling (49), we continued pretraining the model using 120,000 encounters from the SafeUT app (almost 2.5 million messages). The originator of each message (client or counselor) was prepended to each message in an encounter, whereby the concatenation of each pair of consecutive messages in an encounter was provided as inputs to the language model (e.g., back-to-back messages were provided as a single message input). To obtain the embedding representation of an encounter, we averaged the output of 6 transformer encoder layers. Lastly, the encounter embedding was passed through a linear neural layer (a neural network with just one layer of nodes) for binary classification [**Figure 1**; (47)]. To measure the stability of the model, the training process was repeated and averaged across five different random seeds. We used the model with the best AUC performance in the development set (out of the five seeds) for error and system behavior analysis in later sections.

2.5. Tf-logistic regression

In this comparison approach, we vectorized the data using a term frequency-inverse document frequency statistic (tf-idf), combining unigrams (individual words) and bi-grams (pairs of consecutive words) from the messages on the sessions. A binary logistic regression classifier was trained on the vectorized data until convergence was achieved.

1 The size of the encounters and hardware limitations prevented us from fine-tuning the RoBERTa model.

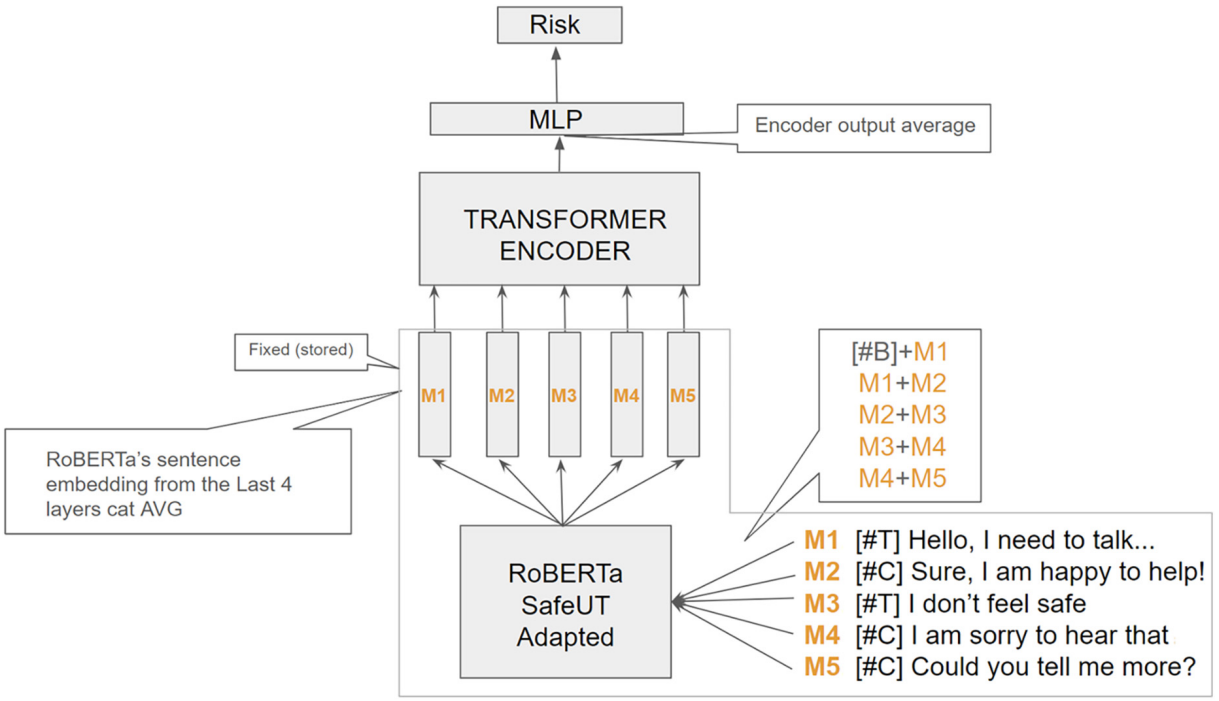

FIGURE 1
Architecture of the neural network model using an example of five messages. B, beginning token; C, client, M, message; MLP, Multiple-layer perception; T, therapist. Example using a 5-message encounter input. Special tokens (#T) and (#C) are prepared to each client and counselor message, respectively, to inform the model about the originator of each message along the conversation. We preprocessed each encounter by obtaining the aggregated RoBERTa sentence embeddings of every pair of consecutive message-spans in the encounter. Each obtained sentence embedding sequence is passed through a transformer-encoder block, whose output is aggregated to obtain an encounter embedding representation. The encounter vector is then fed to a final neural linear layer to obtain the binary confidence estimates for classification.

2.6. Error assessment

A manual evaluation of model errors was conducted to assess features of crisis counseling encounters falsely categorized as "higher risk" or "lower risk" by the neural model to better understand the behavior of the model and its prediction of risk. A team of four human reviewers assessed each encounter erroneously categorized by the neural model for indicators of suicidality, non-suicidal self-injury, abuse, emergency service triage, mobile tips, social service involvement, discussion of therapy services, and client drop-off (i.e., when the client stops responding to the encounter). The degree of resolution of the client's complaint was also evaluated, with resolution indicating a near total reduction of a client's risk or distress and/or de-escalation of client crisis at encounter end. Partial resolution similarly indicates some reduction of client distress with moderate to low client risk at end of the encounter. No resolution indicates minimal to no reduction of client risk or distress with the client remaining at risk at end of the encounter. Lastly, the team of reviewers made a final determination of whether the encounter should be labeled higher risk or lower risk based on the context and indicators of the encounter.

Moreover, the dynamics of the risk probability continuum within a crisis conversation were evaluated to better understand the cumulative signal of risk captured by the neural model as counselor-client dialogue develops. Three crisis counseling encounters were selected at random to illustrate the neural model's performance in predicting actual higher risk (true positives), falsely predicting higher risk (false positives), and falsely predicting lower risk (false negatives). True negative encounters were excluded from this illustration as these were mostly flat lines indicating minimal to no signal of risk throughout a counselor-client dialogue. This secondary evaluation of model errors allowed for a deeper inspection of model behavior and content that drove the model predictions.

3. Results

The neural model achieved an average AUC of 90.37% (Table 3). Precision, specificity, sensitivity, and other model metrics are reported in Table 3. In comparison with the neural model, the tf-idf model demonstrated a slight decrease in performance with an AUC of 88.17 (Figure 2 and Table 3).

Overall, the ROC curves and AUC scores of the two models are similar. Yet there are important differences. The false-negative rate of the neural model was relatively high at 37.98%, but it represents a 22.49-percentage point improvement in classifying risk compared to the tf-idf model at a 60.47% false-negative rate (Table 3). Similarly, the neural model had nearly double the sensitivity compared to the tf-idf model (62.02 vs. 39.52%, respectively; Table 3). The false-positive rate was low for both models, with the neural model slightly higher at 7.11%, highlighting

TABLE 3 Model performance.

	Neural model (SD)	Tf-idf model
ROC AUC	90.37 (0.18)	88.18
Specificity	92.89 (0.46)	97.84
Sensitivity	62.02 (0.54)	39.52
Precision	59.52 (1.80)	75.56
FNR	37.98 (0.56)	60.47
FPR	7.11 (0.46)	2.16

FNR, false negative rate; FPR, false positive rate; SD, standard deviation. Average test performance across training with five different random seeds is shown in the neural model column.

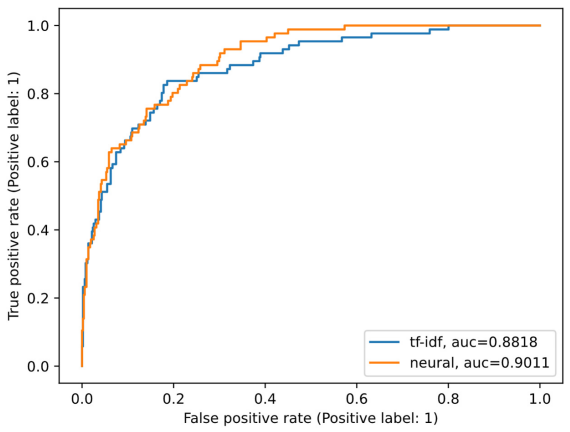

FIGURE 2
Comparison of model ROC AUCs. AUC, area under the curve; ROC, receiver operating characteristic. ROC curves of the tf-idf weighted logistic regression model (blue) and the neural model with the best performance in the development set out of the five runs (orange).

the increased sensitivity of the neural model compared to the tf-idf model. Lastly, the tf-idf model demonstrated a higher positive predictive value and slightly higher specificity compared to the neural model (Table 3); highlighting the tf-idf model's tendency to classify crisis counseling encounters as a lower risk compared to the neural model.

3.1. Manual assessment of errors

Based on counselor dispositions, the neural model incorrectly categorized a total of 32 encounters as lower risk (false negatives–i.e., the model labeled the encounter as lower risk when the human counselor had rated it as having significant risk) and 33 encounters as higher risk (false positives–i.e., the model predicted significant risk in the encounter when the human counselor had rated it as lower risk); Table 4; see Supplementary Appendix II for Tables 5, 6 detailing *ad hoc* human evaluation.

A manual assessment of each falsely categorized encounter revealed that of the 32 encounters where the model rated risk low (when a human therapist had rated it higher risk), 46.9% were considered lower risk by the team assessment (Table 4). Moreover, the majority of these false-negative encounters also had no discussion of other concerning topics such as non-suicidal self-injury, abuse, or involvement of first responders or crisis services (68.7, 81.2, and 81.2%, respectively). While a 75% majority of false-negative encounters had some discussion of suicidality, 62.5% also saw a resolution of the client's initial concerns and reasons for using the service, suggesting some potential appropriateness in the neural model's assessment. On the other hand, only 40% of the encounters categorized as higher risk by the model but lower risk by the counselor (i.e., false positives) were determined to be lower risk by the team of reviewers, while 60.6% included discussions of suicidality. A substantial minority of encounters also included concerns with non-suicidal self-injury, abuse, or involvement of first responders or crisis services (27.3, 33.3, and 36.4%, respectively). Furthermore, the majority of the encounters saw only partial or no resolution of the client's concerns using the service (Table 4).

One potential interpretation of these findings is that the models learned appropriate indicators of risk, making them robust to the inherent inconsistency noise of the human counselor labeling. As noted in the introduction, crisis counselors are responding to multiple high-stress situations and their ratings may not be without error. Furthermore, counselors have access to historical information from clients, such as prior utilization of the SafeUT app, that also may affect the risk assessment.

3.2. Dialogue risk curves

To better understand the neural model's performance, a cumulative probability of higher risk of each message and its contribution to an encounter was evaluated. The probability of higher risk throughout an encounter was visualized to demonstrate

TABLE 4 Summary of manual error assessment.

Measure*		False negatives $N = 32$ encounters n (%)	False positives $N = 33$ encounters n (%)
Higher risk[a]		17 (53.1)	13 (39.4)
Suicidality		24 (75.0)	20 (60.6)
NSSI[b]		10 (31.3)	9 (27.3)
Abuse		6 (18.8)	11 (33.3)
Emergency triage[c]		6 (18.8)	12 (36.4)
Mobile tips		10 (31.3)	4 (12.1)
Social services		6 (18.8)	3 (9.1)
External therapy services		15 (46.9)	16 (48.5)
Client drop off[d]		11 (34.4)	14 (42.4)
Complaint resolution[e]	Yes	20 (62.5)	14 (42.4)
	Partial	4 (12.5)	11 (33.3)
	No	8 (25.0)	8 (24.2)

[a]Higher risk determination based on team assessment of encounters.
[b]Non-suicidal self-injury (NSSI) includes self-harm without intent to die, such as cutting.
[c]Emergency triage includes triaging to emergency responders, hospital emergency rooms, and mobile crisis outreach teams.
[d]Client drop-off indicates the client stopped responding to the counselor.
[e]Resolve indicates a reduction in client risk or distress and/or de-escalation of a client crisis.
*See Supplementary Appendix II for more details on encounter summaries and indicators.

the continual dynamic of risk assessed by the neural model and where the neural model picks up on signals of risk. Three crisis counseling encounters were selected at random to illustrate the neural model's performance in predicting actual higher risk (true positives; Figure 3), falsely predicting higher risk (false positives; Figure 4), and falsely predicting lower risk (false negatives; Figure 5).

Overall, the neural model appears to appropriately detect and predict both logical signals of risk and fluctuations in the degree of risk throughout a crisis counseling encounter. In the example where the neural model accurately predicts higher risk, a sudden increase in predicted higher risk is seen when a client states "I want to kill myself" (Figure 3). Moreover, the neural model seems to capture the higher risk associated with a distressed client who suddenly stops responding to the counselor. Interestingly, the neural model demonstrates an ability to capture the fluctuations in risk even in cases where it inaccurately predicts the level of risk (Figures 3, 4). While the counselor disposition in Figure 4 did not indicate higher risk, the neural model picks up on signals of higher risk when the client confirms suicidality with intent and similarly stops responding to the counselor; this might suggest that the neural model is able to aid a counselor in detecting higher risk. Similar to the examples in Figures 3, 4, the neural model demonstrates a sensible prediction of risk for the false-negative encounter in Figure 5 (where the counselor indicated higher risk and the neural model assigned lower risk). Overall, the neural model positively reflects a higher risk throughout this encounter when suicidality and active distress are present (Figure 5). However, the neural model seems to detect the reduced risk associated with casual conversation and the overall diffusion of the client's distress at the end of the encounter.

4. Discussion

The current study illustrates the development and predictive utility of an NLP-algorithm to detect and classify the level of client suicide risk in a text-based crisis counseling environment. We examined a large sample of anonymous clients engaged in crisis counseling through the SafeUT platform, analyzing the content of crisis counseling text messages with SafeUT counselors.

Overall, the neural model yielded an excellent ROC AUC score of 0.9037. While the false positive and negative rates were higher than ideal (7.11 and 37.98%, respectively), a manual assessment of errors and evaluation of model performance throughout an encounter revealed the neural model was able to detect legitimate signals of higher risk in many of the false-positive encounters as well as lower levels of risk in many of the false negatives. This suggests that the neural model detected signals of risk even when learning from imperfect data. These findings further add support to the use of NLP methods as a potentially effective tool for aiding counselors in evaluating client risk in a text-based crisis counseling environment. This has important practice implications, not only for improving crisis counseling services but also to inform training and best practices for mental health counselors providing those services. In particular, eventual applications of systems like the one evaluated in this article could be used in parallel–not as a replacement–to provider assessment of risk. System detection of valid indicators of risk not identified by providers could provide an important stopgap in documenting key clinical processes when busy providers might be distracted by the next important clinical need.

Clear distinctions exist between our work and more recent efforts in automatic suicide risk detection in mental health counseling. Other studies have relied primarily on telemedicine psychotherapy dyads data including non-crisis interventions, making the base rate of suicide-related content dramatically different from the one found in an exclusive crisis counseling service. The work that pioneered this line of research reports models trained only with client messages from asynchronous encounters, hindering their system from learning crucial aspects of the task such as real-time risk dynamics of counseling, and the effect of counselor messages within the conversation (33). A more recent paper relies on data obtained from a similar text-based counseling platform, encoding entire encounters including counselor and client messages, as we do in our study (41). The authors introduce an interesting model with a knowledge-aware encoding layer obtained from a knowledge graph constructed by mental health experts demonstrating its efficacy through ablation studies. A downside of this kind of handcrafted database approach is the quality analysis, namely how to evaluate the completeness and correctness of the graph (50). In contrast, we propose a purely data-driven system where any existing relationships between concept words is extracted directly from the semantic and syntactic information present in the data. We argue that our approach is more robust and flexible when translated to other clinical fields, as it would only need the new dataset (the more data the better) without the need to rebuild a knowledge database that could depend not only on the specific domain expertise, but also on important aspects like cultural background of the study, data coming from a different language, or domain knowledge availability.

A contribution we consider unique in this article is that we provide detailed descriptive analyses of model results to evaluate the disagreements between the model and counselors who originally labeled the interactions. We had four clinical scientists read and relabel each encounter that had a predicted label different from the original counselor-generated label. From these experiments, we observed that for a significant number of encounters, the experts agreed with the neural model. This may indicate that our model is generalizing beyond the noise usually present in the labeling of clinical assessment datasets like this one. We extended our error analysis by creating dialog risk plots for such encounters, observing that our model captures risk in sync with the dynamics of the conversation. Although more analysis is needed, these results suggest that it is possible to obtain message-level supervision from encounter-level risk disposition labeling. We consider this observation a promising opportunity for future work.

4.1. Limitations

While this study examined suicide risk with reasonably high performance, it relied on a single crisis counseling encounter source for data. Moreover, the true risk of suicidality could not be reliably determined and instead relied on counselor-provided

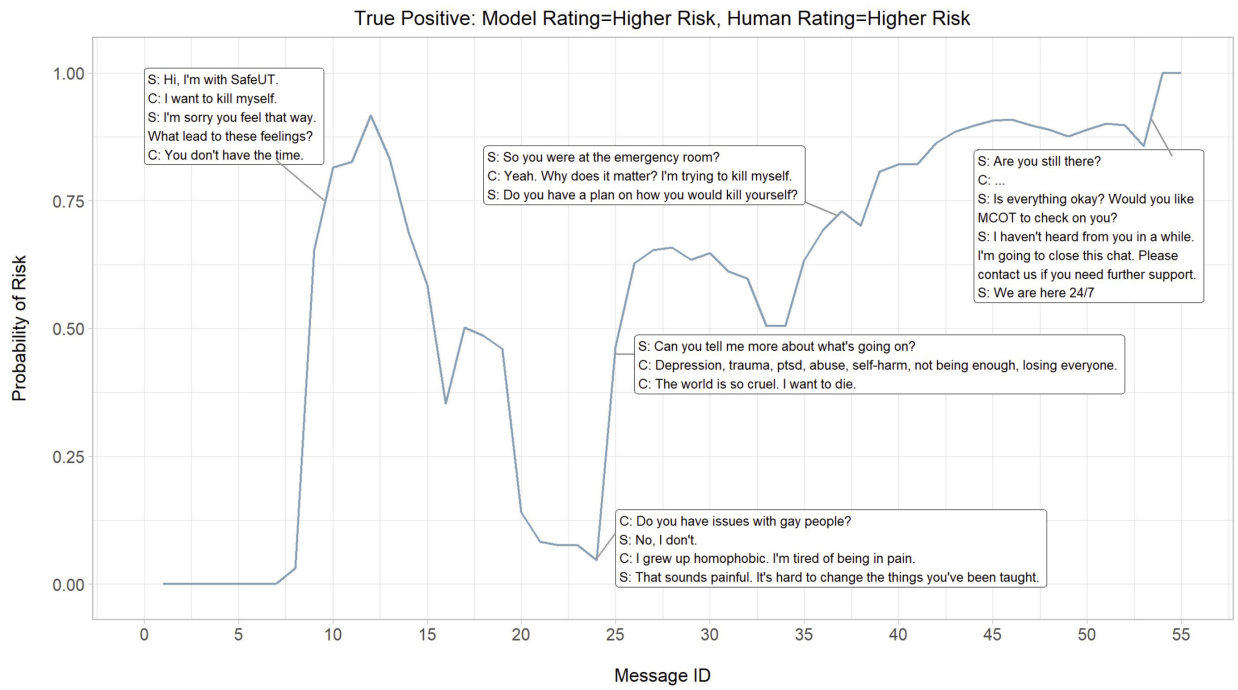

FIGURE 3
Dialogue risk curves: Model rating = higher risk, Human rating = higher risk (True positive). S, SafeUT counselor; C, SafeUT client; MCOT, Mobile Crisis Outreach Team. Crisis counseling encounter has been fictionalized to maintain confidentiality.

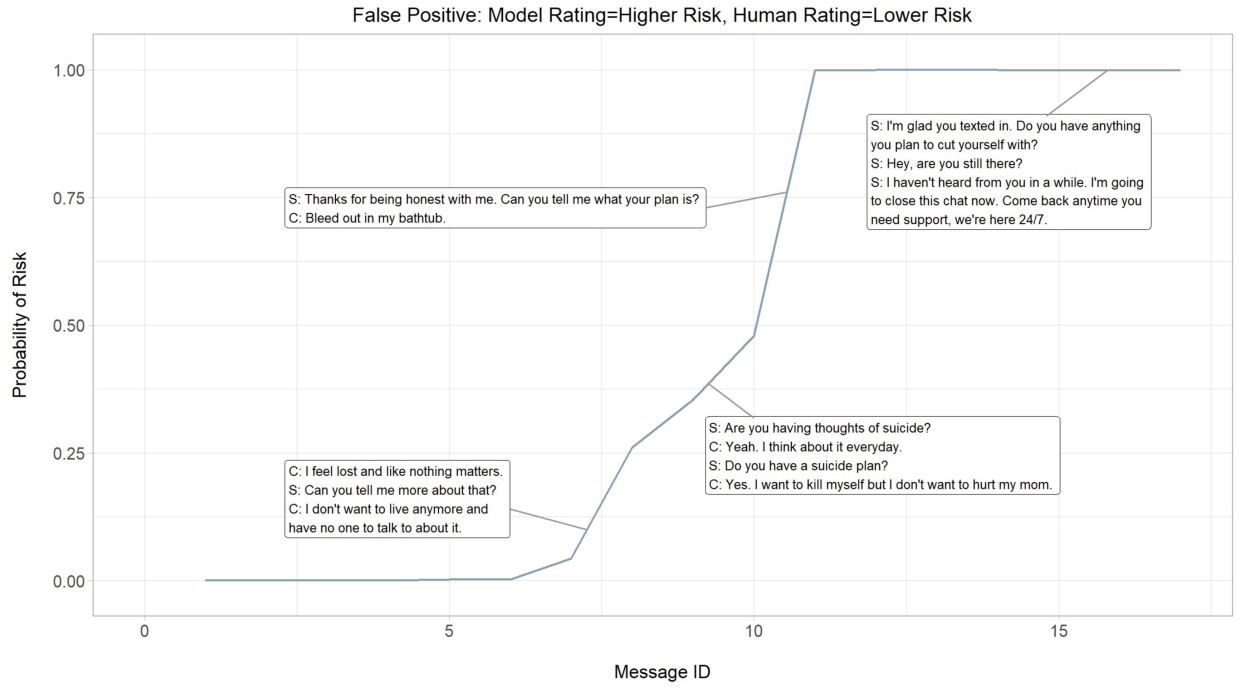

FIGURE 4
Dialogue risk curves: Model rating = higher risk, Human rating = higher risk (False positive). S, SafeUT counselor; C, SafeUT client. Crisis counseling encounter has been fictionalized to maintain confidentiality.

dispositions. These dispositions, used for model training, depend on accurate labeling from the counselors. Similarly, counselors may have access to historical information, such as prior utilization of the SafeUT app. It is possible that counselors do not adhere to the same standards for disposition selection or consideration of historical client information, potentially biasing model training

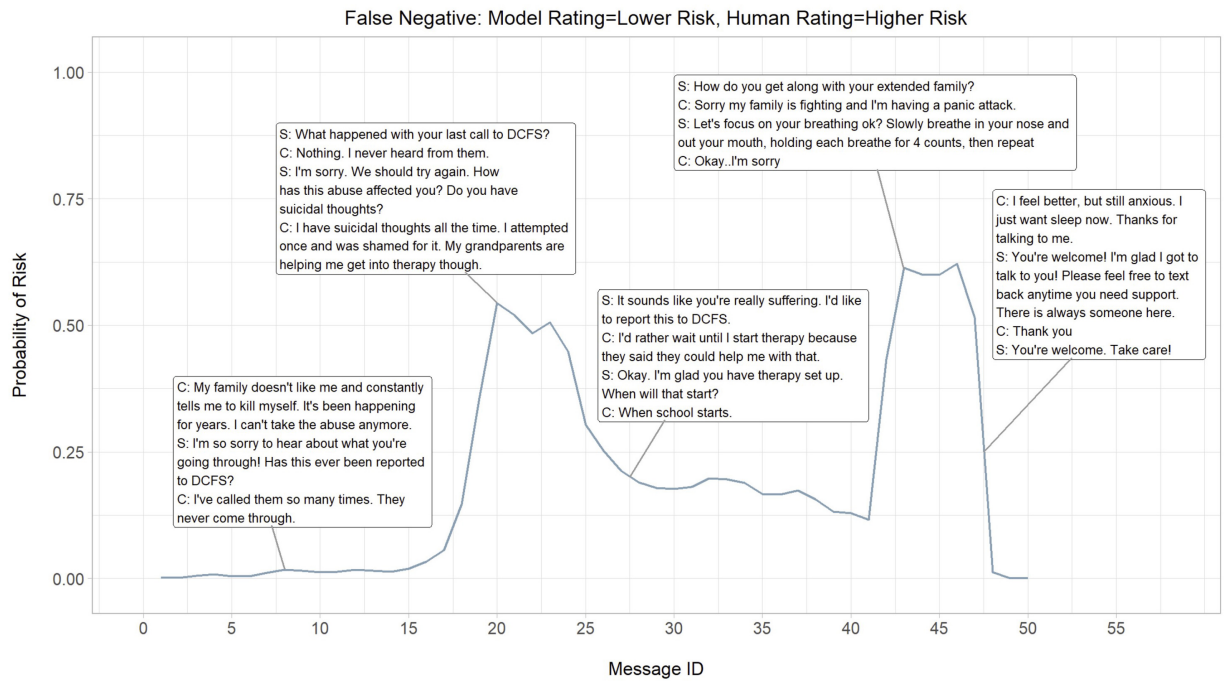

FIGURE 5
Dialogue risk curves: Model rating = lower risk, Human rating = lower risk (False negative). S, SafeUT counselor; C, SafeUT client; DCFS, Division of child and Family Services. Crisis counseling encounter has been fictionalized to maintain confidentiality.

results. This is further suggested by the manual assessment of errors and evaluation of dialogue arcs, with some "lower risk" crisis counseling encounters (deemed "lower risk" by the counselor dispositions and classified as having "higher risk" by the neural model) found to contain suicide-related content or risk-associated discourse (e.g., active self-harm, abuse, and requests for emergency responders). As such, future research should utilize human coding to evaluate and establish a baseline for suicidality (both client expression and counselor assessment). It is important to point out that in spite of the advances brought by modern NLP methods to the mental health community, further studies need to be done to assess the robustness of these systems (51–53). Lastly, client demographic data was not available for this study. Large language models have been shown to underperform when utilized by populations these models were not trained on (54–57). As such, it is possible these study findings may not generalize to populations whose racial, ethnic, or cultural demographics differ from the population in this study.

5. Conclusion

We observed that NLP-based models are capable of detecting suicide risk at the conversation level on text-based crisis encounters, suggesting important practice implications. Our results show outstanding AUC score performance, and remarkable precision and recall metrics by a modern neural transformer-based architecture. Manual analysis indicates that these models can learn appropriate indicators of risk making them robust to the inherent noise of the labels in real-time crisis encounters services. Furthermore, the dialog risk curves are a novel demonstration of how risk prediction fluctuates at the message level, capturing the dynamics of risk throughout the different stages of real crisis counseling conversations.

Data availability statement

The datasets presented in this article are not readily available. Due to privacy and ethical concerns, the data cannot be made public. Requests to access the datasets should be directed to KA, kate.axford@utah.edu.

Ethics statement

The studies involving human participants were reviewed and approved by the University of Utah Institutional Review Board. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MB and MM contributed to the data preparation and analysis. MB, MM, and KA took the lead in the writing and preparation of

the manuscript. MM, XZ, and VS designed the model. VS, BK, and ZI provided the feedback and insight that facilitated the analysis and manuscript. All authors contributed to the overall end product, contributed to the article, and approved the submitted version.

Conflict of interest

ZI is co-founder and minority equity stakeholder of a technology company, Lyssn.io that is focused on developing computational models that quantify aspects of patient-provider interactions in psychotherapy.

The remaining 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

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1110527/full#supplementary-material

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Physiological and neural synchrony in emotional and neutral stimulus processing: A study protocol

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Background: As psychotherapy involves at least two individuals, it is essential to include the interaction perspective research. During interaction, synchrony, i.e., the occurrence of simultaneous responses, can be observed at the physiological, neural, and behavioral level. Physiological responses include heart rate and electrodermal activity; neural markers can be measured using electroencephalogram. Emotionally arousing stimuli are allocated more attentional resources (motivated attention), which is reflected in physiological activation and brain potentials. Here we present a protocol for a pilot study implementing a new research methodology, and replication of the motivated attention to emotion effect in in dyads. There is evidence that higher synchrony is associated with more positive (therapeutic) relationships. Thus, the secondary outcome will be the association between physiological and neural synchrony and subjective ratings.

Methods and design: Individuals (18—30 years) will participate in same-sex pairs in two experiments. In the first experiment (triadic interaction), both participants attentively watch unpleasant, neutral and pleasant pictures, and read/listen to standardized scripts (unpleasant, neutral, and pleasant, respectively) for the imagination task. In the second experiment, participants will read out three scripts (unpleasant, neutral, pleasant) to each other, followed by a joint imagination period. Stimuli will be presented in counterbalanced orders. After each picture and imagination, participants rate their subjective arousal and valence. In the beginning and in the end of the procedure, dyads rate their relationship, sympathy, and bonds (Working Alliance Inventory subscale). Heart rate, electrodermal activity and electroencephalogram will be continuously measured during both experiments using portable devices (EcgMove4 and EdaMove4, nine-channel B-Alert X-Series mobile-wireless EEG). Synchrony analyses will include the dual electroencephalography analysis pipeline, correlational analyses and Actor–Partner Interdependence Models.

Discussion: The present study protocol provides an experimental approach to investigate interpersonal synchrony during emotion processing, allowing for the establishment of research methods in a pilot study, which can later be translated

into real-life psychotherapy research. In the future, fundamental understanding of such mechanisms in dyadic interactions is essential in order to promote therapeutic relationships, and thus, treatment effectiveness and efficiency.

KEYWORDS

attention, emotion processing, heart rate, ECG, skin conductance, SCL, EEG/ERP, synchrony

1. Introduction

To date, a main focus of psychotherapy research has been on randomized-controlled trials and meta-analyses to investigate the effectiveness of specific psychotherapy procedures and methods. However, robust data on predictors of response, and mediators of change are lacking, leaving the specific mechanisms of action of psychotherapy largely unclear (1, 2). A thorough understanding of the mechanisms of action and its biopsychosocial determinants allows for the identification of person characteristics that contribute to the effectiveness and efficiency of a specific psychotherapeutic intervention [including the neuroscience-based approach; e.g., (3)].

Since psychotherapy involves at least two persons, understanding the interaction between patient and therapist (e.g., relationship, synchrony) is likewise important to advance psychotherapy research. The interaction can be described as triadic, where therapist and patient focus on the same object (e.g., a work sheet or a phobic stimulus), and dyadic, which is the face-to-face interaction between therapist and patient (4). Synchrony refers to the occurrence of two or more people's responses at the same time (literally); the notion of simultaneity, or similar expression, which can be more or less pronounced (4). For example, synchrony can be observed in body movements (5), voice tone (6), and physiological responses [for reviews, see Koole et al. and Mende et al. (7, 8)]. Physiological responses in synchrony research include heart rate (4, 9), skin conductance (10, 11), and brain activity (12). Brain activity of two or more people can be measured simultaneously using hyperscanning methods [e.g., (13)]. For hyperscanning, broader research from the field of developmental psychology on parent-child interactions exists [for reviews, see (14, 15)], but methods might translate well into psychotherapy research. For example, using functional near-infrared spectroscopy (fNIRS), synchronous brain activity has been observed in therapist-patient interactions, and synchrony was especially pronounced for experienced therapists, which was associated with better working alliance ratings (16, 17). Furthermore, neural synchronization has been found to predict learning outcomes in teaching contexts [for meta-analysis, see Zhang et al. (18)], leading to the assumption that synchrony might also play a crucial role in new (inhibitory) learning essential to psychotherapy success (19). However, data on hyperscanning in psychotherapy is still a white spot on the research agenda.

Preliminary research found that positive relationships (e.g., a good therapeutic alliance/bond as a prerequisite for psychotherapy) go along with higher synchrony between individuals (7, 20). Although positive correlations between therapeutic alliance and therapy outcomes are modest, they are a robust finding (21). Accordingly, interactional subjective and (neuro-) physiological data should be integrated into the holistic view of mechanism-based personalized psychotherapy research.

The aim of the present study is to implement the measurement methodology and analysis of interpersonal synchrony using paradigms for emotion induction already established in individual settings. These allow for the simulation of emotional and neutral interactions, as they may also occur in psychotherapy, under laboratory-controlled, experimental conditions and in healthy students.

Emotions can be induced *via* various stimuli. Standardized picture material [International Affective Picture System, IAPS; e.g., (22–24)] and scripts for mental imagery [e.g., (25–29)] are particularly suitable. In contrast to neutral information, emotional content is allocated more attentional resources, and, consequently, more in-depth processing [motivated attention; (30)]. These processes can be investigated using neural (electroencephalogram; EEG) and peripheral physiological correlates, e.g., electrocardiogram (ECG, including heart rate, heart rate variability) and electrodermal activity (EDA).

During picture viewing, a triphasic pattern of heart rate response is usually observed, including (1) initial deceleration (orienting response), (2) acceleration, and (3) secondary deceleration (30, 31). The present pilot study focuses on the first two observations. Unpleasant (and, less consistently, high arousing, in contrast to low arousing pleasant) pictures have been found to evoke more pronounced initial HR deceleration, whereas pleasant pictures provoked higher acceleration relative to unpleasant [neutral pictures ranging in between; (30, 32)]. In line with these findings, evidence from appetitive and aversive conditioning suggest, that initial bradycardia might be rather valence-independent, indicating stimulus novelty or significance (33, 34).

Viewing of emotionally arousing, relative to neutral pictures has been associated with higher skin conductance level (SCL), pointing to higher sympathetic arousal (29, 30, 32). In the EEG, and especially in event-related potentials (ERPs), elevated Late Positive Potentials (LPPs) for emotionally arousing, relative to neutral pictures, have been observed over centro-parietal electrodes, starting at about 400 ms post-stimulus onset and lasting for several 100 ms, likewise indicating motivated attention (23, 24, 35). Preceding the LPP, the early posterior negativity (EPN, 150−350 ms post-stimulus onset) is also reliably enhanced for emotionally arousing, relative to neutral stimuli (36).

Similar reaction patterns during picture viewing and imagery have been observed for heart rate and skin conductance [(37, 38); for summary, see Ji et al. (39)]. In contrast, during imagery, the LPP emotion effect might emerge over more posterior electrodes, compared to picture viewing (40). However, there are conflicting

LPP results, and research on ERPs of emotional imagery is still sparse (40, 41).

2. Methods and analysis

2.1. Participants

Inclusion criteria for participation in the intended study will be German language (level B2 or higher), student status (University of Greifswald), and age between 18 and 30 years. Females will be required to use oral hormonal contraceptives to exclude menstrual cycle influences on emotion processing [e.g., (42, 43)].

Exclusion criteria will be non-Caucasian, current or past mental or neurological disorder, as well as acute illness and/or medication. Participants will be required to have normal or corrected-to-normal vision and hearing. Participants will receive course credit for participation. For controllability, only same-sex pairs with heterosexual orientation will be included.

2.2. Stimulus materials

2.2.1. Picture stimuli

Sixty pictures (20 unpleasant, 20 neutral, 20 pleasant) have been selected from the International Affective Picture System [IAPS (22) and the EmoPics (44)] according to their normative valence (unpleasant: M = 2.4, SD = 0.63; neutral: M = 5.22, SD = 0.41; pleasant: M = 7.11, SD = 0.63; all $ps < 0.001$) and arousal ratings (unpleasant: M = 6.13, SD = 0.6; neutral: M = 2.87, SD = 0.33; pleasant: M = 5.97, SD = 0.79; unpleasant = pleasant >neutral, $p < 0.001$). Semantic categories include attack, mutilation, accident/disgust for unpleasant, neutral objects and people, and nature/buildings for neutral, and cute animals, babies/people, erotica, and sports/adventure for pleasant scenes, respectively, (see **Supplementary material 1**).

2.2.2. Imagination scripts

Nine scripts (3 unpleasant, 3 neutral, 3 pleasant) have been selected from the Affective Norms for English Text [ANET; (26)], German translation (see **Supplementary material 1**).

2.3. Procedure

After arrival to the lab, participants will provide written informed consent to the study protocol approved by the ethics committee of the University Medicine Greifswald and sensors will be attached according the manufacturers' manuals. If necessary, participants will get to know each other introducing themselves briefly (first name, age). Then, they will fill in the modified Working Alliance Inventory [WAI-SR, German; (45)] bonds-subscale (Items 3, 5, 7, 9, see **Supplementary material 2**) and rate their relationship and sympathy on a nine-point Likert scale (1 = "completely unknown/do not like at all" to 9 = "very well-known/like very much"; ratings are never revealed to the partner and participants have to sign a declaration of confidentiality). Data acquisition will take place in a sound-attenuated, dimly lit cabin. Following a 10 min baseline (rest, black screen), experiments A and B will be conducted in counterbalanced order. Finally, individuals will fill in the bonds-subscale (WAI-SR) and will be told the objectives of the experiment. Apart from the experimental interaction procedure, participants will be instructed neither to engage in conversation, nor to communicate *via* gesture or mimics.

2.3.1. Experiment A—Triadic synchrony

Participant pairs will be seated in front of a 27-inch computer screen (*distance* = 1.5 m) and stimuli will be presented using Presentation Software (Version 23.1; Neurobehavioral Systems Inc., Berkeley, CA, USA).

2.3.1.1. Picture viewing task

A block design has been chosen to avoid serial position effects for emotionally arousing and neutral pictures [(23); see **Figure 1**] Neutral (N), pleasant (P), and unpleasant (U) picture blocks will be presented in six orders randomly assigned to each participant pair (NPU, NUP, UPN, etc.). Pictures will be presented for 3,000 ms following a fixation cross of 500 ms (varying inter-stimulus interval 2,000, 2,500, and 3,000 ms). Individual self-paced Self-Assessment Manikin (SAM)-ratings for valence and arousal on a 9-point Likert scale (46) will follow each picture presentation.

2.3.1.2. Imagination tasks

In the silent reading + imagination task (see **Figure 2**), each script will be presented for 15 s followed by a 12 s imagination period. Each imagination will be followed by a SAM-rating. A variable inter-stimulus interval of 15, 16, and 17 s will be used.

The procedure in the listening + imagination task will be identical to silent reading, except that participants will now listen to audio files. Emotion order and reading/listening tasks will be counterbalanced between pairs. Audio files for the listening task will be read by male or female voice and will be counterbalanced, too.

2.3.2. Experiment B—Dyadic synchrony

In experiment B, participants will only perform the reading/listening + imagination task, seated facing each other at a distance of 1.5 m. One partner, viewing the screen, will read out the scripts presented analogous to experiment A, the other partner (with the back to the screen) is listening. Then, both imagine the scene for 12 s and do individual SAM-ratings. After three runs (unpleasant, neutral, pleasant in counterbalanced order), positions are changed.

2.4. Data acquisition and pre-processing

Subjective rating data will be registered *via* Presentation Software (Version 23.1; Neurobehavioral Systems Inc., Berkeley, CA, USA) and logfiles will be further processed using IBM SPSS Statistics Version 29.0 (IBM Corp., Armonk, NY, USA) SPSS (Version 29.0, Armonk, NY, USA). ECG and EDA will be measured using EcgMove4[1] and EdaMove4[2] (movisens GmbH, Karlsruhe, Germany), respectively. For the continuous single channel ECG

1 https://docs.movisens.com/Sensors/EcgMove4/#welcome

2 https://docs.movisens.com/Sensors/EdaMove4/#welcome

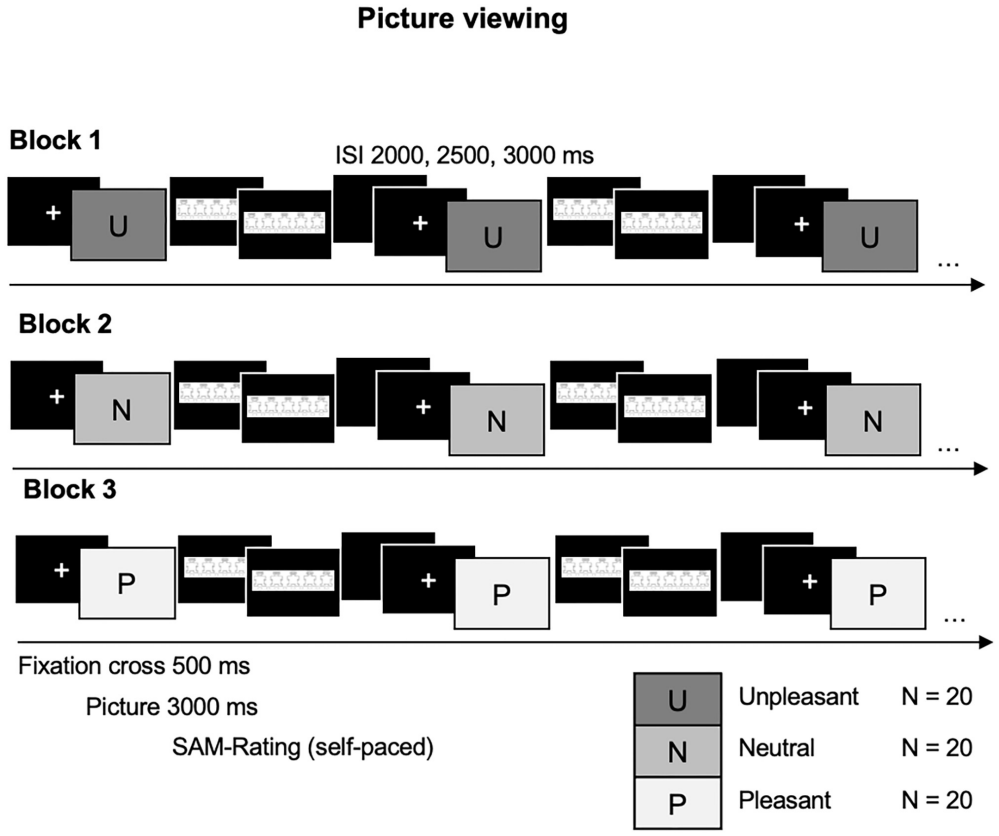

FIGURE 1
Picture viewing task. Blocked presentation of unpleasant (U), neutral (N), and pleasant (P) pictures for 3000 ms, following a 500 ms fixation cross; self-paced Self-Assessment Manikin (SAM) ratings follow each picture presentation. Variable inter-stimulus interval (ISI) of 2,500, 3,000, and 3,500 ms.

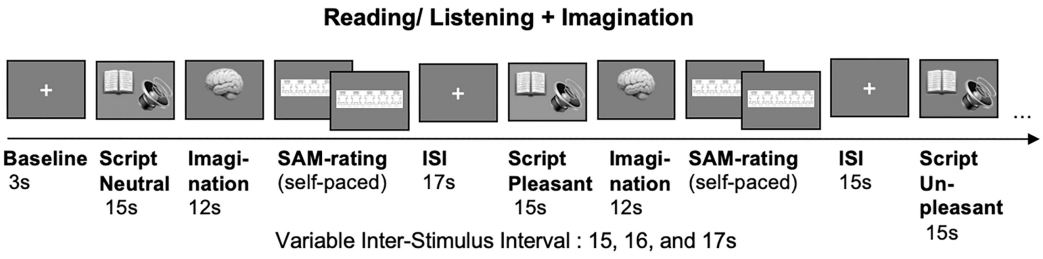

FIGURE 2
Imagination task. Unpleasant (U), neutral (N) and pleasant (P) scripts are presented for 15 s (listening/reading), followed by a 12 s imagination period and the self-paced Self-Assessment Manikin (SAM) rating. Variable inter-stimulus interval (ISI) of 15, 16, and 17 s.

signal (sampling rate of 1024 Hz), a dry electrode chest belt associated with the EcgMove4 system will be used. An EDA sensor associated with the EdaMove4 system will be used to continuously measure EDA (sampling rate of 32 Hz) using a wrist-band and two disposable electrodes are attached to the hypothenar. The built-in activity sensor will register acceleration in three-dimension, angular rate (gyroscope), air pressure and temperature.

Raw sensor data will be read out, visualized and saved using the free and open software UnisensViewer (movisens GmbH, Karlsruhe, Germany), and will then be exported into MATLAB (The MathWorks Inc., Natick, MA, USA; raw ECG data and skin conductance level, SCL, for EDA). For subsequent analyses, ECG raw data will be digitally sampled down at 400 Hz and corrected for artifacts using the Autonomic Nervous System Laboratory [ANSLAB; (47)]. The software automatically detects R-wave-triggers to marker single heart beats; misplaced R-wave-triggers will be checked and corrected whenever they occur. The data will be converted into heart rate in beats per minute for every half-second bin of the sampling period and further analyzed with SPSS. The built-in activity sensor data (acceleration in three-dimension, angular rate, and temperature) will be analyzed together with EDA because of the potential influence of these variables on EDA. To control for possible effects of differences in the overall skin conductance level (SCL) on phasic SCL changes, SCL will be

range-corrected per subject using all available data points during all experimental tasks. Both, SCL and heart rate (computed by converting RR-intervals into beats per minute) will be reduced into 1 sbins for synchrony analyses.

Electroencephalogram will be measured using two nine-channel B-Alert X-Series mobile-wireless EEG systems[3] (BIOPAC Systems Inc., Goleta, CA, USA). Channel configuration includes F3, F4, C3, C4, P3, P4, Fz, Cz, and POz (monopolar configuration) with linked mastoids as reference. EEG data acquisition and pre-processing will be realized *via* Acq*Knowledge* Acquisition and Analysis Software (BIOPAC Systems Inc., Goleta, CA, USA; including high-pass and low-pass filtering at 0.1 Hz and 67 Hz, respectively).

2.5. Data analysis

Questionnaires and behavioral data will be imported from Presentation into SPSS (Version 29; IBM, Armonk, NY, USA).

To investigate the emotion effect, ANOVAs involving the within-subjects factor emotion (unpleasant vs. neutral vs. pleasant) will be conducted. Involving the additional between-subjects factor partner (partner 1 vs. partner 2), requires a total sample size of $N = 42$ to reveal medium size effects [obtained with G*Power, Version 3.1; alpha error probability = 0.05; power = 0.95; partial $\eta^2 = 0.06$; (48)]. For theses analyses, heart rate will be extracted between 1 s prior to picture onset (baseline) and picture offset (3 s). Skin conductance change will be scored as the maximum response (between 1 and 3 s after picture onset). During the imagery reading/listening task, autonomic reactions will be determined by subtracting amplitudes in the first second prior to script presentation from response averages during the 15 s read and 12 s imagery periods.

For ERP analyses, data will be segmented starting 100 ms before (baseline) and 1.200 ms after stimulus onset for each sensor and means ERPs for each emotion category and subject are calculated [see (23)]. Time-windows and sensor sites for EPN and LPP analyses will be chosen following visual and statistical data inspection of individual averages for each valence category, using Randomization Graphical User interface toolbox (49).

For the picture viewing paradigm, each valence block is expected to last approximately 15 min, depending on the speed of the self-paced SAM-ratings. In the imagination task, a run including the three valences will take about 3.5 min, again depending on individual SAM-rating durations.

Thus, for synchrony analyses, signal streams will be synchronized for both subjects and then transformed in interval data. These time rows will be imported into SPSS for further analysis.

For this purpose, EEG data will be exported as MATLAB file (synchronized data for both individuals) and transformed *via* script into Brain Vision Analyzer (Version 2.2.2; Brain Vision, Morrisville, NC, USA) format to allow for artifact correction, filtering and further processing with dual electroencephalography (EEG) analysis pipeline [DEEP; (50)].

3 https://www.biopac.com/wp-content/uploads/b-alert-x10-setup.pdf

Moreover, correlational analyses and Actor–Partner Interdependence Models (APIM) are planned to analyze the influence of synchrony on subjective and interpersonal ratings (51, 52). Separate APIMs are planned for each measure (Heart rate, skin conductance, EEG) in the different tasks (independent variables) and subjective bonds-rating after the experiments (dependent variables).

2.6. Outcome and hypotheses

Primary research question is the successful implementation of the picture viewing and imagination paradigms from an individual setting into the two-person interaction, aiming at the replication of the enhanced attention to emotion effect [motivated attention; (30)] in subjective ratings (SAM), physiological (ECG, EDA) and neuronal (EEG) markers, and the development and testing of new data analysis strategies. Secondary outcome will be the influence of synchrony in physiological and neuronal activity during picture viewing and imagination on subjective emotion experience and interpersonal ratings after the experiment (WAI-SR).

2.6.1. Emotion effect

In line with standard ratings and previous studies, we expect higher subjective arousal ratings for emotional, relative to neutral, pictures and scenes, and valence ratings unpleasant<neutral<pleasant according to the biphasic model (30). During picture viewing, we expect emotionally arousing pictures to evoke more pronounced initial HR deceleration, whereas pleasant pictures will provoke higher post-orienting acceleration relative to unpleasant stimuli over time (30). Higher skin conductance levels are expected for emotionally arousing, relative to neutral pictures (30). In ERPs, emotional modulation of the EPN is expected between 150 and 350 ms post-stimulus onset (36). Over centro-parietal electrodes, elevated Late Positive Potentials (LPPs) for emotionally arousing, relative to neutral pictures, are expected, starting at about 400 ms post-stimulus onset (23, 24, 35).

During imagery, analogous reaction patterns are expected for heart rate and skin conductance [(29, 37, 38); for summary, see Ji et al. (39)]. Possibly, the LPP emotion effect might emerge over more posterior electrodes, compared to picture viewing (40), if it is not blunted at all during imagery (41).

2.6.2. Influence of physiological and neuronal synchrony on subjective ratings

In the individual setting, physiological and neural responses reliably covary with subjective emotion ratings, especially for arousal (30, 53). Thus, higher synchrony in ECG, EDA, and EEG patterns during picture viewing and imagination should result in higher concordance during SAM-ratings, particularly in arousal ratings.

2.6.3. Influence of physiological and neuronal synchrony on interpersonal ratings

Given that higher synchrony between individuals has been associated with more positive relationships (7, 17, 20), participants with higher synchrony in HR, EDA, and EEG

during picture viewing and imagination tasks are expected to provide better interpersonal ratings after the experiment on the bonds-subscale (WAI-SR).

3. Discussion

The present study will provide an experimental approach to investigate interpersonal synchrony, using emotion-induction paradigms that are well-established in individual settings. The controlled experimental setting allows for the simulation of interactions from psychotherapy, and the establishment of research methods, which can later be translated into more naturalistic settings. The standardized emotion elicitation procedure and thus, controllability of an experiment, is a major strength for establishing synchrony methodology and understanding emotion processing in dyads. However, of course, it limits the generalization to real psychotherapy interactions. To increase ecological validity and to elicit more spontaneous emotional reactions, the dyadic interaction task as described by Roberts et al. (54) would be suited for subsequent experimental research. But this procedure is far less standardized and requires significantly more resources (e.g., topic identification, protocol), making it less suitable for the present study.

The study's primary outcome will be the replication of the emotion effect in dyads, and, especially during interactions, an effect which is such a common finding in the individual setting with established methods (30). Maybe, altered attention to emotion will be observed in dyads, as reflected by different neural and physiological responses. One possible explanation would be the (implicit or explicit) use of emotion regulation strategies (55), e.g., attentional deployment or emotion suppression, when facing an interaction partner. For example, if participants were instructed to suppress emotional responses, increased skin conductance, but stronger heart rate deceleration have been observed, suggesting differential activation patterns during emotion suppression (56). Notably, participants showed no differences in subjective reports after affective suppression, and no sex differences were observed (56). Emotion regulation, e.g., attentional deployment, is also reflected by blunted LPP responses toward arousing stimuli (57). During interaction, both partner's emotions (including empathy) and emotion regulation strategies are involved in a context-dependent manner (58). Keeping this in mind, using standard stimuli instead of individual, personal emotional experiences might prevent such strong empathy effects. Although the present study does not involve explicit emotion regulation instructions, the screening includes the Emotion Regulation Questionnaire by [Gross and John (59); German Version: (60)], and allows for including habitual use of cognitive reappraisal and expressive suppression as covariates.

Interestingly, Koole and Tschacher (7) also integrated emotion regulation as third level into their Interpersonal Synchrony (In-Sync) model of psychotherapy, which describes the therapeutic alliance to be "[. . .] grounded in the coupling of patient and therapist's brains." Along with the In-Sync model, the present study might complement level one, which is movement synchrony, with physiological and neural synchrony correlates, and complex cognition (level two) might be affected as well by the present emotion induction (and measured *via* subjective reports).

In line, the secondary outcomes include the relationship between physiological and neural synchrony and (1) subjective emotional experience, and (2) interpersonal relationship. Whilst it is very likely that high physiological and neural synchrony will go along with similar subjective ratings, at least on the arousal dimension (30, 53), there is some evidence for more positive relationships with higher synchrony (17, 20, 61); but this correlation has been mainly observed in parent-child and romantic partner interactions, and has been shown to grow with experience [(18); for review, see Koole et al. (7)]. Therefore, this relationship might be more pronounced in individuals who indicate being more familiar with each other in the beginning of the experiment. Notably, higher SCL synchrony has been associated with therapeutic bond during imagery, but not during application of cognitive-behavioral strategies (such as psychoeducation or identification of automatic conditions) suggesting that the association between synchrony and (therapeutic) relationship might also be task-dependent (61).

Fundamental understanding of interpersonal synchrony is critical to further examine interactions in the psychotherapy setting, and to potentially positively influence the therapeutic relationship through targeted interventions in a next step (e.g., neurofeedback, biofeedback). This approach is in line with the vision of translating basic bio-psychological research into disorder-independent clinical psychotherapy research—and back (3). Here, we focus on (neuro-) physiological correlates of emotion processing, which would mainly relate to the function domain of negative emotionality in mental disorders. Thus, research using and extending the present approach might identify dysfunctional (emotional) interaction patterns in sub-clinical and clinical samples from a *trans*-diagnostic perspective. Only recently, Saul et al. (62) proposed to not only investigate inter-brain synchrony in social anxiety disorder, but also to improve treatment *via* adding neurofeedback, pointing to fascinating new research perspectives. Moreover, as Koole and Tschacher (7) point out, the In-Sync model of psychotherapy provides the framework for training psychotherapists using feedback on movement and language synchrony in order to improve the therapeutic relationship. This might also include physiological and neural feedback strategies.

To conclude, the third outcome of the present study is to inspire further investigations, aiming at conducting psychotherapy research that is "going beyond self-report data" and which adds the interactional perspective.

Ethics statement

The study protocol was reviewed and approved by the Ethics Committee of the University Medicine Greifswald (BB167/22). All participants were required to provide written informed consent to participate in the study.

Author contributions

MH and JW: conceptualization and writing—original draft. MH, HM, JR, TK, and JW: methodology, programming, and analyses planning. JW: supervision and administration. All authors contributed to the article and approved the submitted version.

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.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1133760/full#supplementary-material

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Understanding the role of emotion and expertise in psychotherapy: An application of dynamical systems mathematical modeling to an entire course of therapy

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Introduction: The therapeutic relationship continues to be one of the most important factors in therapeutic outcomes. Given the place of emotion in the definition of the therapeutic relationship, as well as the demonstrated positive impact that emotional expression has on therapeutic process and outcome, it stands to reason that studying the emotional exchange between the therapist and client further would be warranted.

Methods: This study used a validated observational coding system--the Specific Affect Coding System (SPAFF) and a theoretical mathematical model to analyze behaviors which make up the therapeutic relationship. Specifically, the researchers used to codify relationship-building behaviors between an expert therapist and his client over the course of six sessions. Dynamical systems mathematical modeling was also employed to create "phase space portraits" depicting the relational dynamics between the master therapist and his client over six sessions.

Results: Statistical analysis was used to compare SPAFF codes and model parameters between the expert therapist and his client. The expert therapist showed stability in affect codes over six sessions while the client's affect codes appeared to be more flexible over time, though model parameters remained stable across the six sessions. Finally, phase space portraits depicted the evolution of the affective dynamics between the master therapist and his client as the relationship matured.

Discussion: The clinician's ability to stay emotionally positive and relatively stable across the six sessions (relative to the client) was noteworthy. It formed the basis for a stable base from which she could explore alternative methods to relate to others that she had allowed to dictate her actions, which is in keeping with previous research on the role of therapist facilitation of the therapeutic relationship, emotional expression within the therapeutic relationship, and influence of these on client outcomes. These results provide a valuable foundation for future research on emotional expression as a key component of the therapeutic relationship in psychotherapy.

KEYWORDS

therapeutic relationship, master therapists, dynamical system (DS), psychotherapy, affect coding, emotion

Introduction

The therapeutic relationship continues to be one of the most important factors in therapeutic outcomes. Defined by the APA's Third Interdivisional Task Force on Evidence Based Relationships and Responsiveness, as "(t)he *feelings* and attitudes that therapist and client have toward one another, *and the manner in which these are expressed*" [(1), p. 3, *italics added for emphasis*], the emphasis on emotional expression is central to the definition of the therapeutic relationship. The therapeutic relationship is not unlike social relationships, though it is unique, and considered to be "therapeutic in and of itself" [(2), p. 56]. In fact, the task force concluded that effective therapeutic relationships make "substantial and consistent" contributions to therapeutic outcomes, and facilitate improvement regardless of the type of therapy conducted [(3), p. 329]. According to Norcross and Lambert (1), the therapy relationship accounts for 15% of the explained variance in psychotherapy outcome attributable to therapeutic factors. This was the third largest percentage, following unexplained variance (35%), and patient contribution (30%), but ahead of treatment method (10%) and the individual therapist (7%). Taken together, the individual therapist and therapeutic relationship make up 22% of the outcome variance. This led Norcross and Lambert to their conclusion that "the *person* of the psychotherapist is inextricably intertwined with the outcome of psychotherapy" (2019, p. 7).

Research on emotional expression as a relationship element

The same APA task force commissioned a series of meta analyses to investigate different aspects of the therapeutic relationship. Fluckiger, Del Re, Wampold, and Horvath (4), conducted several meta analyses that replicated previous findings about the relationship of the therapeutic alliance (one aspect of the therapeutic relationship) to patient outcome ($r = 0.28$). However, they also found that there were no differences in effect size between alliance and outcome for studies that were random-controlled trials and other research designs. They also noted specifically that the therapeutic alliance is dependent on "creating a *warm emotional bond* or collaborative attachment with the patient" (p. 61, *italics added*). Peluso and Freund (5) contributed to the task force by conducting a series of meta analyses that examined the impact of emotional expression in therapy on the therapeutic relationship and on therapy outcomes. They found significant medium effect sizes for emotional expression and the therapeutic process for clients ($d = 0.63$) and for therapists ($d = 0.54$). In terms of the relationship to outcomes, a medium effect size for therapist emotional expression and therapeutic outcome was observed ($d = 0.56$), with a medium to large effect size for client emotional expression and therapeutic outcome ($d = 0.85$). Given the place of emotion in the definition of the therapeutic relationship, as well as the demonstrated positive impact that emotional expression has on therapeutic process and outcome, it stands to reason that studying the emotional exchange between the therapist and client further would be warranted. Currently, however, there is a paucity of research on how these therapists mobilize emotional and relationship-building behaviors to effect positive change in their clients, which has led researchers to call for further investigation into this factor (5–11).

Use of dynamical systems to assess relationship dynamics

Norcross and Wampold (3) in their summary of the APA task force recommended that future research include an investigation of relationship components on a second-by-second basis, as well as the use of designs that investigate more complex interactions. They also suggested that researchers use observational methods, and attempt to understand the therapist contribution to the therapeutic relationship. Dynamical systems (DS) is an approach that has been used to measure complex phenomena, both mechanical and human, like relationships that can change over time (12). Simply put, "DS is the measure of changes over time using mathematical equations" [(6), p. 224], which makes it a powerful tool for investigating powerfully dynamic interactions, like the therapeutic relationship or other aspects of psychotherapy (13, 14). In fact, Baker et al. outline that there are two aspects of investigation with DS, time-span (ranging from second-to-second, to session-to-session, and beyond), and the element of psychotherapy being studied (e.g., emotional exchanges, word choices, and coordination of movement). Following their investigation, Peluso and Freund (5) recommended that DS modeling could "provide a rich graphical description of the dynamics of the relationship to therapists and researchers alike" (p. 449). Tschacher and Haken (15) described how DS approaches were uniquely suited to psychotherapy research as it can successfully temporal aspects of therapy, as well as the deterministic features (i.e., attractors), and stochastic (changing) elements within the dyad. While it may be a potentially useful method for studying the dynamics and processes within the therapeutic relationship, "these methods have rarely been used in psychotherapy research" [(16), pp. 607].

Perhaps one of the most successful applications of DS modeling to the effects of emotional expression on a relationship is the work of John Gottman and his associates. Using an observational coding system, physiological measures, and DS modeling, he was able to predict, with approximately 94% accuracy, which romantic relationships would end in divorce or remain together 5 years later (17–19). Liebovitch et al. (20) modified Gottman's original dynamical systems nonlinear equations [equations are described below, see (18) for more details] to apply them to therapists and clients. Peluso et al. (21) then used these equations to create simulations of different relationship dynamics by manipulating the parameters of the mathematical model this work revealed that the internal dynamics of the relationship could be meaningfully modeled. Luedke et al. (22), following from recommendation of Peluso et al. (18), implemented a process-based observational method of analyzing the therapeutic relationship, using a modified version of Coan and Gottman's (17) Specific Affect Coding System (or, SPAFF). The researchers cataloged the second-by-second affective exchanges of clinicians and clients, and successfully predicted client retention in recorded sessions of psychotherapy (22).

Over the last few years, other researchers have successfully used nonlinear equations of Peluso et al. (18) to model aspects of the therapeutic relationship or therapeutic process. Soma et al. (23) used dynamical systems analysis to analyze the degree to which fluctuations in the fundamental frequency of either the therapist's or client's voice (as a measure of arousal) would influence the other person. Though they did not use an ordinary differential equation (ODE), to model the dynamics (as Peluso et al. (21) did) their findings did show that, using a dynamical systems framework, a mutual association between therapist and client does exist. Li et al. (24) and Li and Kivlighan (16)

also applied a version of equations of Peluso et al. (18) to ascertain the dynamics of the relationship between therapist and client using ratings of the working alliance as a measure of therapist responsiveness, and the influence and of each person on the other on clinical outcomes. They concluded that this approach was "a viable technique in modeling nonlinear dynamic therapy processes under other theoretical frameworks in future research" [(24), p. 12].

Most recently, Baker et al. (6) used Peluso et al. (18) DS modeling and the same affect coding system (SPAFF) following Luedke et al.'s (22) method and applied it to actual therapy sessions from separate theoretical orientations (cognitive-behavioral therapy, emotion-focused therapy, and psychodynamic therapy) conducted by three expert therapists from each approach (Judith Beck, Leslie Greenberg, and Nancy McWilliams) who saw the same two clients. They found that: (1). DS mathematical modeling could be used to accurately capture and explore the emotional exchanges of the therapeutic relationship and (2) expert therapists, despite using vastly different theoretical approaches, construct very similar relationship dynamics that are dependent on the client rather than school of therapy. Specifically, they found that each of the three therapists had similarities in the graphic representation of the relationship models for the female client and for the male client, and less similarity within each therapist. This provided evidence for the tailoring or relationships based on the client, as well as evidence for the relationship as a common factor rather than a specific ingredient based in a theoretical approach (1, 2, 6). In their conclusion, they recommended following up their findings by applying DS mathematical modeling to a full course of therapy, and consider how expert (or "master") therapists develop the therapeutic relationship over time.

Expert psychotherapists, *Psychotherapy over time* video series and *How master therapists work*

Some clinicians can form effective therapeutic relationships better than others. These differences in ability to form these relationships have been shown to impact clinical effectiveness (2). "Master" or expert therapists differ from novices, and even professional therapists, in several important ways (8, 25–27). A hallmark of these experts is the clinician's technical skill, as well as her response to larger contextual issues (7, 8). In order to demonstrate this competency, one must have exceptional relationship skills, and cultivate strong working alliances (8, 28). Several studies and simulations have demonstrated that high-performing therapists have significantly better outcomes than others. For example, Nissen-Lie et al. (10) differentiated therapists based on over 6,000 client outcomes. Specifically, they found that the majority of therapists (approximately two-thirds) could not be categorized because their clinical outcomes were mixed (some good, some poor). However, approximately 15–20% of clinicians could be identified with consistently good outcomes, and approximately the same level for clinicians with consistently poorer outcomes (11). More recently, Pereira et al. (25) conducted a systemic review of highly effective therapists and found that emotional expression was a significant predictor of therapist effectiveness. It stands to reason that clinicians who consistently have better outcomes, must construct their therapeutic relationships differently than other professional clinicians. In fact, their analysis lead Peluso and Freund to speculate that "there might be an element of mediation between how experience and mastery affect the expression of affect and its impact on clinical outcomes" (2019, p. 448). Unfortunately, there is a lack of definitive research on how expert therapists accomplish this, let alone utilize an effective relationship to effect change in their clients (7, 8, 25–27, 29).

In 2006, the APA created a video series, *Psychotherapy Over Time* as a way to observe acknowledged experts in the field of psychotherapy working with a client. This series went beyond a "one-shot" demonstration, which is prevalent in many therapy training videos. The first video in the series was by series creator, Dr. Jon Carlson, who demonstrated Adlerian theory (41). What was compelling about Carlson's series was that approximately 10 years after the videos were recorded, Sperry and Carlson (26) published the book *How Master Therapists Work: Effecting Change from the First through the Last Session and Beyond*. In their text, Sperry and Carlson expand on the specific characteristics of master therapists, thusly:

> They are voracious learners; draw extensively from accumulated experience; value cognitive complexity; *are emotionally receptive and non-defensive*; are mentally healthy and mature individuals who *attend to their own emotional well-being*; are aware of *how their emotional health affects work* quality; *possess strong relationship skills and are experts in using those skills in therapy*; trust their clients; are culturally competent; and *believe that the foundation for therapeutic change is a strong therapeutic alliance* (p. 16, *italics added for emphasis*).

In fact, this is not very different from the criteria that Hill et al. (8) used to define "expert" therapists: "*the manifestation of the highest levels of ability, skill, professional competence, and effectiveness*" (p. 9, *italics in the original*). In addition, Hill et al. stated that *better* research on expertise in therapy is needed that goes beyond cross-sectional designs that compare novice therapists to experts over longer periods of time.

What is noteworthy about the Carlson videos and book is that their text is an in-depth study of Carlson's original videos, which includes both Carlson's reflections on the sessions, as well as the reflections of the client who participated (which we will utilize in our analysis) nearly a decade later. Given Baker et al.'s (6) and Hill et al.'s (8) recommendation above, and with this definition of mastery fitting with the interest in investigating the emotional expressions in the therapeutic relationship, we felt that both the six-session videos, as well as the reflection contained in the subsequent book was a unique combination of works that add an enriched analysis to the mathematical modeling of the relationship between Carlson and his client.

The present study

There remain questions about what aspects of the therapeutic relationship are stable and which ones change over the course of therapy (1–3). Peluso and Freund (5) speculated that emotional expression would be an aspect of the therapeutic relationship that would change from session to session but did not have any conclusive evidence of exactly how. In addition, there was little empirical evidence of the degree to which client therapist emotional expression changes from session to session and how this impacts the overall therapeutic relationship, and ultimately therapeutic outcome. One of the limitations of work of Baker et al. (6) was that each expert only had one session with either of the clients on their video, rather than multiple sessions with the same

therapist. The present study is an extension of this work and includes an in-depth investigation into the evolution and change of the therapeutic relationship within a single, brief course of therapy, conducted by an expert therapist, that goes from the establishment of the relationship through the working phase and ultimately to termination. Given that most courses of psychotherapy are brief (less than eight sessions), this is a reasonable analog of a successful therapy as defined—at the time of termination and retrospectively—by both the therapist and the client (2, 26). DS modeling of the emotional expressions across multiple sessions of therapy will provide a measure of the changes in emotional expression within a session, as well as between sessions across the entire course of this one case of therapy. The present study builds on the foundations of research established by Peluso and his colleagues, as well as others, to use DS modeling in order to address the questions resulting from previous studies on the therapeutic relationship. The focus of this paper will be on the dynamics of the relationship, particularly the emotional expression of the therapist and client, and whether and how they change. This will be investigated through the following research questions:

> *Research Question 1*: How does emotional expression for both the therapist and client change across the entire course of therapy (as measured by SPAFF observational codes). Given the lack of consensus on the subject, this hypothesis is non-directional.
>
> *Research Question 2*: How do the emotional dynamics of the relationship for both the therapist and client change across the entire course of therapy (as measured by the DS mathematical model parameters of initial state, inertia, uninfluenced steady state, and influence function thresholds). Again, given the lack of consensus on the subject, this hypothesis is non-directional.
>
> *Research Question 3*: How does the overall therapeutic relationship change across the entire course of therapy? As this will be depicted by phase-portraits that will graphically represent the mathematical models across the six sessions, this will be a qualitative analysis of each of the portraits to examine how each session is similar or differs from one another [similar to analysis of Baker et al. (6)].

Methods

Participants

The APA-produced six DVD series *Psychotherapy Over Time* featured Dr. Jon Carlson, and his client, Aimee (41), which was used for the coding and mathematical modeling. Permission to use the APA published *Psychotherapy Over Time* series was obtained from The American Psychological Association for research purposes (G. VandenBos, personal communication, June 13, 2014).

Therapist

Dr. Jon Carlson (1945–2017) was a highly established, peer-nominated expert therapist and was well-regarded by his peers in the disciplines of counseling, psychology, and medicine. Carlson earned doctoral degrees in counseling and clinical psychology and emphasized the use of Adlerian or Individuals Psychology in his work with clients (26). He received lifetime contributions awards from several professional organizations, including the American Psychological Association and the American Counseling Association, and was named one of the Living Legends in Counseling in 2004. He published 60 books, 170 professional articles, and has produced over 300 video training programs (Lake Geneva Wellness Clinic, n.d., Sperry & Carlson). Using criteria of Hill et al. (8) for evaluating expertise, the researchers were comfortable accepting Carlson as an identified expert therapist whose skills merited closer examination.

Client

At the time of her sessions with Carlson, Aimee was a 30-year-old, single mother to two boys, ages 12 and 13. According to Sperry and Carlson (26), Aimee was employed as a limousine driver while attending graduate school part-time and reportedly sought counseling in order to better cope with resentment toward her mother. Prior to counseling, Aimee endorsed taking a passive and avoidant approach in life and, in particular, with her mother. Some of her additional concerns included the impending release of her ex-husband from prison, whom she had divorced due to his abusive behaviors. Aimee reported having headaches, poor sleep, anxiety, depression, and nightmares at the time of counseling. She would be most accurately diagnosed with Unspecified Depressive Disorder with Mixed Features and Dependent Personality Disorder with Obsessive Compulsive Traits (26).

Measures

The specific affect coding system[1]

The Specific Affect Coding System, or SPAFF, was originally developed (30) and validated (31) for the examination of the marital relationship. SPAFF has 20 separate behavioral codes (17). It includes one affect code for neutral behavior, seven positive affect codes (affection, high validation, humor, interest, surprise/joy, low validation, and tense humor), and 12 negative affect codes (contempt, belligerence, criticism, stonewalling, defensiveness, high domineering, low domineering, anger, sadness, whining, disgust, and tension) (32). These codes are applied in real-time *via* marked keys on a computer keyboard while watching split-screened, video-taped interactions uploaded into observational research software. This creates a second-by-second data stream of the interaction.

Specific Affect Coding System was initially used in examining marital conflict interactions (17), although the codes within the system can be applied to any type of conversation in the relationship (18). SPAFF has now been successfully used to assess other types of relationships including: triadic parent-baby interactions (18), the relationship between medical doctors and their patients (33), and most recently, to therapeutic relationship (22, 34, 35). Van Walsum (33) indicated negative emotion had an effect on simulated patients working with student physicians, and Erzar et al. (34) demonstrated SPAFF could be applied to the counseling relationship using a Slovenian translation of the system. Luedke et al. (22) examined interactions between therapists and their clients using SPAFF and found significant differences in the affective behavior of clients who returned to therapy and those who dropped out of therapy.

1 Due to space limitations, in-depth discussions of SPAFF coding procedure, as well as additional information regarding SPAFF (e.g., definitions) please consult the Supplementary material for this article.

Procedure

Once recorded, filmed sessions were edited down into three, 15-min segments to maintain fidelity to procedure of Coan and Gottman (17) to prevent coder fatigue. Each 15-min segment requires 45 min of coder time (22). While not all tapes could be evenly edited into 15 min segments, the average length of sessions recorded was 45 min. Furthermore, sessions that were longer or shorter than 45 min tended to vary from, on average, by less than 1 min. As a result, for all data analyses, percentage of time was used to account for any discrepancies.

Video affect coding procedure

The therapist's and client's affective exchanges were coded using the 20-code SPAFF system (32). The manual provided by the Gottman Institute (32) was the basis for training the coders employed by the current study. All coders employed in the current study were involved in intensive three-day (8 h per day) SPAFF coding training conducted by a Gottman Institute coding trainer. The coders then coded 10 videos over the course of the next few weeks, and maintained inter-rater reliability with the coding trainer (gold standard coder) for the last six consecutive videos, as per the training procedure established by the Gottman Institute. Coders are considered to have achieved inter-rater reliability in SPAFF coding if their codes show windowed kappa, free-marginal kappa, and windowed free-marginal kappa coefficients of 0.6 or higher, which is slightly lower than is expected, due to SPAFF being a real-time coding system with 21 codes that is used over a longer period of time compared to other observational coding systems (J. Gottman, personal communication, February, 1, 2016).

The coding procedure required three viewings of each 15-min session segment. The first viewing is to establish a contextual baseline, the second viewing is to code one of the parties (i.e., the therapist), and the third viewing is to code the other party (i.e., the client). The coded data is then exported for manipulation in statistical programs. Twenty-five percent of coded videos were "double coded" by two independent coders and a kappa over 0.6 must be obtained in order to ensure continued inter-rater reliability (coders for this project demonstrated kappas over 0.7). This procedure was established in Gottman's research during the validation of SPAFF (17), and has been used in research on the therapeutic relationship (22, 35).[2]

Data preparation for modeling

Following Gottman's research protocol, using Noldus Observer v. 11, each second of the session was assigned a code[3] and each code was weighted; then every 6 s of material was summed to create 150 data points from 900 s (15 min) of video (18). The weighting of the codes varies from −4 to +4 so a range of −24 to +24 for each unit is possible (for original weighting see, (18)). Luedke et al. (22) posited that the therapeutic relationship carries an inherent power differential that is not assumed in a marital relationship, and completed a discriminant function analysis on a sample of SPAFF-coded therapy segments. Using the structure matrix coefficients derived from the discriminant function analysis as a numerical basis, Peluso (36) created a new weighting system with separate weights for clients and therapists, which was employed in the current study.

Dynamical systems mathematical modeling

We will briefly describe the DS equations initially developed from the work of Gottman and his colleagues (18, 19) and modified by Liebovitch et al. (20) and Peluso et al. (21).[4] As mentioned above, DS equations assess changes over time, as a result, they are often expressed as differential equations, where there is a change in a measure (*dT, dC*), over a period of time (*dt*), and expressed as a mathematical function. In our case, the equations that we used are below (see Equation 1).

$$\frac{dT}{dt} m_1 T + b_1 + c_1 F_c\left(C\right)$$

$$\frac{dC}{dt} = m_2 C + b_2 + c_2 F_T\left(T\right) dt \qquad (1)$$

Each variable in the equation represents either a score at a moment in time, or a parameter that is a mathematical representation of an element of the phenomenon being studied (in this case, the therapeutic relationship). In Equation 1, b_1 and b_2 are the initial state for the therapist and the client, and m_1 and m_2 are each person's inertia (or their tendency to stay in a previous emotional state). According to Baker et al. (6):

> These four parameters (called the *uninfluenced parameters*[5]) are derived using a least squares method, and computed by summing the scores of one partner when the other person is neutral, and compared the changes in scores for each of these at moment $t + 1$. The *initial state* parameter is derived by total positive and negative scores, when the other person's score is zero (or is having no influence). Broadly speaking, this can be thought of as the individual's unique disposition (positive, negative or neutral), that introduces a constant… via the b_1 and b_2 parameters. The *inertia* parameter is "the tendency of remaining in the same state for a period of time" (19, p. 114), and is estimated by taking an average of positive scores minus negative scores when the other partner's score was zero[6]. The greater a person's inertia is, the less likely they are to be open to influence from the other person (pp. 225-226).

2 More information on the training procedure is included in the Supplementary material.

3 The coder operates a keyboard with codes assigned to different keys. When a code is detected, the coder presses the appropriate key for the code. Each second is assigned the code until the coder presses another key for another code. As a result, a continuous second-by-second data stream is created. See supplemental material for more information.

4 For a more in-depth explanation of the equations, parameters, and the modeling procedure, please see Baker et al. (6), as well as the Supplementary material for this article.

5 These two parameters are combined to created uninfluenced steady state combining the inertia parameter (resistance to change), and the initial state (the individual's dispositional characteristics) using the formula: b_1/m.

6 For specific information on the derivation of parameters, please see Gottman et al. (17).

TABLE 1 SPAFF codes for Dr. Jon Carlson over six sessions.

Code	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
Low domineering	13 (0.50)	18 (0.67)	112 (4.15)	47 (1.85)	62 (2.30)	46 (1.70)
Tension	8 (0.30)	6 (0.22)	74 (2.74)	31 (1.22)	63 (2.33)	40 (1.48)
Tense humor	5 (0.19)	1 (0.04)	6 (0.22)	1 (0.04)	9 (0.33)	12 (0.44)
Neutral	2,132 (81.19)	2047 (75.81)	2,128 (78.81)	1951 (76.87)	1906 (70.59)	1859 (68.85)
Interest	130 (4.95)	79 (2.93)	136 (5.04)	150 (5.91)	142 (5.26)	103 (3.81)
Low validation	194 (7.39)	252 (9.33)	118 (4.37)	226 (8.90)	240 (8.89)	212 (7.85)
High validation	135 (5.14)	289 (10.70)	119 (4.41)	126 (8.90)	263 (9.74)	405 (15.0)
Affection	8 (0.30)	8 (0.30)	3 (0.11)	0	8 (0.30)	13 (0.48)
Humor	0	0	0	4 (0.16)	7 (0.26)	7 (0.26)
Surprise/Joy	1 (0.04)	0	4 (0.15)	2 (0.08)	0	3 (0.11)
Total positive	468 (17.82)	628 (23.26)	380 (14.07)	508 (20.02)	660 (24.44)	743 (27.52)
Total negative	26 (0.99)	25 (0.93)	192 (7.11)	79 (3.11)	134 (4.96)	98 (3.63)

Number of Seconds per code (Percentage in parentheses).

The next parameters, $c_1F_1(T)$, $c_2F_C(C)$ are the influence functions of the therapist on the client, and of the client on the therapist, respectively (6).

We generated the initial state, inertia, uninfluenced steady state[7], the thresholds for the influence functions in the negative and positive regimes, as well as the strength and threshold for the repair parameter using procedure Gottman et al. (18) for deriving parameters used in the DS equations.[8] This provided the necessary parameters to create unique mathematical models for each of the six therapy sessions for both therapists and clients, in accordance with approach of Peluso et al. (21). The key difference in this analysis is that each of the parameters were derived from the weighted and summed SPAFF data coded in each of the six sessions.

Using an ODE solver in MATLAB[9] [again, see (6, 20), for details] to show the changes over time, the phase-space portrait was created based on solutions to the two ordinary differential equations in Equation 1. An advantage of using differential equations is that they allow for continuous (rather than discrete) analysis of the dynamical system and create a more realistic interaction between the two partners, by creating trajectories from *each potential starting point* (6, 12).[10] This approach allows for a more complete exploration of the system, which will be illustrated below.

Data analysis

In order to explore research questions 1 and 2, a Kolmogorov–Smirnov Exact test will be used on the percent of time spent in each SPAFF code for both the therapist and the client. This is a non-parametric test that is appropriate for several reasons. First, there were fewer than 30 observations per variable (in fact, there were exactly six), and second, the scores themselves were numerically less than 5, which made a chi-square (the usual method for investigating) invalid. Secondly, we chose to compare scores to each other, rather than impose a normal distribution to the scores, as we wanted to see if they differed significantly from one another, from session to session. In instances like the present study, the Kolmogorov–Smirnov Exact test is recommended (37).

Research question 2 will also be answered using a Kolmogorov–Smirnov Exact test, using the parameters for the DS models (initial state, inertia, positive and negative influence thresholds, repair strength, and repair location) for the therapist and client for all six sessions. Furthermore, the DS models will be graphically depicted using phase portraits which will allow for a visual inspection of the relationship dynamics as modeled (6). These will be used specifically to respond to research question 3.

Results

We will begin with an analysis of the individual SPAFF codes for both Jon Carlson and Aimee that were detected across all six sessions. Next, we will present an analysis of the mathematical models of all six sessions, beginning with the model parameters that were derived from the SPAFF data, and then we will evaluate the phase-portraits for the overall dynamics of the relationship at each session. Where applicable, all alpha levels were set a 0.05.

Comparison of affect codes

One of the overarching questions posed in this paper is whether there were any systemic differences in the therapeutic relationship, between Jon Carlson and Aimee as indicated by SPAFF coding of the affect across the sessions. Table 1 lists the number of seconds and the percentage of Carlson's individual SPAFF codes, as well as the total positive and total negative codes. The number of seconds and percentages of SPAFF codes were compared across the six sessions using a Kolmogorov–Smirnov Exact test.

Looking at Table 1, the SPAFF codes that were detected for Carlson included: Low Domineering, Tension, Tense Humor, Neutral, Interest, Low Validation, High Validation, Affection, Humor, and Surprise/Joy. In addition, we computed the Total Positive and Total

7 The uninfluenced steady state is a ratio of b/m parameters, see Gottman et al. (17).

8 Several programs are available to accomplish this, such as the 'dyad' package written in the R programming language, and freely available (47).

9 Although any ODE solver in R or Python would be just as useful.

10 Again, a more thorough discussion of these topics are in the Supplementary material.

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TABLE 2 SPAFF codes for Aimee over six sessions.

Code	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
Disgust	0	0	8 (0.30)	0	0	0
Low domineering	0	0	0	0	5 (0.19)	0
Tension	277 (10.55)	132 (4.89)	584 (21.63)	168 (6.62)	583 (21.59)	140 (5.19)
Tense humor	5 (0.19)	1 (0.04)	4 (0.15)	0	10 (0.37)	10 (0.37)
Sadness	89 (3.39)	19 (0.70)	0	21 (0.83)	0	0
Neutral	2,176 (82.86)	2,403 (89.00)	1984 (73.48)	2047 (80.65)	2,107 (74.70)	2,279 (84.41)
Interest	2 (0.08)	1 (0.04)	0	54 (2.13)	0	7 (0.26)
Low validation	62 (2.36)	100 (3.70)	120 (4.44)	164 (6.46)	71 (2.63)	189 (7.0)
High validation	15 (0.57)	40 (1.48)	0	79 (3.11)	7 (0.26)	34 (1.26)
Affection	0	0	0	0	3 (0.11)	0
Humor	0	0	0	0	4 (0.15)	4 (0.15)
Surprise/Joy	0	4 (0.15)	0	5 (0.20)	0	0
Total positive	7 (3.01)	145 (5.73)	120 (4.44)	302 (11.90)	81 (3.0)	230 (8.52)
Total negative	371 (14.13)	152 (5.63)	596 (22.07)	189 (7.45)	598 (22.15)	187 (6.93)

Number of seconds per code (Percentage in parentheses).

TABLE 3 Dynamical systems model parameters for Jon Carlson.

	a2	r2	UnSS	*n*th	*p*th	kr	sr
Session 1	0.5692533	0.3138643	0.82965119	−2.2	−0.5	−2.6	4.1
Session 2	0.7704783	0.3137779	1.1227827	−0.5	0.6	−1	0.4
Session3	0.01937659	0.456303	0.03563858	−3	−1.3	−3.7	1.7
Session 4	0.1355777	0.3912368	0.22271008	−0.6	−0.2	−5.7	1.3
Session 5	0.6156569	0.3420887	0.93577493	−2.7	−1.6	N/A	N/A
Session 6	0.8492836	0.3576016	1.32205124	−0.5	0.9	−1	0.5

a1, initial state; r1, inertia; UnSS, uninfluenced steady state; *n*th, influence function negative threshold; *p*th, influence function positive threshold; kr, threshold of repair; and sr, strength of repair.

Negative scores. The only SPAFF code that was significantly different from session to session was Humor, $D(5) = 0.500$, $p < 0.05$. If we look at Table 1, Carlson did not have any seconds of humor in sessions 1–3, but did in sessions 4–6, though the length was fewer than 10 s in each instance. What may be more interesting is the fact that none of the other SPAFF codes differed significantly from session-to-session, including the Total Positive and Total Negative scores.

An analysis of the SPAFF codes for Aimee over the span of the six sessions was also conducted. Table 2 lists Aimee's individual SPAFF codes included: Disgust. Low Domineering, Tension, Tense Humor, Sadness, Neutral, Interest, Low Validation, High Validation, Affection, Humor, and Surprise/Joy. In addition, just as with Carlson, we computed both the number of seconds, and the percentages as well as the Total Positive and Total Negative scores. Unlike Carlson's scores, Aimee's scores did show significant differences from session to session for the following SPAFF codes: Disgust [$D(5) = 0.833$, $p < 0.05$], Low Domineering [$D(5) = 0.833$, $p < 0.05$], Interest [$D(5) = 0.711$, $p < 0.05$], Affection [$D(5) = 0.833$, $p < 0.05$], Humor [$D(5) = 0.667$, $p < 0.05$], and Surprise/Joy [$D(5) = 0.667$, $p < 0.05$]. Neither Total Positive or Total Negative were significantly different, however. Looking at Table 2, Disgust and Low Domineering only appeared in one session out of the five, and even then for less than 10 s. Interest (typified by asking questions), however, showed a marked increase in session 4. Like the finding for Carlson, Humor did increase in sessions 5 and 6, while Surprise/Joy was present in Sessions 2 and 4 (but not other sessions).

Taken together, in terms of coded emotional expression in sessions over time for this particular series of therapy sessions, the therapist displayed fewer emotion codes than the client, and the proportion of therapist codes did not significantly change (except one). At the same time, the client did show significant changes in a number of codes over the six sessions. However, in order to assess the dynamic nature of the relationship, and the impact of this on the overall system, we will consider the results of the mathematical modeling next.

Mathematical modeling of the therapeutic relationships

Comparisons of parameters across sessions

Following the procedure laid out by Baker et al. (6) using Peluso et al.'s (2012) equations, mathematical models and parameters for all six sessions were computed. Table 3 lists the derived parameters for all six sessions for Jon Carlson and Table 4 lists the parameters for Aimee. Just as before, in order to determine if the parameters differed from significantly from session-to-session a Kolmogorov–Smirnov Exact test was employed. For both Jon Carlson and Aimee, the parameters of their

TABLE 4 Dynamical systems model parameters for Aimee.

	a2	r2	UnSS	*n*th	*p*th	kr	sr
Session 1	−0.2270265	0.3979142	−0.3770667	−1	1.8	−1.5	1.1
Session 2	0.1203736	0.232378	0.15681364	−1.6	−0.2	−3.7	3.1
Session3	−0.4135209	0.3502402	−0.6364212	−1.2	3.4	−1	1.3
Session 4	−0.1998837	0.1183646	−0.2267192	−2.6	3.4	−1.4	1
Session 5	−0.7585239	0.2088656	−0.9587801	1.4	6.2	N/A	N/A
Session 6	0.1575602	0.3890159	0.25787938	−1.2	0.2	−5	1

a2, initial state; r2, inertia; UnSS, uninfluenced steady state; *n*th, influence function negative threshold; *p*th, influence function positive threshold; kr, threshold of repair; and sr, strength of repair.

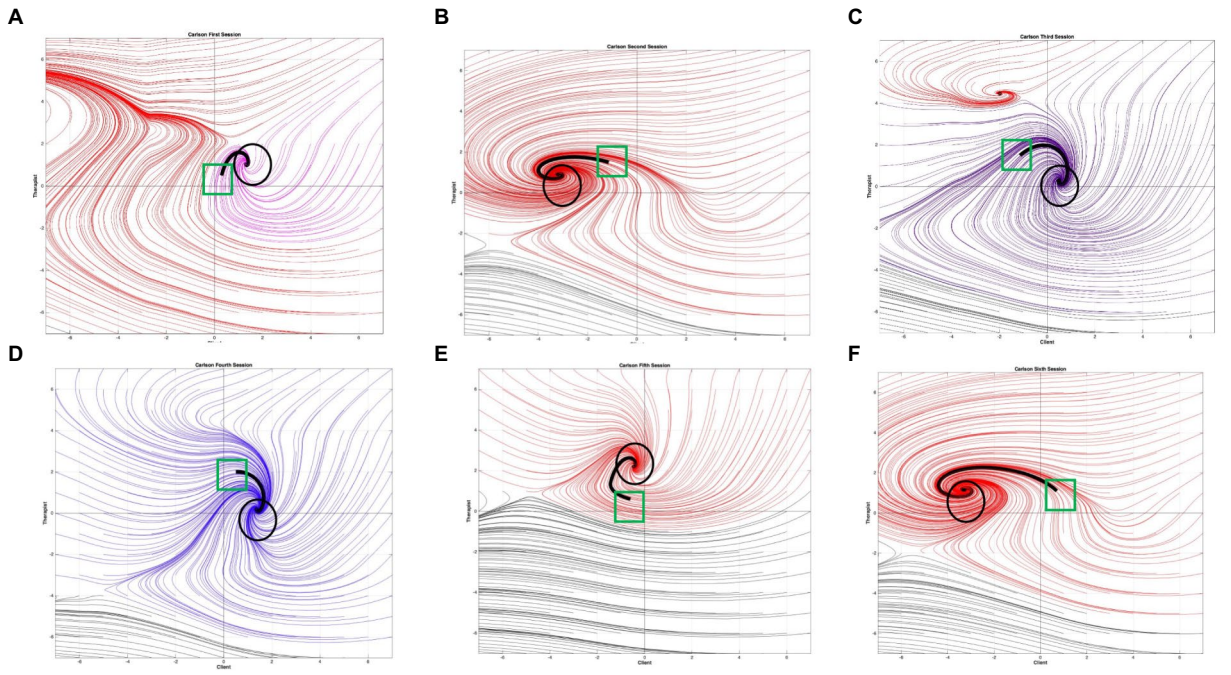

FIGURE 1
Phase portraits of all six sessions of therapy between Jon Carlson and Aime. **(A)** is the phase portrait for session 1, **(B)** is for session 2, **(C)** is for session 3, etc. Beginning coordinates denoted by green circles, and ending coordinates denoted by black circles. Black line is the trajectory that the session likely took based on the starting coordinates.

models were not significantly different from one another, suggesting that despite the differences detected in Aimee's individual SPAFF codes described above, the model parameters for both Carlson and Aimee are relatively consistent across the sessions over time. One explanation for this is that the parameters are derived primarily from summed scores when one partner or another is negative or positive. In the analyses above, neither Carlson or Aimee's total positive or total negative scores were significantly different. However, as we will see below, there are dynamic variations in each session that are worth exploring.

Phase portrait visualization of the therapeutic relationships

The models in the current study were derived from the SPAFF data of the emotional expression in the six sessions of real therapy with Jon Carlson and his client Aimee taken from the *Psychotherapy Over Time* video series (Carlson, 2006). The parameters that are derived from the mathematical models are best considered using a graphic visualization, especially for complex systems (20). The phase-space portraits in Figure 1 shows two-dimensional phase-space portraits of all six sessions,[11] and were created using the parameters derived from the differential equations (see Equation 1, above listed in Tables 3, 4). This was an iterative process using 10 time-steps, and displays the trajectory lines for every set of all potential starting coordinates for the system, as well as the critical point (s) in the system. Hence, by knowing what the initial starting point is for the session, the actual trajectory of the session can be estimated. This is accomplished in each of the six sessions in Figure 1 by averaging the first 10 percent of the SPAFF codes for therapist and client. In each of the phase portraits in Figure 1 these coordinates (client starting point value on the *x*-axis, therapist starting point value on the *y*-axis) is

11 The phase portraits can also be rendered in a three-dimensional phase-space portraits of the dynamic nonlinear models using time steps as the z-axis. These are available upon request.

denoted by a green square. The estimated trajectory of the actual sessions are then drawn on the phase-space portrait (as a black line) to indicate the best estimation of how the math model predicted the quality and endpoint of the relationship in the session where the parameters for the whole system were derived. The quadrant in which the critical points are located is an indication of the quality of the relationship (e.g., a positive–positive quadrant vs. negative–negative quadrant), while the black trajectory line represents the estimated actual endpoint of the therapeutic relationship (6, 18–21). The endpoint coordinates of the trajectory in each of the phase portraits in Figure 1 is denoted by a black circle.

There are several noteworthy aspects of the phase-space portraits for the six sessions as in Figure 1. In the first, third and fourth session (Figures 1A,C,D, respectively), there are attractors in the positive–positive quadrant, with all three having actual trajectories (representing what actually happened, compared to what could have happened) in that quadrant (again, as indicated by the black square). The other three sessions (Figures 1B,E,F) all have dominant attractor points in the therapist positive/client negative quadrant (though it can be argued that in session 5 (Figure 1C), the attractor point is just barely outside of the positive–positive quadrant). While seemingly not as satisfactory as an attractor in the positive–positive quadrant, it is noteworthy that in those sessions, the location of the attractor represents the optimal outcome of the particular session, and that the trajectory from the actual session did move toward the optimal attractor. It is also noteworthy that none of the sessions ended up in the negative–negative quadrant of the phase portrait. This quadrant is indicative of a poor session outcome, with each participant displaying overt negativity, with no attraction to a positive emotional state (6).

Discussion

The present study used an affect coding system and a dynamical systems approach to mathematical modeling to map the therapeutic relationship of an expert psychotherapist, Jon Carlson and his client Aimee over the course of six sessions in order to illustrate elements of emotional expression and relationship building behaviors by a master therapist and their impact on the client over time. The overarching research questions that were investigated were:

1. How does emotional expression for both the therapist and client change across the entire course of therapy (as measured by SPAFF observational codes)?
2. How do the emotional dynamics of the relationship for both the therapist and client change across the entire course of therapy (as measured by the DS mathematical model parameters of initial state, inertia, uninfluenced steady state, and influence function thresholds)?
3. How does the overall therapeutic relationship change across the entire course of therapy?

These questions followed from previous work and the results of the present study provided some evidence that these dynamics have both elements of stability and change within them. These elements will be discussed below, as well as limitations of the current study and next steps in this line of research.

Changes in emotional expression between sessions

One of the interesting findings was the consistency of the therapist's SPAFF codes across the six sessions. At the same time, the ratio of positive to negative scores were as high as approximately 20:1 (session 2) and went as low as 2:1 (session 3), and averaged 10:1. This finding is in line with work from Wolf et al. (27) who found that highly effective therapists displayed less negative affect, and depiction of the stability of therapist demeanor of Wampold et al. (11) in the face of client affect. This is also reflected in Aimee's scores, which showed significant differences from session to session, particularly in the negative SPAFF codes of Disgust and Low Domineering, and in the positive SPAFF codes of Interest, Affection, Humor, and Surprise/Joy. Interestingly for Aimee this change in client emotional expression—particularly with positive emotional expression—is positively associated with successful treatment outcomes (5).

Parameters from mathematical models

The parameters generated from the math models are helpful for comparing sessions to each other using a common metric (6, 20, 21). Based on the results of the analysis, we can conclude that there is evidence for stability in each person's parameters (particularly initial state and inertia) across the six sessions. While there may not have been significant differences between the sessions, one noteworthy comparison between the therapist and the client is that the initial state parameter for Jon Carlson are all positive, meaning that he started from a positive emotional state, while Aimee's initial state was negative in four out of the six sessions and positive in two. Baker et al. (6) found similar results between the master therapists of three different approaches with all positive initial state parameters, while the clients started from negative initial states in half the sessions. This is consistent with the recommendations from the APA Task Force on Therapeutic Relationships against confrontations and negative processes (1), as well as (46) and Hill et al., (8) findings about therapist effects on clinical outcomes and clinical mastery.

At the same time, the inertia parameter (the tendency to stay in a previous emotional state; where lower scores are indicative of less inertia and higher scores are indicative of more inertia) had some dynamics worth exploring (20, 21). Jon Carlson's inertia scores were generally higher than Aimee suggesting that in each session, he was less likely to move from one emotional state to another, and that Aimee was more likely to move from one state to another. One interpretation of this result was that Carlson remained more emotionally constant in the sessions, while Aimee was freer to move from her previous emotional responses throughout the session. This was corroborated by the significant differences in Aimee's SPAFF scores, while Carlson's did not change. Two notable exceptions were in the first and last session where Aimee's level of inertia was greater than Carlson's. In the first session, this might have been important because the therapist must make an effort to engage the client, and create the therapeutic relationship. While in the final session, Carlson was more expressive regarding the ending of therapy with Aimee, as evidenced by the fact that he was positive over 27% of the time, which was the largest percentage over the six sessions (see Table 1).

A final observation involves the parameters in session 3 and 4 (see Tables 3, 4), and the interaction between therapist and client. First, in session three, Carlson's initial state was close to zero or neutral (0.019), while his inertia parameter was the highest of the six sessions (0.456). Aimee's initial state was strongly negative for her (−0.413), while her inertial as also high (0.350). In this session, Carlson was actively pointing out Aimee's ambivalence about confronting her mother's behavior (which was a significant issue for Aimee), while Aimee was demonstrably uncomfortable about the issue (see Aimee's comments below). In terms of the specific SPAFF codes, Carlson displayed the code Low Domineering (taking control of, or directing the conversation) 4.15% of the time, and the code Tension 2.74% of the time (which were the highest among the six sessions of each SPAFF code). For her part, Aimee demonstrated her discomfort by displaying the code Tension during 21% of the session, which was also the highest for her among the six sessions. While this may suggest the potential for a therapeutic rupture (38), in the next session, Aimee had the highest percentage of total positive SPAFF scores (nearly 12% of the time), and had her lowest level of inertia (0.118). Not surprisingly, this was after she was able to have a frank conversation with her mother about her sadness over the state of their relationship. Taken together, these results also highlight Carlson's use of what he called using the "velvet hammer," a skillful pattern of balancing therapeutic support and challenging (or positive and negative affect) during sessions (J. Carlson, personal communication, April 2, 2016). This is in keeping with several theories about the role and structure of the therapeutic relationship, including the Social Relations Model (39) or Wampold and Imel's (2) Contextual Model. It is a good demonstration of how the affect coding and parameters derived from the mathematical model can provide a method to understand complex therapeutic interactions (6, 20, 21).

Phase space portraits: Carlson and Aimee

Phase space portraits of Carlson's six sessions with Aimee were created in order to explore the emotional dynamics between a master therapist and his client over a brief course of therapy (see Figure 1). In the first session, both client and therapist have trajectories toward an attractor in the therapist-positive/client-positive space (Figure 1A). This shows positive affect for both parties at the emotional endpoint for this session. In fact, Carlson acknowledges this:

> I believe that my calmness… influences Aimee and she believes that I have seen this situation before… If Aimee feels a strong alliance with me, she will feel safe enough, and hopeful enough to want to talk about issues that previously were seen as too intimate, painful or taboo" [(26), p. 46].

However, in session 2 (Figure 1B), the attractor is in the client negative/therapist positive quadrant. This shift into mild client negativity may indicate an increase in therapeutic challenging and emotional heightening of the client for clinical purposes. Carlson as much as confirmed this idea when reviewing this session, saying: "Aimee's negative self-talk has to be challenged and changed as it is very powerful and serves to limit what she can become" (p. 72).

In session 3 (Figure 1C), two possible attractors emerge within the portrait, one in the therapist-positive/client-negative space, and one in the therapist-positive/client-positive space. It seems that in this session, too much therapist positivity in response to more client negativity would result in greater client negativity. It is possible that excessive therapist positivity, when the client is expressing negative affect, may be interpreted as insensitive by the client. As Carlson reflected: "Aimee did a lot of work in this session. Her thinking and increased verbal participation showed her level of engagement. My role was to facilitate the discussion by asking questions and challenging her thinking in a positive manner" [(26), p. 125]. This is consistent with previous research indicating the critical role of therapist attunement to client emotions during sessions (40, 41) and demonstrating warmness, hopefulness, and empathy through the use of facilitative interpersonal skills (11).

In session 4 (Figure 1D), trajectories lead both client and therapist to an attractor in the positive/positive space, indicating a mildly positive emotional state for both parties at the end of this session. This shift toward positivity for both client and therapist at the end of session could represent a deliberate attempt by Carlson to augment his client's positive affect as he approaches termination. In session 5, the attractor in the therapist-positive/client-negative space was only mildly negative for the client and mildly positive for the therapist (see Figure 1E). Finally, in session 6 (Figure 1F), Aimee ends the session in a mildly negative space while Carlson ends the session with mild positivity. While it may be surprising that Aimee ends this course of therapy with a mildly negative endpoint, during this session, client and therapist were discussing ways in which client has grown in therapy and how Aimee intends to carry this growth into her life after therapy with Carlson. Again, Carlson reflected on this session, stating:

> In terminating therapy, I find it helpful to go over what has been accomplished and what is unfinished. It is also important to identify future areas of challenge where relapse might be more likely to occur and to obtain some commitment from the client to keep moving toward their goals [(26), p. 171].

In this context, Aimee's somewhat negative affect at the end of this session may indicate her feelings about terminating the therapeutic relationship. Phase space portraits of these sessions conducted by Carlson may well depict his intentional management of both his own and his client's emotional state (26). This finding is similar to (42) for therapist effects associated with treatment outcomes:

> It is not about the therapist mimicking or offering a therapeutic relationship identically to the relationship desired or perceived by the patient but being open and flexible enough to recognize and accept the patient views on the bond and adapt his/her interactional style and therapeutic practice in accordance (p. 10).

Clearly, Carlson's approach provided both the warmth that Aimee was seeking (as evidenced by the positive affect scores), but did not shy away from emphasizing the agency that she had to make changes in her life and relationships.

Ultimately, Aimee's reflection over the course of her therapy, may be the most important indication of the overall success of the therapy. Sperry and Carlson (26) were able to ask Aimee for her feedback

approximately 7 years following the course of therapy with Carlson. She said:

> The aspect of our work together that stands out the most was the challenge to confront my mother. There was valuable time spent discussing my animosity toward her, but what seemed effective was the confrontation. I hesitate to use the word confrontation but that's how I felt when I was faced with it. It was more of an overdue expression of feeling… The main changes that I made during our work together were to begin living my life with my mental health in mind. I needed to learn to be mindful of my needs instead of others'. Additionally, I needed to forgive my mother for the experiences I had in childhood. Once I began to forgive her, I felt as if I had begun to start healing from deeply embedded emotional needs wounds within me (p. 172).

Perhaps there is no better indication of a successful course of psychotherapy, than the testimony from a client almost 10 years after the termination of therapy. Aimee's comment is consistent with findings from a Social Relations Model (and others) that patient reports of strong therapeutic relationships were directly linked with better outcomes (42). Both Carlson and Aimee credit the relationship that they built in the six sessions as being an important factor in the success of the therapy.

Limitations and future directions

The present study makes a unique contribution to the literature on in-session affect, therapeutic expertise, and in-session client and therapist indicators in the development of an effective therapeutic relationship. While most studies of therapist affect look at therapist and client affect as measured before and after session, this study examined the within-session affective dynamics of therapy. Perhaps the greatest value of this study is the way in which it addresses a significant gap in the research on both therapeutic expertise and the affective dynamics of effective therapy (1, 6, 8, 10, 11).

The present study was not without some limitations. As Hill et al. (8) noted, many studies of expertise lack statistical power due to low numbers. This project was focused on one course of therapy that was relatively brief (six sessions). Investigating longer-term therapeutic relationships may yield deeper insights into how these relationships are developed and change over time. While the results of this study was similar to another investigation of expert therapists using DS modeling (6), there are other avenues to pursue including how this investigation of therapeutic relationships (using observer coding) differ depending on client and therapist self-report measures of the therapeutic alliance (8, 11). In addition, other modeling procedures (e.g., Bayesian modeling), may provide additional insights to the emotional exchange between therapists an dlcients. Lastly, while both participants rated the course of therapy to be successful, there were no contemporaneous measures of outcome or symptom reduction reported. Future research using DS modeling with expert or non-expert clinicians would benefit from including outcome measures.

Another limitation of the coding system used is the significant percentage of time that is coded Neutral. This stems from the definition of the code (when one person is talking, unless there is convincing evidence of additional affect codes present, the code is Neutral), the fact that as one person is talking, the other person is listening (particularly in therapy), or when there is a segment of time that is uncodeable, then Neutral is the default code. There may be more subtle affect displays that are not well-accounted for in SPAFF that may be detected using computer vision, affective computing and machine learning which may facilitate more real-time feedback to clinicians (5, 6, 43, 44).

Conclusion

The purpose of this paper was to use DS modeling of observational measures of emotional expression between therapists and clients in a complete course of psychotherapy to determine the stability as well as the changes in the therapeutic relationship observed over different sessions. Overall, the results yielded some important implications for future research as well as clinical practice and training. Carlson's ability to stay emotionally positive and relatively stable across the six sessions (relative to Aimee) is noteworthy. It formed the basis for a stable base from which she could explore alternative methods to relate to others that she had allowed to dictate her actions (i.e., her mother, father, and ex-husband). This is in keeping with previous research on the role of therapist facilitation of the therapeutic relationship, emotional expression within the therapeutic relationship, and influence of these on client outcomes (5, 7, 8, 11, 27, 42). Investigating expert psychotherapists using dynamical systems mathematical models is a useful approach for understanding complex phenomena in psychotherapy. Further research is needed into the use of therapist affect to develop high-quality therapeutic relationships, assess and repair therapeutic ruptures, and monitor client affect for indications of clinical progress and relationship strength.

Clinical significance/Impact statement

Dynamical systems mathematical modeling can be used to explore the complexities of the therapeutic relationship. Such an analysis allows for complex study and prediction of outcome based on the coding of interpersonal affective behaviors of video-recorded psychotherapy as it unfolds over time. It can be used as an instructional and exploratory tool to explore the process of creating change with clients in psychotherapy.

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 Florida Atlantic University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. 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

PD, PP, RF, AB, and GP contributed to the design, coding, data collection, and analysis and reporting of this article. All

authors contributed to the article and approved the submitted version.

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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.980739/full#supplementary-material

SUPPLEMENTARY FIGURE S1
Influence Functions and Phase-Space Portrait for Generic Model.

SUPPLEMENTARY FIGURE S3
Time Series scatterplots of SPAFF scores for all six sessions of therapy between Jon Carlson and Aime. **(A)** is the phase portrait for session 1, **(B)** is for session 2, **(C)** is for session 3, etc. Colors denoted by the bar on the right signify the time (in seconds) in the session for the data point.

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Body exposure and vocal analysis: validation of fundamental frequency as a correlate of emotional arousal and valence

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Introduction: Vocal analysis of fundamental frequency (*f*0) represents a suitable index to assess emotional activation. However, although *f*0 has often been used as an indicator of emotional arousal and different affective states, its psychometric properties are unclear. Specifically, there is uncertainty regarding the validity of the indices of $f0_{mean}$ and $f0_{variabilitymeasures}$ ($f0_{dispersion}$, $f0_{range}$, and $f0_{SD}$) and whether higher or lower *f*0 indices are associated with higher arousal in stressful situations. The present study therefore aimed to validate *f*0 as a marker of vocally encoded emotional arousal, valence, and body-related distress during body exposure as a psychological stressor.

Methods: *N* = 73 female participants first underwent a 3-min, non-activating neutral reference condition, followed by a 7-min activating body exposure condition. Participants completed questionnaires on affect (i.e., arousal, valence, body-related distress), and their voice data and heart rate (HR) were recorded continuously. Vocal analyses were performed using Praat, a program for extracting paralinguistic measures from spoken audio.

Results: The results revealed no effects for *f*0 and state body dissatisfaction or general affect. $F0_{mean}$ correlated positively with self-reported arousal and negatively with valence, but was not correlated with $HR_{mean/maximum}$. No correlations with any measure were found for any $f0_{variabililtymeasures}$.

Discussion: Given the promising findings regarding $f0_{mean}$ for arousal and valence and the inconclusive findings regarding *f*0 as a marker of general affect and body-related distress, it may be assumed that $f0_{mean}$ represents a valid global marker of emotional arousal and valence rather than of concrete body-related distress. In view of the present findings regarding the validity of *f*0, it may be suggested that $f0_{mean}$, but not $f0_{variabilitymeasures}$, can be used to assess emotional arousal and valence in addition to self-report measures, which is less intrusive than conventional psychophysiological measures.

KEYWORDS

fundamental frequency, paralinguistic, psychophysiology, body exposure, body image

Introduction

Verbally expressing one's emotions and understanding the affective responses of others are central to human communication. To assess the expression of affect, many studies [e.g., (1–3)] have integrated a two-dimensional approach splitting affect into arousal [level of physiological awareness; (4)] and valence [level of pleasure/displeasure; (5)]. While there are several well-validated questionnaires to measure both arousal and valence, the reliance on questionnaire data can entail a risk of self-report bias (6, 7). Further, a lack of emotional introspection or interoception in the participant may bias the data [e.g., (8)]. A more objective bodily indicator to measure affect is the use of psychophysiological indices [e.g., blood biomarkers, heart rate (HR), electrodermal activity or endocrine parameters]. Such markers are often applied in research in order to generate more objective data (9). However, although these psychophysiological measures are less subjective than self-report questionnaire measures, they likewise appear to come with a risk of bias: Due to their salience and visibility, they are likely to distract participants from the task at hand (6). Moreover, the invasive nature of some methods, such as the collection of blood markers, decreases participants' compliance (10) and physical comfort (11). In addition, some psychophysiological measures are likely to cause artifacts due to the draping of wires and the restriction of participants' mobility [cf. (12)]. These limitations of psychophysiological methods likely contribute to the low correspondence of psychophysiological measures among each other (13) and with subjective data (14).

Vocal analysis, as a well-established tool in clinical psychology (15), may counteract some of the disadvantages of psychophysiological measures. A particular quality of vocal analysis is that voice data can be derived from audio recordings (16), rendering the method user-friendly for the participant. Moreover, given its non-invasive nature (17), vocal analysis may potentially reduce the bias that is inherent in measuring affect using other psychophysiological methods (16). Fundamental frequency ($f0$) is a commonly used instrument to examine affect by means of the voice (18). $F0$ is the measurable substrate with which the perceived vocal pitch is highly correlated, and refers to the vibration of vocal folds (19). It physically represents the lowest vocal frequency harmonic of a waveform measured in Hertz (Hz); (20). Under the assumption that $f0$ is an indicator of vocally encoded emotional arousal [e.g., (21, 22)], it has been examined in a variety of different contexts. For example, $f0$ has been viewed as an indicator of arousal in the context of discussions in romantic relationships [(23); i.e., $f0_{mean}$] or family conflicts [(24); i.e., $f0_{range}$] and has also been investigated as an indicator of stress [(25); i.e., $f0_{range}$], empathy [(26); i.e., $f0_{mean}$] or to detect clinical social anxiety [(27); i.e., $f0_{mean}$]. Besides this, numerous studies have suggested that $f0$ might represent a marker of specific emotional states (28) such as fear [e.g., (29); i.e., $f0_{mean;}$ (30); i.e., $f0_{range}$]. Other studies found no difference in $f0$ between diametrically opposed emotions such as happiness and fear [(31); i.e., $f0_{mean}$ and adapted $f0_{range}$], thus calling into question the suitability of deriving different emotions from $f0$. If not as a marker of a single emotion, but as a marker of the dimension of valence [pleasant, unpleasant; (5)], $f0$ has received less research attention (32) and there is little (if any) agreement on whether $f0$ is associated with valence in general [cf. (33)]. Therefore, while $f0$ has been studied in many contexts, it has not been directly validated as a marker of arousal. Likewise, while it has been examined with regard to specific emotional states, it has not yet been directly validated as a broad marker of valence.

Furthermore, the question of which distributional characteristic of $f0$ fits to examine affect remains unanswered. Two debated parameters described in literature are $f0_{mean}$ [e.g., (34, 35)] and $f0_{variabilitymeasures}$ [e.g., (30)]. $F0_{mean}$ refers to the arithmetic mean of $f0$. As the most common statistical measure used to indicate the central tendency of a distribution (36), it refers in this case to the interval-scaled variable of $f0$, and it is calculated as the sum of all measured values divided by the number of values (36). Regarding $f0_{variabilitymeasures}$, we refer to the statistical indices of $f0_{range}$ (i.e., $f0_{max}$–$f0_{min}$) and $f0_{SD}$. By using the term $f0_{dispersion,}$ we refer to an adapted range, because the usual calculation of $f0_{range}$ might bias information about the $f0$ distribution in the case of natural outliers (29). Therefore, as described in Hirst (37), $f0_{dispersion}$ displays the calculated difference between the largest and the smallest measured value with a cut of the 0.1 and the 0.2 quantile from the top and bottom $f0$. It is debatable whether $f0_{mean}$ (34, 35) or $f0_{variabilitymeasures}$ (30) are more valid to detect arousal and valence in acoustic features. Both indices seem reasonable, as they have been generally found to be markers of affect [for an overview see (28)]. However, in terms of direction, arousal and valence have been reported to be related to both higher $f0_{mean}$ (19, 38) and higher $f0_{variabilitymeasures}$ (39), as well as lower $f0_{mean}$ (34) and lower $f0_{variabilitymeasures}$ (30, 40). For instance, Rothkrantz and colleagues (38) designed an experiment in which cognitive workload was induced using different stress provoking tasks (e.g., Stroop test) and found an increase in $f0_{mean}$ and $f0_{variability}$ with heightened levels of emotional stress. Likewise, Lively and colleagues (40) induced emotional stress in their participants using a visual tracking task to manipulate cognitive workload. However, in this experiment, the authors found a decrease in $f0_{variability}$ and no consistent effect for $f0_{mean}$. Therefore, although both tasks were equally stress-provoking, the outcome regarding $f0$ was ambivalent. Thus, it is unclear whether affect is associated with higher (19, 24, 41, 42) or lower (30, 43, 44) $f0_{mean}$ and $f0_{variabilitymeasures}$.

To sum up, $f0$ has not yet been directly validated as a correlate of affect (i.e., arousal and valence). Moreover, its underlying dimensions of arousal and valence as well as the significance of high and low $f0$ indices are yet to be examined. The domain of body image might be a suitable research field to resolve this uncertainty and to further validate $f0$, as real-time measurements are of importance in this field: On the one hand, given that body image is known to have a trait-like and a state component (45), prospectively or retrospectively assessed questionnaire data might be biased due to natural state fluctuations in body image (46). On the other hand, non-invasive psychophysiological measurements may be useful in the field of body image. As the main stimulus or stressor is often the subject's own body [e.g., (47)], visible psychophysiological measures applied on the body (e.g., electroencephalogram) may be distracting and might directly influence the validity of the respective studies. In the clinical context, body exposure is a commonly used technique to improve body image, in which individuals are instructed to look at their body while verbalizing the arising thoughts and emotions (48). Body exposure is therefore

suitable to create physiological affective reactions [cf. (49)], as it has been shown to create arousal (50–52) and body-related distress (49) according to self-reported questionnaire data, including in healthy populations (47, 50).

Underlining the importance of non-invasive measures in the field of body image, two studies have already examined the predictive value of $f0$ as a correlate of body-related distress during a body exposure task (34, 35). However, in line with the aforementioned ambiguity of previous research, the results differed according to the respective sample of each study: $F0_{mean}$ was found to be positively related to the construct of state body dissatisfaction in a sample of female participants with overweight and obesity (35) but unrelated to the same construct in a sample of women with binge eating disorder (34). The authors explained this discrepancy by a lack of ability of individuals with eating pathology to adequately engage physiologically in tasks that provoke body-related distress (34). In both studies, $f0$ was assessed only as a correlate of body dissatisfaction and not as a correlate of affect or its underlying dimensions arousal and valence (3, 33). Besides the fact that the above-mentioned studies exclusively focused on body-related distress, they also lacked detailed analyses of other metrics: Contrary to recommendations [cf. (53)], additional vocal indices (e.g., $f0_{varabilitymeasures}$) and the connection to different physiological measures such as HR (34) have not yet been discussed in the context of body exposure. As such, indications that $f0$ represents a marker of vocally encoded affect, arousal, valence, and potentially body-related distress, remain scarce.

In the present study, we therefore aimed to validate the indices of $f0_{mean}$ and $f0_{varabilitymeasures}$ ($f0_{dispersion}$, $f0_{range}$, $f0_{SD}$) as correlates of vocally encoded emotional arousal, valence, and body-related distress (i.e., trait-like eating disorder severity and state body dissatisfaction) during body exposure in healthy women. To examine psychophysiological activation (i.e., valence, arousal, body-related distress), we used voice and HR data from a 7-min body exposure session in which participants looked at their body and freely described their body-related thoughts and feelings. We compared this body exposure (experimental) condition to a preceding neutral, non-body-related baseline (control) condition. Trait-like eating disorder severity was assessed directly before participants underwent the stressor of body exposure. As state measures, we administered self-report questionnaires on state body dissatisfaction, arousal, valence, and general affect before, (during), and after the body exposure.

Despite the ambiguity regarding the direction of $f0$, in our first hypothesis, we expected an increase in $f0_{mean}$ during the body exposure condition compared to the baseline condition, in line with previous studies on vocally encoded body-related distress (34, 35). Moreover, based on studies in patients with anxiety disorder [e.g., (30)], we expected a decrease in $f0_{variabilitymeasures}$ during the body exposure condition compared to the baseline condition. Second, in accordance with findings by Baur and colleagues (35), we hypothesized that body exposure would induce more arousal for individuals with higher trait-like eating disorder severity, which should be reflected in increased $f0_{mean}$ and decreased $f0_{variabilitymeasures}$. Third, in line with the positive correlations between $f0$ and questionnaire-based pathology reported in patients with anxiety disorder (54), for state measures, we hypothesized positive correlations of $f0_{mean/variabilitymeasures}$ with state body-related distress, self-reported arousal, and negative correlations with self-reported valence and general negative affect. Fourth, also in terms of convergent validity, we hypothesized significant positive correlations between $f0_{mean/variabilitymeasures}$ and the psychophysiological marker of $HR_{mean/maximum}$. Further, in terms of comparability between the two psychophysiological measures, we assumed that the HR would follow the expected pattern of an increase during body exposure, as also hypothesized for $f0_{mean/variabilitymeasures}$.

Materials and methods

Participants

The study was approved by the local Ethics Committee (4/71043.5). The sample was community-based and recruited by means of the local university's mailing list, social media advertisements, as well as personal contacts. The inclusion criteria were identifying as female and an age between 18 and 45 years, and the exclusion criteria were self-reported current or past diagnosis of a mental disorder, history of and current drug abuse or acute intoxication by psychotropic substances, and past or present suicidal tendencies or self-harm behavior. We only included participants who identified as female, as this population is likely to show greater body dissatisfaction than, for example, participants who identify as men (55), and we therefore expected higher stress responsiveness in females than in a mixed-gender sample. Moreover, due to potential natural variations in $f0$ between different genders [i.e., higher in females; (42) and lower in males, (56)], it was important for the comparability of the data to remain within the range of a female $f0$. Recruitment began with a first email contact and prospective participants subsequently underwent a structured telephone screening to check the inclusion and exclusion criteria. Out of 113 initial email contacts, $n = 2$ participants did not meet the inclusion criteria, $n = 21$ reported no further interest in participating, and $n = 13$ did not respond to any contact attempts. During the course of the study, $n = 2$ participants dropped out and $n = 1$ declared a diagnosed eating disorder in remission after testing. During the analysis, $n = 1$ participant was excluded due to missing data. Therefore, data from $N = 73$ female participants were ultimately analyzed. As reimbursement, participants received course credits or a €5 gift voucher per hour of participation.

Psychological measures

Trait-like measures

Sociodemographic and study-relevant characteristics

Participants provided information on basic sociodemographic data such as age, nationality, employment status, education, and body-related personal data such as hours of exercise including weight-training weight-training, dieting, and therapeutic treatment. The body mass index (BMI) was retrospectively calculated by dividing self-reported weight (in kg) by height squared (in m^2).

Eating Disorder Examination-Questionnaire

The Eating Disorder Examination-Questionnaire [(EDE-Q); (57, 58)] is a trait-like instrument assessing the frequency and severity of eating disorder symptoms. It comprises 22 items divided across four subscales: Restraint, Eating Concern, Weight Concern, Shape Concern. Items are rated on a seven-point Likert scale (from 0 = *no days/none of the time/not at all* to 6 = *every day/every time/markedly*). Internal consistencies were found to be good to excellent in a validation study [$\alpha = 0.97$ for the global score; $0.85 < \alpha < 0.93$ for the separate subscales; (59)] and in the present study ($\alpha = 0.92$ for the global score, $0.76 < \alpha < 0.86$ for the separate subscales).

Eating Disorder Inventory-2

The Eating Disorder Inventory-2 [(EDI-2); (60, 61)] is a self-report instrument measuring trait-like eating disorder severity. In the present study, we used the two subscales Body Dissatisfaction (nine items) and Drive for Thinness (seven items) to assess the participants' (dis)satisfaction with body parts and preoccupation with their body. All items are rated on a 6-point Likert scale (from 1 = *never* to 6 = *always*). Previous studies in healthy females have demonstrated excellent Cronbach's α for both subscales [Body Dissatisfaction: $\alpha = 0.90$, (62); Drive for Thinness: $\alpha > 0.86$, (63)], as did the present study (Body Dissatisfaction $\alpha = 0.84$; Drive for Thinness Scale $\alpha = 0.88$)].

State measures

Body Image States Scale

The Body Image States Scale [(BISS); (45, 64)] was used to assess cognitive-affective changes in state body dissatisfaction. The BISS contains six items assessing current (dis)satisfaction with one's physical appearance on a nine-point Likert scale (from 1 = *extremely dissatisfied* to 9 = *extremely satisfied*). In a previous study in healthy females (55), internal consistency ranged from good to excellent ($0.82 < \alpha < 0.90$), which was also the case in the present study ($0.89 < \alpha < 0.91$).

Self-Assessment Manikin

The Self-Assessment Manikin [(SAM); (65)] is a picture-based instrument in which participants rate the broad dimensions of Arousal and Valence on the depicted figures. In the present study, the SAM was used as a state instrument (i.e., directly before, during, and directly after body exposure). Participants performed single ratings on a nine-point Likert scale (from 1 = *extremely calm* to 9 = *extremely aroused* for Arousal and from 1 = *extremely unpleasant* to 9 = *extremely pleasant* for Valence). In a previous study in a population of individuals without mental disorders, Cronbach's α values were excellent to acceptable [$\alpha = 0.98$ for Arousal, and $\alpha = 0.63$ for Valence; (66)]. In the present study, both dimensions showed excellent Cronbach's α values ($\alpha = 0.90$ for Arousal and $\alpha = 0.89$ for Valence).

Positive and Negative Affect Schedule–Expanded Form

To assess self-reported general affect in relation to one's body, the Positive and Negative Affect Schedule–Expanded Form [(PANAS-X); (67, 68)] was applied as a state measure. The General Negative Affect scale and the General Positive Affect scale each contain 10 items rated on a five-point Likert scale (1 = *not at all* to 5 = *extremely*). The German version of the PANAS-X has proven to be highly internal consistent for both subscales [$0.77 < \alpha < 0.92$; (68)]. Internal consistency in the present study was in a similar range ($0.69 < \alpha < 0.78$ for General Negative Affect; $0.86 < \alpha < 0.90$ for General Positive Affect).

Physiological measures

Fundamental frequency: vocally encoded emotional arousal and valence

*F*0 (in Hz) in the baseline condition and the body exposure condition was analyzed using Praat, a free-of-charge speech analysis program (69). The procedure of vocal analysis is depicted in **Figure 1**. Before examining $f0$, default settings limited the $f0$ range from 100 to 350 Hz, which corresponds to the usual female speaking voice (70). Next, the previously recorded instructions (lasting for 1 min) were muted on the tape in both conditions, leaving pure participant voice data for the baseline condition (3 min) and for the body exposure condition (6 min). Using the free audio editor Audacity 2.1.2 (71), the remaining voice data in the body exposure condition were cut into two 3-min intervals in order to facilitate the comparability with the baseline data within subsequent autocorrelation estimates. In a next step, using Praat, we manually eliminated non-verbal interjections (i.e., coughing, exhaling, throat-clearing), ambient noise (i.e., mouse clicking), and periodicity (i.e., existing algorithm without corresponding voice) to improve data quality. The specific excluded noises are shown in **Table 1**. A further $f0$ adaptation was implemented using the two-step approach suggested by Hirst (37). To further ensure that an individual's range still corresponded to the usual female vocal range of 100 to 350 Hz, following the procedure of Hirst (37), an additional top and bottom limitation was added.

For all audio data, mean $f0$ estimates for each 25 ms were established using autocorrelation methods provided in Praat, resulting in an $f0$ score for each participant for the baseline and the body exposure condition. Following Baur and colleagues (35), it was necessary to calculate the $f0$ baseline for each person separately in order to control for pre-existing individual vocal differences. As a type of baseline centering (16), the calculated difference scores were assumed to depict the participants' change in vocally encoded emotional arousal from baseline to body exposure (i.e., $\Delta f0_{\text{exposure}-\text{baseline}} = f0_{\text{exposure}} - f0_{\text{baseline}}$).

Heart rate

Heart rate (in beats per minute; bpm) was assessed using an HR monitor (i.e., Garmin Vivosmart 4) worn on the participants' left wrist. Participants told the instructor the time they started and ended each condition, such that a trigger was set and the HR monitor was paused when a new state measure was to be completed. Analogous to $f0$ [cf. (35)] and to account for individual differences in HR, mean difference scores in the body exposure condition relative to baseline were calculated (i.e., $\Delta HR_{\text{exposure}-\text{baseline}} = HR_{\text{exposure}} - HR_{\text{baseline}}$). To draw from different indices, HR was assessed using two commonly used parameters, that is HR_{mean} (72) and HR_{maximum} (73). HR_{mean} describes the arithmetic mean of the HR interval while HR_{maximum} depicts the highest HR value of the HR interval.

Experimental conditions

The procedure of the present study was structured into a two-part repeated measures design consisting of baseline and a body

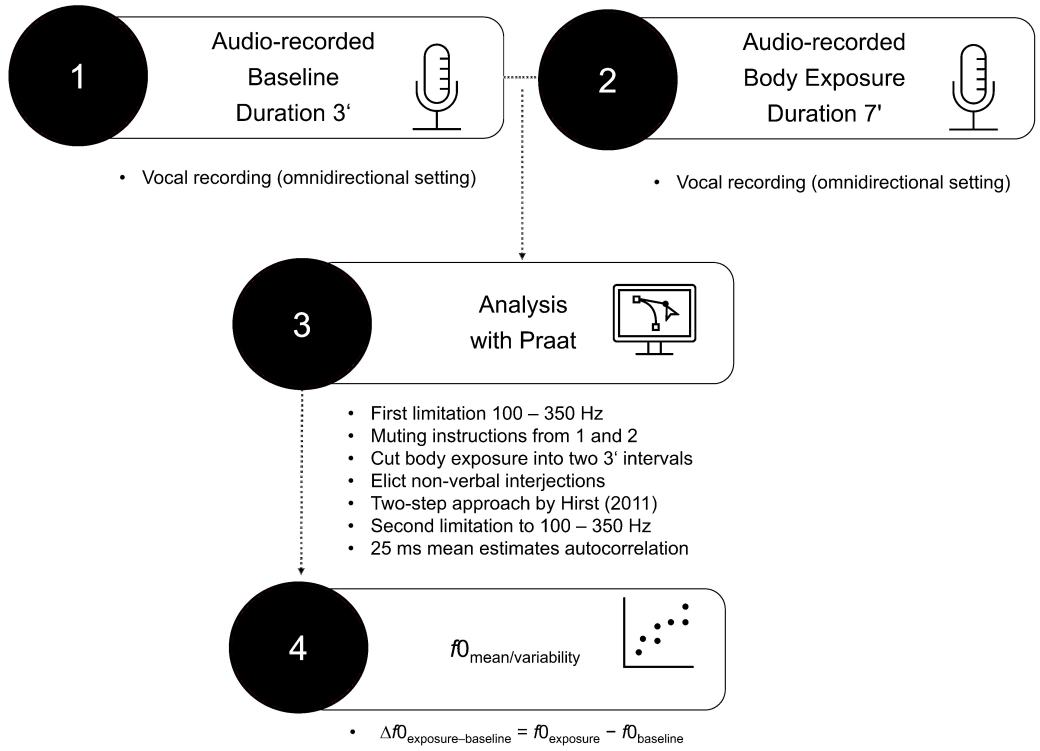

FIGURE 1
Procedure of vocal analysis.

TABLE 1 Specific eliminated noises of voice recordings.

Voice		Noise		
Participant	Human	Environmental	Technical	Artifact
Coughing (3)	Technician (2)	Mouse click (7)	PC sound (2)	Hum (21)
Vocal sound (5)	Laughing (2)	Rustle (12)	Microphone (1)	Creak (2)
Laughing (20)	Coughing (2)	Melody (2)	Telephone (1)	
Throat-clearing (5)	Throat-clearing (3)	Bell (1)		
Breathing (7)	Breathing (2)	Dull sound (3)		
Interjection (7)		Chairs (1)		
Yawning (13)				
Nose-blowing (5)				
Inhale (10)				
Exhale (10)				
Question (1)				
Smacking one's lips (2)				

Numbers in brackets depict the number of events ($N = 73$).

exposure session (as depicted in Figure 2). The 3-min baseline measure served the purpose of using voice and HR as a reference for the body exposure condition. During the baseline measure, participants were asked to describe out loud nine neutrally validated pictures from the Open Affective Standard Image Set [(OASIS); (74)] database, which were hung at the top of a curtain in the mirror cabin. The instructions for the baseline condition were as follows: "For the next 3 min, please describe the nine pictures you see right in front of you. The accuracy of your statements is not important; all that matters is the recording of your voice and HR. It does not matter which images you describe in which order. We ask that you speak for the entire time. You are welcome to repeat sentences [. . .]." During the baseline condition, participants wore their everyday clothes, and the mirror sides of the cabin were covered with a white curtain to avoid distraction. Subsequently, the experimental condition of body exposure with non-guided verbalization [cf. (47)] was implemented. During 7-min sessions encompassing 1 min of standardized audio instructions and 6 min

of verbalization, participants were asked to freely reflect on their body-related cognitions and affect. The instructions for the experimental condition were as follows: "This exercise is about freely talking out loud about your thoughts and feelings about your body. There is no right or wrong way to do this; it is all about your feelings and thoughts. You will hear a tone signal right away, after which you should begin to talk about your thoughts [. . .]." In the experimental condition, participants undressed to their underwear and the curtain of the mirror cabin was removed such that participants viewed their entire body from the front, back, and both side angles.

Mirror cabin equipment

The standardized settings consisted of a three-sided mirror cabin designed for the purpose of the study, including a microphone (i.e., type: t.bone SC1100, Thomann GmbH Germany; setting: omnidirectional) and an LED light inside. Both the baseline and the body exposure condition took place in this cabin, which had a height of 2.12 m and a width of 0.85 m for each of the three sides, enabling the participants to look at themselves from all angles.

Procedure

The study was part of a larger experiment whose procedure is described elsewhere (47) and consisted of an additional three 48-min body exposure sessions that followed the present experiment. Data were gathered in two identically equipped laboratories of the local university. The general setup is depicted in **Figure 2** and was as follows: First, the rationale of exposure was described, and participants were informed about the goals of the study and provided informed consent. Next, the participants completed the trait-like and state questionnaires. Subsequently, the HR monitor was placed around their wrist and they entered the mirror cabin. To protect their privacy, participants were alone in the cabin while a graduate student provided assistance, if necessary, from behind a screen. Then, the microphone and the HR monitor were started for continuous recording and the baseline condition was completed. First the baseline and then the body exposure condition took place. After completing the full experiment, participants got dressed and were shortly debriefed. In addition, they were able to talk about their mental state. For the purpose of standardization, all instructions in the baseline and body exposure conditions were played as pre-recorded audio instructions. When completing the paper-and-pencil measures on general state affect and state body-related distress before and after the baseline and the body exposure condition, the participants wore a bathrobe. State arousal and valence were assessed before, during, and after exposure by asking participants to describe their present arousal and valence with the help of the SAM figures that were hung on the mirror.

Data analysis

The analyses were run using the IBM Statistical Package for the Social Sciences (SPSS, version 28.0). Plausibility checks were performed for all variables. For this purpose, box plots created in SPSS were inspected for signs of obvious errors in $f0$ extraction. There were no extreme outliers (>three times the interquartile range). Moreover, Mahalanobis distance analysis only identified one participant's vocal data as an outlier, but since this was due to a naturally high $f0$ we retained this participant's responses in the dataset. Regarding the final dataset, sample characteristics were analyzed descriptively. Assumptions for the t-test for dependent variables were met and the robustness of bivariate normal distribution for correlations was presumed [cf. (75)]. The hypothesized increase in $f0$ during body exposure compared to baseline was likewise tested using a (two-tailed) t-test for dependent variables, separately for $f0_{mean}$ and $f0_{variabilitymeasures}$. Furthermore, to test the influence of trait-like eating disorder severity on $f0$, we conducted linear regression analyses separately for $f0_{mean}$ and $f0_{variabilitymeasures}$ as dependent variable and trait-like questionnaires as independent variables. Regarding state measures, Pearson's product-moment correlations were used to examine the relationship of $f0$ with self-reported state body-related distress (BISS), arousal and valence (SAM), and positive and negative affect (PANAS-X). To compare self-reported data with $f0$, for the SAM, we averaged arousal and valence measures using data from before, during, and after each condition; for the BISS and the PANAS-X, we aggregated data from before and after each condition. Pearson's product-moment correlations between $f0$ and HR were additionally calculated. As a manipulation check for HR, to ensure that the task indeed elicited an HR response, we tested the difference between baseline and body exposure for HR_{mean} and $HR_{maximum}$ using a (two-tailed) t-test for dependent variables. Effect sizes were classified as small ($|d|$= 0.2), moderate ($|d|$= 0.5), and large ($|d|$= 0.8) in line with Cohen [(76), pp.77–83]. For all analyses, the significance level was set at $\alpha = 0.05$, with Bonferroni-Holm alpha-level corrections (77) applied to account for multiple testing.

Results

Participant characteristics

Participants' characteristics revealed a mean age in the early twenties (M: 23.1, SD: 3.2; range: 18–36), a mean BMI in the normal-weight range (M: 21.3 kg/m^2, SD: 2.8 kg/m^2; range: 18.2–37.9 kg/m^2), and an average amount of exercise per week (M: 4.4 h, SD: 2.3 h; range: 1–8 h) compared to the general population (78). Likewise, the trait-like eating disorder severity and state body dissatisfaction (presented in **Table 2**) lay within the usual range for women without eating disorders (59, 64). Participants' physiological characteristics are depicted in **Table 3**. For voice, the $f0$ ranged from 103.1 to 284.2 Hz in the baseline condition and from 110.2 to 285.81 Hz in the body exposure condition, which lies within the range of female $f0$ (70). HR ranged from 56 to 116 bpm during the baseline condition and from 65 to 123 bpm during the body exposure condition, indicating normotonic values within the sample [(79), (p. 12)].

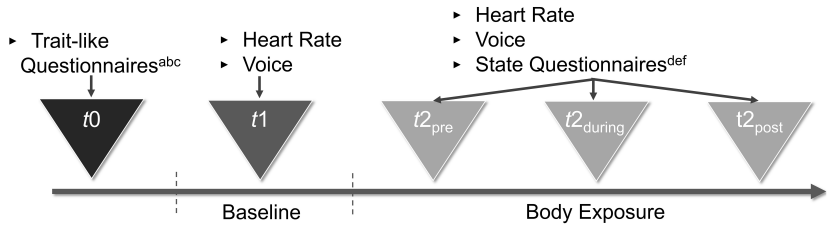

FIGURE 2
Procedure of the study. [a]Sociodemographic Characteristics. [b]Eating Disorder Examination-Questionnaire. [c]Eating Disorder Inventory–2. [d]Body Image States Scale. [e]Self-Assessment Manikin. [f]Positive and Negative Affect Schedule–Expanded Form.

TABLE 2 Means and standard deviations of study-relevant trait-like and state measures.

Variable	Subscale	Preliminary			Condition					
					Baseline			Body exposure		
Trait-like measures		*M*	*SD*	*Range*						
EDE-Q[a]										
	Global score	0.9	0.7	0.3–3.1						
	Shape concern	1.2	0.8	0.2–4.0						
	Weight concern	0.9	0.8	0.2–3.1						
	Restraint	1.0	1.0	0.1–3.6						
	Eating concern	0.5	0.6	0.1–2.6						
EDI-2[b]										
	Drive for thinness	2.7	0.7	1.7–4.9						
	Body dissatisfaction	3.4	0.3	1.4–4.2						
State measures					*M*	*SD*	*Range*	*M*	*SD*	*Range*
SAM[c,d]										
	Arousal				3.0	1.2	1.0–6.0	3.9	1.6	1.0–7.4
	Valence				5.9	1.3	3.0–8.0	6.0	1.3	2.4–9.0
PANAS[e,f]										
	Positive affect				2.5	0.6	3.1–4.5	2.4	0.8	3.2–4.3
	Negative affect				1.4	0.4	2.3–3.3	1.4	0.4	2.2 – 3.4
BISS[f,g]					6.4	1.4	5.7–8.1	5.9	1.3	6.0–8.0

[a]Eating Disorder Examination-Questionnaire.
[b]Eating Disorder Inventory-2.
[c]Self-Assessment Manikin.
[d]Average of assessments before, during, and after each condition.
[e]Positive and Negative Affect Schedule.
[f]Average of assessments before and after each condition.
[g]Body Image States Scale.

Increase of fundamental frequency during body exposure compared to baseline

With respect to the first hypothesis, paired-samples *t*-tests revealed a significant increase from baseline to body exposure for $f0_{mean}$, indicating higher vocally encoded arousal during exposure sessions for $f0_{mean}$ [$t(72) = -3.96$, $p \leq 0.001$, $d = 0.46$]. However, for $f0_{variabilitymeasures}$, we did not find statistically significant differences after Bonferroni-Holm correction [for $f0_{dispersion}$ $t(72) = -0.39$, $p = 0.694$, $d = 0.05$; for $f0_{range}$ $t(72) = -0.77$, $p = 0.223$, $d = 0.09$; for $f0_{SD}$ $t(72) = -1.09$, $p = 0.140$, $d = -0.13$].

Prediction of fundamental frequency by trait-like eating disorder severity

Regarding the severity of eating disorder symptoms as a predictor of $\Delta f0_{mean}$, the multiple correlation of $R = 0.39$ was found to be statistically significant [$F(3,68) = 4.17$, $p = 0.009$]. Furthermore, a higher $EDE\text{-}Q_{global}$ score led to higher $f0$ ($\beta = 6.22$, $p = 0.026$), while no significant predictions emerged for the EDI-2 subscales Body Dissatisfaction ($\beta = 6.11$, $p = 0.116$) and Drive for Thinness ($\beta = -1.30$, $p = 0.623$). Regarding the severity of eating disorder symptoms as a predictor of $\Delta f0_{variabilitymeasures}$, no significant results emerged. Thus, for $\Delta f0_{dispersion}$, the multiple

correlation of $R = 0.21$ was not found to be statistically significant [$F(3,68) = 1.08$, $p = 0.361$]. Moreover, the EDE-Q_{global} ($\beta = -3.06$, $p = 0.681$) and the EDI-2 subscales Body Dissatisfaction ($\beta = -10.36$, $p = 0.320$) and Drive for Thinness ($\beta = -4.06$, $p = 0.570$) did not contribute significantly to the prediction of $\Delta f0_{dispersion}$. Likewise, regarding $\Delta f0_{range,}$ the multiple correlation of $R = 0.28$ was not found to be significant [$F(6,65) = 2.84$, $p = 0.464$] as neither were the EDE-Q_{global} ($\beta = -7.80$, $p = 0.420$) as well as the EDI-2 subscales Body Dissatisfaction ($\beta = -2.42$, $p = 0.856$) and Drive for Thinness ($\beta = -2.89$, $p = 0.757$). Also, regarding $\Delta f0_{SD,}$ the multiple correlation of $R = 0.27$ was not statistically significant [$F(6,65) = 2.73$, $p = 0.519$]. Thus, no significant predictions could be done for the EDE-Q_{global} ($\beta = 3.14$, $p = 0.667$) or the EDI-2 subscales Body Dissatisfaction ($\beta = 15.78$, $p = 0.121$) and Drive for Thinness ($\beta = -3.16$, $p = 0.964$).

Correlations between physiological variables and state questionnaire data

In terms of convergent validity, state body-related distress (BISS) was not significantly correlated with $\Delta f0_{mean}$ ($r = 0.14$, $p = 0.218$) or with $\Delta f0_{variabilitymeasures}$ (for $\Delta f0_{dispersion}$: $r = -0.17$, $p = 0.141$; for $\Delta f0_{range}$: $r = -0.32$, $p = 0.792$; for $\Delta f0_{SD}$: $r = -0.13$, $p = 0.264$). Regarding the correlations of $f0$ and questionnaire-based arousal (SAM) averaged over the course of body exposure (i.e., before, during, and after body exposure), $\Delta f0_{mean}$ yielded significant positive correlations ($r = 0.30$, $p = 0.026$), while no significant correlation was shown between arousal and $\Delta f0_{variability\ measures}$(for $\Delta f0_{dispersion}$: $r = -0.22$, $p = 0.058$; for $\Delta f0_{range}$: $r = -0.07$, $p = 0.554$; for $\Delta f0_{SD}$: $r = -0.01$, $p = 0.944$). Regarding questionnaire-based valence (SAM) averaged across the three time stamps, $\Delta f0_{mean}$ correlated significantly negatively with valence ($r = -0.34$, $p = 0.009$), but again, no significant correlations were found for $\Delta f0_{variabilitymeasures}$ (for $\Delta f0_{dispersion}$: $r = 0.11$, $p = 0.353$; for $\Delta f0_{range}$: $r = 0.57$, $p = 0.629$; for $\Delta f0_{SD}$: $r = 0.15$, $p = 0.193$). Regarding affect, no statistically significant results emerged when applying Bonferroni-Holm corrections. Thus, neither $\Delta f0_{mean}$ ($r = 0.15$, $p = 0.192$) nor $\Delta f0_{variabilitymeasures}$ ($\Delta f0_{dispersion}$: $r = 0.11$, $p = 0.361$; $\Delta f0_{range}$: $r = -0.01$, $p = 0.992$; $\Delta f0_{SD}$: $r = 0.21$, $p = 0.082$) correlated significantly with General Positive Affect (PANAS-X). Likewise, neither $f0_{mean}$ ($r = 0.23$, $p = 0.050$) nor $\Delta f0_{variabilitymeasures}$ ($\Delta f0_{dispersion}$: $r = -0.33$, $p = 0.075$; $\Delta f0_{range}$: $r = -0.39$, $p = 0.073$; $\Delta f0_{SD}$: $r = -0.12$, $p = 0.299$) correlated significantly with General Negative Affect (PANAS-X).

Further, in terms of the relationship of $f0$ with HR, no significant results emerged. Regarding ΔHR_{mean}, neither $\Delta f0_{mean}$ ($r = 0.15$ $p = 0.207$) nor $\Delta f0_{variabilitymeasures}$ ($\Delta f0_{dispersion}$: $r = 0.03$ $p = 0.796$; $\Delta f0_{range}$: $r = 0.06$, $p = 0.620$; $\Delta f0_{SD}$: $r = -0.06$, $p = 0.614$) correlated significantly with ΔHR_{mean}. Also, regarding $\Delta HR_{maximum}$, no significant correlations were found for $\Delta f0_{mean}$ ($r = 0.06$ $p = 0.602$) or $\Delta f0_{variabilitymeasures}$ ($\Delta f0_{dispersion}$: $r = 0.08$ $p = 0.506$; $\Delta f0_{range}$: $r = 0.16$, $p = 0.167$; $\Delta f0_{SD}$: $r = -0.13$, $p = 0.284$). However, as with $\Delta f0_{mean}$, HR increased during body exposure [for $HR_{maximum}$: $t(71) = -2.09$, $p = 0.040$, $d = 0.25$; for HR_{mean}: $t(71) = -5.80$, $p \leq 0.001$, $d = 0.69$] compared to baseline.

Discussion

The aim of the present study was to validate $f0_{mean}$ and $f0_{variabilitymeasures}$ as correlates of vocally encoded arousal, valence, and body-related distress. To achieve this, healthy women underwent a 3-min neutral, non-body-related baseline condition and a subsequent 7-min body exposure session depicting an experimentally induced stressor. Both indices of $f0_{mean}$ and $f0_{variabilitymeasures}$ have been used previously in different stress-provoking tasks but the results have been inconclusive overall. While higher self-reported arousal led to higher $f0_{mean/variability}$ in some studies [e.g., (38, 41)], it led to lower $f0_{mean/variabilitymeasures}$ in others [e.g., (30, 34)]. In line with our first hypothesis, for $f0_{mean}$, we found the predicted increase during body exposure compared to baseline, providing a first indication that $f0_{mean}$ is influenced by psychological distress. However, regarding $f0_{variabilitymeasures}$, we did not find the expected decrease or any differences between the baseline and body exposure condition, indicating that the induced stressor of body exposure was not evident in $f0_{variability\ measures}$.

In terms of our second hypothesis, only one of two measures of trait-like eating disorder severity was found to be significant, with higher trait-like severity emerging as a predictor of higher $f0_{mean}$. Again, no associations were found for $f0_{variabilitymeasures}$. Therefore, it cannot be conclusively stated that $f0$ is a parameter of trait-like eating disorder severity. These findings corroborate the results of previous research: In a study in persons with binge eating disorder, lower $f0_{mean}$ was associated with higher trait-like body dissatisfaction (34), whereas in line with our study on eating disorder severity, a study in a sample of females with overweight and obesity reported that higher $f0_{mean}$ correlated with higher trait-like body dissatisfaction (35). This demonstrates the unclear direction of $f0$ as a correlate of trait-like eating disorder severity, which is potentially related to the different samples of clinical persons [i.e., females with binge eating disorder; (34)] and samples of individuals without mental disorders [i.e., females without mental disorders in our study, females with overweight/obesity; (35)].

Third, regarding the state parameters, the expected associations of $f0_{mean/variabilitymeasures}$ with state body dissatisfaction were not found in the present study. This is in line with the lack of correlation between $f0_{mean}$ and state body dissatisfaction in females with binge eating disorder reported by Baur and colleagues (34), but is in contrast to the negative correlation between state dissatisfaction and $f0_{mean}$ in females with overweight found in another study by Baur and colleauges (35). As a

TABLE 3 Means and variabilities (standard deviations) of psychophysiological measures.

Variable	Index	Baseline	Body exposure
Fundamental frequency[a]	*M (SD)*	204.7 (20.5)	209.1 (19.8)
	Variability (SD)	71.9 (25.4)	73.0 (24.6)
Heart rate[b]	*M (SD)*	84.5 (10.8)	86.7 (11.0)
	Maximum (SD)	99.4 (10.3)	107.5 (11.0)

[a]In Hz.
[b]In beats per minute.

whole, no clear pattern emerges regarding $f0$ in terms of trait-like and state body-related distress. Therefore, $f0$ may not be suitable as a marker of distinct clinical constructs such as body-related distress, social anxiety disorder (54), or pathological fear (30), but may potentially be viewed as a broader correlate of arousal and valence.

Following the pattern of findings reported for the first hypothesis, the expected positive association between $f0_{\text{mean/variabilitymeasures}}$ and self-defined arousal and the negative association with valence were only evident for $f0_{\text{mean}}$ and not for $f0_{\text{variabilitymesasures}}$. Regarding arousal, our results – in line with previous literature on anxiety exposure (54) and body exposure (35) – provide further indication that $f0_{\text{mean}}$ is a correlate of vocally encoded arousal. With regard to valence, the correlation with $f0_{\text{mean}}$ yields more evidence that not only specific emotional states [e.g., fear, (29)], but also general valence, should be considered as correlates of $f0_{\text{mean}}$. Therefore, future studies should analyze affect in $f0$ on the bipolar dimension of arousal and valence (33). Contrary to our assumption, there were no significant correlations between general affect and $f0_{\text{mean/variabilitymeasures}}$. In part, this contrasts with our findings on arousal and valence, which are both commonly seen as dimensions of affect (80). Hence, based on our inconclusive results, $f0$ cannot be clearly seen as a correlate of general affect. Fourth, the findings did not reveal the hypothesized positive association between $f0_{\text{mean/variabilitymeasures}}$ and $HR_{\text{mean/maximum}}$, although greater activation was shown in both psychophysiological parameters in the body exposure condition compared to baseline.

The finding that both $f0$ and HR increased from baseline to body exposure is in line with several experiments on stress-inducing tasks [e.g., for $f0$: (38), for HR: (81)]. However, the lack of correlation between the two psychophysiological measures is unexpected, as theoretically, changes in $f0$ should (among other factors) be caused by cyclic changes in heartbeat (82). Further, positive associations between $f0$ and HR were found during other laboratory stressors [i.e., arithmetic mental stress task (83); or during a couple's conflict about a problematic relationship topic (22)]. This is in contrast to the non-significant correlations of $f0$ and HR during body exposure found in the present study. One possible explanation for this finding may be that both markers seem to be dependent on the distinct stressor that is used to provoke arousal. For instance, Alvear and colleagues (83) found a stronger association between $f0$ and HR under stress induced by cognitive load (i.e., subtracting units from a number) compared to stress induced by physical stressors (i.e., cold pressor test). Moreover, the distinct variable assessed may influence the association, as $f0$ was unrelated to systolic, diastolic and mean blood pressure, but was related to HR (83). In addition, it has not yet been resolved which precise physiological mechanisms are responsible for the association between the two measures (83). To further explore the relationship between these two psychophysiological parameters, future investigations should include different stressors and different cardiovascular measures.

Further, the null findings for $f0_{\text{varabilitymeasures}}$ on all variables of our study indicate that the interpretation on $f0_{\text{varabilitymeasures}}$ lacks a clear direction. From a theoretical perspective, body-related distress is assumed to create sympathetic arousal, leading to a decrease in $f0_{\text{varabilitymeasures}}$ in stressful situations (18) such as body exposure. Moreover, our results are thus in contrast to Hagenaars and van Minnen (30), who reported negative associations between $f0_{\text{varabilitymeasures}}$ and the specific emotional state of fear in patients with panic disorder with agoraphobia. Nevertheless, the lack of effects regarding $f0_{\text{varabilitymeasures}}$ in the present study underline the inconsistent results in the literature [e.g., (4)], with some studies reporting increased $f0_{\text{varabilitymeasures}}$ in response to arousal and valence created using laboratory stressors (28), others reporting decreased $f0_{\text{varabilitymeasures}}$ (30), and some finding no correlation in this regard (84).

The present study was the first to examine arousal, valence, and general affect as depicted by $f0_{\text{mean}}$ and $f0_{\text{varabilitymeasures}}$ during body exposure. Some limitations need to be taken into consideration when interpreting the results: First, methodically, from our correlational findings, we are unable to draw conclusions regarding causality in the sense of a causal link between the psychophysiological cues of $f0$ and HR and the experience of arousal in the body exposure task. Moreover, the study might have lacked statistical power, because the sample was relatively small and the results showed mostly small to medium effects. With a larger sample size, effects might have become more visible or additional effects might have been detected. In addition, future studies should address the potential relationship between body size (i.e., height and weight) and $f0$. However, the literature is inconclusive: A recent metanalysis on 39 independent samples referring to this topic found that the relationship between $f0$ and height/weight accounted for only less than 2% variance within individuals (85). We retrospectively calculated the correlation between $f0_{\text{(all indices)}}$ and BMI and also found no significant effects in our study.

Furthermore, although we implemented a neutral baseline condition, we did not counterbalance the two conditions of baseline and body exposure, and therefore cannot rule out an order bias. However, body exposure is well researched as a suitable stressor, with previous studies demonstrating heightened levels of self-reported arousal (48) and body-related distress (49) in response to body exposure. Second, we examined emotions only in terms of general affect, arousal, and valence rather than analyzing specific emotions, whereas some studies reported a different pattern of $f0$ with regard to individual emotions such as anger [e.g., (19)], sadness [cf. (30)], or disgust [e.g., (86)]. We chose to stick to the two dimensions of arousal and valence because this bipolar scale has been used to measure affect in other questionnaire-based studies [e.g., (65)]. Moreover, the investigation of individual emotions may yield ambiguous findings due to the difficulty of differentiating between distinct emotions such as anger and sadness from one particular $f0$ pattern [cf. (18)]. Third, our sample only comprised Caucasian women without mental disorders, and future studies should therefore consider a more heterogeneous and potentially clinical sample. However, research on vocally encoded affect found comparable results across gender (87) and different ethnic groups (88), indicating that our findings might be transferred to different samples. Furthermore, some studies hint at an influence of phonological differences with regard to the language being spoken [(89); $f0_{\text{range}}$], while others indicate that differences in $f0$ between languages might rather be a cultural artifact [(90); $f0_{\text{mean}}$]. To contribute to resolving this debate, our study should be replicated in samples with other languages. Fourth, future research should consider validating $f0$ based on further

acoustic parameters such as speech rate (30), amplitude (91), or formant frequencies (F_1, F_2; quality of voice; (92), and further on additional psychophysiological measures such as eye-tracking [e.g., 93), cortisol (24), blood pressure (42)], or neurological aspects [e.g., neural network-based approaches, (94)]. Finally, we utilized a wrist monitor as a non-invasive measure of HR. Although the device has shown appropriate validity and reliability in other studies (95), other specific instruments to assess HR or HR variability [e.g., electrocardiogram, (52); automatic cuffs for blood pressure, (42)] should be considered, albeit with the potential cost of distracting participants from the assigned task.

In summary, the present study contributes to research on vocal analyses of affect, as only $f0_{mean}$, but not $f0_{varabilitymeasures}$, emerged as a valid marker of vocally encoded arousal and valence. We further suggest that $f0_{mean}$ represents a valid global marker of emotional arousal and valence rather than of concrete body-related distress. Due to its economical and non-invasive nature (17, 96, 97) and – as our study shows – sufficient validity, the analysis of $f0_{mean}$ might be used prospectively as an adjunctive psychophysiological measure to examine affect in a manner that is less biased than conventional methods (16).

Data availability statement

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

Ethics statement

This study involving human participants was reviewed and approved by the Ethics Committee of Osnabrück University (4/71043.5). The patients/participants provided their written informed consent to participate in this study.

Author contributions

VO: data collection, analysis, writing—original draft, and review and editing. JT and SV: conceptualization and design. JB and JS: data–vocal analysis. AH: conceptualization. All authors contributed to the revision of the manuscript, read, 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.

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The experience of closeness and distance in the therapeutic relationship of patients with different attachment classifications: an exploration of prototypical cases

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Background: Individuals with different attachment classifications (Secure, Avoidant and Preoccupied) may experience emotional closeness differently, in their intimate relationships but also as clients in psychotherapy. However, evidence for this assumption almost exclusively comes from research with self-report questionnaires.

Aims: In this paper, we use observer-rated measures to explore in depth how patients with different attachment classifications experience closeness and distance from the therapist in different phases of therapy.

Method: Three patients' and their therapists' narratives about the therapeutic relationship at three time points during therapy were extracted and analyzed with two transcript-based observational measures: The Patient Attachment Coding System (PACS), which classifies patients' attachment according to their discourse behavior, and the therapeutic-Distance Scale-Observer version (TDS-O), which assesses the therapeutic relationship in terms of closeness, distance, autonomy and engagement. Cases were chosen from a larger research project due to their different prototypical attachment classification on the PACS. The narratives were obtained from Relationship Anecdote Paradigm (RAP) interviews in which the patients and their therapists narrated separately about meaningful interactions with each other, at early, middle and late phases of therapy. In addition, we followed patients self-report of the alliance and symptoms (OQ-45).

Results: Although all patients reported experiencing discomfort with feeling distant from the therapist the therapeutic distance, the secure patient was able to reflect on his feelings and, in the therapist's recollection, was able to share them with the therapist. This allowed the therapist to harness these feelings for the benefit of the therapy. The avoidant and the preoccupied patients both experienced the therapist as distant, but the avoidant patient prevented closeness by a minimal expression of feelings, and the preoccupied described strong frustration with the therapist in a one-sided manner that prevented collaborative processing and left the therapist confused.

Discussion: It appears that patient discourse is a stable (trait-like) component of attachment, while the therapeutic-distance is a process (state-like) component that may change along therapy. The discourse of insecure patients may hinder

therapists' ability to adjust the therapeutic-distance to patients' needs. Therapists' knowledge about the ways patients with different attachment classifications communicate their proximity wishes may improve their attunement.

KEYWORDS

psychodynamic therapy, attachment style, therapeutic relationship, therapeutic alliance, therapeutic-distance, relationship narratives, relationship-anecdote-paradigm, client characteristics

1. Introduction

The relationship between patient and psychotherapist is considered a key component of psychotherapy, capable of bringing about change (1–3). Research has shown that the quality of the therapeutic relationship contributes to differences in therapy outcome to a significant degree (1, 4); yet, our understanding of the mechanisms through which the therapeutic relationship can influence change remains incomplete and in search of sharper definition.

One of the most popular conceptualizations of the patient–therapist relationship in psychotherapy is the one first proposed by Bowlby (5) in his attachment theory. Bowlby proposed that the patient–therapist relationship could be considered an attachment relationship, given that it is one in which the patient seeks protection and support from the therapist. Bowlby further hypothesized that the therapeutic relationship would evoke in patients their generalized representations of attachment relationships, which had emerged on the basis of early attachment experiences with their parents, and would orient individuals' behavior in close relationships. For this reason, Bowlby hypothesized that patients with less felicitous attachment experiences could face difficulties in establishing connection and emotional intimacy with the therapist.

Nevertheless, through the experience of a different, more supportive relationship, Bowlby thought that patients could be helped to revise their Attachment models and achieve greater interpersonal security. After Bowlby, other scholars have elaborated on the process of building stronger patient–therapist attachments and the conditions that allow the therapist to become an attachment figure for the patient (6, 7).

The attachment-informed study of the therapeutic relationship has attracted considerable attention (8–10), but still has significant limitations. In particular, such studies are often conducted through self-report questionnaires, such as the widespread Experiences in Close Relationships Scale [ECR; (11)], or specifically in relation to the therapist through the Patient Attachment to Therapist Scale [CATS; (12)]. For a review of the most commonly used attachment measures in psychotherapy research, see Levy and Johnson (13) and Strauss et al. (14). In addition to their known limitations (15), self-report measures may only summon the patient's conscious expectations about intimacy, whereas Bowlby had hypothesized that attachment-related differences would not be accessible to consciousness (14). For this reason, attachment-oriented psychotherapy researchers have suggested the need to develop appropriate measures that go beyond the self-report perspective (16, 17).

In this article, we explore how patients with different attachment classifications experience closeness and distance in the therapeutic relationship at different phases of therapy by using prototypical clinical examples. To do so, we conducted a preliminary study employing two attachment-informed observational measures for assessing the therapeutic relationship: the Patient Attachment Coding System [PACS; (18, 19)], and the Therapeutic Distance Scale–Observer version [TDS-O; (20, 21)]. The PACS is an established transcript-based instrument that analyses patients' discourse behavior and classifies their attachment patterns according to how discourse influences patient–therapist emotional proximity at an observed level. The TDS-O, developed more recently, is a transcript-based measure designed to assess therapeutic relationships in terms of patients' expressed needs for closeness-distance, autonomy, and engagement in psychotherapy (22, 23).

1.1. Attachment in adults

Bowlby posited that individuals develop mental representations of self and others based on early attachment experiences with their caregivers. He called these representations *internal working models* [IWMs; (24–27)]. According to attachment theory, IWMs play a central role as mechanisms of continuity between early experiences with caregivers and later socio-emotional development since they help to anticipate, interpret, and guide interactions with friends, romantic partners, children, and therapists (28–30). Attachment research in early childhood has relied on Mary Ainsworth's pioneering work using the Strange Situation to classify infants into three attachment types: secure, avoidant, and ambivalent. Mary Main later developed the Adult Attachment Interview [AAI; (31, 32)] to assess attachment-related differences in adulthood. Based on individuals' narratives of their experiences with caregivers, the attachment representations were classified into three attachment types corresponding to the infant classifications: secure, dismissing, and preoccupied.

Another model describing attachment in adults was formulated by Griffin and Bartholomew (33). They described individual differences in IWMs by locating the individual in two-dimensional space defined by attachment avoidance and attachment anxiety. This representation reflects both the person's sense of attachment security and the ways in which they deal with threats and distress. Individuals who score low on these dimensions are generally secure and tend to employ constructive and effective affect-regulation strategies and interpersonal contacts. Those who score high on either the anxiety or the avoidant dimension (or both) suffer from attachment insecurities and tend to rely on secondary attachment strategies (34–36).

Individuals who are high in attachment anxiety and low in attachment avoidance rely on hyperactivating strategies. They

intensify dependency needs and wish for closeness in their relations with attachment figures. These people tend to seek greater proximity to the attachment figure, exhibit maximal amplification of attachment behaviors, and show hypersensitivity to any sign of rejection. Individuals who are low in attachment anxiety and high in attachment avoidance rely on deactivating strategies. They increase distance so as not to get hurt (37) and tend to divert their attention from distressing situations or from attachment-related thoughts and emotions (36). Both of these secondary attachment strategies might form a challenge for therapists who aspire to find ways to work through patients' insecurities and establish a collaborative alliance (29, 38).

1.2. Attachment in psychotherapy

Pre-treatment attachment differences have been examined in psychotherapy research both as a predictor of outcome and as a moderator of change. A recent meta-analysis by Levy et al. (39) demonstrated that patients with secure attachment pre-treatment showed better psychotherapy outcomes than patients with insecure attachment. Further, it revealed that improvements in attachment security during therapy (i.e., with the therapist) may coincide with better treatment outcome [e.g., (8)]. Finally, Levy et al.'s preliminary moderator analyses suggested that those who experience low pretreatment attachment security may find better treatment outcome in therapy that incorporates a focus on interpersonal interactions and close relationships. This finding may point to the need for therapists to find ways to enhance secure therapeutic attachment, especially among insecure patients.

Despite the understanding we have gained about the relationship between patients' attachment and therapy outcome, much less is known about how change in attachment occurs. More research is needed to understand how therapeutic attachments are formed and develop during therapy, especially with insecurely attached patients, and how patients' internal working models may affect therapists' responsiveness.

Mallinckrodt and his colleagues addressed this question (22, 23, 29). They introduced the concept of *therapeutic distance*, which they defined as "the level of transparency and disclosure in the therapeutic relationship from both patient and therapist, together with the immediacy, intimacy, and emotional intensity of a session" [(22), p. 559]. They suggested that expert therapists regulate the therapeutic distance according to patients' attachment needs and phase of therapy.

Thus, since hyperactivating patients tend to feel that their therapist is too distant (e.g., cold, remote, or not helpful enough), Mallinckrodt suggested that at the beginning of therapy with these patients, therapists should attempt to minimize the therapeutic distance in order to allow the patient to feel safer. As therapy progresses, therapists should then strive to gradually increase the therapeutic distance in a manner that allows their patients to experience autonomy and independence, for example by encouraging their self-reliance and by supporting their independent decisions.

In contrast, they proposed that deactivating patients tend to perceive their therapist as too close (e.g., pushing for disclosure and emotional proximity to an excessive degree). Therefore, they suggested that during the initial phase of therapy, therapists should respect these needs by allowing a measure of therapeutic distance. Only during more advanced phases should therapists begin to challenge these needs for distance by establishing a closer, more engaged and caring relationship (22, 23, 29). In order to test their model, Mallinckrodt et al. (23) developed the Therapeutic Distance Scale (TDS), a self-report questionnaire that measures patients' experience of therapeutic distance and their feelings of growing autonomy and engagement. The TDS comprises four subscales: *too distant* and *too close* (both referring to patients' experience of therapeutic distance), and *growing autonomy* and *growing engagement* (both referring to the expansion of their IWMs). A preliminary study provided initial support for the TDS construct validation (23).

1.3. Patient Attachment Coding System

The Patient Attachment Coding System (PACS) also assesses attachment in therapeutic relations. It is based on the assumption that people implicitly use their discourse to regulate closeness and connection with the other, including the therapist (18, 19). Using psychotherapy session transcripts, the authors found that various patterns of in-session communication reliably predicted differences in patients independently obtained by Adult Attachment Interview classifications [AAI; (31)].

In the PACS, secure patients convey their present experience openly. They disclose their emotions in the here-and-now and share vivid narratives of past experiences that clearly convey their current feelings. Secure patients also communicate needs in the therapeutic relationship and share their present intentions, autonomous reflections, and positive experiences. These speech acts, rated on the PACS scales *proximity seeking* (distressful emotions in the here-and-now), *contact maintaining* (positive feelings like appreciation, gratitude and love toward the therapist or therapeutic process), and *exploring* (examining internal states in the "here-and-now") allow the therapist to take part in the patient's experience, reflect or elaborate by asking questions, and increase closeness.

Avoidant patients tend to decline requests to express their feelings or are reluctant to describe their experiences in sufficient detail; they tend to downplay recent emotional experiences (positive or negative) and convey unwillingness to change. These types of communication, rated by the PACS *avoidance scales*, preempt any offer of support and connection by shifting the listener's attention away from the speaker's internal state. Preoccupied (anxious) patients share their experience in a one-sided, exaggerated, or confusing way that leaves little room for the therapist to respond. For example, they may persuade the therapist to join their point of view (*involving* markers), or convey their experience in an impersonal, difficult to understand way (*merging* markers). These patterns tend to limit the extent to which the therapist can make meaning of patients' experience, leaving no room for contradiction, challenge, or elaboration, and they actually disregard the therapist's interventions.

Studies using the PACS with different patient samples in a range of therapeutic modalities have confirmed that AAI classifications predict marked differences in patients' in-session communication, and that by analyzing such differences in a single session, one can predict patients' AAI classifications (19). One study also identified these communication patterns in post-treatment interviews conducted by an unfamiliar interviewer, not a psychotherapist (40, 41). Moreover, the PACS *exploring* scale has been shown to predict patients' ratings of mentalizing assessed independently (40, 41); PACS *security* scales

have also predicted greater resolution of alliance ruptures (42, 43) and greater physiological synchronization between patient and therapist (44).

1.4. The therapeutic distance scale–observer version (TDS-O)

Following Mallinckrodt and Jeong's (45) model, and taking a relational perspective (46), the TDS-O was developed to track the unique dyadic dance between patient and therapist, focusing on the closeness–distance experiences of both patients and therapists. The TDS-O expanded the TDS by creating an observer-narrative-based version [TDS-O; (20, 21, 47)], which enables the researcher to follow both the patient's and the therapist's experiences through their descriptions of their interactions with each other. The narratives told by patients and therapists provide a window into subjective significant moments at different phases of therapy by coding the narratives on the four scales of the TDS-O. While coding by judges entails interpretive aspects, at the same time they also allow identifying the implicit needs, expectations, and feelings of each of the partners, which may not be accessible by means of self-report questionnaires. In a previous study, Egozi et al. (20), showed that patients' and therapists' experiences of therapeutic distance change during the course of therapy. Patients showed a decrease in perceiving therapists as *too distant* and an increase in engagement, and therapists showed a decrease in perceiving patients as *too close* and an increase in granting *autonomy* and *engagement*.

Convergent validity of the TDS-O was established through associations with self-report measures—the attachment measure of the ECR and the Working Alliance Inventory [WAI; (48)]. In these studies, patient and therapist narratives were analyzed by trained observers using the TDS-O at three phases of therapy. During the same phases, the patients and therapists answered the self-report questionnaires. The first study (21) showed that attachment characteristics shaped the closeness–distance dynamics. Appling a dyadic approach to examine associations between attachment patterns of patients and therapists, as measured by the ECR, and their experience of therapeutic distance, the study showed that patient *attachment anxiety* related to different proximity needs than patient *avoidance*, and both needs varied along therapy. Therapist *anxiety* motivated more closeness with patients but was not always congruent with patient experience. Therapist *avoidance* impeded attaining optimal distance in the therapeutic dyad, especially during the initial phase. The TDS-O enables us to follow congruence and incongruence between patient and therapist experiences regarding their proximity, and thus has the potential to contribute to therapist ability to attune to patient emotional needs at the specific moment (49). The second study (47), demonstrated significant relations between the TDS-O and the therapeutic alliance. Patient and therapist decrease in their sense that the partner was *too distant* correlated with increase in the alliance, as did therapist decrease in the sense that the patient was *too close*. Increases in both partners' engagement were also related to alliance improvement.

Overall, the TDS-O appears to be a promising attachment-informed measure that allows following change in the therapeutic relationship between patient and therapist along therapy from the perspectives of both patients and therapists.

Following Strauss et al. (14), who pointed to the need to define and interpret the convergence and divergence of different attachment measures, we suggest that although both the PACS and the TDS-O are attachment-informed, each focuses on different aspects of attachment: The PACS classifies patients by attachment patterns (*secure*, *avoidant*, or *preoccupied*) and the TDS-O follows the closeness–distance dynamics along therapy.

1.5. The present study

This article presents a preliminary study designed to explore the various pathways that patients with different attachment classifications, according to the PACS, experience. It relies on measures of *closeness*, *distance*, *engagement* and *autonomy* (according to the TDS-O) at different phases of therapy, using three prototypical clinical cases. We also analyzed the therapists' narratives in order to evaluate how the therapist understands the patient's closeness–distance needs, and possible effects of the patient discourse pattern on these perceptions. To enrich our understanding of the patient–therapist encounter and outcome we also examined patients' self-report of the therapeutic alliance, as well as their symptom change.

2. Method

2.1. Patients

The cases for this study were selected from a larger research project at a university counseling center (50, 51). In this study, the patients were 67 young adults suffering from distress for which they sought treatment at the community psychological services provided by the university they were attending. Most of them were diagnosed with either mild depression and/or anxiety, presenting with difficulties in relationships, in academic studies, or issues pertaining to the formation of their identity. Twenty-five patients (17 females and eight males) were randomly selected from the larger sample recruited for the project, and their interviews were classified with the PACS. Of these 25 patients, seven were classified as secure, seven as avoidant, and 11 as preoccupied.

For this paper, we selected three patients who most clearly represented the three prototypical attachment communication patterns classified on the PACS (secure, avoidant, and preoccupied), namely, those who received the highest prototypical values specific to the respective attachment classifications as agreed by two independent judges (the first and second author). Although this was not a selection criterion, the three patients started therapy with a symptom level higher than the clinical cut-off (> 63 according to the OQ–45, see below).

2.2. Therapists

Twenty-nine therapists participated in the large research project. They held MA degrees in clinical psychology or clinical social work. The therapists of the three prototypical patients in this study were all females, aged 32–34, who were at the advanced stage of their internship at the university counseling center.

2.3. Therapy

Treatment was provided at the university psychological services of a large university. The therapeutic approach of the therapists was psychodynamic, based on the core principles outlined by Summers and Barber (52), which were employed in all therapies. All the therapists received weekly individual psychodynamic supervision. Treatment consisted of weekly 50-min sessions and was not defined *a priori* as time limited. Median treatment length was 14 months. The therapy is not protocol-based and reflects psychotherapy practice in Israel. [For further details on the sample and the therapy, see (51)].

2.4. Measures

2.4.1. Relational anecdote paradigm (RAP) interviews

All patient and therapist participants were administered the Relational Anecdote Paradigm (RAP) interview (53). In this interview, participants were asked to choose and describe three meaningful interactions that had recently taken place with their partner in the therapeutic dyad (either the therapist or the patient). The interviewer asked the participant about their feelings and thoughts during the interaction [for details see (17)]. Patients and therapists were interviewed separately by different interviewers without being exposed to their partner's narratives. The interviews were held three times over the course of therapy: early phase—after session 5, mid phase—after session 15, and late phase—after session 28. Session 5 was chosen order to assess the emerging alliance, sessions 15 and 28 were chosen as time points that reflect deep therapeutic work. Session 28 was also close to the end of the academic year, and either preceded termination or a short break before the second year. Thus, we wanted the measurements to reflect a continuous therapy process uncolored by termination or separation.

In total, each patient and therapist related nine narratives (three per time point) about their therapist or patient, respectively. The interviews were conducted during the week following the designated session, depending on scheduling constraints (some the following day and up to a few days later). The PACS and TDS-O were applied independently to the nine narratives of each patient.

2.4.2. Attachment-informed observer narrative-based measures

2.4.2.1. Patient Attachment Coding System

The Patient Attachment Coding System [PACS; (18, 40)] assesses patients' attachment classification by examining their verbal communications in a clinical setting with a therapist or an interviewer. The measure can be applied to any transcribed therapy session or interview, regardless of the therapy type or the content of the topics discussed. The PACS was developed following the identification of a number of in-session discourse characteristics that were shown to be statistically associated with patients' independently obtained AAI classifications (18, 40). The occurrence of these characteristics in a psychotherapy session transcript leads to the assignment of one of three PACS attachment classifications (secure, avoidant, or preoccupied). To code with the PACS, the transcript is rated as a whole, without segmenting the text. The coder first identifies in the transcript any number of the 59 discourse markers described in the coding manual. The markers refer to distinct ways of communicating about present internal experience. Each marker belongs to one of five main scales, which are rated from 1 to 7, based on the frequency and intensity of the markers.

Proximity seeking rates the disclosure of painful emotions and narratives about distressing experiences; *contact maintaining* rates communications about the positive impact of the therapy or the therapist; *exploring* rates in-the-moment reflections (occurring in present time) about mental states, expressions of self-assertion and intentions, and reports of positive experiences; *avoidance* rates instances in which the patient fails to disclose in response to the conversation-partner's queries (subscale: *direct resistance*) or downplays the magnitude or importance of their experience (subscale: *releasing*); *resistance* rates instances in which the patient ignores or changes topic in response to the conversation-partner's queries (subscale: *direct resistance*), or communicates about internal experience in excessive, vague detail, or in exaggerated, one-sided terms (*involving* or *merging* subscales).

The PACS classification is obtained using an algorithm based on the scores of the five main scales. Secure patients show high ratings on the *proximity seeking*, *contact maintaining*, and *exploring* scales and low ratings on *avoidance* and *resistance*, while avoidant and preoccupied patients show high ratings on *avoidance* and *resistance* respectively, and low ratings on the scales associated with security. The authors reported good concurrent validity with the Adult Attachment Interview [AAI; (31)]. For details on PACS psychometric properties and more detailed descriptions of the markers and scales, see Talia et al. (19).

2.4.2.1.1. PACS rating

To implement the PACS on patient's RAP interviews, the first author was trained by the author of the PACS, Talia, to use the PACS and reached sufficient reliability when rating therapy-session transcriptions with him. At the next phase, for the purpose of establishing inter-judge reliability, 14 of the current study's RAP interviews (56%) were translated from Hebrew into English and rated by both Talia and the first author. They obtained 86% agreement on the global PACS classifications.

The three patients selected for the current study were rated by the first and second authors and there was an agreement on their classifications. They were chosen as prototypical cases of the three PACS classifications: *secure*, *avoidant*, and *preoccupied* (see the limitations section).

2.4.2.2. Therapeutic distance scale-observer version (TDS-O)

The TDS-O (20, 21) is based on the self-report measure developed by Mallinckrodt [TDS; (23)]. For the observer version, the items of the original questionnaire were adapted to assess the narratives related by the patients and the therapists about each other in their RAP interviews. Thus, two versions were constructed—one to assess patient narratives and the other to assess therapist narratives. In the patient version, the focus of the four scales was on their own experiences. In the therapist version, the *too distant* and *too close* scales focused on the therapists' own experiences, and the *autonomy* and *engagement* scales dealt with their attempts to enable these components for their patients. The following is a description of each scale and relates to the two versions:

Too Distant: A 7-item scale that measures the extent to which the partner is perceived as distant and inaccessible. In the patient version, the emphasis is on the extent to which the patient perceives their therapist as cold, distant, and unhelpful, for example, "There are times when the counselor seems cold and personally distant"; in the therapist version, the emphasis is on the extent to which the therapist feels rejected by their patient and unable to assist them, for example, "Therapist feels that he/she has not been helpful to the patient." *Too Close*: A 7-item scale that measures the extent to which the partner is perceived as intrusive and forcing closeness. For example, in the patient version, "The patient feels that the therapist wants them to reveal too much personal information"; in the therapist version, "The patient insists on pursuing a topic even though the therapist does not want to go there." *Autonomy*: A 6-item scale that measures the extent to which therapy empowers the patient, encouraging them to make independent decisions and take the initiative. For example, in the patient version, "The therapist helps the patient generate their own solutions instead of telling them what to do"; in the therapist version, "The therapist feels that they are helping the patient to generate their own solutions instead of telling them what to do." *Engagement:* A 6-item scale that examines the extent to which the therapeutic relationship allows the patient to discuss sensitive issues and relinquish their concerns regarding the need to reveal themselves. The scale emphasizes the changes in the patient's automatic patterns (distrust and inability to get close) that is unique to their relationship with the therapist. For example, in the patient version, "The patient feels that the counselor has helped them feel more relaxed and comfortable to talk about very personal topics"; in the therapist version, "The therapist feels that they have helped the patient feel more relaxed and comfortable to talk about very personal topics."

2.4.2.2.1. Scoring the TDS-O

The raters were asked to rate each item on a 6-point Likert scale from 1 (*not at all present*) to 6 (*strongly present*). They were instructed to first read the narrative transcript as a whole, and then rate the extent to which each item appeared in the narrative. The three narratives in each of the three interviews during psychotherapy were rated separately, so that a total of nine assessments were received for each participant: three narratives at three different time points (18 narratives for each dyad). Then, we calculated a mean interviewee score across the three narratives of each time point, so that each participant had a total of 12 different scores: four scores for each of the TDS-O scales for the three time points. The mean scores, like the scale, ranged from 1 to 6, so that high scores represented a high degree of presence in the narrative. Inter-rater reliability of the TDS-O items (α Cronbach) ranged from 0.86 to 0.97. For further details on the rating process, including internal reliability and validity of the TDS-O, see Egozi et al. (21).

2.4.3. Self-report measures

2.4.3.1. Working Alliance inventory

The WAI (48) is a widely used 36-item self-report questionnaire that was developed based on Bordin's (54) conceptualization of the alliance; it consists of three subscales: *bond*, *task*, and *goal*. Each item is rated on a 7-point Likert scale from 1 (*lowest alliance rating*) to 7 (*highest alliance rating*). The psychometric properties of the WAI are well-established (55). A Hebrew version of the scale yielded high internal consistency, in the present study $\alpha = 0.87$. The patients answered the questionnaire three times: at early phase (session 5), mid phase (session 15), and late phase (session 28).

2.4.3.2. Outcome questionnaire (OQ-45)

The OQ-45 (56), is a self-report instrument designed for repeated measurement of client symptom changes throughout therapy. Clients are asked to rate their functioning during the past week on a 5-point Likert scale, from 0 (*never*) to 4 (*almost always*), five times along therapy: at intake, early phase (session 5), mid phase (session 15), late phase (session 28), and follow-up (after session 32). The OQ-45 consists of symptom distress, interpersonal problems, and social role. It has adequate test–retest reliability (0.84) and high internal consistency (0.93). Concurrent validity has been demonstrated with a wide variety of self-report scales (e.g., Beck Depression Inventory, State–Trait Anxiety Inventory). Using formulas developed by Jacobson and Truax (57), the reliable change index of the OQ has been estimated at 14 points (56); that is, participants whose change was in a positive or negative direction by at least 14 points are regarded as having made reliable change. The OQ-45 is widely used and has been translated into several languages, including Hebrew (58). The clinical cut-off score in the Israeli sample was 63, similar to the cut-off score in the U.S., and the reliable change index was also the same. In the present study, the alpha coefficient of the total OQ-45 was 0.91 (50).

3. Prototypical cases: the meeting of the lenses of the PACS and TDS-O

To illustrate how patients with different attachment classifications (according to the PACS) experience the therapeutic distance in their relationship with the therapist at different phases of therapy (according to the TDS-O), we describe a detailed analysis of the narratives of three patients according to the two measures. For each case, we use examples from the RAP interviews, presenting the characteristics of the therapeutic distance and how they developed through therapy, as well as the discourse patterns as reflected through the PACS rating. In addition, we examine the therapists' narratives to understand how they experienced the relationship, and the possible impact of the patient's discourse patterns on the therapist's experience of therapeutic distance with their patient. We also provide the scores on the self-reported alliance (WAI) and the outcome from the patient's point of view (OQ-45) for each case. It should be noted that these scores were not taken into consideration in the choice of these cases. Instead, the WAI and OQ-45 scores were drawn from the larger study in retrospect in order to provide self-report information on the alliance of the patients over time, as well as OQ-45 scores pre-and post-therapy. These measurements are used to discuss the added value obtained from using the observational attachment-informed indices.

3.1. Secure patient: Doron

Doron is a single, 24-year-old male undergraduate student. He was classified secure on the PACS: During all three interviews he exhibited a great many *exploring* and *proximity seeking* markers (see Figure 1A). The TDS-O graph shows a moderate decrease in his feeling that the therapist was too distant and an increase in engagement

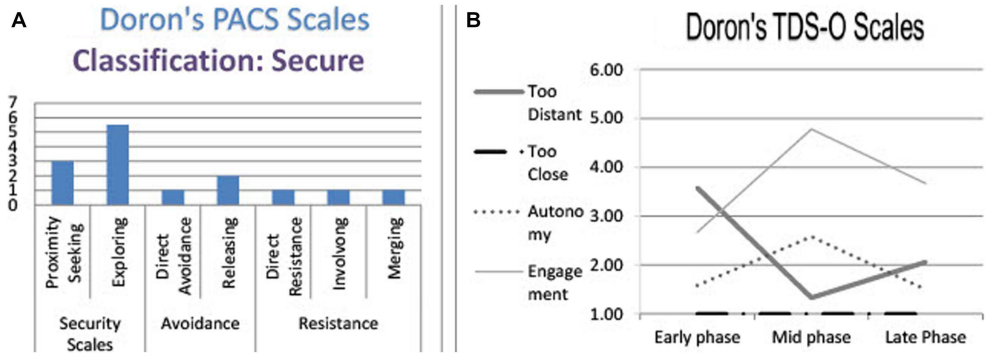

FIGURE 1
Doron's TDS-O and PACS markers. **(A)** Doron's PACS scales. **(B)** Doron's TDS-O scales.

at the middle phase, as well as some decrease in engagement and some increase in too distant at the late phase (Figure 1B).

Working Alliance and OQ self-report measures: Doron's working alliance scores were relatively high and stable along the three measurements (5.36, 5.19 and 5.28 respectively). His OQ scores decreased from 66 at intake (above clinical cut-off) to 45 at the follow-up (reliable change). The OQ scores seem relatively stable in the early and middle phases (66 and 65 respectively) and then decreased to 54 in the late phase and continued to show improvement at follow-up.

3.1.1. Early phase (after session 5)

3.1.1.1. Patient narrative

During the interview, Doron described a desire for the therapist to get to know him, see his uniqueness, and learn to like him. The narratives contain attempts to impress the therapist, but Doron discussed complex emotions that arose in this phase:

> *I have this persona that I enjoy playing, of an English gentleman, and it protects me … keeps me away … I started playing this character and it really amused her. I like to entertain, and I enjoyed seeing her laugh. But it was complicated—because it felt like I was doing exactly what I came to therapy not to do… I think maybe I expected her to understand that it was something I had to show her, but not to take too seriously. Maybe she understood that this is the game of my life, at home, in my dealings with myself.*

In the second narrative, he described another attempt to initiate a deeper mutual connection:

> *I was preoccupied with something before the session and read a passage I had written about it in my notebook. Then, when I went into the session … I read this passage to her. It was my way of testing her: Here, I share with you my own inner discourse, with all sorts of fantasies … as if I was checking how much you could understand me, even when I am in such a distant place. But when reading it to her, I censored one line—something I wrote about love, something more sexual that I felt I wouldn't like to reveal to her, not yet. I think it was a showoff situation—I introduced her to my qualities: my theatrical skills and my ability to write. Like, this is part of who I am, something I ask you to know, to understand, but also to find its beauty and be impressed.*

Both narratives are characterized as exploring according to the **PACS:** Doron described a "defining moment" in a vivid and emotional way, allowing a listener to respond in a variety of fashions (identify, ask questions, elaborate, etc.). He *reflects* on his behavior, trying to explain gaps between opposing perceptions: The need to impress and "show off" and the longing for love; the need to amuse and please; and the desire that the therapist would be able to understand the defenses involved.

In terms of the TDS-O, the narratives are evaluated as *too distant* (medium level). Doron described a longing for closeness, but challenged the distance by initiating interactions that he hoped would allow a better acquaintance. The fact that he initiated the approach and did not leave it in the hands of the therapist resulted in a medium score on the scale. In addition, he ensured that he would not create too much intimacy by maintaining the theatrical "English gentleman" persona in the first narrative, and by censoring the text in the second. In fact, he expressed a hidden fear of the therapist becoming *too close*, but since he did not attribute it to the therapist and considered himself responsible for the degree of closeness between them, he received the minimum rating on the *too close* scale.

3.1.1.2. Therapist's TDS-O markers

The therapist also felt that they had still not managed to find the right distance. She felt *too distant* (for example, when having difficulties finishing the session on time, and felt guilty for "*having to dump him out*"), as well as *too close* (for example, when offering an interpretation and afraid of being "*too deep too early*"). Nonetheless, she seemed optimistic about their future relationship: "*Maybe there is no good way of saying goodbye now (at the end of the session), but we may be able to talk about it sometime.*"

In summary, during the first interview both patient and therapist felt they had not yet managed to find the right distance, but they both attributed this to their short acquaintance and looked forward to a change for the better. Doron, as a secure patient, showed initiative and opened dialogue about feelings and thoughts, which allowed the listener to participate in his experience and respond in a variety of ways. His relatively high alliance rating at this early phase strengthens this interpretation. Although therapist and patient were interviewed

separately, the feelings they described about their closeness–distance dynamics appear quite synchronized.

3.1.2. Mid phase (after session 15)

3.1.2.1. Patient's narrative

Doron's narratives were less preoccupied with closeness–distance at this phase. It seems as if he felt their relationship had established the "right distance," and the narrative revealed more aspects of engagement and autonomy. For example, he related that they decided to discuss his fear of death in the next session, but during that session he began talking about other things:

> *I felt I'm not able to start talking about that. I had to speak about other topics first. Not to get into this immediately. I expected her to notice … and I guess she did. She referred to it, but not as if I'm wasting time or anything, but also not as if it's the "main course." I felt good. I felt that I'm not forced to speak. It was important for me to be in a place where I can feel emotionally connected to the things I'm talking about, where I feel safer. She understood that, and it made me feel comfortable.*

In terms of the **PACS,** Doron's discourse is characterized as an *affective sharing*: He praised the therapist's ability to be attuned to his needs and expressed his gratefulness. The open description of his feelings allowed the listener to identify with him and feel closer.

His **TDS-O** rating was low in both *too distant* and *too close*, since Doron did not seem troubled by their proximity. He implied autonomy—the therapist let him set the rhythm of the conversation. By doing so, he felt understood and encouraged. The therapist allowed him to feel safe and gradually reached the difficult topic (his fear of death) and therefore, Doron rated high on the *engagement* scale.

3.1.2.2. Therapist's TDS-O markers

At the same time, the therapist described a rupture: She related to a moment in which Doron expressed difficulty connecting to therapy. At first, she felt guilty for not being helpful enough (too distant), but she moved quickly to the "here-and-now"—they understood, together, that the "*difficulty in feeling connected*" was a part of the issues he brought to the room, and they may have to "*learn to bear it for some time, in order to understand it.*" In her intervention, the therapist helped to contain the distance and transformed it from a "separating" to a "connecting" component, in which both shared the expectation of developing their relationship beyond this barrier (therefore, she encouraged engagement). She also granted autonomy by allowing Doron to dictate the pace and conveyed a belief in his ability to move forward.

In summary, during the mid phase, both partners were less occupied with the therapeutic distance, as expected during the working phase. Doron was grateful for the secure base the therapist provided (which can also be seen in his high rating of the alliance). The therapist, although momentarily feeling distant and unhelpful, was able to use this feeling to repair the collaboration and be flexible in the therapeutic tasks.

3.1.3. Late phase (after session 28)

3.1.3.1. Patient's narrative

During this late phase, Doron's narratives reflected several aspects of the therapeutic distance: On the one hand, he felt close and comfortable with the therapist, but on the other, there was a desire to approach the therapist a little more (perhaps beyond what is possible in therapy), together with some critical attitude toward the sense of ease that their proximity produced at the expense of achieving the therapeutic goals.

Example 1:

> *There was a moment during our conversation when I suddenly leaned back with some new ease, and it had to do with a few things: First, I have the feeling that she knows me well; I can speak to her in my language and she will understand. I enjoyed talking to her during recent sessions because … she was able to communicate in a way that made me feel very comfortable.*
>
> *But there was also something a little disturbing in this ease—this comfortable place scared me a little. We could sit and talk forever, but somewhere this ease preserves a kind of discourse I had hoped to go beyond. I came here to talk and to feel understood, but also to learn a new language. And this ease—it was something that seemed to be on the border between those two things.*

Here, like in previous phases, Doron's discourse is characterized according to the PACS by *affective sharing* and *exploring*: He observed and analyzed his feelings in the moment. The ability to acknowledge and understand contradicting emotions is unique to secure patients.

He acknowledged comfort regarding the therapeutic distance (low values of *too distant* and *too close*), in addition to the feeling that the therapist understood his special language (high *engagement*). Nevertheless, he pointed to the limitations of this engagement by expressing concern that it may reduce the ability to explore new regions in therapy.

Example 2:

> *I was talking about my fears of a long-term, binding relationship, and then she said that when you really experience a serious, obligating relationship, there is something about it that reduces this great fear. And the moment she said this, I remembered that I saw her once near the coffeeshop I work at. I don't think she saw me, but she was with her husband and son. And during the session, I really wanted to ask her how she feels … How she experiences living with a person you love … and I didn't ask her because…I don't know, I guess I felt that "this is not what we're here for" … But I had this curiosity … sometimes I want to enrich our relationship. As if, to know her better as a person.*

This narrative, like the previous ones, is characterized by PACS *exploring* markers: by describing a defining moment and how it challenged their relationship, Doron would have allowed the listener to enter his inner world.

In terms of therapeutic distance, Doron sensed that the therapist was a bit more distant than he would have liked her to be. He wanted

to know more about the therapist as a person, but unlike in the first interview, he did not initiate an approach, due to his understanding of the boundaries of the therapeutic relationship. He acknowledged a certain sense of sadness, together with an acceptance that this, probably, cannot be changed.

3.1.3.2. Therapist's narrative

At late therapy, the therapist emphasized her ability to respond freely to Doron:

> *With him I can just talk about it. I told him that I have this feeling that he is not connected, and that I can't reach him. I have the expectation that he will be able to hear it and to accept it. I have other patients I wouldn't tell that to. And with him—yes. I have the expectation that he can relate to this.*

The therapist felt that she had the space to act in a variety of ways with Doron—she could raise subjects that had the potential to create ruptures. By saying, "*He will be able to hear it and to accept it*," she implied that she was not concerned about resistance, and that she believed that his ability to explore would allow them to harness these moments for the benefit of the therapy.

In summary, analysis of Doron's PACS communication patterns, which were prototyped to secure patients, shows an open discourse about negative and positive feelings and the ability to explore gaps in the experience. This seemed to encourage the therapist to continue elaborating on his experience and probably to attune accurately to his relational needs.

The analysis of this prototypical case of a PACS secure patient shows that in terms of the therapeutic distance, the patient allowed a gradual approach and did not leave the responsibility of creating the relationship to the therapist alone. In accordance with the theoretical model (22), preoccupation with the therapeutic distance appears mainly during the early phase of therapy and in the advanced stage (perhaps towards termination?), while in the mid phase the relationship constitutes an infrastructure for the therapeutic work. At the same time, according to the self-report measures, Doron's alliance rating remained relatively high and stable throughout the three measurements, and his symptom level decreased (good outcome).

3.2. Avoidant patient: Rotem

Rotem is a 24-year-old female, single, undergraduate student who was classified as avoidant on the PACS. Her narratives contained frequent instances of direct *avoidance* (avoiding direct descriptions of her feelings) and *releasing* markers (shifting the listener's attention from her mental state). In the TDS-O graph (Figure 2A) we can see a minor increase at the late phase in the feeling that the therapist was *too distant* and a decrease throughout in her *autonomy*. Her narratives do not reveal feeling that the therapist was *too close* at the initial phase (as expected with avoidant patients in Mallinckrodt's theoretical model), nor an increase in her engagement along therapy. On the contrary, the therapist was perceived as *too distant* at all phases (Figure 2B). In general, the range of emotions arising from Rotem's narratives was limited. The therapist experienced Rotem as *too distant* along the entire process.

Working Alliance and OQ self-report measures: Rotem's working alliance scores show a medium level at the early phase (4.61) with a decrease with time from mid therapy to late therapy (4.17 and 4.03 respectively). Her OQ scores increased from intake to the early and mid phases (79 to 93 and 95 respectively) showing heightened distress as she attempted to engage in therapy. Then there was a decrease, with a return to close to the intake point (76 and 78, for late and follow-up respectively), but she still remained above the clinical cut-off.

3.2.1. Early phase (after session 5)

3.2.1.1. Patient's narrative

> *I remember that during the first session I didn't know how to behave … what to talk about. There were moments when I was silent. I did not have much to say. Such confusion and perhaps embarrassment created between two people. I remember that I did not know what to do, how to continue. Perhaps if the therapist had asked specific questions; but on the other hand, I don't know if it's in the nature of therapy to ask questions … I guess this is a matter of how to open up…I'm not used to disclosing myself.*

According to the PACS, Rotem's discourse contains *downplaying:* Immediately after what may be construed as a complaint or request for help, she shifted the interviewer's attention from her discomfort by claiming that this was probably not the therapist's fault: "*I do not know if it's the nature of therapy to ask questions*."

In terms of the TDS-O, Rotem seemed to perceive the therapist as both *too distant* and *too close*: The therapist did not help her start the conversation (*too distant*), but she was not sure the therapist was supposed to do so (minimized her disappointment), therefore—her rating on the scale was medium-low. The need to be in the same room with the therapist and to disclose was strange and embarrassing (*too close*), but unlike the secure patient, she did not acknowledge her feelings and the observer (and probably the therapist, too) had to interpret them from what little she said about them. Therefore, the values of the *too close* scale were medium-low. Interestingly, at this early phase her symptoms increased, perhaps due to the difficulty caused by the need to open up and get closer.

3.2.1.2. Therapist's narrative

The therapist related that she had to cancel one of their sessions at the last moment and felt guilty about it. Regarding Rotem's possible response, she says:

> *I had this fear that even if she was mad, she wouldn't show that anger. If she had expressed this, we would have been able to deal with it, but she wouldn't say …*

Here, the therapist described the difficulty of getting close to the patient's emotional experience, due to her avoidant speech patterns.

In another narrative, the therapist described Rotem's tendency to downplay her emotions and the distancing effect it had on her:

> *I felt like I couldn't connect with her. There was something flat, I did not feel any intense emotions there. I thought about patients I had worked with in the past, who I always felt something immensely powerful about. It's different with her.*

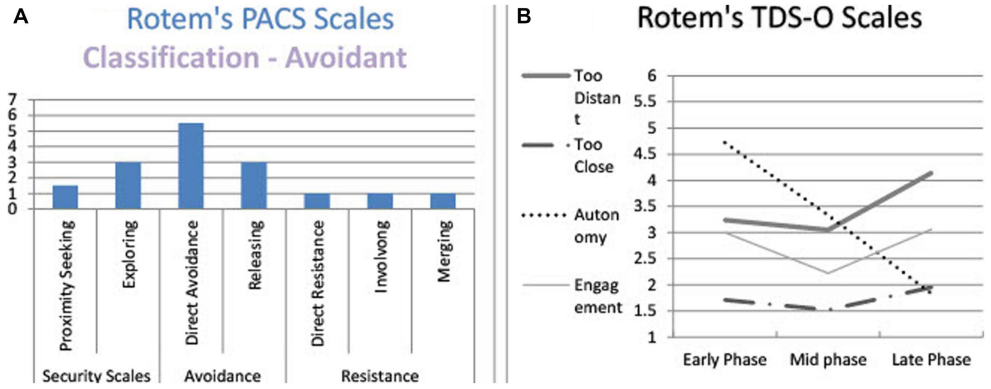

FIGURE 2
Rotem's and PACS and TDS-O markers. **(A)** Rotem's PACS scales. **(B)** Rotem's TDS-O scales.

The therapist felt distant. Although she acknowledged Rotem's tendency to keep others away from her feelings, she felt guilty for not being able to connect.

3.2.2. Mid phase (after session 15)

3.2.2.1. Patient's narrative

> *I told her that I found it very difficult to self-disclose and to trust. And then she asked if this happens here also, in therapy, and I told her yes, it's very difficult to reveal myself to you—because this is a situation with a stranger. When I started therapy, I thought it would be very easy to treat me, because I analyze everything and I'm very rational. But then I understood it's not going to be so easy, since I don't express emotions, and I'm careful not to enter "dark corners." I said that I'm afraid I won't be able to do it. And she said that that is something to relate to…but I also don't think it can be different. I don't see how it could be different.*

This narrative, like the earlier one, reveals a *downplaying* discourse pattern: After expressing some frustration with the therapeutic relationship, she claimed it could not be different. In doing so, she released both the therapist and herself from responsibility for change.

Although it may seem that during the interview, Rotem was *exploring* the reasons for her emotional detachment, it was not considered an exploring marker according to the PACS because the thinking was done in the past and was over before the interview; the interviewer in fact had no reason to ask her to elaborate. While reflection and exploration are ways to encourage a listener's attunement, such a report carried out in the past releases the interviewer from the need to react.

In terms of the TDS-O, Rotem described the therapist as *too distant*. She had difficulty in trusting the therapist, who is perceived as a stranger. Rotem realized she prevented the therapist from getting closer, and yet she "*does not think it can be different*." She also recognized the therapist's attempts to engage her, but resisted these attempts by claiming that nothing could change.

Rotem's alliance decreased at this phase, and her OQ was still higher than at the intake level.

3.2.2.2. Therapist's narrative

> *It is very difficult to connect with her. There's a big gap between what she conveys and her ability to become intimate. I felt uncomfortable, uneasy…that I can't really be there for her since she has this laconic speech. She made me feel like "her not-good-enough mother," as if I was constantly being tested.*

Here too, the therapist felt guilty for being too distant and described her difficulties in feeling empathic and connected to Rotem, due to her "flat" discourse.

3.2.3. Late phase (after session 28)

3.2.3.1. Patient's narrative

> *There is some kind of image in my head, that, after all, it's her profession and she listens to me because that's what she should do, but beyond her professional interest there is nothing more. It's a functional relationship. But then…I felt in her response that maybe she doesn't want it to be so. I mean, I'm not saying a relationship beyond therapy, but…that I would see our relationship not only as a functional relationship, and that it is important to her what I think. I think it surprised me. To some extent it's a kind of reinforcement because it shows that I also have influence on her, not only does she have influence on me.*
>
> ***Interviewer: And how did it make you feel, good?***
>
> *Uh…yes, somewhat, but … it seemed to me like a very small thing.*

Rotem's PACS markers are characterized, like in the former phases, in a *downplaying* pattern: The therapist's concerns did not really move her: "*It seemed to me like a very small thing*."

In terms of the therapeutic distance, the therapist is still *too distant*: She was only doing her job. According to Rotem's perception, the therapist was not supposed to care. Yet, in this late phase, she understood that the therapist did care, and was quite surprised about

it. This understanding encouraged her cooperation, which raised her level of engagement. Yet, on the alliance self-report measure her score was lower than earlier.

3.2.3.2. Therapist's narrative

The therapist seemed a bit more optimistic at this phase:

> *When she started therapy, she couldn't talk about herself at all. Today we have much more space—she's able to bring herself and be authentic … But there is also a question I always ask: When there is something so hurt inside of her, how do you reach it? Now I feel I have something to hold on to. But there is also something so impassable, blocked.*

The therapist still feels that Rotem is distant, but also acknowledges some minor new engagement in their relationship.

In summary, the therapeutic relationship was perceived as distant by both partners along the three interviews. The distance was caused, among other reasons, by Rotem's difficulty in facing and acknowledging emotions and by her tendency to downplay them. The downplaying pattern also resulted in relatively low ratings in the TDS-O scales, at least in the early and mid phases. The patient seemed to hold the distance and prevent possible closeness, but she became embarrassed at the late phase, when she understood that the therapist probably did not want it to remain that way. Although the therapist recognized Rotem's part in keeping the distance between them, she felt guilty and perceived the therapy as stuck and frustrating. Note that the therapy failed to decrease the patient's symptoms.

3.3. Preoccupied patient: Noam

Noam is a 26-year-old male, single, undergraduate student. His communication patterns were preoccupied according to the PACS (Figure 3A): He employed a lot of proximity seeking—describing and elaborating distressing experiences or self-states that aimed to encourage attunement from the listener. This marker is also used by secure patients, but in the preoccupied discourse it is usually accompanied by resistance markers (involving/merging)—an implicit attempt to force a listener to accept the point of view of the speaker, and that alone. By doing so, the preoccupied person overrides the listener's response. This combination of proximity seeking, and resistance is experienced as confusing and overwhelming, and could decrease the attunement of the listener, who may feel unnecessary.

Noam's TDS-O graph shows that he felt the therapist was *too distant* along the three interviews, together with a slight increase in his engagement, yet no change in his patient's autonomy (Figure 3B).

In the therapist's narratives, Noam was perceived as too distant all along, but, surprisingly, reported a relatively high level of engagement, which even rose slightly in the late phase.

Working Alliance and OQ self-report measures: Noam's working alliance scores were low at the early and mid phases (3.81 and 3.86 respectively), lower than among the secure and avoidant patients. At the late phase his alliance increased to 4.64, which was higher than that of the avoidant patient. His OQ scores at intake were extremely high (117), but decreased dramatically after he began therapy (70), remained around that point at mid therapy (74), and decreased more at late therapy (64) to the point of reaching the cut-off point at follow-up (63).

3.3.1. Early phase (after session 5)

3.3.1.1. Patient's narrative

> *I said that I felt uncomfortable in therapy, that I couldn't connect to her [the therapist] and that she looked too young. She said, "I'm not young," and I said, "It doesn't matter, you look young. You don't take part, it's only me talking, I could just as well talk with a doll … I don't remember you or any reactions from you … so what's the point?" And then she asked me what I wanted. Do I want more interaction? And I like, you tell me. You're the therapist … She tried to apply things she had learned, and I could not connect. I thought it was problematic.*

This quotation is part of a long monologue in which Noam expressed his frustration with the therapy with quotes from his conversations with the therapist. According to the **PACS,** the narrative is marked as an *involving dialogue*: The patient was frustrated and criticized the therapist in a one-sided description. There was no option available for a listener to elaborate or contribute in a way that could ease Noam's pain. The possible responses were either identification or distancing.

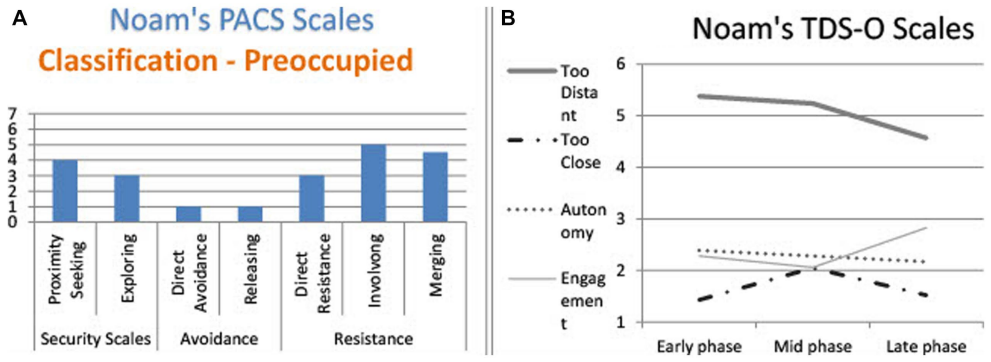

FIGURE 3
Noam's TDS-O and PACS markers. **(A)** Noam's PACS scales. **(B)** Noam's TDS-O scales.

In terms of **therapeutic distance,** the therapist was perceived as *too distant*: she did not help and seemed cold and distant "*like a doll*." In addition, he discarded the therapist's attempts to create engagement: When the therapist asked what he would like, he referred to it as a "protocol" response and rejected it: "*You tell me. You're the therapist*."

3.3.1.2. Therapist's narrative

> *I had a good feeling and anticipation during our first session: Yes, here we start. And then suddenly, when this crisis came [referring to the patient's criticism], I suddenly felt that from his side it's a big "no" … and I had the feeling that it's directed at me: like, "Something doesn't feel good here for me and I wouldn't like to go on with you."*

The therapist's narrative revealed frustration and confusion. She could not figure out what Noam wanted. While she had a sense of a convenient therapeutic distance, she realized that Noam felt distant and maybe even wanted to terminate.

It is interesting, however, that despite the frustration expressed in the interview and the low WAI score, Noam's symptoms decreased significantly from intake to this early phase, and continued to decrease throughout therapy.

3.3.2. Mid phase (after session 15)

Noam continued to express his frustration and doubt about the effectiveness of the therapy, as well as his criticism of the therapist. The therapist expressed a feeling of coming to a *"dead end."* She felt his frustration but could not find the right way to help.

3.3.3. Late phase (after session 28)

3.3.3.1. Patient's narrative

> *And then she mentioned that my dream about an intimate relationship is always related to my little brother. As if the love I want to give and feel is like the love I have for him. This is a love that, if I can imagine how I would feel towards my own child, this is like I feel towards him: to give to him, to smile when he smiles, not to think twice before I give something: time, money, gifts, everything … this is totally unconditional.*
>
> ***Interviewer: And how did you react to her saying this?***
>
> *That sounds kind of sick … She kind of phrased it like … it sounded bad. But I understand what she meant. I always have dreams—if not about my brother, then I dream about a baby. So, this link kind of explained it.*
>
> ***Interviewer: What do you hope for when telling her the dream?***
>
> *I don't hope too much … I don't believe … It's as if I didn't learn what to expect from her … Sometimes there are connections here and there…the most meaningful sessions are those when talking about the therapy itself. As if, if it's this or that, and then talking, and we reach a different, unrelated topic, and then there is some improvement or something.*

Noam's discourse pattern is defined as *direct resistance* in terms of the PACS: He did not answer the interviewer's question about his hopes (*"I do not hope too much … I do not believe."*) Another marker is *merging:* He changed his evaluation of the situation from positive to negative. His feelings in the narrative were confusing and unclear, which would again decrease a listener's ability to take an active part in the conversation.

In terms of the therapeutic distance, Noam perceived the therapist as a bit less distant than during the previous phases, but still did not trust her interpretation, even when it was intended to empower him by showing him how devoted he could be to a person he loves (granting *autonomy*). Noam was not able to absorb this empowerment. At first, he was afraid that she had criticized him for being over-involved with his brother ("*That sounds kind of sick*"), and when he understood what she meant, he became preoccupied with the instability of their ability to connect. Yet, alliance scores increased at this phase and his symptoms continued to decrease.

3.3.3.2. Therapist's narratives

The therapist, at this phase, discussed issues related to the therapeutic work, and it seems that there is more engagement between them. For example, she related that Noam again raised the question of the purpose of therapy and wondered whether it was helpful. For the first time, she said, she was able to connect his questions to feelings he had outside the room in interactions with other people. She felt that Noam accepted the connection and this helped them touch on some of the main issues of the therapy. Despite this, the therapist still had the feeling that she was unable to help him.

> *At a certain moment, after responding to a question he raised, I asked: "Did it help you, to discuss this with me? I'm not sure." And he answered: "OK, there is still time to decide." I felt throughout the whole situation as if he was examining me.*

In summary, along the three interviews, the relationship between Noam and the therapist failed to reach a comfortable therapeutic distance. Even moments of engagement were perceived as temporary and fragile. It seems that Noam's communication patterns, characterized by proximity seeking (through the expression of negative feelings) on the one hand, and the exclusion of the listener through the *merging* and *involving* patterns, on the other, made interaction with him confusing and frustrating. This appears to have negatively influenced the therapist's ability to attune to him. However, there was a gap between the negative picture depicted in the narratives and self-report of the alliance and the symptom level that are more optimistic.

4. Discussion

The purpose of this study was to explore the various pathways that patients with different attachment patterns follow in negotiating therapeutic distance. We used two attachment-informed observational

measures: The Patient Attachment Coding System (PACS) and the Therapeutic Distance Scale–Observer version (TDS-O). The results were compatible with the view that the PACS relates to the stable (trait-like) component of patient's attachment classification, while the TDS-O relates to a more flexible, dynamic (state-like) component—the closeness–distance dyadic "dance."

This preliminary study shows that the PACS can be implemented on RAP narratives and yield agreement between judges on attachment classifications, even though it was originally designed to be applied to transcripts of therapy sessions. This reinforces the findings of the developers of the PACS, according to which discourse patterns are a universal personality element that can be identified in various types of interaction (40). In addition, analysis of the PACS scales suggested that the discourse patterns remained stable along therapy. Thus, the secure patient used *exploring* and *proximity seeking* at all three phases; the avoidant patient used *direct avoidance* and *releasing;* and the preoccupied patient continued to use *proximity seeking* together with *involving* and *merging* along the three phases.

In contrast, although the discourse patterns seemed stable, the therapeutic distance on the TDS-O scales changed along the three phases. In the case of Doron, the secure patient, he moved from issues of negotiating closeness and distance in the early phase; only after establishing comfortable engagement was he able to focus on issues of autonomy at the mid phase. At the late phase, he re-examined proximity and engagement, and presented a complex picture of these dimensions: While he felt close and secure in his relationship with the therapist, he wondered about the amount of exploration possible when the relationship was so relaxed and comfortable. Rotem, the avoidant patient, experienced the therapist as *too distant* throughout the three interviews, but her *engagement* developed, allowing her to feel more empathy towards the therapist's attempts, and for the therapist to connect to the patient's emotional world, which she experienced as "flat." Finally, Noam, the preoccupied patient, experienced the therapist as *too distant* and unhelpful along the three phases. The therapist was also frustrated at not being able to help him. At the mid and late phases, signs of autonomy and engagement appear in their narratives, but they failed to decrease Noam's sense of distance and his ambivalence regarding the relationship.

The relative stability throughout the RAP interviews of the PACS discourse patterns on the one hand, and changes in the dimensions of the therapeutic distance, on the other, support the premise that attachment has trait and state components (59). The expansion of the IWM in therapy concerns, according to this preliminary study, aspects of the situational (state), while characteristic attachment as expressed in the discourse patterns remained relatively resistant to change, at least in the 28 sessions of this study.

Exploration of the intersection of the two measures allows us to expand our understanding of therapeutic distance and its expressions in patients with different attachment patterns, shedding light on the therapeutic relationship from an attachment-informed perspective in several respects:

First, the prototype example of avoidant patients implies that the releasing pattern may result in a low to medium rating of the *too distant* and *too close* scales, since even when the patients expressed these feelings, they tended to downplay their statements or attribute the difficulty to external circumstances ("*That's how it is in therapy*"), and the emotional experience that emerged from the description was minimal. This makes it difficult to identify feelings using narrative-based observational measures like the TDS-O and may obscure the differences between avoidant and secure patients regarding the sense of excessive closeness or engagement.

Second, the prototype example of the preoccupied patient implies that such patients tend to intensify the emotional experience and thus receive high ratings on the TDS-O proximity–distance scales (with an emphasis on *too distant*), but their speech patterns are full of details or vague speech, leaving the listener out of the conversation. This should be especially noted when assessing the *autonomy* and *engagement* scales. It is possible that these patients will dismiss the therapist's efforts to grant autonomy or to encourage engagement; however, the case example shows that there may be a gap between the observer's impression and the preoccupied patient's self-reports, which might be more positive than the observer's regarding both the alliance and the symptom level. This gap may be related to preoccupied patients' need to keep the listener close and avoid possible abandonment by intensifying their distress.

In addition, contrary to the original therapeutic distance model (23), the RAP interviews show that secure patients may also experience the therapist as more distant or close than they would like at the moment. This corresponds with the findings of Miller-Bottome et al. (42), who showed that secure patients can also have trouble regarding closeness. However, their ability to express feelings freely and reflect on them, as well as the initiative they might take to change the uncomfortable situation, allow the therapist to get closer to their emotional experience and respond to it with a wide variety of reactions. Similiarly, Miller-Bottome et al. (43), studying alliance rupture resolution with the PACS, demonstrated, using examples from session transcripts, that "secure patients are particularly responsive to resolution strategies that focus on the here-and-now, while insecure patients' (avoidant and preoccupied) characteristic ways of communicating pose significant challenges to the resolution process" (p. 175).

Finally, the narrative-based observation may point to some differences in the way engagement is perceived and negotiated by different patients. The secure patient took the initiative of engaging with the therapist; the preoccupied patient placed responsibility for engaging on the therapist, but unconsciously prevented the possibility of engaging through his confusing and vague communication, especially when asked about his feelings or wishes; the avoidant patient tried to dismiss the need for engagement and underestimated its importance. In addition, the analysis of the patients' as well as the therapists' relational narratives extends previous findings showing a relationship between patients' ability to explore and a secure attachment to the therapist (60). The narratives demonstrated the possible influence of the ability to explore on the therapist's interventions: Doron's therapist noted their ability to work through ruptures through inquiry, while both Rotem and Noam's therapists remained very cautious in their interventions.

As mentioned, this is a preliminary study, and as such has a number of limitations. First, we only assessed three single cases, so the results must be taken with caution. In this context, it is important to note that although the patients suffered from depression and anxiety, they were functioning young adults and may not reflect more severe patients. In addition, the use of prototypical patients for this demonstration raises a question about less prototypical patients' communication patterns and their closeness–distance dynamics. A study of a larger sample needs to be conducted, including relating the

TDS-O measure with outcome, which emphasizes the need for caution in drawing conclusions.

Second, we only assessed patients' attachment discourse. It is presumed that therapist communication patterns would also have an impact on the closeness–distance dynamics in the dyad (61–64). In addition, it is important to note that patients and therapists of each dyad were interviewed separately in RAP interviews. We did not assess their real in-session transcripts, therefore, our understanding of patients' influence on therapist attunement (64) is only estimated; it is based on the patients' responses to the interview, as well as therapist narratives (which were assessed at the same time points and emotional parameters of closeness and distance as the patients'). Nevertheless, while during the therapeutic session therapists intervene relying on their professionalism and experience in attuning to patients' needs, the narratives in the RAP interview encourage expression of their feelings that are not usually apparent to the patient.

To the best of our knowledge, this is the first study to apply the PACS to analyzing narratives collected through RAP interviews. Our preliminary findings support the use of the PACS for identifying attachment patterns in different kinds of conversation-based transcripts related to mental states (19, 40), and therefore expand the application of the PACS as an effective attachment-based assessment in a variety of observational studies.

Although time-consuming and expensive to implement, observing the therapeutic relationship with the PACS and the TDS-O allows expansion of understanding the in-session attachment dynamics with different patients. An example is the understanding that an "ideal" therapeutic distance is not a goal to be achieved at early phase of therapy, but a dynamic process that may change throughout therapy. At the late phase, a feeling of distance may re-emerge, possibly related to the approaching termination, and may raise automatic defense mechanisms relating to patient attachment. In addition, the inquiry reveals additional more implicit aspects of the alliance that cannot be identified through traditional self-report measures.

We believe that this article has implications for therapist training and supervision, as it suggests different pathways through which patients' attachment classifications may affect the therapeutic relationship. For example, the avoidant patients' tendency to downplay emotions may be reflected in therapists' feelings of boredom, guilt, and self-doubt. Preoccupied patients can be confusing and overwhelming because of their tendency to combine proximity seeking and resistance. It has been suggested that the consequences of this kind of combination indeed leads therapists to feel irritated and overwhelmed (65, 66). Therapists' familiarity with research on attachment classifications in sessions and the ways patients with different attachment patterns may express their wishes for proximity could improve their ability to attune to their patients' emotional needs. Further research is needed to examine possible therapist responses that would allow working with these discourse behaviors to facilitate appropriate responsiveness and collaboration that would enable a corrective emotional experience.

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 Ethics Committee of the Paul Baerwald School of Social Work and Social Welfare at the Hebrew University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SE, HW, and AT contributed to conception and design of the study. AT trained SE and HW for the observation using the PACS and coded the interviews, together with SE. SE organized the database, performed the statistical analysis and wrote the first draft of the manuscript, with the help of HW. All authors contributed to the article and approved the submitted version.

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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Psychophysiological stress response after a 6-week Mindful Self-Compassion training in psychiatric rehabilitation inpatients: a randomized post-test only study

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Objectives: Mindfulness-based interventions (including self-compassion interventions) are effective in improving stress management at psychological and physical levels. Mindful Self-Compassion (MSC) is a newly developed program particularly aimed at increasing self-compassion. The main objective of this study was to determine whether the psychophysiological stress response during a social-evaluative speaking task differs in inpatients participating in the MSC or the Progressive Muscle Relaxation (PMR) program at the end of their 6-week psychiatric rehabilitation stay (i.e., post-test only design).

Method: Data from 50 inpatients (25 MSC, 25 PMR, 35 female) aged 19 to 76 years ($M = 47.22$, $SD = 12.44$) were analyzed in terms of psychophysiological stress response. For this purpose, heart rate variability, heart rate, and blood pressure were assessed together with several psychometric variables: positive and negative affect (PANAS), subjective stress perception (Visual Analog Scale), self-compassion (Self-Compassion Scale), cognitive reappraisal and suppression (Emotion Regulation Questionnaire), psychological distress (Brief Symptom Inventory-18), and appraisal and rumination (selected items).

Results: After correction for alpha inflation no differences in the psychophysiological stress response and psychometric parameters between the MSC and PMR group were found.

Discussion: In general, our results indicate that MSC is not superior to PMR training. However, more research with clinical randomized controlled trials investigating larger samples are needed to further affirm these initial findings.

KEYWORDS

heart rate variability, blood pressure, mindfulness, self-compassion, stress task, clinical trial

Introduction

Stress plays an important role in psychiatric diseases and can be responsible for the frequency and actual course of mental illness (1, 2). According to Selye (3) stress is related to a physical reaction in the body. It helps us to survive by converting the unbalanced state in our body to homeostasis (4). Immediate adaptations include a rise in Heart Rate (HR), Blood Pressure (BP), and glucose consumption, concurrent lack of appetite, activation of the immune system and mobilization for energy regulated by the Autonomic Nervous System (ANS) comprising the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS) (5–7). Parasympathetic activity is associated with vagal tone which can be measured by the changes in duration of heartbeats (8). These rapid beat-to-beat changes are predominantly due to the PNS, which is reflected in Heart Rate Variability (HRV) and can be used to assess ANS function (9, 10). Accordingly, the brain and heart are bidirectionally connected, as the brain influences the heart and vice versa (10, 11).

The role of HRV for stress coping

Elevated HRV, which refers to greater variability and higher vagal tone, signifies greater stress adaptability (12). Additionally, it has been associated with more positive emotions, more enjoyment of social interaction, less negative emotions during stressful tasks and higher social connectedness (13–15). In contrast, lowered HRV has been suggested to be a marker for all types of diseases and can predict mortality (16, 17). In correspondence to this, various mental diseases such as panic disorder, posttraumatic stress disorder and depression are linked with an imbalance in the ANS, as evidenced by attenuated HRV compared to healthy controls (18–20). The Neurovisceral Integration Model, introduced by Thayer and Lane (21), offers a possible explanation regarding the relationship between psychopathology, stress, and HRV. It postulates that stress could impact brain function, thus hampering adaptive and flexible behavior as indicated by low HRV (10, 22, 23). Therefore, developing effective treatment programs to counter stress associated with psychopathology is of special interest in scientific research (24).

Mindfulness-based interventions (MBI) in psychiatric diseases

Treatment methods of high relevance and increased recognition in recent years are MBI (25, 26). These techniques are about accepting the reality we live in, letting go off thoughts and living in the here and now, which could facilitate psychological well-being (27). Evidence showed efficacy of MBI in reducing stress, anxiety, and depression in clinical populations (28–30) as well as in healthy subjects (31–33). Furthermore, they appeared to be linked with a substantial increase in self-compassion, quality of life, coping with problems, happiness, resilience and overall psychological well-being (34–37).

Mindful Self-Compassion (MSC)

A specific MBI essential in the present study is the MSC program founded by Neff and Germer (38). Self-compassion has gained increased attention since its introduction in 2003 (39) and can be described as "the ability to be kind and understanding toward ourselves when we suffer, fail, or feel inadequate" (40, p. 861). The program contains the three important aspects: self-kindness versus self-judgment, mindfulness versus over-identification, and common humanity versus isolation (40). MSC comprises an 8-week program, with one session each week (2.5 h) and a half-day silent meditation retreat (38). It consists of guided sessions including various topics regarding self-compassion (i.e., practicing loving-kindness) and additional homework which enables to practice self-compassion in a formal (sitting meditation) as well as an informal (during everyday life) way (38, 40). Neff and Germer (38) demonstrated that the MSC program improved self-compassion, mindfulness, sympathy for others, life happiness, as well as well-being, and lowers stress, anxiety, and depression.

Self-compassion has shown to be repeatedly associated with well-being and coping with unpleasant or stressful life events (41–46). People high in self-compassion showed decreased worry, rumination, subjective stress, and positive emotion regulation (47–49). In sum, self-compassion is a well-established program to reduce psychological stress and help to better cope with stressful situations (50–52). However, to the authors' knowledge, there are few findings on self-compassion and physiological stress reactivity. In general, research demonstrated that mindfulness could buffer physiological stress responses (53, 54). Correspondingly, literature showed an increase in HRV and decrease in BP during mindfulness training (55–57). Additionally, self-compassion and mindfulness training could lead to better stress coping and buffer physiological stress (58–61). However, findings are heterogenous (62–64).

The present study

In the psychiatric rehabilitation clinic Sonnenpark Neusiedlersee in Rust, Austria, the MSC program was modified to fit the typical 6-week length of stay at the clinic to see if this form of MSC shows positive results. While some of the meditations and exercises, such as the inquiry, are identical to the 8-week MSC course, other parts are modified to suit the patients need in the rehabilitation clinic. Gaiswinkler et al. (51) demonstrated higher self-compassion and happiness after 6-week MSC program in comparison to the active control intervention of Progressive Muscle Relaxation (PMR) in this rehabilitation clinic. Moreover, they observed psychiatric and quality of life parameters improving in both groups to the same extent (51). PMR is a very well-established and empirically strong validated relaxation technique (65). Individual muscle groups are tensed and loosened immediately after to increase inner relaxation (66). More specifically it can be useful to decrease stress (67). Since it does not include the mindful/ self-compassion aspect it previously has been chosen as an adequate option for an active control group (68, 69).

Research aims

The primary aim of this study was to investigate if rehabilitation in-patients who received MSC training show less pronounced stress reactions compared to patients who received PMR training regarding psychophysiological stress reactivity using a social-evaluative stress paradigm. HRV, HR, BP, Positive and Negative Affect (PA/NA), and Subjective Stress Perception (SSP) were compared between groups. So far, the MSC program has only been explored on a psychometric level (51). Therefore, this study served to explore the MSC program on a biometric level in a clinical setting. We expected lower physiological responses to the stressor in the MSC group (i.e., lower HRV decrease, HR increase, and blood pressure increase, from baseline to stress). For secondary outcome, we intended to investigate whether Self-Compassion, Emotion Regulation (Cognitive Reappraisal and Suppression), and Appraisal are higher in the MSC compared to the PMR group. Furthermore, we expected that Rumination and Psychological Distress should be higher in the PMR group.

Method

Participants

The presented study is part of a broader study ($n = 170$) which has not yet been published. Within that study, patients were randomly assigned into two groups (MSC, PMR) prior to their start of the rehabilitation stay. For the present study, the randomized allocation was adopted. Participants were adults attending a 6-week psychiatric rehabilitation stay at Sonnenpark Neusiedlersee clinic, located in Burgenland, Austria. All exclusion criteria of the rehabilitation clinic applied to the current study, such as acute suicidal and psychotic episodes or acute addiction disorders, determined by the treating psychiatrist at the clinic. Besides, people with severe cardiovascular diseases were not included. In this investigation, 59 participants were recruited of which nine were excluded (4 = drop out, 3 = no speech, 1 = cardiac arrythmia, 1 = previous stroke). All participants signed a consent form and the investigator ensured that participation was voluntary and withdrawal from consent throughout possible. After the examination, they got a coffee voucher from the in-house café. A sample of 50 individuals (35 female) aged from 19 to 76 ($M = 47.22$, $SD = 12.44$) was examined (25 MSC, 25 PMR). The study was ethically approved by the ethics committee of the University of Graz (GZ. 39/84/63 ex 2020/21).

Measures

Physiological assessment

A mobile electrocardiogram [ECG; VarioPort (70)] provided by the University of Graz with sampling rate of 256 Hz was used to measure HRV and HR non-invasively (Becker Meditec, Karlsruhe, Germany). Three electrodes were placed on the right collar bone, below the left ribcage and on the lower abdomen [modified Einthoven Lead II; (71, 72)]. As indices of HRV established time-domain (Root Mean Square of Successive Differences (RMSSD); Standard Deviation of NN Intervals (SDNN)) and frequency-domain measures (High-Frequency HRV (HF-HRV [0.15–0.4 Hz]); Low-Frequency HRV (LF-HRV [0.04–0.15 Hz])) were assessed (73, 74). RMSSD is mostly used in HRV research and indicates mainly vagal, parasympathetic activity as well as HF (10, 75). SDNN and LF represent the cumulative variance of sympathetic and parasympathetic function (74, 76). Respiration rate, assessed via a respiration belt, was added as a control variable (73). An automated BP device (Bosch + Sohn, Boso Medicus (77),) was used to assess Systolic (SYS) and Diastolic (DIA) BP, and was applied on the right upper arm.

Treatment intervention

Before the arrival in the rehabilitation clinic an independent work counsellor assigned patients randomly to the MSC and PMR group with permuted block for gender, age, and psychiatric diagnosis, which allowed maintaining a balance between treatment groups (78). Both interventions took place once a week for 75 min over 6 weeks and were guided by an experienced MSC or PMR trainer. On the basis of this initial assignment, the patients also participated in the present experimental study (see Figure 1).

Stress induction

The stress intervention was based on common social-evaluative stress protocols that have proven to be valid in inducing stress comparable to a negative stress situation, such as the Trier Social Stress Test (TSST) or public speaking tasks (79–85). Participants were prompted to give a 5-min speech introducing themselves for a job offer of their choice. They were filmed and told that the speech was going to be evaluated by experts. Beforehand, they could prepare some ideas by means of questions. After 3 min the judge stopped the speech. If the participants finished their speech before the expiration of time, the investigator asked standardized questions to not stop the flow of speech.

Psychometric assessment

For primary outcome: The Positive and Negative Affect Schedule [PANAS; (86)] measures PA and NA with 10 adjectives each on a 5-point Likert scale (1 = *not at all* to 5 = *extremely*). Participants rated how much the adjectives described their emotional state at that moment. Internal consistency (Cronbach's α) was high (PA: baseline = 0.86, speech prep. = 0.92, recovery = 0.93; NA: baseline = 0.87, speech prep. = 0.86, recovery = 0.87).

Participants' SSP was assessed on a visual analogue scale (0–100) where 100 (*extremely stressed*) was the highest degree to which they perceived the situation as stressful (81, 87).

Appraisal items were administered with a 6-point Likert scale (1 = *not at all* to 6 = *extremely*). A Demand Resource Evaluation Score (DRES) was formed by subtracting means of evaluated demands (task demand/threat) from means of resources (coping, performance, perceived control, experience) (85, 88, 89). A positive score stands for an Appraisal more of a challenge state and a negative score for threat state (88). Internal consistency was acceptable (threat = 0.78, resources = 0.83).

Rumination was assessed with seven items based on the Rumination Thought Style Scale (RTS), the Rumination-Suppression Scale (RS-8), and the Thoughts Questionnaire [TQ; (90–92)]. Participants rated on a 6-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). Cronbach's α was 0.83.

Secondary outcomes included the Self-Compassion Scale [SCS-D; (93, 94)] which assesses Self-Compassion via 26 items on a 5-point Likert scale (1 = *almost never* to 5 = *almost always*). Cronbach's α was observed to be 0.89.

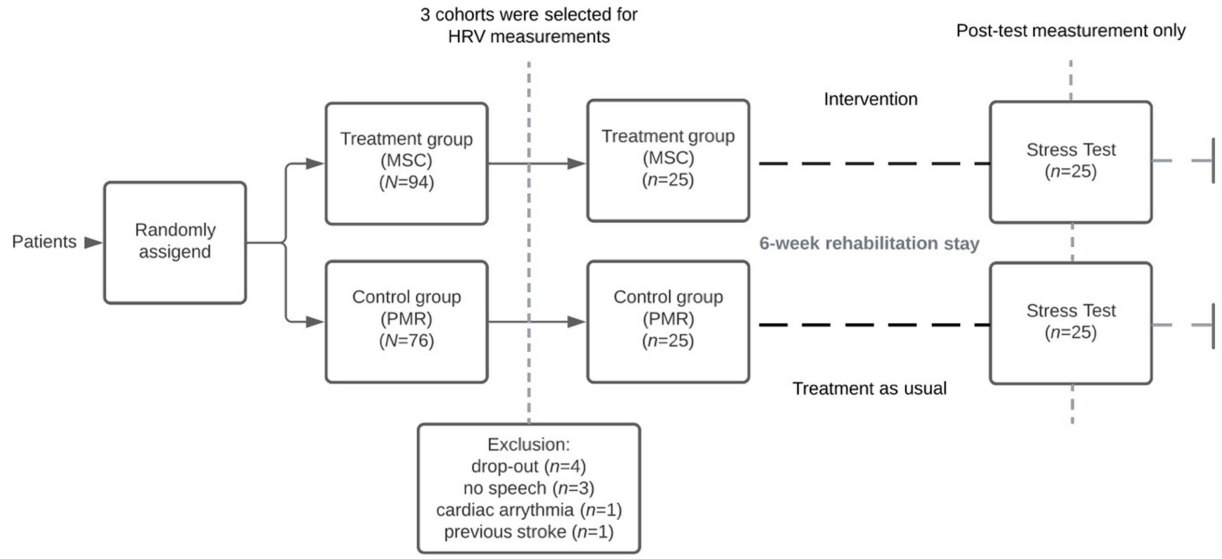

FIGURE 1
Posttest-only control group design.

The Emotion Regulation Questionnaire [ERQ; (95)] tests Reappraisal and Suppression as emotion regulation strategies using 10 items on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*; Cronbach's $\alpha_{reappraisal} = 0.84$; Cronbach's $\alpha_{suppression} = 0.77$).

The Brief-Symptom Inventory [BSI-18; (96)] measures the Global Severity Index (GSI) of psychological distress via 18 items on a 5-point Likert scale (0 = *not at all* to 4 = *extremely*). Cronbach's α was 0.88.

Procedure

Participants were tested in the last week of their stay at the clinic (post-test only experimental design; see Figure 1). They were requested not to consume caffeine, alcohol, nicotine, and sugary drinks, as well as to refrain from physical exertion 2 h before the testing (73, 97, 98). Initially, participants' height, hip, and waist circumference were measured, and anamnestic data collected. During the recording, participants sat quietly in an upright position and were asked not to move (98). HRV and HR were measured continuously. BP was measured 6 times (baseline & recovery: min 2:30, 4:00; speech prep.: min 0:30, 2:00). For the 5-min baseline recording, landscape pictures were presented on a screen. After the 3-min speech preparation, the actual 3-min speech took place. The recovery phase followed, identical to baseline. After baseline, speech preparation, and recovery PANAS and SSP were presented. Appraisal was collected after speech preparation and recovery and Rumination after recovery. Finally, participants were debriefed. It was made clear that the video recordings were not evaluated at all and were deleted immediately, but only served to reinforce stress (99). One female judge (S.K.) was present during all stress induction, wearing a white coat. There was always the same judge (S.K.). One camera was mounted right beside the computer screen. SCS-D, ERQ, and BSI-18 were presented on the last day of the 6-week stay. The time of day when the stress induction took place could not be controlled, otherwise it would not have been possible to give all patients an appointment for testing.

Data parametrization

HRV analyzes were conducted with the software packages AcqKnowledge 4.3 (100) and Kubios HRV Premium 3.3.1 (101). R-R time series (interbeat intervals) were interpolated with 4 Hz (101). Fast Fourier Transformation (FFT) was applied to quantify HF-HRV [0.15–0.4 Hz] and LF-HRV [0.04–0.15 Hz] with 180 s window and no overlap (73, 102). The smoothness priors algorithm was used for detrending (101). To control for artifacts, HRV data were visually inspected by the examiner and corrected with the automatic correction algorithm in Kubios software if necessary (101). For further analyzes, only data containing less than 5% of artifacts were considered. An exception was made for one subject due to the small violation of the limit during recovery (artifacts = 5.16%). One person had to be excluded due to excessive artifacts (baseline = 23.63%, speech prep. = 20.09%, recovery = 25.85%). In addition, one participant could not be included in HRV, and HR analyzes due to flawed recordings. RMSSD, HF, SDNN, LF, and HR means of the last 3 min of the 5 min recordings (baseline, recovery) as well as means of the 3 min recording (speech prep.) were analyzed which seemed a sufficient length for ultra-short term HRV measures (74). Due to the sensitivity to movement in HRV recordings, an *a priori* decision was made to incorporate speech preparation as a stress phase (73). Research shows, stress anticipation can also trigger adequate stress responses (103). Prior to analyses, RMSSD and SDNN data were subjected to a natural log transformation to account for skewness (73, 104).

Statistical analyzes

Statistical analyzes were done with SPSS, version 27 by IBM. Group comparisons regarding anamnestic variables were conducted by means of chi-square and unpaired *t*-tests. For primary outcome, separate two-way mixed ANOVAs with the between-subject factor group (MSC, PMR) and the within-subject factor time

(baseline, speech prep., recovery) regarding psychophysiological measures (HRV, HR, BP, PA, NA, SSP) were performed. For post-hoc analyzes, Bonferroni pairwise comparisons were implemented. Secondary outcome analyzes included unpaired *t*-tests with the independent variable group (MSC, PMR) regarding Self-Compassion, Emotion Regulation, Psychological Distress, Appraisal, and Rumination. The statistical significance was set to $p < 0.05$ (two-sided). Alpha-error-accumulation was controlled via Bonferroni correction.

Results

Descriptive statistics

Participants were on average overweight [BMI: $M = 28.01$, $SD = 5.93$; (105)]. All individuals had a psychiatric diagnosis and 33 (66%) of them at least one comorbid psychiatric diagnosis as reported by the International Classification of Diseases [ICD-10; (106), Chapter F), presented in Table 1. Primarily, people with affective disorders (F30-F39) participated in the study [44 (88%) people; (106)], followed by neurotic, stress-related, and somatoform disorders [F40-F49; (106)]. Thirty-eight (76%) participants took psychotropic drugs, all of them antidepressants, followed by additional neuroleptics intake (14 (36.8%) people). Of note, 24 (48%) participants reported doing sports on a regular basis. Sixteen (32%) people smoked regularly, and four (8%) participants drank alcohol habitually.

Group comparisons regarding anamnestic data (health-related variables, psychiatric diagnoses, medication) did not reveal significant differences (see Table 1).

Forty-eight participants were included in the HRV and HR-analyzes, 47 for Respiration and 44 for the BP analyzes. If there were no more than 10% missing data in a questionnaire, the mean of the remaining items was inserted for the missing item (107). This procedure was applied for three participants for PA, two for NA and three for SCS-D. For SSP, Appraisal, and Rumination 49 people were enclosed. Data of 44 participants were included in the analyses of SCS-D and BSI-18. For ERQ Reappraisal, 42 people and for ERQ Suppression, 43 people were included (see Tables 1, 2).

HRV-norms and respiration

Published resting short-term HRV norms of approximately 5 min length collected in 21,438 non-clinical individuals in sitting or lupine position (74) were compared to the 3 min baseline measurement in this clinical sample for exploratory reasons. The present sample showed significantly lower RMSSD, HF-HRV, and SDNN during baseline measurement as compared to the non-clinical norms. For LF-HRV, no significant difference was found (see Table 3). According to Shaffer and Ginsberg (74) participants should breathe at 11–20 breaths per minute (BPM) that short-term HRV values are adequate. Respiration rate for baseline measurement was on average 15 BPM ($M = 15.30$, $SD = 4.46$), for speech preparation 17 BPM ($M = 17.21$, $SD = 3.12$), and for recovery 15 BPM ($M = 15.41$, $SD = 4.86$). Mixed ANOVA with Respiration rate showed no significant main difference between MSC and PMR group (see Table 2). Therefore, no further analyzes including Respiration deemed necessary.

Primary outcome results

For all Mixed ANOVA calculations, prerequisites have been checked. When the assumption of sphericity was not fulfilled, the Greenhouse–Geisser correction was applied (see Table 2[a]) (109). Normal distribution was assessed by Shapiro–Wilk test ($p > 0.05$), and if violated, ANOVAs were still calculated due to the central limit theorem (110). Box's Test showed homogeneity of covariances for all calculations [$p > 0.05$; (111)]. Except for SSP in recovery phase, homogeneity of variances was given by Levene's test ($p > 0.05$). Post-hoc comparisons were still interpreted for SSP (112).

Stress induction: changes in HRV, HR, and BP

For HRV, HR, and BP, calculations revealed significant main effects of time for SDNN ($p = 0.42$; *ns* after Bonferroni correction), LF ($p = 0.019$; *ns* after Bonferroni correction), HR, SYS BP, and DIA BP (all $p < 0.001$), respectively. There were no significant main effects group or interaction effects regarding HRV, HR and BP (see Table 2).

For SDNN, pairwise comparison showed no significant results between baseline and speech preparation ($p = 0.106$), and speech preparation and recovery ($p = 0.130$), respectively. LF-HRV was significantly lower during baseline ($M = 5.13$, $SD = 1.55$) than during speech preparation ($M = 5.52$, $SD = 1.52$, $p = 0.023$). No significant changes were found towards recovery ($p = 0.151$). For HR, pairwise comparisons indicated a significant increase from baseline ($M = 76.26$, $SD = 12.59$) to speech preparation ($M = 80.06$, $SD = 11.92$, $p < 0.001$) and decrease from speech preparation to recovery ($M = 76.52$, $SD = 12.22$, $p < 0.001$). Pairwise comparison for SYS BP revealed a significant rise from baseline ($M = 117.00$, $SD = 14.07$) to speech preparation ($M = 124.83$, $SD = 14.13$, $p < 0.001$). No significant decrease towards recovery was found ($p = 0.059$). DIA BP revealed a significant increase from baseline ($M = 89.15$, $SD = 9.65$) to speech preparation ($M = 93.02$, $SD = 9.61$, $p < 0.001$) and a decline from speech preparation to recovery ($M = 89.93$, $SD = 10.31$, $p < 0.001$).

Stress induction: changes in PA, NA, SSP

As detailed in Table 2 the results of the stress intervention indicated expected reactions with significant main effects time on PA, NA and SSP. PA showed a significant rise from baseline ($M = 2.55$, $SD = 0.68$) to speech preparation ($M = 2.86$, $SD = 0.87$, $p < 0.001$) and significant decline to recovery phase ($M = 2.52$, $SD = 0.88$, $p = 0.003$).

For NA, there was no significant increase to speech preparation ($M = 1.72$, $SD = 0.65$, $p = 0.085$), but a significant decrease to recovery ($M = 1.41$, $SD = 0.55$, $p < 0.001$). SSP was significantly higher at speech preparation ($M = 44.98$, $SD = 27.99$) than at baseline ($M = 24.04$, $SD = 22.29$, $p < 0.001$) and lower at recovery ($M = 26.71$, $SD = 24.55$, $p < 0.001$) than at speech preparation. No significant main effects group nor interaction effects were found (see Table 2).

Secondary outcome results

For unpaired *t*-tests, normal distribution was given, as assessed by Shapiro–Wilk test ($p > 0.05$) except for PMR group regarding Psychological Distress and Rumination (110). Homoscedasticity was evident in all calculations (Levene's test: $p > 0.05$). For Self-Compassion, Suppression, Psychological Distress, Appraisal, and Rumination, no group differences were detected. The MSC group

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TABLE 1 Sample characteristics.

Variable	MSC		PMR		df	t/χ^2	*p*	Cramers *V*/ Cohen's *d*
	$n_{(total)}$	*M* (*SD*) /*f*(%)	$n_{(total)}$	*M* (*SD*) /*f*(%)				
Anamnestic data								
Female Sex, *f*(%)	25	17(68)	25	18(72)	1	0.01	0.758	0.04
Age, *M*(*SD*)	25	48.16(13.59)	25	46.28(11.38)	48	0.53	0.598	0.15
Education: ≥ High School, *f*(%)	25	15(60)	25	18(72)	1	0.80	0.370	0.13
In Education/Working, *f*(%)	25	15(60)	25	15(60)	1	0	>0.999	0.00
In Relationship/Married, *f*(%)	25	11(44)	25	11(44)	1	0	>0.999	0.00
Health-related variables								
BMI, *M*(*SD*)	25	27.90(5.40)	24	28.13(6.56)	47	−0.13	0.894	−0.04
Waist-to-hip Ratio, *M*(*SD*)	25	0.87(0.09)	25	0.87(0.09)	48	−0.34	0.732	0.00
Sports, *f*(%)[a]	25	11(44)	25	13(52)	1	0.32	0.571	0.08
Cigarettes, *f*(%)[a]	25	7(28)	25	9(36)	1	0.37	0.544	0.09
Alcohol, *f*(%)[a]	25	2(8)	25	2(8)	1	0	>0.999	0.00
Coffee, *f*(%)[a]	25	20(80)	25	20(80)	1	0	>0.999	0.00
Sugary Drinks, *f*(%)[a]	25	3(12)	25	6(24)	1	1.22	0.269	0.16
(ICD-10) Diagnosis, *M*(*SD*)	25	2.20(1.00)	25	1.88(0.93)	48	1.17	0.247	0.33
F30-F39, *f*(%)	25	23(92)	25	21(84)	1	0.76	0.384	0.12
F40-F49, *f*(%)	25	14(56)	24	12(50)	1	0.18	0.674	0.06
F50-F59, *f*(%)	25	0(0)	25	2(8)	1	2.08	0.149	0.20
F60-F69, *f*(%)	25	3(12)	25	4(16)	1	0.17	0.684	0.06
F90, *f*(%)	25	1(4)	25	1(4)	1	0	>0.999	0.00
Z73.0 Burn Out, *f*(%)	25	5(20)	25	4(16)	1	0.14	0.713	0.05
High BP Family Member, *f*(%)	25	9(36)	25	13(52)	1	1.30	0.254	0.16
High BP, *f*(%)	25	4(16)	25	6(24)	1	0.50	0.480	0.10
Psychotropic Medication, *f*(%)	25	18(72)	25	20(80)	1	0.44	0.508	0.09
Psychotropic Medication, *M*(*SD*)	18	2.44(1.50)	20	2.60(1.50)	36	−0.32	0.752	−0.11
Antidepressants, *f*(%)	18	18(72)	20	20(80)	-	-	-	-
Antiepileptics, *f*(%)	18	2(11.1)	20	5(25)	1	1.22	0.270	0.18
Anxiolytics, *f*(%)	18	2(11.1)	20	1(5)	1	0.49	0.485	0.11
Neuroleptics, *f*(%)	18	7(38.9)	20	7(35)	1	0.06	0.804	0.04
Antipsychotics, *f*(%)	18	2(11.1)	20	2(10)	1	0.12	0.911	0.02
Benzodiazepines, *f*(%)	18	1(5.6)	20	1(5)	1	0.01	0.939	0.01
Hypnotics, *f*(%)	18	0(0)	20	1(5)	1	0.92	0.336	0.16
Cardiovascular medication								
Antihypertensive, *f*(%)	12	3(25)	14	5(35.7)	1	0.35	0.555	0.12
Thyroid, *f*(%)	12	7(58.3)	14	6(42.9)	1	0.62	0.431	0.15
Antihistaminics, *f*(%)	12	2(16.7)	14	0(0)	1	2.53	0.112	0.31
Analgesics, *f*(%)	12	2(16.7)	14	3(21.4)	1	0.09	0.759	0.06
Muscle Relaxants, *f*(%)	12	0(0)	14	1(7.1)	1	0.89	0.345	0.19
Secondary outcome variables								
SCS-D total, *M*(*SD*)	22	3.05(0.82)	22	2.67(0.64)	42	1.71	0.095	0.52
ERQ Reappraisal, *M*(*SD*)	20	4.60(1.33)	22	3.84(1.04)	40	2.08	0.045*[a]	0.64
ERQ Suppression, *M*(*SD*)	21	3.15(1.49)	22	3.43(1.30)	41	−0.65	0.519	−0.20
GSI, *M*(*SD*)	22	2.98(2.47)	22	3.12(2.47)	42	−0.18	0.855	−0.06
Rumination, *M*(*SD*)	24	3.34(1.11)	25	3.26(1.27)	47	0.22	0.824	0.07
DRES-Score, *M*(*SD*)	24	0.74(1.98)	25	0.06(2.44)	47	1.07	0.291	0.31

M = Mean; *SD* = Standard Deviation; f = frequency; % = percentage; BMI = Body Mass Index; F30-F39 = Affective Disorders; F40-F49 = Neurotic, Stress-Related, and Somatoform Disorders; F50-F59 = Behavioral Syndromes associated with Physiological Disturbances/Physical Factors; F60-F69 = Personality and Behavioral Disorders; F90 = Attention-Deficit Hyperactivity Disorder; BP = Blood Pressure; SCS-D = Self-Compassion Scale; ERQ = Emotion Regulation Questionnaire; GSI = Global Severity Index (Psychological Distress; BSI-18); DRES-Score = Demand Resource Evaluation Score (Appraisal); [a]Regular Sport, Cigarettes, Alcohol, Coffee, Sugary Consumption – Participants answered with Yes; Group comparisons were analyzed with chi-square and unpaired t-tests.

*$p < 0.05$.

[a]ns after Bonferroni correction.

TABLE 2 Results of mixed two-way ANOVAs regarding psychophysiological stress response.

Variable	MSC		PMR		ANOVA				
	n	*M* (*SD*)	*n*	*M* (*SD*)	Effect	*df*	*F*	*p*	η_p^2
lnRMSSD (ms)									
Baseline	25	2.73 (0.79)	23	2.79 (0.78)	T	2, 92	1.05	0.353	0.022
Speech-preparation	25	2.80 (0.76)	23	2.77 (0.76)	G	1, 46	<0.01	0.969	<0.001
Speech-recovery	25	2.71 (0.79)	23	2.71 (0.75)	T x G	2, 92	0.47	0.628	0.010
HF FFTlog (ms^2)									
Baseline	25	4.38 (1.74)	23	4.95 (1.71)	T	2, 92	1.66	0.195	0.035
Speech-preparation	25	4.56 (1.60)	23	4.74 (1.59)	G	1, 46	0.54	0.465	0.012
Speech-recovery	25	4.32 (1.72)	23	4.57 (1.54)	T x G	2, 92	1.13	0.328	0.024
lnSDNN (ms)									
Baseline	25	2.90 (0.70)	23	3.03 (0.65)	T	2, 92	3.29	0.042*[b]	0.067
Speech-preparation	25	3.10 (0.69)	23	3.08 (0.63)	G	1, 46	0.17	0.681	0.004
Speech-recovery	25	2.92 (0.72)	23	3.03 (0.62)	T x G	2, 92	1.18	0.313	0.025
LF FFTlog (ms^2)									
Baseline	25	4.94 (1.73)	23	5.33 (1.34)	T	2, 92	4.15	0.019*[b]	0.083
Speech-preparation	25	5.47 (1.74)	23	5.57 (1.27)	G	1, 46	0.43	0.518	0.009
Speech-recovery	25	5.07 (1.57)	23	5.38 (1.41)	T x G	2, 92	0.62	0.539	0.013
HR[a] (bpm)									
Baseline	25	75.04 (12.31)	23	77.58 (13.03)	T	1.75, 80.39	40.93	<0.001***	0.471
Speech-preparation	25	78.67 (11.93)	23	81.56 (11.99)	G	1, 46	0.60	0.444	0.013
Speech-recovery	25	75.22 (12.34)	23	77.94 (12.19)	T x G	1.75, 80.39	0.07	0.911	0.002
SYS BP[a] (mmHg)									
Baseline	20	117.10 (17.40)	24	116.92 (10.96)	T	1.69, 71.04	25.48	<0.001***	0.378
Speech-preparation	20	125.45 (17.75)	24	124.31 (10.59)	G	1, 42	<0.01	0.981	<0.001
Speech-recovery	20	118.30 (17.11)	24	119.92 (12.74)	T x G	1.69, 71.04	0.75	0.456	0.018
DIA BP[a] (mmHg)									
Baseline	20	90.18 (10.05)	24	88.29 (9.43)	T	1.63, 68.24	17.63	<0.001***	0.296
Speech-preparation	20	93.45 (9.59)	24	92.67 (9.81)	G	1, 42	0.21	0.650	0.005
Speech-recovery	20	90.65 (10.98)	24	89.33 (9.90)	T x G	1.63, 68.24	0.33	0.678	0.008
PA[a]									
Baseline	25	2.62 (0.66)	25	2.48 (0.71)	T	1.74, 83.55	10.65	<0.001***	0.182
Speech-preparation	25	3.08 (0.81)	25	2.64 (0.89)	G	1, 48	2.15	0.149	0.043
Speech-recovery	25	2.69 (0.84)	25	2.35 (0.91)	T x G	1.74, 83.55	1.72	0.189	0.035
NA[a]									
Baseline	25	1.52 (0.73)	25	1.56 (0.55)	T	1.65, 79.31	11.26	<0.001***	0.190
Speech-preparation	25	1.77 (0.69)	25	1.66 (0.62)	G	1, 48	0.04	0.834	0.001
Speech-recovery	25	1.42 (0.58)	25	1.39 (0.52)	T x G	1.65, 79.31	0.72	0.466	0.015
SSP									
Baseline	24	21.13 (22.76)	25	26.84 (21.91)	T	2, 94	29.60	<0.001***	0.386
Speech-preparation	24	43.71 (26.44)	25	46.20 (29.90)	G	1, 47	0.41	0.527	0.009
Speech-recovery	24	24.71 (19.93)	25	28.64 (28.59)	T x G	2, 94	0.15	0.862	0.003
Respiration[a] (Hz)									
Baseline	25	0.27 (0.08)	22	0.24 (0.06)	T	1.42, 63.80	10.21	0.001**	0.185
Speech-preparation	25	0.29 (0.06)	22	0.28 (0.05)	G	1, 45	2.32	0.134	0.049
Speech-recovery	25	0.27 (0.09)	22	0.24 (0.07)	T x G	1.42, 63.80	1.24	0.287	0.027

ln = Natural Logarithmic Normalization of the Data; lnRMSSD = Logarithmized Root Mean Square of Successive Differences; lnSDNN = Logarithmized Standard Deviation of NN Intervals; HF = High-Frequency Band; LF = Low-Frequency Band; HR = Heart Rate; SYS BP = Systolic Blood Pressure; DIA BP = Diastolic Blood Pressure; ms = milliseconds; ms^2 = milliseconds squared; FFTlog = logtransformed with Fast Fourier Transformation; bpm = beats per minute; mmHg = millimetres of mercury; PA = Positive Affect, PA activation = Facet of PA; NA = Negative Affect; SSP = Subjective Stress Perception; Hz = Hertz; time (baseline, speech prep., recovery); MSC = Mindful Self-Compassion; PMR = Progressive Muscle Relaxation; G = group; T = time.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

[a]Greenhouse–Geisser correction.

[b]ns after Bonferroni correction.

TABLE 3 Non-clinical short-term HRV norms (n = 21,438) in comparison to clinical sample (n = 48) (108).

	Non-clinical		Clinical		t(21484)	p	Cohen's d
	M	SD	M	SD			
RMSSD (ms)	42	15	20.54	14.05	9.90	<0.001***	1.431
SDNN (ms)	50	16	23.81	14.80	11.33	<0.001***	1.637
HF (ms^2)	657	777	312.98	416.78	3.07	0.002**	0.444
LF (ms^2)	519	291	467.22	726.23	1.22	0.221	0.176

RMSSD = Root Mean Square of Successive Differences; SDNN = Standard Deviation of NN Intervals; HF ms^2 = Absolute Power of the High-Frequency Band; LF ms^2 = Absolute Power of the Low-Frequency Band; M = Mean; SD = Standard Deviation. Adapted from Shaffer, F., & Ginsberg, J. P. (2017). An overview of heart rate variability metrics and norms. Frontiers in public health, 5, 258. https://doi.org/10.3389/fpubh.2017.00258.
**$p < 0.01$.
***$p < 0.001$.

showed significantly higher values in Reappraisal than the PMR group (see Table 1), indicating a medium effect size (Cohen's $d = 0.64$; *ns* after Bonferroni correction). However, this result was non-significant after Bonferroni correction.

Discussion

The main purpose of this study was to determine whether the psychophysiological stress response differed in inpatients attending the MSC or PMR program at the end of their 6-week psychiatric rehabilitation stay in the Sonnenpark Neusiedlersee clinic. Overall, no difference was found. Participants were comparable on several anamnestic variables such as diagnoses or medication intake, Self-Compassion, Suppression, and Psychological Distress, as well as in HRV, HR, BP, PA, NA, SSP, Respiration rate, Appraisal, and Rumination in the course of the stress induction. While participants in the MSC group exhibited increased Cognitive Reappraisal as an emotion regulation strategy, as compared to the PMR group, this difference did not remain significant after controlling for multiple testing.

On a psychophysiological level, substantial stress-related changes were observed in both groups, thus demonstrating effectiveness of the stress task. In particular, alterations in SDNN, LF-HRV, HR, BP, PA, NA, and SSP throughout the three measurement points (baseline, speech prep., recovery) of the stress task could be observed. However, no significant changes were detected for RMSSD and HF-HRV.

This study is, to the authors' knowledge, the first to compare MSC training with an active PMR control group regarding psychophysiological stress reactivity. Initial indications for group differences were provided by the study of Gaiswinkler et al. (51), where MSC training was associated with higher self-compassion and happiness than PMR training after a 6-week intervention in the Sonnenpark Neusiedlersee clinic. In this study, a tendency for higher Self-Compassion in the MSC group ($p = 0.095$) was found, as well as a superior Cognitive Reappraisal ($p = 0.045$), which confirms recent findings on how self-compassion increases the ability of cognitive reappraisal as self-compassion helps us to look at ourselves and situations we are in with more kindness (47, 113, 114). Higher reappraisal could also help to better deal with stressful situations as they are perceived as evolving (115, 116). Besides, the MSC and the PMR training seem to produce quite similar results like several other studies comparing mindfulness and PMR (66, 68, 117, 118). Although - resonating with previous research - our findings hint towards effects of MBIs on psychological stress response regarding SSP (119), Emotion Suppression (120), Psychological Distress (117), Appraisal (85, 121), and Rumination (49, 122), this study did not employ a placebo group which significantly restricts the generalizability of our findings.

In psychophysiological research, heterogeneous findings exist where differences between mindfulness and relaxation interventions were found (53, 119, 123). Especially for brief self-compassion and meditation interventions on physiological stress reactivity, adaptive psychophysiological reactions could not be confirmed (32, 124). These results may be due to short-term interventions that have predominantly been conducted in healthy or subclinical populations (53, 119). In contrast, in this study, a 6-week-long intervention was performed in a clinical population. Generally speaking, there are studies showing mindfulness and self-compassion training increasing HRV and buffering psychophysiological stress response (33, 55, 57, 58, 125, 126). Similar to self-compassion programs, PMR may buffer psychophysiological stress reactivity (67, 127). These studies suggest that both programs might be equivalent. To further test this hypothesis future studies should apply equivalence testing on the effects of both relaxation techniques.

A moderate stress response was evident in individual psychophysiological parameter. The stress response of HR, BP, NA, and SSP was observed congruent with literature since both groups showed a rise from baseline to speech preparation and a decline towards recovery (82, 119, 125, 128, 129). Additionally, a significant increase to speech preparation was observed in PA, which seems surprising at first glance (130, 131). Nevertheless, no parasympathetic change regarding RMSSD and HF-HRV was observed, possibly indicating no adaptive stress behavior (20, 132). This is rather uncommon in stress experiments, but could be due to the clinical population and their low flexibility of the ANS (18, 19, 133, 134).

While we did not find significant differences between MSC and PMR, future investigations might examine characteristics of specific groups for whom MSC works particularly well or people who do not benefit from it. E.g. previous research identified neuroticism and conscientiousness as possible moderators of mindfulness based interventions (135). Regarding the moderate stress response, the stress induction might be applicable for future stress experiments. Especially in clinical populations, it may be advantageous not to obtain a strong but moderate stress response due to vulnerability.

Limitations and future research

The first point to be mentioned is the sample size in this study. This only allows for large effects to be revealed by statistical evaluation (136, 137). To detect medium and small effects, a larger sample size is certainly required. Additionally, a within subject design study would be desirable (73). Quintana and Heathers (131) recommend collecting multiple data from one individual at several times in psychophysiological studies. Due to the selected stressor, we were not able to apply the speaking task twice, otherwise a learning effect and therefore an inadequate stress response might have been detected (73). For future studies, however, we should consider presenting a different stress task at the beginning of the 6-week stay as well as at the end to reveal the changes within a person pre- and post-treatment (73). Recently, Asbrand et al. (138) showed that the standardized TSST could be used in repeated measures, which might constitute an additional approach for future replication studies.

Besides, a non-clinical control group additionally to the active PMR control group would be essential to compare clinical and non-clinical subjects (139). In this study, an attempt was made to compare HRV norm values in non-clinical studies with the present sample, which indicated lower HRV values in comparison to norms. However, to our knowledge, no norm values exist for stress reactivity (74). Still, studies show blunted HRV reactivity in a stress experiment in patients with mental illness as compared to healthy individuals, which is in line with the Neurovisceral Integration Model and makes comparative values preferable in future studies (18, 19, 21, 79, 140). Considering that affective disorders are most frequent in the rehabilitation clinic, this is of particular interest since Jandackova et al. (141) consider HRV as an influencing factor on the onset of depression.

In the present study, the two instructors, teaching MSC and PMR, were not supervised. Thus, it would be interesting to address the training of the instructors as well as their mindset. Showing compassion for others requires us to be aware of our own pain and may help clinicians be more effective in therapy (142).

Conclusion

In sum, this study was the first one to compare MSC and PMR program with respect to psychophysiological stress reactivity with clinical context. The results of this experiment showed no significant difference in the psychophysiological stress responses of inpatients at the end of their psychiatric rehabilitation stay, thus suggesting no difference in the response profile of both the MSC and PMR program.

Yet, larger studies will be needed to further explore differences and similarities of both interventions in more detail.

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.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the University of Graz. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SK, AA, PK, EP, AS, and H-FU conceptualized the study. SK, CS, and AA collected the data. SK and CT analyzed the data. SK interpreted the data. SK, JF, AA, AS, and H-FU drafted the manuscript. AS, CT, CR, JF, AA, and H-FU critically reviewed it. All authors contributed to the article and approved the submitted version.

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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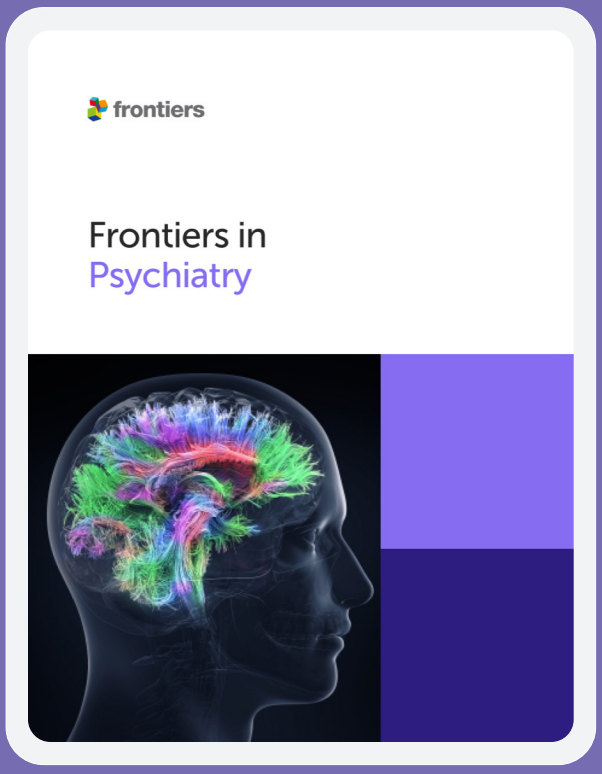

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