Academic Self-Regulation, Chronotype and Personality in University Students During the Remote Learning Phase due to COVID-19

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During the COVID-19 shutdown phase in Germany, universities stopped presence teaching and students had to turn to digital instruction. To examine their capability to cope with the changed learning situation, we assessed how basic psychological need satisfaction and frustration, motivational regulation, vitality, and self-efficacy of 228 German biology-teaching students (75% female) relate to their chronotype and personality (Big Five). Specifically, we were interested in possible effects of chronotype and personality dimensions on variables related to successful remote learning. Since the pandemic and remote learning will accompany teaching and learning at university in 2021, predictors of successful remote learning need to be identified to support student learning optimally in digital learning environments. In our study, morning-oriented, conscientious, and open students with low neuroticism seem to better cope with the shutdown environment due to vitality, self-efficacy, and partly their self-determined motivation. Moreover, our findings implicate students might need different support depending on their chronotype and personality during the digital learning phase.

Keywords: chronotype (morningness-eveningness), big five personality, motivation, self-efficacy, vitality, basic psychological needs (BPN), remote learning (distance)

INTRODUCTION

During the COVID-19 pandemic, the German government-imposed restrictions to limit viral transmission. As a part of this strategy, universities implemented online teaching and required students to work from home. In combination with asynchronous learning arrangements, students were able to change their sleep-wake cycle to sleeping later and longer (Staller and Randler, 2020). This led to a natural approximation to the inherent biological rhythm. The chronotype as the measurable manifestation of the biological rhythm describes the time of day at which a person is best able to cope with particularly challenging tasks. It is becoming an increasingly important predictor of *academic achievement* (see e.g., Arbabi et al., 2015; Tonetti et al., 2015). Since students were able to live in accordance with their own biological rhythm the conditions for academic success with respect to the chronotype may have improved during the restriction phase in Germany. This is corroborated

by a study of Horzum et al. (2014). These authors suggested that online teaching with free-choice time schedules diminished the achievement discrepancies between chronotypes. Besides their chronotype, students' motivation has a crucial impact on *academic achievement* (Ryan and Deci, 2017). With the sleep schedule in line with the inherent biological needs rather than with social expectations, the pandemic and remote learning phase open a rare opportunity to study the relationship between chronotype dependent characteristics and motivation-related constructs such as basic psychological need satisfaction and frustration, motivational regulation, vitality, and self-efficacy (see e.g., Eccles and Wigfield, 2002; Richardson et al., 2012; Kirmizi, 2015; Ryan and Deci, 2017). Additionally, we examine personality dimensions (Big Five) which are related to chronotype (e.g., DeYoung et al., 2007; Tonetti et al., 2009; Randler and Saliger, 2011) as well as motivational regulation (e.g., Müller et al., 2006; Komarraju et al., 2009) to provide a more holistic picture. Our study aimed at offering a first exploratory insight into the relationships of chronotype, well-being and motivation in the situation of asynchronous learning arrangements. Our findings provide valuable guidance for the design of digital learning environments and further analyses during remote learning.

THEORETICAL AND EMPIRICAL BACKGROUND

Chronotype and Circadian Preference

Chronotype is a personality-like trait in which humans are categorized according to their daytime preference, their wake and bedtimes, or their midpoint of sleep on days off. According to the current state of research, chronotype is divided into either demarcated types (morning type, evening type, or neither type; e.g., Adan et al., 2012; Horne and Östberg, 1976) or determined by a score on a continuum (from morningness to eveningness; Roenneberg et al., 2003). As a personality trait, it refers to the preferred daytime for physical or cognitive activities, thereby indicating the particularly efficient periods. Morning-oriented people reach their peak performance in the morning while evening-oriented people show their best performance in the late afternoon (Kerkhof and Van Dongen, 1996; Roenneberg et al., 2003). Chronotype differs from sleep duration by its inherent trait of timing that is irrelevant to the length of sleep (Adan et al., 2012). In the current study, we view chronotype as a unidimensional construct with a parametric score.

Motivation in Organismic Integration Theory

In Organismic Integration Theory, a sub-theory of self-determination theory (Ryan and Deci, 2017), motivational qualities and regulations that differ in their degree of perceived self-determination during an action are described. The prototype of a self-determined action is the intrinsically motivated action (Ryan and Deci, 2002). Here, an individual only pursues the goal of performing the action itself and no contingencies outside the action (Guay et al., 2000; Ryan and Deci, 2017). The action is performed to feel an inherent

satisfaction and pleasure (Ryan and Deci, 2017). Extrinsically motivated actions, on the other hand, are performed to achieve a goal that is separable from the action (Guay et al., 2000; Vallerand and Ratelle, 2002; Ryan and Deci, 2017). They are therefore described as instrumental (Vallerand and Ratelle, 2002). However, this does not mean that extrinsically motivated actions are solely perceived as externally determined (Reeve, 2002; Ryan and Deci, 2017). Based on the perceived degree of heteronomous control or self-determination, Ryan and Deci (2017) describe four types of motivational regulation of extrinsically motivated actions: external, introjected, identified, and integrated.

Externally regulated actions are performed to achieve a positively rated state (e.g., a reward) or to avoid a negatively rated state (e.g., a punishment) (Vallerand and Ratelle, 2002; Ryan and Deci, 2017). The execution of such actions is experienced as being externally determined (Ryan and Deci, 2017; Thomas et al., 2018). Actions that are based on introjected regulation are described as being rather externally determined (Ryan and Deci, 2002). With the execution of introjected regulated actions, individuals tend to avoid guilt and shame (avoidance type; Guay et al., 2000; Vallerand and Ratelle, 2002) or to strengthen or maintain their self-esteem (approach type; Assor et al., 2009). One regulation that results in a rather self-determined quality of action is the identified regulation (Ryan and Deci, 2002, 2017; Vallerand and Ratelle, 2002). An individual performs an identified regulated action when the goal and the underlying values of this action are considered valuable by the individual (Ryan and Deci, 2017). The underlying goals of such self-determined actions can be separated from the beliefs of the individual (Vallerand and Ratelle, 2002). If the beliefs of the individual and the goals of the action are no longer separable, an action is subject to integrated regulation (Vallerand and Ratelle, 2002; Ryan and Deci, 2017). The goals and needs of the self are in line with the goals of the action while performing an integrated regulated action (Ryan and Deci, 2002). These actions already share qualities with intrinsically regulated actions such as the voluntary execution and perceived self-determination (Ryan and Deci, 2002).

Motivation in Basic Psychological Needs Theory

The motivational regulation of an action is determined, among other things, by the degree of the perceived satisfaction and frustration of the three-universal basic psychological needs for autonomy, competence, and relatedness (Ryan and Deci, 2017; Vansteenkiste et al., 2020). The need for autonomy describes an individuals' striving to be the origin of his/her action and having a sense of choice in actions (Reeve, 2002; Ryan and Deci, 2017). Moreover, individuals perceive themselves as being autonomous if they can execute actions voluntarily and without external pressure (Reeve, 2002; Ryan and Deci, 2017). The need for competence entails an individuals' desire to feel effective and be able to express and improve his/her own skills in his/her interactions with the environment (Reeve, 2002; Ryan and Deci,

2017). The need for relatedness describes an individuals' wish to belong to a community and to interact with significant others (Reeve, 2002; Ryan and Deci, 2017). A satisfaction of the depicted needs most likely results in a self-determined motivational regulation whereas a frustration thereof fosters controlled types of motivational regulation and negatively affects self-determined regulation (Vansteenkiste et al., 2020). Furthermore, the satisfaction of the basic needs facilitates well-being (Ryan and Deci, 2017). Vitality is regarded as one indicator of well-being and is defined by the availability of energy and feelings of enthusiasm (Ryan and Frederick, 1997; Martela et al., 2016). A satisfaction of the basic psychological needs combined with low levels of needs frustration support the facilitation of vitality (Ryan et al., 2006; Ryan et al., 2010).

Self-Efficacy

Self-efficacy in academic contexts can be described as the belief in one's abilities to organize and execute the action(s) required to reach a given educational goal (Bandura, 1997; Elias and McDonald, 2007) and is linked to motivation (Zimmermann, 2000) and academic achievement (Valentine, Dubois, and Cooper, 2004; Zajacova et al., 2004). Self-efficacy is related to the perception of competence. Since one's own belief about mastering tasks affects the balance between one's own ability and the requirements of the task it is a central prerequisite of perceiving competence. At the same time, events that resulted in a high or low perception of competence affect self-efficacy positively or negatively. Self-efficacy might therefore play an important role in coping with new and potentially challenging situations such as the remote learning phase.

Academic Achievement and Personality Characteristics

Academic achievement is determined by ability factors (e.g., cognitive abilities; Ackerman and Heggestad, 1997) as well as non-ability factors (e.g., personality characteristics; Chamorro-Premuzic and Furnham, 2006). For example, achieving academic goals requires the cognitive ability to understand the content, the ability to control distracting emotions as well as to work and learn in an appropriate manner. These, among other factors, must be properly fulfilled to accomplish *academic achievement*. In this context, personality characteristics need to be considered as important predictors for *academic achievement* because 1) certain personality traits affect behavior which, in turn, can have an influence on *academic achievement* (e.g., conscientiousness; Rothstein et al., 1994), 2) personality traits reflect behavior which a person will show rather than what a person is theoretically capable of (Goff and Ackerman, 1992; Furnham and Chamorro-Premuzic, 2004), and 3) in an university setting, personality traits show more predictive power than cognitive ability for *academic achievement* (Ackerman et al., 2001; Furnham et al., 2003; O'Connor and Paunonen, 2007). For example, conscientiousness has been consistently related positively to *academic achievement* prior to (O'Connor and Paunonen, 2007; Poropat, 2009) and during the COVID-19 pandemic (Corazzini et al., 2020). As a personality dimension

of the big five, it determines self-regulation and impulse control (John et al., 2008), which proved to be important in utilizing emotions to achieve academic goals (Pekrun, 1992; Pekrun et al., 2002). Since *academic achievement* belongs to the most important influencing factors on educational and professional careers in modern society, students are confronted with both their actual academic performance and their expectations thereof.

The expectation of their academic performance triggers a variety of personal and task-related emotions as well as different motivational regulations, which, in turn, influence cognitive processes and performance (e.g., Ryan and Deci, 2017). Emotions that are directly linked to *academic achievement* are called *academic emotions* (e.g., anxiety and motivation to learn) (Pekrun et al., 2002). These modulate a student's behavior by triggering positive or negative directed intentions. Taken together, personality traits predefine how emotions influence behavioral tendencies and in consequence *academic achievement*.

Bridging Academic Achievement and Circadian Preference

Another important dimension of a personality trait-like characteristic affecting *academic achievement* is the circadian preference. Evening-oriented students show significantly worse grades in elementary school (Arbabi et al., 2015), middle school (Kolomeichuk et al., 2016), high school (Randler and Frech, 2006), and university (although this correlation weakens depending on the degree of free time allocation; Tonetti et al., 2015). Reasons given for this relationship are early school schedules (Goldstein et al., 2007) and the resulting lack of sleep for evening-oriented students (Roberts et al., 2009). These conclusions are further underlined by the findings of Jovanovski and Bassili (2007) who reported evening-oriented students prefer watching lectures online instead of attending them. Moreover, no correlation of chronotype with course performance was found. Horzum et al. (2014) reported similar results: the disadvantages evening-oriented students face in classroom teaching disappear with the switch to online teaching, because the students could adapt the lecture time to their personal needs. Additionally, various personality traits which favor *academic achievement* could be linked to morning orientation (e.g., conscientiousness; Adan et al., 2012; O'Connor and Paunonen, 2007; Önder et al., 2014; Poropat, 2009), while those which negatively affect advantageous academic behavior can be associated with evening orientation (e.g., extraversion; Adan et al., 2012; Chamorro-Premuzic and Furnham, 2005; Furnham and Chamorro-Premuzic, 2004; Furnham et al., 2003; Goff and Ackerman, 1992). However, the negative relationship between extraversion and *academic achievement* has yet to be validated, since some research shows no correlation or even suggests a positive correlation (e.g., Rothstein et al., 1994). Furthermore, evening orientation relates to the use of external stimuli (caffeine; Fleig and Randler, 2009), smoking and soft drinks (Gariépy et al., 2019), excessive cell phone use (Randler et al., 2016a;

Demirhan et al., 2016), and long screen times (Kauderer and Randler, 2013; Shimura et al., 2018; Gariépy et al., 2019). According to Ryan and Frederick (1997), these factors may affect vitality negatively. Overall, the relationship of circadian preference with self-regulation and *academic achievement* builds on a small but growing body of literature. Work in this domain suggests that evening orientation is associated with characteristics and behaviors that hinder *academic achievement*.

Remote Working, Chronotype, and Motivation

Previous research shows that the change in students' sleep-wake cycle caused by working from home resulted in positive alterations of sleep parameters for many people in different countries (Cellini et al., 2020; Gao and Scullin, 2020; Leone et al., 2020; Sinha et al., 2020; Staller and Randler, 2020). These findings support a modern approach to work environments called "New Ways of Working" (NWW; Baane et al., 2011). This concept tries to create temporal and spatial flexibility for employees while focusing on innovation and productivity with simultaneously reduced costs for employers (Nijp et al., 2016). It is proposed to adjust work to private life (Gajendran and Harrison, 2007; Nijp et al., 2015) and the employees' biological needs such as chronotype (Wittmann et al., 2006). The remote working situation that the students found themselves in during the COVID-19 restriction phase in Germany reflects the temporal and spatial flexibility NWW tries to create. Positive effects of this working approach are assumed to be e.g., employees' improved motivation due to gaining autonomy (Pritchard and Payne, 2003) and increased efficiency (Demerouti et al., 2014). By contrast, the lack of collegial support and exchange, which is considered a negative aspect of NWW (Halford, 2005), also applies to the university students' current situation. There is also evidence that NWW might lead to exhaustion at the end of the workday (Ten Brummelhuis et al., 2012). Thus, vitality might be undermined. In line with self-determination theory (Ryan and Deci, 2017), these characteristics of remote working may affect the relationship between academic self-regulation and *academic achievement*.

Taken together, our study aimed at providing insight into the relationship between different related personality and motivational variables that affect *academic achievement*. Some interactions between these variables have already been shown in previous studies. Our study takes a more holistic approach to the relationship between these variables. Moreover, as shown, these relationships may be influenced by the remote learning situation. However, knowing these relationships is significant for designing learning environments that enable students to learn successfully in times of remote learning.

Research Question

Our study aims to investigate the effects of personality variables on various variables related to successful learning in an unprecedented situation, lockdown, and digital teaching. The

identification of such predictors of successful remote learning can help to support student learning optimally in digital learning environments. As to the unprecedented situation we opted to derive an exploratory research agenda for A) the personality traits and B) chronotype based on findings of literature and previous studies in face-to-face teaching that are specified hereafter in more detail.

A) In respect to the personality traits we derive:
  - the big five personality variables have an impact on the satisfaction and frustration of the students' basic needs (Deniz and Satici, 2017)
  - the big five personality variables have an impact on the students' motivational regulation (Müller et al., 2006; Komarraju et al., 2009).
  - the big five personality variables have an impact on the students' vitality (Nishimura and Suzuki, 2016).
  - the big five personality variables have an impact on the students' self-efficacy (Şahin and Çetin, 2017).
B) Regarding chronotype, it can be assumed that:
  - chronotype has an impact on the satisfaction and frustration of the students' basic needs (Tavernier et al., 2019)
  - chronotype has an impact on the students' motivational regulation (Kadzikowska-Wrzosek, 2020)
  - chronotype has an impact on the students' vitality (Randler and Schaal, 2010).
  - chronotype has an impact on the students' self-efficacy (Przepiórka et al., 2019).

METHODS

Participants and Data Collection

We investigated biology-teaching students (N = 228; M_{Age} = 23.36 years, SD_{Age} = 4.24 years, range = 18–43 years; 75% female, n = 171) in their bachelor or master studies participating in an one-time online survey. The study took place during the first lockdown in Germany in June 2020. Participants were invited via email distribution lists. These students gave their permission to use their anonymous data for scientific purposes and were included in our evaluation. Their participation in the survey was voluntary. After filling out the questionnaire, all participating students could take part in a raffle to win gift cards/vouchers. All participants studied in an online environment and took very different courses (e.g., lecture series or seminars). Furthermore, they all had access to a learning platform (e.g., Lernraum or studIP). 48 subjects were not included in the calculations because they did not complete the questionnaire. The dropouts are similar to the sample in demographic data, gender (dropouts: 69% female/sample: 75% female), age (dropouts: Ø 23 years (youngest: 19 years/oldest: 34 years)/sample: Ø 23 years (youngest: 18 years/oldest: 43 years)) and origin. In conclusion, the aforementioned 228 students were included in the statistical analyses. Together with the questionnaires, participants' time spent on other commitments per week was assessed. Participants spent on average 17.66 h (SD = 19.30 h) on

other commitments beyond their study. Here, participants (N = 228) reported these commitments mainly in the categories (part-time) job (46.5%), nursing/caregiving activities (4.4%), family (7%) and household activities (11.4%). 16% of the investigated students lived alone at the time of the survey, while 83% lived in a shared apartment with roommates, their partner and/or children. 1% of the students did not specify their situation at home.

Big Five Personality

We followed the big five-dimensional concepts of personality (e.g., Costa and McCrae, 1995). To measure personality, we used a German translation of the short version of the big five inventory (Rammstedt and John 2007; Rammstedt et al., 2013). This scale was based on the BFI-44 (Benet-Martínez and John, 1998) and was shortened to a 10-item questionnaire with two items for each personality dimension (extraversion, agreeableness, openness, neuroticism, and conscientiousness). The items were rated on a seven-point rating scale (see 3.3). The BFI-10 always showed a clear five factor structure and correlations with peer-ratings showed good external validity (Rammstedt and John, 2007). Due to its brevity, the scale can be used when personality assessment is only one aspect of a study design and when time is short. We used a confirmatory factor analysis to test the model structure of the BFI. Root mean square error of approximation (RMSEA) was 0.057 (CI 0.028–0.083). The comparative fit index CFI was 0.954. This suggests a good fit of the scale.

Morningness-Eveningness Questionnaire (Reduced)

To assess circadian preference, we used the Adan and Almirall (1991) short Morningness-Eveningness Questionnaire (rMEQ). This scale is based on five different questions regarding wake and bedtime preferences, peak performance, morning affect and self-classification. The scale ranges from 4 to 25 (4–11: evening type; 12–17: neither type; 18–25: morning type). The rMEQ is a time efficient questionnaire that has received a lot of support for its convergent validity (Di Milia et al., 2013). For example, the reduced form correlates between 0.87 and 0.90 with the full scale containing 19 questions (Di Milia et al., 2013). The questionnaire scores have been validated against biologically measured variables, such as objectively assessed sleep-wake variables based on actigraphy (Thun et al., 2012). The German version of the rMEQ has been established and validated (Cronbach's α = 0.72; Randler, 2013).

Basic Psychological Need Satisfaction and Frustration Scale

To assess the satisfaction and frustration of the students' basic psychological needs during the online semester, Heissel et al. (2018) validated German scales were used. The dimensions for satisfaction and frustration of the respective needs are the following: need for autonomy (satisfaction: four items, Cronbach's α = 0.74; frustration: four items, Cronbach's α = 0.84), need for competence (satisfaction: four items, Cronbach's α = 0.85; frustration: four items, Cronbach's α = 0.83), and the need

for social relatedness (satisfaction: four items, Cronbach's α = 0.74; frustration: four items, Cronbach's α = 0.72). A five-point rating scale ("1 = not true at all" to "5 = absolutely true") was applied.

Scales for Motivational Regulation in Learning

To assess the students' motivational regulation during the online semester, the scales for motivational regulation in learning (Thomas et al., 2018), a translated and adapted version of the Academic Self-Regulation Questionnaire (Ryan and Connell, 1989), were used. The instrument contains four subscales: intrinsic motivational regulation (three items, Cronbach's α = 0.88); identified motivational regulation (three Items, Cronbach's α = 0.72); introjected motivational regulation (six items), and external motivational regulation (three items, Cronbach's α = 0.72) (Thomas et al., 2018). In this study, the subscale introjected motivational regulation was assessed separately as approach type (three items, Cronbach's α = 0.78) and avoidance type (three items, Cronbach's α = 0.83). The items of all subscales were rated on a seven-point rating scale ("1 = not true at all" to "7 = absolutely true").

Vitality

Students' vitality during the online semester was assessed with a translated version of Ryan and Frederick (1997) Subjective Vitality Scale. Analysis of the factorial validity was carried out with a principal axes factor analysis (PFA; Moosbrugger and Kelava, 2012). The Kaiser-Meyer-Olkin criterium (KMO = 0.90) was found to be good (Hutcheson and Sofroniou, 1999) and showed that the sample was entitled for analysis. Bartlett's test of sphericity was significant with a $p < 0.001$. PFA showed one factor (eigenvalue of 4.58) and 65.40% of explained variance. The items had satisfactory factor loadings with values of 0.57–0.90 (Stevens, 2002). The seven items were rated on a seven-point rating scale as well (see 3.3). The internal consistency of the items was good (Cronbach's α = 0.91).

Self-efficacy

To examine students' self-efficacy during the online semester, seven items by Jerusalem and Schwarzer (1986) were applied. The items were again rated on a seven-point rating scale (see 3.3). The internal consistency of the items was satisfactory (Cronbach's α = 0.82).

Statistical Analyses

No specific assumptions were made in advance for the situation in which the study group found itself during the lockdown. We therefore analyzed the data in an exploratory manner based on related previous research (see *Research Question*) and looked for relevant models. To determine internal consistency as Cronbach's α, we used IBM SPSS Statistics 26. Afterward, we ran a series of multiple regressions with all 14 dependent variables. Independent predictors were personality, chronotype and the demographics age and gender. Only the significant total models were inspected for further analyses. We set a $p = 0.01$ as a threshold to accept a model as significant. For

TABLE 1 | Means, standard deviations and ranges of the independent (personality, chronotype) and dependent variables (basic psychological needs, motivational regulation, vitality, self-efficacy).

	Mean	Standard deviation	Range	Scale range
Extraversion	4.53	1.61	1–7	1–7
Neuroticism	4.23	1.41	1–7	1–7
Openness	4.91	1.59	1–7	1–7
Conscientiousness	4.80	1.27	2–7	1–7
Agreeableness	4.48	1.27	1.5–7	1–7
rMEQ score	14.63	4.04	5–23	4–25
Need frustration autonomy	3.38	0.97	1–5	1–5
Need frustration competence	2.29	0.99	1–5	1–5
Need frustration relatedness	2.11	0.83	1–4.5	1–5
Need satisfaction autonomy	3.24	0.82	1–5	1–5
Need satisfaction competence	3.36	0.85	1.25–5	1–5
Need satisfaction relatedness	2.92	0.85	1–5	1–5
Need satisfaction relatedness—Lecturer	3.53	0.83	1.25–5	1–5
Need satisfaction relatedness—Peers	3.63	0.87	1.33–5	1–5
Intrinsic regulation	3.65	1.64	1–7	1–7
Identified regulation	4.94	1.23	1.33–7	1–7
Introjected approach regulation	4.32	1.58	1–7	1–7
Introjected avoidance regulation	3.88	1.66	1–7	1–7
External regulation	4.72	1.46	1–7	1–7
Vitality	4.12	1.19	1–7	1–7
Self-efficacy	4.21	1.14	1.29–6.71	1–7

TABLE 2 | Correlation matrix between the independent (personality, chronotype) and dependent variables (basic psychological needs, motivational regulation, vitality, self-efficacy).

	Extraversion	Neuroticism	Openness	Conscientiousness	Agreeable-ness	rMEQ score
Need frustration autonomy	0.048	0.069	−0.107	−0.128	−0.007	**−0.151***
Need frustration competence	−0.096	**0.284***	0.010	**−0.325***	−0.012	**−0.186****
Need frustration relatedness	**−0.180****	**0.226****	**0.131***	−0.091	−0.103	−0.113
Need satisfaction autonomy	−0.103	0.069	0.093	0.128	0.053	0.117
Need satisfaction competence	0.019	**−0.179****	**0.131***	**0.162***	0.055	**0.157***
Need satisfaction relatedness	0.056	−0.097	−0.042	0.122	**0.195****	0.088
Need satisfaction relatedness—Lecturer	−0.051	−0.014	**0.234***	−0.062	0.031	−0.011
Need satisfaction relatedness—Peers	0.059	**−0.135***	−0.009	0.019	0.121	0.017
Intrinsic regulation	**−0.185****	0.041	**0.146***	0.126	0.110	0.107
Identified regulation	−0.038	0.105	0.126	**0.233***	0.097	**0.159***
Introjected avoidance regulation	−0.118	**0.320***	0.041	**−0.160***	−0.048	0.026
Introjected approach regulation	−0.009	**0.147***	**0.177****	0.067	0.080	0.119
External regulation	0.048	0.002	0.112	−0.043	−0.024	0.028
Vitality	−0.015	**−0.247***	0.077	**0.250***	0.117	**0.264***
Self-efficacy	0.022	**−0.322***	0.092	**0.186****	0.022	**0.178****

*Note: *p< .05, **p< .01, ***p< .001.*
Note: Significant correlations are highlighted in bold.

the confirmatory factor analysis, AMOS 26 was used. Correlations between personality dimensions were tested and intercorrelations were below 0.28 showing below medium effects in all cases.

RESULTS

We calculated the distribution of the datasets and found them neither to be substantially skewed nor was a distinct kurtosis visible in any variable (the values for both, skewness and kurtosis did not exceed/fall below ±1). **Table 1** summarizes

the means, standard deviations, and ranges of all investigated variables.

The mean rMEQ score was 14.63 ($SD = 4.04$) and ranged from 5–23. Men had a lower score compared to women (men: 13.65, $SD = 4.38$; women: 14.95, $SD = 3.88$; $F = 4.52$, $p = 0.035$, $\eta^2 = 0.020$). Age was unrelated to the rMEQ score ($r = 0.027$, $p = 0.685$). **Table 2** gives an overview of the correlations between the big five dimensions/chronotype and all investigated dependent variables. Furthermore, we calculated the correlations of the big five personality dimensions and the rMEQ score which showed mostly no significant correlations. Extraversion ($r = 0.076$, $p = 0.253$), Neuroticism ($r = 0.010$, $p = 0.882$), Openness ($r = -0.109$,

TABLE 3 | Results of the full models (linear regression) with the dependent variable (left column) and gender, age, rMEQ score, and personality as predictor variables of the basic psychological need satisfaction and frustration, motivational regulation, vitality, and self-efficacy. The corrected R-squared is only given for the models with a $p < 0.01$.

	F	p	Corrected R^2
Need frustration autonomy	1.79	0.08	
Need frustration competence	7.38	0.001	0.18
Need frustration relatedness	3.25	0.002	0.07
Need satisfaction autonomy	1.61	0.124	
Need satisfaction competence	3.12	0.002	0.07
Need satisfaction relatedness	2.19	0.03	
Need satisfaction relatedness—Lecturer	2.12	0.035	
Need satisfaction relatedness—Peers	1.60	0.125	
Intrinsic regulation	3.97	0.001	0.10
Identified regulation	3.26	0.002	0.07
Introjected approach regulation	2.76	0.006	0.06
Introjected avoidance regulation	5.47	<0.001	0.14
External regulation	0.67	0.72	
Vitality	6.91	<0.001	0.17
Self-efficacy	8.38	<0.001	0.21

$p = 0.101$), Agreeableness ($r = 0.103$, $p = 0.122$) with the exception of conscientiousness ($r = 0.283$, $p < 0.001$) which correlated with morningness.

Due to the many correlations, we ran a series of multiple linear simultaneous regressions with each of the motivation-related scales and subscales as dependent variables. **Table 3** presents the results of the full models.

In the following section, only the significant models with a $p < 0.01$ for the full model were analyzed (see **Table 4**).

A significant impact of gender on motivational aspects were found, with men reporting a higher degree of self-efficacy and women being more intrinsically motivated. Age showed a negative relationship with introjected avoidance motivational regulation. Extraversion related negatively to intrinsic motivational regulation. Neuroticism related negatively to self-efficacy, vitality, and need satisfaction competence while it related positively to introjected approach and avoidance motivational regulation, as well as need frustration competence and relatedness. Openness correlated positively with self-efficacy,

intrinsic, identified, and introjected approach motivational regulation, as well as need satisfaction competence. Conscientiousness was related positively to self-efficacy, vitality, identified motivational regulation, need satisfaction competence, and negatively to introjected avoidance motivational regulation and need frustration competence. For the rMEQ, positive correlations were found with self-efficacy, vitality, and need satisfaction competence.

DISCUSSION

In our sample of biology-teaching students, the mean rMEQ score did not differ significantly from other German study samples (Randler 2013; Randler et al., 2016b). This is an expected result because chronotype remained stable during the COVID-19 shutdown phase in Germany while only sleep-wake timing changed (Staller and Randler, 2020). Gender differences in line with previous studies were found, with men being more evening-oriented (e.g., Randler and Engelke, 2019). Age effects were absent, most likely due to the low age variation (see e.g., Randler et al., 2016b, for a larger sample with the rMEQ). The relationship between morningness and vitality in our sample might have a biological reason: Morningness was linked to the cortisol awakening response in previous studies (CAR; see e.g., Randler and Schaal 2010), which may take account of this correlation as it reflects the theoretical connection to the diurnal cycle. Overall, personality and chronotype had a significant impact on online learning during the COVID-19 pandemic in these biology-teaching student sample.

Effects of Gender on Self-Efficacy

Our results are in line with previous findings on gender differences regarding self-efficacy (e.g., Fallan and Opstad, 2016). However, in a meta-analysis, Huang (2013) showed that such gender effects vary depending on the investigated subject domain. Whereas female students seem to have a higher self-efficacy in language arts, male students express a

TABLE 4 | Results of the multiple regressions. Full models are presented in **Table 3**. Standardized coefficient beta for the predictor variables is given. Predictors were gender, age, personality and rMEQ score. Dependent variables were basic psychological need satisfaction and frustration, motivational regulation, vitality, and self-efficacy.

	Gender	Age	Extraversion	Neuroticism	Openness	Conscientiousness	Agreeableness	rMEQ score
Need frustration autonomy	−0.029	−0.028	0.082	0.090	−0.120	−0.123	0.009	**−0.140***
Need frustration competence	0.084	0.022	0.039	**0.320*****	−0.023	**−0.304*****	0.079	−0.105
Need frustration relatedness	0.059	0.085	−0.094	**0.208****	0.096	−0.026	−0.048	−0.079
Need satisfaction competence	0.032	0.033	−0.041	**−0.189****	**0.153***	**0.151***	0.028	**0.137***
Intrinsic regulation	**−0.173***	0.07	**−0.219*****	−0.049	**0.131***	0.107	0.076	0.074
Identified regulation	−0.019	0.046	−0.050	0.083	**0.147***	**0.207****	0.068	0.109
Introjected approach regulation	−0.060	−0.089	0.025	**0.147***	**0.205****	0.019	0.064	0.120
Introjected avoidance regulation	0.063	**−0.167*****	−0.012	**0.343*****	0.049	**−0.174****	−0.004	0.092
Vitality	0.049	−0.025	−0.125	**−0.269*****	0.113	**0.223*****	0.071	**0.225*****
Self-efficacy	**0.228*****	−0.108	−0.072	**−0.293*****	**0.137***	**0.215*****	0.013	**0.174****

Note: *p < .05, **p < .01, ***p < .001.
Note: Significant coefficient beta values are highlighted in bold.

higher degree of self-efficacy in mathematics, social sciences, and computers (Huang, 2013).

Effects of Gender on Intrinsic Motivational Regulation

Biology as a school subject is assumed to be a female domain (e.g., Budde, 2008). Thus, females exhibit both more interest (Dietze et al., 2005) and a higher intrinsic motivational regulation than males in the school subject biology (Renaud-Dubé et al., 2010; Großmann et al., 2019). As a scientific field, biology might show the same underlying gender-related effects as described by Huang (2013) as well. However, since the study sample only consisted of biology-teaching students, the interest and intrinsic motivational regulation of all participants might have been above average, which could argue against the former conclusion.

Effects of Age on Introjected Approach Motivational Regulation

Our results show that younger students reported a higher level of introjected approach motivational regulation than older students. However, the correlation is small. One possible explanation might be that younger students feel more obligated to prove their abilities to others than older students do. They might have a stronger desire to manage what others think about them. However, we did not find such age-related effects for the avoidance type of introjected motivational regulation. Acting to avoid negative feelings such as guilt and shame seems to be independent of students' age. To test the reliability of the current findings more research is needed.

Effects of Extraversion on Intrinsic Motivational Regulation

In our sample, extraversion related negatively to intrinsic motivational regulation. This result is contrary to the findings of Komarraju et al. (2009) and Müller et al. (2006), who found a positive relationship between these variables. When it comes to the teacher profession, positive correlations between extraversion and intrinsic motivation should become particularly apparent, since extraversion predicts satisfaction and success in teacher training programs as well as in the teaching profession (Mayr, 2014). A possible explanation for our result might be that other people and external stimuli play a more important role to extroverts than to introverts. Specifically, extroverts' decision-making and behavior may be significantly influenced by what others think of them, suggesting a more externally determined rather than self-determined motivational regulation. A situation in which extrinsic motivational factors are largely absent, such as the COVID-19 shutdown, might lead to a lower level of both intrinsic motivation for learning and self-efficacy regarding extroverts. A lack of social exchange with peers and lecturers may therefore have a stronger effect on extroverts' motivation and might (at least partially) explain the contradiction to what Komarraju et al. (2009) and Müller et al. (2006) reported.

Effects of Neuroticism

The results of our sample replicated previous findings concerning the negative relationship between neuroticism and self-efficacy as well as vitality (Nishimura and Suzuki, 2016; Deniz and Satici, 2017). Neurotic people are less open toward new and unpredictable situations (Borkenau and Ostendorf, 2008). The unpredictable situation resulting from the COVID-19 pandemic and the unexpected move to online learning constitutes a major challenge for neurotic people. The significant correlations between neuroticism and the tested motivation-related variables (positive correlation with introjected approach and avoidance motivational regulation, need frustration competence and relatedness; negative correlation with need satisfaction competence) are in line with previous studies (Müller et al., 2006; Komarraju et al., 2009; Önder et al., 2014; Nishimura and Suzuki, 2016).

Effects of Openness

As was the case in the sample in Şahin and Çetin's (2017) study, our sample also yielded a positive correlation between openness and self-efficacy. This is contrary to the results of Judge et al. (2007), who found no impact of openness on self-efficacy. Openness as a predictor of self-efficacy might be explained by one's inherent openness to situations and experiences. More "open" students may face more challenging and difficult situations that allow them to perceive more self-efficacy than students with a more "reserved" character. This conjecture is backed up by the result of Corazzini et al. (2020) who found high levels of openness to new experiences correlating with better student scores during the COVID-19 pandemic. Moreover, openness correlated positively to intrinsic motivation, replicating the work of Komarraju et al. (2009) and Önder et al. (2014). Furthermore, it related to the other self-determined types of motivational regulation, namely identified and introjected approach. Self-determined motivational regulation indicates perceived competence. Therefore, the positive correlation of openness and need satisfaction competence fits into this line of reasoning. Moreover, openness and need satisfaction competence were shown to correlate positively in previous work as well (Nishimura and Suzuki, 2016). Regarding the remote learning phase during COVID-19 shutdown, we reason that openness to new experiences might be beneficial when new methods of learning are implemented, even though more research is needed to test the reliability of the current findings.

Effects of Conscientiousness

Conscientiousness showed a strong positive correlation with self-efficacy and vitality, thereby replicating previous findings (Nishimura and Suzuki, 2016; Deniz and Satici, 2017). This was a somewhat expected result, as conscientiousness is one of the most important influencing factors on learning and *academic achievement* (O'Connor and Paunonen, 2007; Poropat, 2009). Also, conscientiousness was found to be highly correlated to student scores during the COVID-19 pandemic (Corazzini et al., 2020). Our results are in line with Komarraju et al. (2009), Önder et al. (2014), and Müller et al. (2006), who found that

conscientiousness is a positive predictor of intrinsic motivation. Komarraju and others (2009) also found that there is a positive correlation between identified as well as introjected motivational regulation and conscientiousness. Moreover, conscientiousness was a positive predictor of extrinsic motivation (measured as identified, introjected and external motivational regulation) in their study. In our study, we replicated the positive relationship between conscientiousness and identified motivational regulation, but our data showed a negative correlation between conscientiousness and introjected avoidance motivation. This diverging result might be explained by the fact that Komarraju et al. (2009) did not differentiate between approach and avoidance introjection. Furthermore, self-determined motivational regulation indicates perceived competence, which relates to conscientiousness (see Nishimura and Suzuki, 2016). This positive correlation between conscientiousness and need satisfaction competence was evident in our data as well. Since it correlates negatively with introjected avoidance regulation, the connection to the need frustration competence meets expectations.

Effects of Chronotype on NWW

Morningness was related to self-efficacy and need satisfaction competence, which, in turn, were shown to correlate with conscientiousness, thus supporting the findings of previous work (Komarraju et al., 2009). Furthermore, morningness has been shown to correlate with conscientiousness (Adan et al., 2012) which could be replicated in this sample. Eveningness relates positively to extraversion (Adan et al., 2012, which could not be replicated in this sample) as well as negatively to intrinsic motivational regulation (in our sample). Our data indicate that the NWW approach might be more suitable for morning types, though this research question should be examined in more detail. The negative effects of NWW discussed in the literature (e.g., missing collegial support and a structured working environment; see theoretical background) might affect evening types more because they are less intrinsically motivated. The absence of extrinsic motivational factors may therefore have a stronger effect on evening types' motivation and on their work and learning success. By contrast, morning types, may benefit more from the opportunities which NWW present (temporal and spatial flexibility) because of the relationship between morningness and characteristics such as self-efficacy and conscientiousness.

CONCLUSION

In this study, we found correlations indicating that the changeover to a remote or distant learning setting during the COVID-19 shutdown phase in Germany affects student teachers' motivational regulation depending on their chronotype and big five personality characteristics. These effects on motivation have implications for students' learning success in these new and probably challenging learning environments. The morning-oriented students dealt with the digital semester better and were more vital during the restrictions than evening-oriented students. Morning orientation further correlated with the personality traits in a distinct pattern. It

correlated positively to personality characteristics that strengthen the relationship to intrinsic motivational regulation such as self-efficacy and need satisfaction competence and negatively to characteristics that weaken this connection such as extraversion (Adan et al., 2012). This study could replicate some prior findings in the field of motivational research such as the correlation between conscientiousness and intrinsic motivational regulation. Furthermore, some new findings emerged: 1) Extraversion was a negative predictor of intrinsic motivational regulation. This finding is contrary to that of Komarraju et al. (2009). 2) Whereas the introjected approach motivational regulation seems to be dependent on the students' age, this dependency was not found for the avoidance type of introjected motivational regulation. We nevertheless recommend more testing for reliability which would give a stronger basis for the conclusions.

Strengths and Limitations

In this study, we revealed opportunities and obstacles in terms of remote learning following the restriction measures in Germany. This situation will accompany university teaching and learning further on. Even when the pandemic is over, digital elements may remain present in university teaching as blended learning. Therefore, identifying important predictors of successful learning in digital learning environments might help instructors to redesign these in a beneficial way. We did not limit the data collection to a single theoretical perspective but rather examined many covariables to ensure the results we conclude from this study are not directionally biased. This allowed for a broad perspective at the current motivational characteristics in relation to well-being and personality traits. Nevertheless, the explanatory power of this study is limited due to its exploratory cross-sectional nature. The ongoing pandemic prevented appropriate pre-testing from being carried out. Furthermore, it was not possible to use measurement methods that would complement the self-reports as the data access is restricted by the data protection act and in addition other non-self-report measures could not be applied due to the lockdown situation. We researched a small and narrow sample that refers exclusively to biology-teaching students. With our results, we are able to offer an insight into the relationships of personality dimensions, chronotype, motivational regulation and vitality of biology-teaching students during the first lockdown, even though the results may be less transferable to other groups. In this respect, future studies should expand the sample under consideration. Although this study provided information regarding the life situation of the participants, the situation of the online studies as well as study circumstances should be focused in more detail in future studies as they offer valuable insight and influence the perception of the digital study itself. We discussed conceivable relationships of the variables under consideration with academic achievement which should be investigated in further projects, as we have not included a measure of academic achievement here. Although the measurements used in this study are widely applied in the literature and are validated, the validity of the vitality measurement is limited due to the German translation used here. Moreover, our findings offer a

valuable steppingstone for further research such as longitudinal studies that focus on the long-term effects of the lockdown on students' learning processes.

Implications for Further Research

Future cross-sectional and longitudinal studies might take the subject matter into account since it can be assumed that personality traits can have different effects on experience and behavior (see Mayr, 2014). The present study showed that it could be a worthwhile research desideratum to clarify the connection between NWW and chronotype as well as to identify possible moderators between the two variables. In such studies, students' temporal and spatial flexibility that is offered in their university courses might be surveyed. This flexibility most likely has an impact on students' perception of autonomy and, in turn, their motivation. Students' use of learning strategies has not been assessed in this study. As the use of learning strategies could very well influence the time invested in a course and as such be directly connected to the perception of workload (Kember, 2004; Kember and Leung, 2006) this aspect could be interesting for future studies. Moreover, we believe that it is necessary to investigate whether students have developed more appropriate coping strategies than at the beginning of the COVID-19 crisis which might result in a more self-determined motivation. Such changes and relationships can be clarified by longitudinal or cohort designs.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the authors still use this dataset for further studies. The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation. Requests to access the datasets should be directed to nadine.grossmann@uni-bielefeld.de.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the ethics comission of Universität Bielefeld, Antrag-Nr.: 2020-200; Az.: 1266. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

AE, NG, MW, and FM, CR conceptualized and designed the study, AE, NG, MW, and FM performed the data collection, CR, NS, and NG made the statistical calculations, CR, NG, and NS wrote the first draft of the manuscript, AE, NG, MW, FM, CR, and NS agreed on the final submission of the study, FM managed and overlooked the whole project.

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