Chronotype-Dependent Changes in Sleep and Performance Components Caused by the Transition to Digital Teaching Due to COVID-19 Infection Control Measures in German Students

DISSERTATION

der Mathematisch-Naturwissenschaftlichen Fakultät
der Eberhard Karls Universität Tübingen
zur Erlangung des Grades eines
Doktors der Naturwissenschaften
(Dr. rer. nat.)

vorgelegt von
NAOMI STALLER
aus Nastätten

Tübingen
2023

Gedruckt mit Genehmigung der Mathematisch-Naturwissenschaftlichen Fakultät der Eberhard Karls Universität Tübingen.

Tag der mündlichen Qualifikation: 17.10.2023

Dekan: Prof. Dr. Thilo Stehle
1. Berichterstatter: Prof. Dr. Christoph Randler
2. Berichterstatterin: Prof. Dr. Caterina Gawrilow

Danksagung

Einen großen Dank richte ich an meine Betreuenden, Herrn Prof. Randler und Frau Prof. Gawrilow, für ihre Unterstützung und Hilfe. Ich bin sehr dankbar für die Möglichkeit das ursprüngliche Dissertationsprojekt aufgrund der Schulschließungen während der COVID-19-Pandemie zu ändern. Vielen Dank für Ihr „offenes Ohr“, Ihre Flexibilität, Ihre Ratschläge, Ihr großes Interesse an verschiedenen Forschungsfragen und das gemeinsame Beschreiten dieses Weges.

Des Weiteren danke ich meinen Kolleginnen für die Hilfe bei der Beseitigung der kleinen und großen Steine auf diesem Weg, den Beistand und die Erfahrungsberichte. Vielen Dank auch an meine Koautoren, die mit mir bis zur Veröffentlichung der hier betrachteten Studien zusammen viele Stunden Ideen ausgetauscht und gearbeitet haben.

Ich möchte mich ganz herzlich bei allen bedanken, die mir bei der Gestaltung, Formatierung und beim Korrekturlesen meiner Arbeit geholfen haben. Vor allem danke ich dir, Erik, für die vielen Stunden, die du mit mir das LaTeX-Chaos bewältigt hast. Liebe Nadine, Caro, Irina und Tina, vielen Dank auch an euch für die Zeit, die ihr investiert habt, um mir zu helfen.

Vielen Dank an Robin, Ralf und Chucky für die Motivation, den Gedankenaustausch, die neuen Perspektiven und die Hilfe im Sport. Danke auch an alle anderen, die mich in meinen verschiedenen Lebensbereichen unterstützt haben, so dass ich die nötigen Ressourcen hatte, um diese Arbeit fertigzustellen. Ein besonderer Dank gilt nicht zuletzt meiner Familie, insbesondere meinen Eltern, die mich trotz Gegenwind von verschiedenen Seiten auf meinem Weg bis hierher unterstützt haben.

Table of Contents

List of Abbreviations **i**

List of Publications in this Thesis **iii**

Summary **v**

Zusammenfassung **vii**

Graphical Abstract **ix**

1 Introduction **1**
- 1.1 Secondary Effects of the COVID-19 Measures . . . 2
- 1.2 Pre-Pandemic Social Inequity Affecting Evening Types . . . 3
- 1.3 Chronotypes in Relation to Individual Differences in Personality . . . 5
- 1.4 A Biologically-Based Approach to Explaining Differences in Coping Behavior Among Chronotypes . . . 6
- 1.5 Self-Determination Theory in Academic Self-Regulation During the Pandemic 7

2 Research Objectives **9**

3 Research Methods **11**

4 Chronotype and Sleep while Working Remotely under COVID-19 Restrictions **13**
- 4.1 Contributors . . . 13
- 4.2 Extended Summary . . . 13

5 Learning Behavior and Sleep in German Students during COVID-19 Restrictions **15**
- 5.1 Contributors . . . 15
- 5.2 Thematic Introduction Linking to the Previous Study . . . 15
- 5.3 Extended Summary . . . 16

6 Differences in Sleep Patterns According to Workplace **17**
- 6.1 Contributors . . . 17
- 6.2 Thematic Introduction Linking to the Previous Studies . . . 17
- 6.3 Extended Summary . . . 17

7 Chronotype and Organizational Citizenship Behavior during COVID-19 Restrictions **19**
- 7.1 Contributors . . . 19
- 7.2 Thematic Introduction Linking to the Previous Studies . . . 19
- 7.3 Extended Summary . . . 20

8 Academic Self-Regulation, Chronotype and Personality during COVID-19 Restrictions 23
8.1 Contributors . . . 23
8.2 Thematic Introduction Linking to the Previous Studies . . . 23
8.3 Extended Summary . . . 24

9 General Results 25

10 General Discussion 27
10.1 Pandemic Influences on Sleep Parameters . . . 27
10.1.1 Sleep Duration . . . 27
10.1.2 Social Jetlag . . . 27
10.1.3 Circadian Rhythm Stability . . . 28
10.1.4 Daytime Sleepiness . . . 29
10.1.5 Sleep Timing Regularity . . . 31
10.1.6 Further Pandemic Effects on Sleep Health . . . 32
10.1.7 Summarizing Thoughts on the Discussion of the Pandemic Influences on Sleep Parameters . . . 33
10.2 Pandemic Influences on Performance Components . . . 33
10.2.1 Influences on Adherence to Work Phase Routines . . . 33
10.2.2 Influences on Creativity in Problem-Solving Approaches . . . 35
10.2.3 Influences of the Chronotype on Organizational Citizenship Behavior 37
10.2.4 Influences of Chronotype and Personality on Academic Self-Regulation 38
10.2.5 Summarizing Thoughts on the Discussion of the Pandemic Influences on Performance Components . . . 40

11 Identified Needs for Action in this Thesis 41

12 Outlook and Unresolved Research Questions 43

Literature 45

Annex 61
A Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office . . . 61
B Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic 69
C Onsite versus home-office: differences in sleep patterns according to workplace 79
D Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany . . . 89
E Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19 . . . 105

List of Abbreviations

AES	Aesthetic Sensitivity
AFECTS	Affective and Emotional Composite Temperament Scale
BAS	Behavioral Approach System
BFI-10	Big Five Personality Inventory with ten questions
BIS	Behavioral Inhibition System
BPNSFS	Basic Psychological Needs Satisfaction and Frustration Scale
BPN	Basic Psychological Needs
COVID-19	Coronavirus Induced Disease 2019
EOE	Ease of Excitation
EPI	Eysenck Personality Inventory
EV	Eveningness
FFFS	Fight/Flight/Freeze-System
HOG	Home-Office Group
IST	Irregularity in Sleep Timing
LST	Low Sensory Threshold
MA	Morningness
MESSi	Morningness Eveningness Stability Scale improved
ME	Morningness-Eveningness
MIPS	Millon Index of Personality Styles
MSFsc	Corrected Midpoint of Sleep
OCB	Organizational Citizenship Behavior
OG	Onsite Group
OWFH	Obligation to Work from Home
PDSS	Paediatric Daytime Sleepiness Scale
PHEIC	Public Health Emergency of International Concern
PSQI	Pittsburgh Sleep Quality Index
RST	Reinforcement Sensitivity Theory
rMEQ	Morningness Eveningness Questionnaire (reduced)
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus Type 2
SDT	Self-Determination Theory
$\mathbf{SD_{average}}$	Average Sleep Duration
SJL	Social Jetlag
SMR-LS	Skalen zur motivationalen Regulation beim Lernen im Studium
SPS	Sensory Processing Sensitivity
SQ	Sleep Quality
SSR	Social Sleep Restriction
STQ	Sleep Timing Questionnaire
STR	Sleep Timing Regularity
SVS	Subjective Vitality Scale
SWH	Splitting of Working Hours
TCI	Temperament and Character Inventory
WHO	World Health Organization

List of Publications in this Thesis

1. Staller, N., & Randler, C. (2021a). Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. *Somnologie*, *25*(2), 131–137. https://doi.org/10.1007/s11818-020-00277-2

   Throughout this thesis, this study will be referred to as the first study. The original journal article is attached as Annex A.

2. Staller, N., Kalbacher, L., & Randler, C. (2022). Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic. *Somnologie*, *26*(2), 98–105. https://doi.org/10.1007/s11818-022-00346-8

   Throughout this thesis, this study will be referred to as the second study. The original journal article is attached as Annex B.

3. Staller, N., Quante, M., Deutsch, H., & Randler, C. (2023). Onsite versus home-office: Differences in sleep patterns according to workplace. *Somnologie*. https://doi.org/10.1007/s11818-023-00408-5

   Throughout this thesis, this study will be referred to as the third study. The original journal article is attached as Annex C.

4. Staller, N., & Randler, C. (2022). Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany. *Biological Rhythm Research*, *53*(10), 1612–1625. https://doi.org/10.1080/09291016.2021.1988207

   Throughout this thesis, this study will be referred to as the fourth study. The original journal article is attached as Annex D.

5. Staller, N., Großmann, N., Eckes, A., Wilde, M., Müller, F. H., & Randler, C. (2021). Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19. *6*, 681840. https://doi.org/10.3389/feduc.2021.681840

   Throughout this thesis, this study will be referred to as the fifth study. The original journal article is attached as Annex E.

Summary

This thesis is concerned with chronotype dependent changes in sleep and performance components in students influenced by Coronavirus Induced Disease 2019 (COVID-19) policy measures. Five interrelated studies were conducted. The first study showed positive effects of remote working environments on sleep (increased sleep duration, decreased Social Jetlag (SJL)). The changes were attributed to the elimination of commuting time and more flexible working hours. The second study replicated these findings and showed a reduction in daytime sleepiness as a further positive effect on students' sleep. In addition to these positive effects, a loss of sleep timing regularity was reported. This negative effect on sleep was interpreted as a consequence of unlimited temporal flexibility regarding lecture times. In both studies, these changes were more pronounced as evening orientation increased. In the third study, sleep timing was reconsidered in two samples that differed in their working environment (onsite/remote working). No differences were found, suggesting that sleep timing is not affected by spatial flexibility. The fourth study showed that evening oriented individuals split their work time significantly more than their morning oriented peers in an environment of unrestricted temporal flexibility. Eveningness (EV) related negatively to scales that in turn have been shown to be positively associated with performance components (e.g., Organizational Citizenship Behavior (OCB), creativity in problem-solving approaches). These relationships were interpreted as a result of the limited interaction with peers and lecturers. The fifth study showed a relationship between Morningness (MA) and variables conducive to learning (vitality, self-efficacy, satisfied need for competence and conscientiousness), whereas EV was correlated with a more detrimental variable (frustrated need for autonomy).

Taken together, the results of the first three studies suggest that the sleep health of evening types could be improved by delaying social time constraints. To minimize negative side effects, temporal flexibility should be limited. In contrast, spatial flexibility had no effect on sleep timing regularity, but as a means of reducing time constraints, it offered the opportunity to promote positive changes in participants' sleep. Evening oriented individuals were particularly impaired by the reduction in social contacts, as they needed peer support to feel effective and creative.

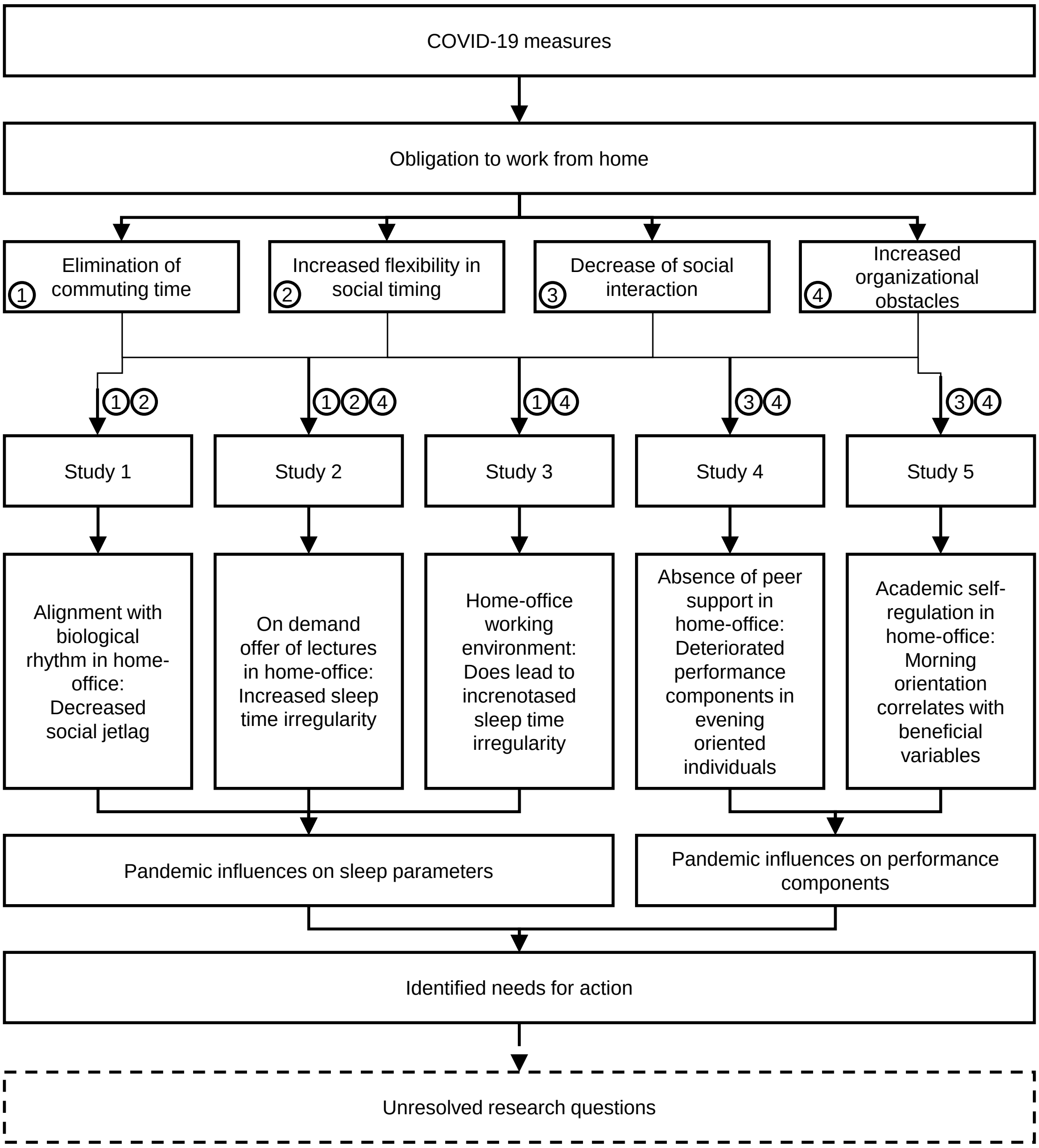
The second, fourth and fifth studies showed that evening oriented individuals were limited in their ability to cope with pandemic working environments, as some personality traits associated with evening orientation have been shown to have detrimental effects. Thus, classes that do not allow for peer interaction (such as recorded lectures), result in an educational disadvantage for evening oriented students. Therefore, in order to better support them in similar settings, exchange and interaction spaces need to be created and integrated into the teaching process. At a general level, students' Basic Psychological Needs (BPN) should be improved.

Zusammenfassung

Diese Dissertation befasst sich mit chronotypabhängigen Veränderungen von Schlaf- und Leistungskomponenten bei Schülern, bedingt durch Maßnahmen zum Schutz vor der Verbreitung von Coronavirus Induced Disease 2019 (COVID-19). Fünf miteinander verbundene Studien wurden durchgeführt. Die erste Studie zeigte positive Auswirkungen von Telearbeit auf den Schlaf (längere Schlafdauer, niedrigerer Social Jetlag (SJL)). Diese Veränderungen wurden auf den Wegfall der Pendelzeit und flexiblere Arbeitszeiten zurückgeführt. Die zweite Studie wiederholte diese Ergebnisse und zeigte zusätzlich eine Verringerung der Tagesmüdigkeit als weiteren positiven Effekt auf den Schlaf von Studierenden. Neben den positiven Effekten wurde jedoch auch ein Verlust der Regelmäßigkeit der Schlafzeiten festgestellt. Dieser negative Effekt auf den Schlaf wurde als Folge der uneingeschränkten zeitlichen Flexibilität hinsichtlich der Unterrichtszeiten interpretiert. In beiden Studien waren Individuen mit steigender Abendorientierung mehr von den Veränderungen betroffen. In der dritten Studie wurde das Schlaftiming bei zwei Stichproben, die sich in ihrem Arbeitsumfeld unterschieden (am Arbeitsplatz/im Home-Office), erneut untersucht. Es wurden keine signifikanten Unterschiede festgestellt, was darauf hindeutet, dass das Schlaftiming nicht durch räumliche Flexibilität beeinflusst wird. In der vierten Studie zeigte sich, dass abendorientierte Individuen in einem Umfeld mit uneingeschränkter zeitlicher Flexibilität dazu neigten, ihre Arbeitszeiten deutlich stärker aufzuteilen als ihre morgenorientierten Mitstudierenden. Darüber hinaus stand die Abendorientierung in einem negativen Zusammenhang mit Skalen, die wiederum positiv mit Leistungskomponenten assoziiert waren (z.B. Organizational Citizenship Behavior (OCB), Kreativität bei Problemlösungsansätzen). Diese Zusammenhänge wurden als Folge der eingeschränkten Interaktion mit Mitstudierenden und Dozierenden interpretiert. Die fünfte Studie zeigte einen Zusammenhang zwischen Morgenorientierung und lernförderlichen Variablen (Vitalität, Selbstwirksamkeit, Bedürfnisbefriedigung: Kompetenz und Gewissenhaftigkeit), während Abendorientierung mit einer eher hinderlichen Variable korrelierte (Bedürfnisfrustration: Autonomie).
Zusammenfassend deuten die Ergebnisse der ersten drei Studien darauf hin, dass die Schlafgesundheit von Abendtypen durch späteres soziales Timing verbessert werden kann. Um negative Nebeneffekte zu minimieren, sollte die zeitliche Flexibilität der Arbeitszeiten jedoch begrenzt werden. Die räumliche Flexibilität hatte keinen Einfluss auf die Regelmäßigkeit der Schlafzeiten, bot aber als Mittel zur Verringerung der zeitlichen Einschränkungen die Möglichkeit, positive Veränderungen im Schlafverhalten der Teilnehmer zu fördern. Abendorientierte Individuen waren besonders von der Reduzierung sozialer Kontakte betroffen, da sie die Unterstützung von Mitstudierenden benötigten, um sich effektiv und kreativ zu fühlen.
Die zweite, vierte und fünfte Studie zeigten, dass abendorientierte Individuen nur begrenzt in der Lage waren, mit den pandemischen Arbeitsbedingungen umzugehen, da manche, mit der Abendorientierung korrelierenden Persönlichkeitsmerkmale, in dieser Situation eher hinderlich waren. So führten z.B. Lehrveranstaltungen, die keine Interaktion mit Mitstudierenden und Dozierenden ermöglichten (beispielsweise aufgezeichnete Vorlesungen)

zu einer Bildungsbenachteiligung abendorientierter Studierender. Um sie in solchen Situationen besser zu unterstützen, müssen Räume für Austausch und Interaktion geschaffen und in den Lehrprozess integriert werden. Grundsätzlich sollten die Basic Psychological Needs (BPN) der Studierenden verbessert werden.

Graphical Abstract



Chapter 1

Introduction

After the novel Severe Acute Respiratory Syndrome Coronavirus Type 2 (SARS-CoV-2) caused the first known case of Coronavirus Induced Disease 2019 (COVID-19) in the Chinese city of Wuhan in early December 2019 (Wu & McGoogan, 2020), a Public Health Emergency of International Concern (PHEIC) was declared (January 30th, 2020; World Health Organization, 2020a). On March 11th, 2020, the spread of COVID-19 was then classified as a pandemic by the World Health Organization (WHO) due to the sharp increase in the number of cases and the global spread (in two weeks, the number of cases increased 13-fold and the number countries affected tripled; World Health Organization, 2020b). The immense public health risks posed by the virus prompted governments to enact measures against its transmission.

Despite the common objective, significant differences in the severity of the adopted measures occurred. In Europe, Italy was the first country where the COVID-19 figures threatened to overwhelm the health care system and the mortality rate spiraled out of control (Ghislandi et al., 2020). The population was strictly socially isolated and locked down. Until May 3rd, 2020, when some measures were eased, it was forbidden to leave the house except for essential tasks (such as purchasing food or medicine; Marelli et al., 2021).

Meanwhile, the number of cases across Europe increased rapidly. The strategies implemented to limit virus transmission varied considerably in terms of starting point (relating to case numbers in the country, not defined as time point) and stringency. They ranged from no restrictions at all to stringent and early restrictions (starting from low overall case numbers in the country). Defining success as the softest possible policy response that achieved both low infection and mortality rates, Norway may have been the most successful European country (Plümper & Neumayer, 2022).

Although, navigating through the pandemic without introducing a lockdown has been colloquially referred to as the 'Swedish way', there were four countries in Europe (Belarus, Iceland, Norway, Sweden) that did not introduce a lockdown or stay-at-home order. Despite the commonality of a no-lockdown policy, implementation in these countries varied considerably. In Belarus for example, the government under Alexander Lukashenko did not implement a COVID-19-adapted policy at all (Radchikova & Odintsova, 2021). The Swedish government, on the other hand, relied on recommendations rather than regulations (Emborg et al., 2021; Tegnell, 2021). The consequences were higher infection and mortality rates compared to peer countries, a significant proportion of which could probably have been prevented by an adapted policy (Modig et al., 2021). Norway decided to impose restrictions on public spaces (such as closure of educational institutions and cancellation of cultural events), but didn't impose a stay-at-home policy (Emborg et al., 2021).

Some countries tried to get through the pandemic without a strict lockdown but were forced to take a different approach. This resulted in a late response to the country's case load. The Republic of Ireland, for example, issued a stay-at-home order on March 27th, 2020. By that time, the number of COVID-19 infections in Ireland had already exceeded 2100 confirmed cases. If the Irish government had acted one week earlier, the peak infection number would have been 75% lower, according to calculations (Plümper & Neumayer, 2022).
Beyond countries that responded late, there were also countries that responded early, but the measures implemented were not sufficient to adequately limit transmission. As a result, the measures stringency had to be increased. In Germany for example, the COVID-19 policy started with a soft lockdown (e.g., recommendation to stay at home). This measure had to be further tightened later (staying at home was mandatory with certain exceptions) because it did not limit transmission as expected (Bundesministerium für Inneres und Heimat (BMI) & Bundesministerium für Gesundheit (BMG), 2020; Landesregierung: Baden-Württemberg, 2020; Ministerpräsidentenkonferenz, 2020a).
Infection control in Germany was managed at both a national and federal level depending on the number of infections. Therefore, measures varied across states. In terms of infection rates, Germany started early with soft restrictions (<5 cumulative infections per 100,000 inhabitants) (Plümper & Neumayer, 2022). In the first two weeks after the introduction of the measures, the number of infections increased (to >10 cumulative cases per 100,000 inhabitants), leading to a need for adjustment (Plümper & Neumayer, 2022).
The respective governments imposed curfews, contact restrictions and the closure of entire sectors of employment (e.g., body-related services) (Bundesregierung, 2020, 2021a; Merkel et al., 2020; Ministerpräsidentenkonferenz, 2020a, 2020b, 2020c, 2020d, 2020e). In addition, working from home was made compulsory for all activities not necessarily related to the workplace (e.g., office work, school, and university studies) (Bundesregierung, 2021b; Landesregierung: Baden-Württemberg, 2020; Ministerpräsidentenkonferenz, 2020e). This provision has been reported as 'Obligation to Work from Home (OWFH)'. In the following, this nomenclature will be used to describe the situation in which individuals could no longer work onsite (e.g., students after the closure of universities), regardless of the date the measure was introduced.
Despite differences in timing and scale, the common goal of governments worldwide was to limit viral transmission, reduce the burden on health systems, and avoid overburdening their infrastructure (e.g., number of ventilators or beds in intensive care units). In addition to the desired effects, there have been far-reaching consequences for other aspects of health (e.g., mental health, sleep health), the economy and social life. The impact of which cannot be assessed yet.

1.1 Secondary Effects of the COVID-19 Measures

The infection control measures had far-reaching secondary effects on the populations and public health. The OWFH, as implemented in Germany, and similar remote working measures, have been accompanied by major changes, four of which are considered here. First, commuting time was eliminated for a large proportion of the populations. This may have had an immense impact on public health, for example, by reducing stress (G. Costa et al., 1988; Gottholmseder et al., 2009) or benefiting sleep health (Pfeifer, 2018). There was also a reduction in traffic, followed by reduced noise and emissions as well as fuel savings (Harantová et al., 2022; Kylili et al., 2020), but private energy costs increased (Krarti & Aldubyan, 2021). The second change was greater flexibility in working hours, which many economic and educational sectors responded to the change with. Here, too, the potential for positive restructuring emerged, for example through a more individualized work-life balance, but negative outcomes were also possible, for example the inability to draw clear boundaries between work and private life due to the spatial concordance (Adisa et al., 2022; Yüceol et al., 2021). The third major change was the decline in social interactions. Contact with colleagues, classmates, and fellow students was now also suppressed. This drastic restriction was accompanied by deteriorating mental health (e.g., Pancani et al., 2021). The fourth impact considered here was the significant organizational barriers faced by the populations. These included a huge increase in screen time (Trott et al., 2022), for example, as physical meetings were replaced by videoconferencing. Moreover, caregivers' work and children's schooling had to take place at home at the same time. This created a double burden for caregivers (Gassman-Pines et al., 2022; Novianti & Garzia, 2020; Schmeer et al., 2023). Another difficulty was the increase in disruptions, such as family interruptions (Leroy et al., 2021).

Other secondary effects of infection control measures faced by populations worldwide include a decrease in physical activity and exercise (Tison et al., 2020), increased vulnerability to depression and anxiety (Bareeqa et al., 2021), increased rates of domestic violence (Piquero et al., 2021), and increased use of alcohol and other substances (A. Roberts et al., 2021). In general, the willingness to seek medical care decreased drastically, for example, because patients were afraid of contracting COVID-19 or did not want to place an additional burden on already overburdened medical staff (van Weert, 2020). This inevitably led to an initial decline in diagnoses of serious diseases. In Spain (Rodriguez-Leor et al., 2020) and Greece (Tsioufis et al., 2020), a sharp decline in myocardial infarction patients was reported. In the Netherlands, the same was reported for skin cancer diagnoses (Dinmohamed et al., 2020). As a result, the number of unrecorded cases and the mortality rate of known cases are likely to increase due to delayed treatment initiation.

Sleep also changed significantly during the pandemic, with about 40% of healthcare workers and the general population experiencing sleep problems, and an even higher prevalence among COVID-19 patients (Jahrami et al., 2021). In addition to the negative effects, some research groups have also shown improvements in sleep health due to better synchronization of circadian and social timing (see e.g., Cellini et al., 2020; Gao & Scullin, 2020; Leone et al., 2020; Marelli et al., 2021).

1.2 Pre-Pandemic Social Inequity Affecting Evening Types

Circadian preference refers to the time of day when an individual is able to perform physically and cognitively demanding tasks. It is either described in terms of distinct chronotypes (morning, neither and evening types) or as a score on a Morningness-Eveningness (ME) continuum. Although chronotype and ME are highly correlated with each other, they are not the same concept (Zavada et al., 2005). Nevertheless, these nomenclatures are often used synonymously, as in this thesis.

A daily routine that does not match this biological need leads to severe fatigue, poor performance, and health consequences (Adan et al., 2012). However, in our society, there is no equity in terms of the biological needs of different chronotypes. The social schedules are rather adapted to the needs of morning types (e.g., school and university schedules), leading to increasing impediment with delaying circadian preference (Evans et al., 2017; Kelley et al., 2015; Wittmann et al., 2006). As a result, a discrepancy between socially prescribed temporal norms and evening types' biological preconditions arises. This in turn leads to the development of a chronic sleep deprivation, called Social Jetlag (SJL) (Wittmann et al., 2006).

In addition to the SJL, Eveningness (EV) is associated with several other negative health outcomes. These are discussed as being caused by the consequences of social timing. One example is a significantly higher tendency to develop psychological problems (Kivelä et al., 2018; Staller & Randler, 2021c). Also, correlations with higher morbidity, higher rates of metabolic disorders and cardiovascular diseases have been shown (Merikanto et al., 2013; Reutrakul & Knutson, 2015; Yu et al., 2015). Knutson and Von Schantz (2018) associated a pronounced EV with an increased mortality rate in a large scale study ($N \approx 433.000$). The authors emphasized the need for more flexible working hours to mitigate the health consequences for evening types and thus added their voice to the scientific community's call for society to recognize the biological differences between chronotypes.
Another common discussion based on these demands is the adjustment of school and university schedules (see e.g., Evans et al., 2017; Kelley et al., 2015; Wahlstrom, 2016). Regardless of chronotype, a pronounced sleep deficit generally leads to a significant loss of cognitive functioning (McCoy & Strecker, 2011; Walker, 2008). The context of school environment explicitly targets this ability, resulting in a disadvantage for individuals with sleep deprivation and therefore evening types. This creates a barrier throughout their education, which has been shown to have a significant impact on academic performance (Arbabi et al., 2015; Kolomeichuk et al., 2016; Preckel et al., 2011; Randler & Frech, 2006; Roeser et al., 2013; Tonetti et al., 2015). Early school start times (Goldstein et al., 2007) and the resulting sleep deprivation (R. E. Roberts et al., 2009) were discussed as causes for this association.
EV is particularly pronounced in adolescents (Randler, Faßl, et al., 2017; Roenneberg et al., 2004; Roenneberg et al., 2003), who on average get less than optimal sleep per night on school nights (Hirshkowitz et al., 2015). Thus, poor sleep health is manifested in terms of short sleep duration in these individuals (Buysse, 2014). Sleep health consists of the dimensions (1) duration, (2) efficiency, (3) timing, (4) regularity and (5) alertness for the five-dimensional and (6) satisfaction/quality for the six-dimensional structure (Buysse, 2014; Ji et al., 2023; Wallace et al., 2021). Among other affected variables, impaired sleep health negatively impacts several facets of mental health, such as an increased risk of mental health problems and suicidality (Dewald et al., 2010; Wolfson & Carskadon, 2003). In line with these findings, evening orientation has been correlated with personality disorders as a facet of mental health problems (Staller & Randler, 2021c).
Good sleep health has been associated with positive effects on cognitive and emotional processes, followed by increased motivation, improved mood, and positive affect (Kahn et al., 2013; Yoo et al., 2007). It has also been shown to reduce stress and negative affect, and increase social engagement, alertness, and cheerfulness (Bouwmans et al., 2017). Objectively measurable indicators of good sleep, such as sleep duration or less activity during nocturnal sleep, have been associated with more positive relationships with others, more successful coping with the demands of daily life, and subjective feelings of purpose in life (Ryff et al., 2004). Also, higher quality of life and life satisfaction have been found to be associated with good sleep quality (Shin & Kim, 2018).
These positive effects of healthy sleep were particularly important during the pandemic and laid the foundation for the development of the studies conducted here. The lockdown severely restricted the population's freedom of choice, movement and contact with others. Daily life changed and so did the demands placed on the populations. This created a situation in which it was important to identify and implement factors that strengthen resilience.

Bazzani et al. (2021) showed a positive association between Sleep Quality (SQ) and resilience, and a negative association between SQ and post traumatic stress reactions. EV and female sex have been shown to be predictors of lower resilience and poorer SQ (Bazzani et al., 2021). The authors suggested that SQ is a mediator between resilience and chronotype, as well as between resilience and post-traumatic stress reactions (controlling for age and sex; Bazzani et al., 2021). These results indicate that SQ could be used as a successful lever to strengthen the resilience of the populations. As evening types have been shown to be a vulnerable subgroup (Bazzani et al., 2021), it is important to improve their SQ to help them cope with the pandemic situation.

1.3 Chronotypes in Relation to Individual Differences in Personality

In addition to the sleep deprivation and the resulting consequences due to social timing that evening types experience, they also differ from their morning type peers in terms of other characteristics. For example, their mating behavior. Evening types have been shown to have higher mating success (Gunawardane et al., 2011; Piffer, 2010; Randler, Ebenhoeh, et al., 2012; Staller & Randler, 2021b), whereas morning types have been shown to have higher reproductive success (Kasaeian et al., 2019; Staller & Randler, 2021b).
Another facet chronotypes have been reported to differ in is creativity and creative thinking. Evening types were shown to score higher in both (Caci et al., 2004; Facer-Childs et al., 2019; Giampietro & Cavallera, 2007). This is also evident in the evaluation of how chronotypes score on the Millon Index of Personality Styles (MIPS). Díaz-Morales (2007) showed an association between EV and thinking styles which could be defined as 'creative' (imaginative/intuiting, feeling-guided, innovation-seeking). Morningness (MA) again, has been associated with thinking styles that could be defined as 'clearly structured and less creative' (realistic/sensing, thought-guided, conservation-seeking) (Díaz-Morales, 2007). In terms of behavior, it has been shown that evening orientated individuals have an unconventional style and morning orientated individuals have a dutiful style (Díaz-Morales, 2007).
In addition, chronotypes differ in Sensory Processing Sensitivity (SPS), one of the dimensions of which is also concerned with creativity. Individuals who manifest this trait are more likely to react to stressors and, as a result, have a higher response level (Jagiellowicz et al., 2016). The SPS model of Smolewska et al. (2006) measures three scales: (1) Low Sensory Threshold (LST), (2) Ease of Excitation (EOE), (3) and Aesthetic Sensitivity (AES). A high value of LST is associated with a low threshold of overstimulation by external stimuli (e.g., bright light), whereas EOE can be triggered by both external and internal stimuli (e.g., stress from multitasking) (Smolewska et al., 2006). LST and EOE are both related to negative emotionality. AES is associated with positive emotionality and can be stimulated, for example, by the enjoyment of art or music (Smolewska et al., 2006).
Staller, Randler, et al. (2023) examined the relationship between SPS and chronotype. In this study, MA has been correlated with LST, while EV has been correlated with AES (and marginally significantly with EOE) (Staller, Randler, et al., 2023). This reinforced the findings described above regarding the relationship between EV and creativity.
Among other possibilities, the reason for this distinction is discussed in terms of the relationship between each chronotype and their correlating personality traits. Studies of chronotype and personality have used a variety of personality inventories (Adan et al., 2012; Tsaousis, 2010).

Early studies mainly used the Eysenck Personality Inventory (EPI) (Eysenck & Eysenck, 1963). In their review, Adan et al. (2012) reported that EV was more strongly related to extraversion and psychoticism than MA using the EPI. It was suggested that the relationship of EV and the psychoticism dimension may indicate a correlation of EV with psychopathology (Adan et al., 2012). The results for neuroticism were inconclusive (Adan et al., 2012).

The 'Big Five' is the most widely used model for examining differences in chronotype and personality. Inventories that assess the general personality traits addressed by the Big Five consist of the following dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness (P. T. Costa & McCrae, 2008). In some studies, this model has shown a stronger relationship between extraversion and EV than MA (Adan et al., 2012; Lipnevich et al., 2017; Randler et al., 2014). Others have shown MA to correlate with extraversion (see e.g., Randler, Schredl, et al., 2017; Ruffing et al., 2015; Staller & Randler, 2021c). Neuroticism (Adan et al., 2012; Gorgol et al., 2022) and openness (Adan et al., 2012; Lipnevich et al., 2017; Randler, Schredl, et al., 2017; Staller & Randler, 2021c) have been shown to correlate with EV. MA, in turn, has been correlated with agreeableness and conscientiousness (Adan et al., 2012; Stevenson et al., 2022; Tsaousis, 2010). The latter has been shown to predict MA the best (Adan et al., 2012; Lipnevich et al., 2017; Staller & Randler, 2021c).

Using the Temperament and Character Inventory (TCI), evening types showed more novelty seeking and less harm avoidance on the temperament dimensions (Adan et al., 2012). Morning types have been shown to score higher on persistence (Adan et al., 2012). No correlation with reward dependence has been reported. The character dimensions have shown lower scores for cooperation and self-directedness and higher scores for self-transcendence in evening types (Adan et al., 2012).

Also, morning types have been reported to show lower impulsivity scores than their evening type peers (Adan et al., 2012; Muro et al., 2012; Russo et al., 2012). In a study using the Affective and Emotional Composite Temperament Scale (AFECTS), evening types were shown to have a less adaptive emotional profile (Ottoni et al., 2012). Here, the facets of control, volition, inhibition and coping were reported to be particularly low in evening types and high in morning types (Adan et al., 2012; Ottoni et al., 2012).

In summary, using various personality inventories, it has been shown that evening oriented individuals are more extraverted, impulsive, novelty seeking, open-minded, and prone to psychopathology (Adan et al., 2012). Morning oriented individuals have been reported to be more introverted, conscientious, agreeable, persistent and emotionally stable (Adan et al., 2012).

1.4 A Biologically-Based Approach to Explaining Differences in Coping Behavior Among Chronotypes

Evening types have been shown to have weaker coping mechanisms for problems related to environmental and social demands (Mecacci & Rocchetti, 1998) and higher levels of stress (Roeser et al., 2012; You et al., 2020). One personality concept that incorporates these variables by their nature as aversive stimuli, is the revised Reinforcement Sensitivity Theory (RST) (Corr, 2008).

This theory is based on responses to rewarding and punishing stimuli. It conceptualizes three dimensions, (1) the Fight/Flight/Freeze-System (FFFS), (2) the Behavioral Inhibition System (BIS), and (3) the Behavioral Approach System (BAS). The FFFS mediates responses to unconditioned and conditioned aversive stimuli (Corr, 2008). The

BIS conceptualizes negative feedback for anxiety-related conflict resolution (Corr, 2008), and is thought to determine individual differences in SPS, highlighting the interrelatedness of personality (Aron & Aron, 1997). The BAS mediates responses to conditioned and unconditioned appetitive stimuli (e.g., impulsivity and reward orientation; Corr, 2008).
The revised RST is used by the BIS/BAS-Inventory (Carver & White, 1994; Randler et al., 2014), which was used to examine the relationship between BIS/BAS and chronotype by Randler et al. (2014). In this study, BAS Drive has been positively related to MA, whereas BAS Fun Seeking has been positively related to EV. Using midpoint of sleep as a clock time based chronotype measure, BIS Fear has been shown to be related to MA (Randler et al., 2014).
Consistent with these findings, evening orientation has been related to negative affect (e.g., Carciofo, 2020a) and mental health problems (e.g., Ahn et al., 2008; Au & Reece, 2017; Giglio et al., 2010; Randler, Stadler, et al., 2012; Staller & Randler, 2021c). In addition, it has been repeatedly reported that EV is associated with behavioral and adjustment problems, addictions such as substance and mobile phone use (see e.g., Díaz-Morales & Sánchez-López, 2008; Goldstein et al., 2007; Hidalgo & Caumo, 2002; Lange & Randler, 2011; Negriff et al., 2011; Randler, 2008a; Staller & Randler, 2021c), dark triad traits and risk-taking behavior (Maestripieri, 2014; Rahafar et al., 2017). Morning orientation, in turn, has been related to positive affect, well-being (see e.g., Biss & Hasher, 2012; Carciofo, 2020b; Jankowski, 2012; Lázár et al., 2012; Randler, 2008b; Randler & Weber, 2015) and proactivity (Randler, 2009). Morning oriented individuals have further been reported to be less prone to indecision and procrastination (Díaz-Morales et al., 2008), traits that have been shown to be associated with low conscientious individuals.
The relationship between evening types and negative emotionality has been argued to be due to the low levels of MA that follow evening orientation (see e.g., Carciofo, 2020b; Jankowski, 2016; Konttinen et al., 2014; Putilov, 2018). High levels of MA in individuals has been correlated with low neuroticism and high conscientiousness, which is further related to life satisfaction (Drezno et al., 2019). Low conscientiousness and high neuroticism have been related to EV, poor SQ, depression, and anxiety (Duggan et al., 2014; Kotov et al., 2010). In summary, these differences suggest difficulties in coping with the effects of the pandemic and subsequent changes in living conditions for evening types.

1.5 Self-Determination Theory in Academic Self-Regulation During the Pandemic

The pre-pandemic literature has not shown clear advantages or disadvantages of online versus face-to-face instruction (for meta-analyses see e.g., Bernard et al., 2004; Machtmes & Asher, 2000; Means et al., 2013; M. Schneider & Preckel, 2017; Zhao et al., 2005), but it has been suggested that hybrid forms may have small advantages over face-to-face instruction (Means et al., 2013; M. Schneider & Preckel, 2017). In synchronous scenarios, higher mean achievement effect sizes were shown in face-to-face versus online teaching settings, while online teaching settings showed higher scores in asynchronous scenarios (Bernard et al., 2004).

The lockdown created a situation where online education had to be implemented without a strategic plan to address the negatives. As the pandemic unfolded, the lack of concept to avoid the known disadvantages of online teaching scenarios led to issues of learner diversity becoming apparent, requiring different approaches to online teaching and learning (Doucet et al., 2020). Scott et al. (2021) summarized that the most commonly reported challenges by students included difficulties with motivation and productivity, time management, and declining mental and physical health.

This suggests underlying difficulties beyond the implementation of online instruction. A causal aspect for students' academic self-regulation and thus their learning success is Basic Psychological Needs (BPN) satisfaction, as considered in the Self-Determination Theory (SDT) (Deci & Ryan, 2013; Ryan & Deci, 2000). Students who have experienced trauma (such as the COVID-19 pandemic) may not have the emotional capacity to focus on learning because they are focused on meeting these needs. SDT considers competence, autonomy, and relatedness to be BPN.

BPN competence describes the need to feel able to perform tasks effectively according to one's own standards and those of the social environment. This need can be satisfied by positive evaluation of outcomes by others (e.g., through feedback from lecturers). BPN relatedness refers to the need to maintain an emotional connection and interaction with the environment and can be satisfied, for example, when lecturers and peers create a supportive and sharing environment (Klassen et al., 2012; Zaccoletti et al., 2020). BPN autonomy describes the need for individuals to feel that their choices shape their reality. However, this need can be met even when an individual's independence and individuality are restricted (Chirkov et al., 2003), as was the case during the pandemic lockdown. To achieve this, the individual must understand the reason for the required behavior, recognise the need for it and perceive the severity of the action as appropriate (Chirkov et al., 2003). In a learning context, BPN autonomy can be satisfied, for example, by understanding why certain tasks are required, that they are necessary to achieve a defined goal, that the work is meaningful and that it can be done in a self-determined way (Reeve, 2018).

In addition, the examination of BPN frustration goes beyond lack of satisfaction and shows when inhibiting or suppressing effects are placed on BPN (B. Chen et al., 2015). Therefore, high satisfaction and low frustration in BPN are important for creating an environment where students have the resources they need to learn successfully (Vansteenkiste & Ryan, 2013). Moreover, the levels of these two variables have a decisive influence on other variables, such as motivation (Ryan & Deci, 2017; Vansteenkiste et al., 2020), vitality (Núñez & León, 2016; Ryan et al., 2010; Ryan et al., 2006), and self-efficacy (Gist, 1987). For example, as perception of control decreases, so does intrinsic motivation (Zuckerman et al., 1978).

Together, the variables BPN satisfaction and frustration, vitality, self-efficacy and motivational regulation account for academic self-regulation in this thesis. Individuals with low scores on these variables, and thus low levels of academic self-regulation, may have had more difficult learning conditions and less learning success during the pandemic. Chronotype may be causal to such differences.

Chapter 2

Research Objectives

While the OWFH was in place, only those sectors of economy necessary to maintain public life and health, such as supermarkets, pharmacies, medical services, and medical technology companies, were allowed to work onsite. These economic sectors were called system relevant. For not-system relevant economical sectors commuting time was eliminated, working hours became more flexible, social interactions decreased and organizational barriers arose. As a result, a large part of the population was able to adapt their daily routine to their circadian needs, but negative developments were also reported (e.g., effects on mental health as a consequence of the decline in social interactions). Given the unprecedented scale of the pandemic and the measures taken to contain it, it is not clear to what extent existing knowledge about behavior (e.g., sleep, coping, learning) is transferable to this situation.
In order to address these research gaps, this thesis reviews differences between chronotypes in coping with the novel situation in terms of students' sleeping and working behavior. The pandemic provided an opportunity for sequential studies of sleep parameters, chronotype and personality relating to aspects of the educational process. The aim of this paper was to assess environmental changes affecting these variables. Particular emphasis was placed on differences attributable to chronotype. The design comprises a total of five interrelated studies, the reported results of which build on each other. The evaluation targeted a better understanding of students' spatial and temporal needs.
Some of the studies presented as part of this thesis assessed samples composed of students and employees. These are the first and fourth studies with the same sample (students: $N = 400$; employees: $N = 281$) and the third study (students: $N = 32$; employees: $N = 37$). The second ($N = 637$) and fifth ($N = 228$) studies focused on students only. In all five studies a total of $N = 1621$ individuals were considered, of whom $78,9\%$ ($N = 1279$) were students. The results for employees are not part of this summarizing work and are therefore not further considered or contextualized here. When not explicitly referring to employees in this paper, the term 'work', 'working time' and the like refers to the tasks and work associated with students' studies.

The first study examined whether the reduced stringency of prescribed working hours was accompanied by a reduction in sleep deprivation and SJL.

1. Hypothesis: Sleep and sleep timing tends to approach the biological needs during the changed circumstances, having a health-promoting effect (Staller & Randler, 2021a).

The effects of the flexibility of lecture times on sleep timing were examined in the second study. The quality of students' sleep before and during the pandemic was compared. A possible relationship between flexibility of teaching and sleep/wake times was assessed.

2. Hypothesis: A relationship between the flexibility of lecture times and sleep/wake times exists during lockdown, leading to a convergence of social and biological times, decreased SJL, and increased Irregularity in Sleep Timing (IST)(Staller et al., 2022).

The third study examined differences in sleep parameters between a sample working remotely and a sample commuting to work. In addition, intrapersonal differences between the week and at the weekend were considered. The data was obtained using actigraphy, thus adding a reliable physiological method to the results obtained from questionnaire studies.

3. Hypothesis: At workdays the Home-Office Group (HOG) shows improved sleep parameters in regard to circadian preference (later midpoint of sleep, longer total sleep time, lower SJL), but deteriorated sleep efficiency due to greater flexibility of sleep times compared to the Onsite Group (OG) (Staller, Quante, et al., 2023).

After assessing the changes in sleep time and subsequent consequences, the fourth study investigated changes in working environment characteristics and personal engagement. Work and break times, creativity in problem-solving approaches and Organizational Citizenship Behavior (OCB) were considered.

4. Hypothesis: A working environment with flexible workplace and working hours as well as reduced supervision leads to a deterioration of performance components in evening types, while morning types show an improvement of the latter (Staller & Randler, 2022).

In the fifth study, the students' ability to cope with online learning was then examined. Facets of BPN satisfaction and frustration, motivational regulation, vitality and self-efficacy were assessed in relation to chronotype and personality.

5. Exploratory research agenda on personality and chronotype based on previous findings from traditional classroom practice (Staller et al., 2021).

Following these studies, the results obtained were evaluated in the light of the current literature. On this basis, needs for action that arose from the experience of online teaching during the pandemic were proposed and research gaps identified, which are suggested as a starting point for further research.

Chapter 3

Research Methods

Table 1 briefly presents the methods used throughout the study project to provide an overview of the data collection measures. The Table is ordered alphabetically and indicates the sub-studies in which the methods were used.

Table 1: Methods used throughout the study project.

Method	Description	Source	Study
Actigraphy	Actigraphy is a measurement method for the physiological monitoring of sleep parameters and activity levels. The data was evaluated according to the manufacturer's manual.	ActiGraph, 2013	3
Average Sleep Duration ($SD_{average}$) (calculated value)	The $SD_{average}$ indicates the mean value of the sleep duration over the whole week, whereby weekdays and weekend days are factored in differently.	Roenneberg et al., 2004	2
Basic Psychological Needs Satisfaction and Frustration Scale (BPNSFS)	The BPNSFS assesses the satisfaction and frustration of the dimensions of need for autonomy/competence/social relatedness.	Heissel et al., 2018	5
Big Five Personality Inventory with ten questions (BFI-10)	The BFI-10 examines two items each for the Big Five dimensions extraversion, agreeableness, openness, neuroticism, and conscientiousness.	Rammstedt and John, 2007; Rammstedt et al., 2013	4, 5
Corrected Midpoint of Sleep (MSFsc) (calculated value)	The MSFsc indicates the corrected midpoint of sleep including individual sleep need, whereby weekdays and weekend days are factored in differently.	Roenneberg et al., 2004	1-3
Morningness Eveningness Questionnaire (reduced) (rMEQ)	The rMEQ is a chronotype measure asking a total of five questions on sleep timing, peak performance, morning affect and self-assessment of chronotype.	Adan and Almirall, 1991	5

Continued on next page

Table 1 – continued from previous page

Method	Description	Source	Study
Morningness Eveningness Stability Scale improved (MESSi)	The MESSi is a chronotype measure consisting of three subscales (morning affect/EV/distinctness) asking a total of five questions per subscale.	Randler et al., 2016	1-4
OCB Instrument	The OCB questionnaire has a five-factor structure with five items representing every factor respectively (altruism, conscientiousness, sportsmanship, civic virtue, in-role behavior).	Staufenbiel and Hartz, 2000	4
Paediatric Daytime Sleepiness Scale (PDSS)	The PDSS assesses daytime sleepiness in students with a total of eight items. Two of these are related to a school/ learning environment.	A.-M. Schneider and Randler, 2009	2
Pittsburgh Sleep Quality Index (PSQI)	As a self-reported inventory the PSQI measures sleep variables in retrospect (four weeks) raised by 19 items. We did not use the five externally assessed items.	Buysse et al., 1989	2
Self-Efficacy Instrument	The self-efficacy scale includes seven items in a seven-point Likert format.	Jerusalem and Schwarzer, 1986	5
Skalen zur motivationalen Regulation beim Lernen im Studium (SMR-LS)	The SMR-LS instrument contains the four subscales intrinsic motivational regulation; identified motivational regulation; introjected motivational regulation, which is further divided into approach/avoidance type; and external motivational regulation.	Thomas et al., 2018	5
Sleep Timing Questionnaire (STQ)	The STQ raises data on individual sleep timing (weekdays/ weekends), sleep schedule stability and frequency/ duration of awakenings during the night with a total of 18 items.	Monk et al., 2003	2
SJL (calculated value)	SJL quantifies the difference of weekday and weekend midpoint of sleep and thus defines the discrepancy between the circadian preference and social temporal norms.	Wittmann et al., 2006	1-3
Subjective Vitality Scale (SVS)	The SVS scale raises data with seven items on vitality in a seven-point Likert format as a self-assessment instrument.	Ryan and Frederick, 1997	5

Chapter 4

Chronotype and Sleep while Working Remotely under COVID-19 Restrictions

The study summarized here, “Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office”, was published in the journal ‘Somnologie’ by Staller and Randler (2021a). The original version of the published article is attached as Annex A.

4.1 Contributors

The authors and their respective contributions to the research are presented in Table 2.

Table 2: Contributors of the first study.

Author	Author Position	Scientific ideas (%)	Data generation (%)	Analysis & interpretation (%)	Paper writing (%)
Staller, N.	1	80	100	50	80
Randler, C.	2	20	0	50	20

4.2 Extended Summary

To reduce the spread of COVID-19, the German government implemented various measures that have significantly restricted the population in many areas of public and private life. These included the introduction of an OWFH for non-essential workers and students. The OWFH led to more flexible working hours and the complete elimination of commuting time for a large proportion of the population. The time previously spent commuting could therefore be spent differently.

Research goals. The changes in the daily routine due to the OWFH could have had a positive effect on health, as it may have resulted in a later wake-up time and therefore longer sleep duration. The latter may have had a particular effect on evening oriented individuals. As they could have experienced a shift away from socially expected sleep-wake times towards their own biological sleep rhythm. This is particularly the case if, in addition to the elimination of commuting time, working hours had become more flexible.

Chronobiological research has repeatedly shown the disadvantages of strict social schedules for evening oriented individuals. They not only have been shown to be affected in their performance (Arbabi et al., 2015; Didikoglu et al., 2022; Kolomeichuk et al., 2016; Randler & Frech, 2006), but also their health (Fabbian et al., 2016; Partonen, 2015). In this study it was hypothesized that sleep hygiene in terms of sleep timing improved, and SJL decreased in evening oriented participants.

Methods. Changes in several sleep parameters in relation to working hours before and during lockdown in Germany were investigated. The study sample was restricted to participants who worked from home. Data on demographics (age, sex, household size, number of children in the household, profession, working hours), sleep parameters (bedtime and wake time during the week/on days off before and during the restriction period) and the MESSi as a measure of chronotype were collected. The raised sleep data were used to calculate sleep duration, midpoint of sleep and changes in sleep behavior.

Results. In the data set collected during the COVID-19 restriction period, the study sample showed health promoting changes in sleep parameters: sleep timing improved and SJL decreased. The value of the negative correlation between EV and sleep duration during the workweek decreased somewhat, but MA showed a negative correlation with sleep duration during the workweek (which was previously a positive correlation). Circadian preference and clock time based chronotype were shown to remain stable. In addition, sleep phase delay influenced by MA/EV and children living in the same household was shown. MA was negatively associated, whereas EV and co-residence with children were positively associated with sleep phase delay in the pandemic dataset.

Discussion. The significant changes in sleep-wake schedules and sleep duration during the remote working phase indicate a synchronization of the biological and social rhythms in evening oriented participants. Morning oriented individuals showed few changes in their sleep timing, as the default timing was more in line with their biological time. The results also showed negative effects of early school start times on children and caregivers.

Conclusion. This study underlined again that social pressure and strict working hours are detrimental to the health of a significant proportion of the population.

Chapter 5

Learning Behavior and Sleep in German Students during COVID-19 Restrictions

The study summarized here, "Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic", was published in the journal 'Somnologie' by Staller et al. (2022). The original version of the published article is attached as Annex B.

5.1 Contributors

The authors and their respective contributions to the research are presented in Table 3.

Table 3: Contributors of the second study.

Author	Author Position	Scientific ideas (%)	Data generation (%)	Analysis & interpretation (%)	Paper writing (%)
Staller, N.	1	40	0	55	80
Kalbacher, L.	2	40	100	25	10
Randler, C.	3	20	0	20	10

5.2 Thematic Introduction Linking to the Previous Study

The pandemic environment led to profound changes in the lives of the population, over and above the changes in commuting conditions discussed in the first study. Students were a group strongly affected by the restructuring on several levels. Following the closure of educational institutions as a result of the OWFH, lectures had to be held digitally via various videoconferencing systems or as recordings. This led to some lectures being offered at fixed times, similar to 'traditional' teaching, and others being available on demand. There are both positive and negative aspects to this move to online teaching. On the negative side, there has been a sharp decline in social interaction in general and a loss of interaction with fellow students and lecturers in particular. Yet, with the elimination of commuting time and more flexible lecture times, sleep parameters have consequently improved (Study 1). As an extension to the first study, this study was explicitly concerned with changes in students' lives brought about by online teaching.

5.3 Extended Summary

Research goals. The focus of this study was the relationship between sleep and lecture times. The question on flexibility of working hours (Study 1) was extended to include an assessment of fixed time versus on-demand lectures. Also, changes in students' sleep parameters as a result of governmental policies were examined. A relationship between the flexibility of lecture times and the flexibility of sleep and wake times during lockdown was hypothesized: On-demand teaching leads to more flexible and therefore less regular sleep schedules. Furthermore, it was expected to replicate the results in terms of bed/wake times and SJL reported in the first study.

Methods. The survey consisted of validated questionnaires (MESSi, PSQI, STQ, PDSS and additional questions. The latter elicited data on demographics, highest educational attainment (type, year, and state of attainment) and the lecture time options offered (five-point Likert scale ranging from fixed lecture times to on demand lectures). The data were collected in two different sampling periods, the first before and the second during the lockdown. This distinguishes the present and first datasets, as the pre-lockdown data collected in the first study was queried retrospectively.

Results. An increase in sleep duration, and a consequent decrease in SJL and sleep deficit were shown, confirming the findings of the first study. Also, in the sample a reduction in the incidence of daytime sleepiness was reported. A relationship between flexibility of lecture and sleep times was shown.

Discussion. The results presented here suggest that the asynchronous learning arrangements during the lockdown had positive effects on sleep (e.g., approximation to the intrinsic biological rhythm, reduction of daytime sleepiness), but were also associated with an increased IST. Research on regular sleep schedules has shown that increased IST is associated with an increase in serious health problems (e.g., Boivin & Boudreau, 2014; Huang et al., 2020).

Conclusion. As a result of the changes brought about by the implementation of online learning, students' sleep patterns changed significantly. An irregularity in sleep and learning times was observed, which could have affected learning performance and overall quality of life.

Chapter 6

Differences in Sleep Patterns According to Workplace

The study summarized here, “Onsite versus home-office: differences in sleep patterns according to workplace”, was published in the journal ‘Somnologie’ by Staller, Quante, et al. (2023). The original version of the published article is attached as Annex C.

6.1 Contributors

The authors and their respective contributions to the research are presented in Table 4.

Table 4: Contributors of the third study.

Author	Author Position	Scientific ideas (%)	Data generation (%)	Analysis & interpretation (%)	Paper writing (%)
Staller, N.	1	70	100	70	70
Quante, M.	2	10	0	10	10
Deutsch, H.	3	0	0	10	10
Randler, C.	4	20	0	10	10

6.2 Thematic Introduction Linking to the Previous Studies

As a result of the classification to system relevant and not-system relevant economical sectors sleep habits changed: Evening types were able to synchronize their biological and social timing (Studies 1-2), and IST increased with temporal flexibility (Study 2).

6.3 Extended Summary

Research goals. The purpose of this study was to compare two different working environments (onsite and remote) and examine how these affected participants’ sleep patterns. The results extended those of the first and second study in two ways: first, by including onsite workers and second, by using actigraphy, a robust physiological data collection method as an extension to questionnaires. The sleep parameters of the two groups were (1) examined in relation to each other, and (2) within each group comparing weekdays and weekend days. The assumption regarding sleep timing (on-demand teaching leads to increased IST) made in the second study was reconsidered examining another possible influencing factor. Here, the influence of working environment was investigated. Later sleep timing and midpoint of sleep, as well as longer nocturnal sleep duration, less SJL, and poorer sleep efficiency in the HOG was hypothesized.

Methods. A total of 75 participants working onsite ($N = 40$) or remote ($N = 35$) were surveyed between December 2020 and January 2022. Participants provided data on demographics (working environment (OG/HOG), age, sex, number of children in the household, profession) and completed the MESSi as chronotype measure. They wore an actigraph (GT3X+, ActiGraph, Pensacola, FL, USA) for seven consecutive days to record sleep parameters. Data collection was supplemented by a sleep diary in which participants reported their bedtimes and rise times, sleep phases during the day, nighttime awakenings (frequency and duration), and the times at which the actigraph was filed. Actigraphic data were analyzed using the accompanying software (ActiLife, Pensacola, FL, USA) according to the manufacturer's manual (ActiGraph, 2013). The Cole-Kripke algorithm was used to estimate sleep and wake times (Cole et al., 1992). The Troiano algorithm (Troiano et al., 2008) was used in conjunction with the sleep diary to determine non-wear times. From the data obtained, the MSFsc (as a second measure of chronotype), SJL and sleep efficiency were calculated.

Results. Overall, the HOG had later bedtimes, midpoints of sleep and rise times on weekdays compared to the OG. No differences in terms of Sleep Timing Regularity (STR) were shown between the groups. Differences on weekdays compared to weekends were seen in each group. In the HOG, bedtime, midpoint of sleep, rise time, and sleep efficiency were significantly different on weekdays compared to weekend days. The OG showed differences in these variables, as well as in total sleep time. HOG workers had a higher sleep efficiency on weekends compared to weekdays, while OG workers had a higher sleep efficiency on weekends compared to weekdays.

Discussion. The two groups differed significantly in age, with the HOG being on average 4.5 years younger than the OG. An examination of the chronotype distribution and SJL showed that the values for the OG could not be considered representative, as they deviated significantly from the expected range. The SJL in the HOG could be considered representative of a comparable sample in terms of age and working environment. This leads to the conclusion that moving to remote working is associated with a reduction in SJL. The flexibility of sleep times did not differ between the groups. The data suggest that working environment is not a predictor of increased IST. The hypothesis in the second study that 'with increasing flexibility in lecture times, IST also increases' was supported by the exclusion of spatial flexibility as another possible factor. Furthermore, overall sleep efficiency did not differ between the groups, but inter-individual differences were seen comparing weekdays and weekend days. The composition of the score differed between the groups. Although significant, this finding is not clinically meaningful.

Conclusion. Working from home had a positive effect on the synchronization of social and biological timing. This reduced SJL, which benefited participants' sleep and health. The sleep efficiency between groups did not differ, although the scores are composed differently in each group. The groups flexibility of sleep and wake times was comparable. The results in this study suggest that the working environment is not a causal factor in the increased IST.

Chapter 7

Chronotype and Organizational Citizenship Behavior during COVID-19 Restrictions

The study summarized here, "Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany", was published in the journal 'Biological Rhythm Research' by Staller and Randler (2022). The original version of the published article is attached as Annex D.

7.1 Contributors

The authors and their respective contributions to the research are presented in Table 5.

Table 5: Contributors of the fourth study.

Author	Author Position	Scientific ideas (%)	Data generation (%)	Analysis & interpretation (%)	Paper writing (%)
Staller, N.	1	80	100	50	80
Randler, C.	2	20	0	50	20

7.2 Thematic Introduction Linking to the Previous Studies

In the first three studies, the impact of the elimination of commuting time (Study 1), the increased flexibility of working hours (Studies 1-2), and the working environment (Study 3) on sleep were considered. It is likely that besides sleep, other factors have also been affected by the OWFH. The findings in the second and third studies suggest that the increased IST in students is related to temporal flexibility. This raised the questions: (1) of what personality traits or transversal competences (such as effective self-management) might be causing this phenomenon and (2) were individuals exhibiting these traits further challenged by decreasing extrinsic control mechanisms (e.g., social interactions in everyday life).

7.3 Extended Summary

Research goals. From a biological point of view, evening types benefit from flexible working environments (temporal/spatial), but these may be less beneficial in terms of performance components. The ability to work with temporal flexibility may lead to lower performance due to the lack of extrinsic control mechanisms. This hypothesis is supported by the association of morning types with traits that have a positive effect (e.g., proactivity; Randler, 2009) and evening types with traits that have a negative effect on performance (e.g., procrastination; Díaz-Morales et al., 2008). It was expected that evening types' performance is more dependant on peer support and fixed structures than morning types' performance. Moreover, changes in work-related transversal competences in relation to circadian preference were hypothesized.

Methods. Participants were asked about their demographics (age, sex, household size, number of children in the household, profession and whether they worked flexible hours). The self-report version of the German OCB scale by Staufenbiel and Hartz (2000) was administered. In addition, changes in two transversal competences were asked about in open questions. First, participants' adherence to work phase routines was assessed in terms of the number and duration of work phases and corresponding breaks (Splitting of Working Hours (SWH)). This was raised as a facet of self-regulation/self-management. Changes in, for example, the duration of work phases may indicate low self-regulation in the form of higher distractibility. Reported data was later grouped in 'same working hours' and 'more and/or longer breaks'. Second, self-perceived changes in problem-solving creativity due to changes in the working environment were examined ('creativity in problem-solving approaches').

Results. A positive relationship was found between MA and the OCB facets of conscientiousness, civic virtue, and in-role behavior. In addition, morning oriented individuals rated themselves as more creative in their problem-solving approaches during the OWFH than before. They also showed a negative relationship with the grouped variable 'more and/or longer breaks'. Evening oriented individuals, on the other hand, showed a negative relationship with conscientiousness, in-role behavior, and creativity, but a positive relationship with 'more and/or longer breaks'. The link between chronotype and OCB is further underlined by the correlation of chronotype with the respective Big Five traits and these, again, with OCB.

Discussion. The data on OCB suggest that morning oriented individuals are more invested in their work than evening oriented individuals. In addition to the asynchrony of biological and social timing and the resulting sleep deficit (see studies 1-2), these findings may point to another cause for the comparatively lower academic performance of evening types. As the OCB questionnaire is based on self-report, the results could also be interpreted differently. It is possible that even with the same level of engagement, evening types still felt that they were not fully using their potential. The difference between morning and evening types could then lie in their assessment of their own potential and not in OCB. Further research with both self- and external ratings is needed to clarify this question.
The evaluation of the open questions showed that morning types rated themselves as more creative in their problem-solving approaches during the remote working phase than before. Evening types, in turn, rated themselves as less creative. Both results could be explained by the lack of peer encounters. MA was negatively correlated with openness (Big Five personality dimension) in this sample. No positive relationship between these variables

has been reported in the literature either (see, for example, Adan et al., 2012). Therefore, morning oriented individuals may be able to focus better on their own ideas as a result of this change. This could have led to an increase in perceived creativity. EV, in turn, was correlated with openness in this sample, replicating findings in the literature (see e.g., Adan et al., 2012). Evening oriented individuals may benefit from other views and perspectives in problem-solving. The absence of this social component may have led to a feeling of less creativity.

As far as working hours are concerned, morning types showed a negative correlation, while evening types showed a positive correlation with 'more and/or longer breaks'. By no SWH, morning types could maintain their habitual rhythm of life without feeling negative effects. Furthermore, morning types have been shown to be more conscientious (as in this study; Adan et al., 2012), proactive (Randler, 2009) and behave according to OCB criteria (as in this study). This may have led to a desire to be available during expected working hours. Evening types lived with a chronic sleep deficit before the pandemic due to social timing. The OWFH enabled them to reduce this deficit. Another result of this measure was temporal flexibility in working hours, which was associated with a simultaneous increase in IST (Study 2). The SWH shown here may be another consequence of this flexibility. The adapted setting due to the OWFH may have led to behavioral changes caused by underlying personality traits such as low conscientiousness, procrastination, and low compliance with OCB criteria in evening oriented individuals.

Conclusion. The relationships of the Big Five personality dimensions and OCB scales suggest that evening types were more reliant on personal contact with peers than morning types. An assessment of the changes in performance components between the pre-pandemic and pandemic phases further supported this hypothesis. Morning types did not seem to be negatively affected by the changes in working environment, but rather benefited from it.

Chapter 8

Academic Self-Regulation, Chronotype and Personality during COVID-19 Restrictions

The study summarized here, "Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19", was published in the journal 'Frontiers in Education' by Staller et al. (2021). The original version of the published article is attached as Annex E.

8.1 Contributors

The authors and their respective contributions to the research are presented in Table 6.

Table 6: Contributors of the fifth study.

Author	Author Position	Scientific ideas (%)	Data generation (%)	Analysis & interpretation (%)	Paper writing (%)
Staller, N.	1	0	0	50	60
Großmann, N.	2	20	25	25	20
Eckes, A.	3	20	25	0	0
Wilde, M.	4	20	25	0	0
Müller, F.	5	20	25	0	0
Randler, C.	6	20	0	25	20

8.2 Thematic Introduction Linking to the Previous Studies

Due to the changes resulting from the lockdown measures, equity in social timing regarding chronotypes was approached. Sleep parameters improved and SJL decreased, as described in the first three studies. The fourth study presented evidence that evening types may have lower intrinsic engagement with their commitments. In addition, evening types seemed to need more peer support than the pandemic setting provided.

8.3 Extended Summary

Research goals. A possible relationship of chronotype with learning-related variables during lockdown induced online teaching was examined. Given this unprecedented situation, an exploratory rather than a hypothesis-driven research approach was chosen to investigate the influences of personality and chronotype on these learning-related variables.

Methods. Participants were asked about demographics, Big Five personality, chronotype, BPN satisfaction and frustration, motivational regulation in learning, vitality, and self-efficacy.

Results. Morning orientation correlated with conscientiousness, self-efficacy, satisfied BPN competence, and vitality, while evening orientation was related to frustrated BPN autonomy. Conscientiousness was positively related to self-efficacy, vitality, identified motivational regulation, satisfied BPN competence, and negatively to introjected avoidance motivational regulation, and frustrated BPN competence. Neuroticism was positively related to introjected approach/avoidance motivational regulation, frustrated BPN competence/relatedness, and negatively to self-efficacy, vitality, and satisfied BPN competence. Extraversion was negatively related to intrinsic motivational regulation. Openness was positively related to self-efficacy, intrinsic/identified/introjected approach motivational regulation, and satisfied BPN competence. Students' age was related to introjected approach motivational regulation, which decreased with age.

Discussion. The results of this study offered a further perspective on online teaching during the pandemic, as these effects may have had implications for learning in this new and challenging environment. In terms of academic self-regulation, students' ability to cope with the new learning arrangements depends, among other things, on a non-modifiable biological characteristic (chronotype). Evening oriented students appeared to be disadvantaged by the distance learning arrangements pursued during the lockdown phase.

Conclusion. The results obtained suggest that the transition to a distance learning environment during the lockdown period affected different learning related variables depending on students' chronotype, Big Five personality traits and age. Morning types coped better with the online teaching environment than evening types.

Chapter 9

General Results

The first study showed positive effects on sleep (increased sleep duration, decreased SJL) directly related to reduced time constraints. In the setting in which the sample was studied, the changes were attributable to the elimination of commuting time and more flexible working hours. The second study reported increased IST in addition to positive effects on sleep (increased sleep duration, decreased daytime sleepiness and SJL). Contrasting to the second study, the first collected data retrospectively on the pre-pandemic period.
The reconsideration of IST in the third study showed no differences between samples with different working environments (onsite/remote). This study used actigraphy as a physical method of collecting sleep data. This method complements the previous studies, which relied on questionnaires. Taken together, the results from the first three studies showed improved sleep parameters due to delayed social time constraints, and increasing IST with increasing temporal flexibility.
The fourth study showed that evening oriented individuals split their working hours significantly more than their morning oriented peers when working with temporal flexibility. Furthermore, evening orientation was negatively related to creativity in problem-solving approaches and scales, which in turn were positively related to performance components (e.g., OCB, conscientiousness). This was supported by the findings on academic self-regulation in the fifth study. Here, morning orientation was related to variables conducive to learning (vitality, self-efficacy, satisfied BPN competence and conscientiousness), whereas evening orientation was correlated with a more detrimental variable (frustrated BPN autonomy).
The second, fourth and fifth studies showed that evening oriented individuals were limited in their ability to cope with the pandemic working environment, as the personality traits closely associated with evening orientation tended to have adversarial effects.

Chapter 10

General Discussion

Sleep variables and performance components examined in this thesis are presented and discussed below in the context of current literature.

10.1 Pandemic Influences on Sleep Parameters

This section discusses the results on sleep and related variables in relation to chronotype.

10.1.1 Sleep Duration

The first study reported an increase in sleep duration for evening types and a decrease for morning types. The second study showed an increase in sleep duration but did not differentiate between chronotypes. A similar Israeli sample of students showed an increase in sleep duration and a delayed sleep onset during lockdown (Lan et al., 2022). Lan et al. (2022) also found longer sleep duration among morning types, in contrast to the sample in the first study. They concluded that lockdown affected sleep by delaying sleep onset and increasing sleep duration. This is further supported by the results of a large number of other research groups (for a review and meta-analysis see Stukalin et al., 2021). The results of the first and second studies, together with the literature, suggest that sleep duration increased during the pandemic lockdown. The shorter sleep duration of morning types in the first study could be interpreted as sample specificity. These findings can be seen as a positive effect on sleep health of evening types as a side effect of the OWFH.

10.1.2 Social Jetlag

A significant reduction in SJL compared to pre-lockdown levels was reported in the first and second study, supported by other research groups using varying samples (Arrona-Palacios et al., 2022; Blume et al., 2020; Borisenkov et al., 2022; Bottary et al., 2022; Facer-Childs et al., 2021; Florea et al., 2021; Korman et al., 2020; Ong et al., 2021; Raman and Coogan, 2022; Ramírez-Contreras et al., 2022; Saxvig et al., 2022; Vollmer and Jankowski, 2022; Wesley et al., 2022; Wright et al., 2020; for partly conflicting results see Sinha et al., 2020).
Bottary et al. (2023) reported a significant reduction in SJL and Social Sleep Restriction (SSR) (difference between sleep duration on working days and days off). They showed that SJL improved most in young adults and that SSR showed the greatest reduction in young adults and evening types. Complementary to these findings, reduced SJL was also found in teachers (Vollmer & Jankowski, 2022) and higher education faculty members (Arrona-Palacios et al., 2022).

In a cross-cultural study it was shown that the reduction of SJL depends on whether an occupation is considered system relevant (working onsite) or not (working from home) (Florea et al., 2021). Participants with non-system relevant jobs showed less SJL (Florea et al., 2021). These findings are supported by various samples, showing reductions in SJL in adolescents (e.g., Saxvig et al., 2022; Wesley et al., 2022), students (e.g., Ramírez-Contreras et al., 2022; Wright et al., 2020), teachers (Vollmer & Jankowski, 2022), university staff (Arrona-Palacios et al., 2022), and professional athletes (Facer-Childs et al., 2021), all of whom were classified as non-system relevant professionals. Consistent with these findings, the third study concluded that remote working is associated with a reduction in SJL.
The results presented here combined with the current literature indicate a more flexible social timing during lockdown led to a reduction in SJL. Thus, resulting in an improvement in sleep timing as a facet of sleep health.

10.1.3 Circadian Rhythm Stability

The circadian preference in the student sample of Lan et al. (2022) remained stable, which is consistent with the results of the first study. It was discussed that the MSFsc was shown to be a stable, unbiased chronotype measure in the first study, but that contrary results have been reported. Leone et al. (2020) showed that the MSFsc was delayed, but the ME preference did not change. The authors described this contradiction as expected, since diurnal preference follows sleep timing. They suggest that this change was due to a weaker light-dark cycle following the lockdown measures (Leone et al., 2020). These alterations in daily temporal habits and a shift towards EV have also been demonstrated by other research groups as the lockdown progressed, contradicting the findings in the first study (see e.g., Bertrand et al., 2022; S. Chen et al., 2022; Dai et al., 2021; Genta et al., 2021; Oliveira et al., 2021; Rome et al., 2021; Santos & Louzada, 2022; Saxena et al., 2021; Sexton-Radek, 2021; Smit et al., 2021).
Considering the circumstances leading to a shift in circadian timing, three key factors were discussed in literature. First, the circadian rhythm is controlled by internal and external zeitgebers. The main external cue is the light-dark cycle and the associated distribution of light intensity throughout the day. The circadian rhythm may therefore be strongly affected by reduced daylight exposure during lockdown measures (Bertrand et al., 2022; Korman et al., 2022; Leone et al., 2020; Oliveira et al., 2021; Sexton-Radek, 2021). In Brazil, for example, the lockdown measures left the population with little daylight exposure (Oliveira et al., 2021). In addition, increased exposure to short-wavelength blue light, especially in the evening hours, has been shown to affect the light-dependent zeitgeber (see e.g., Sexton-Radek, 2021). Increased daily exposure to electronic devices that emit this light (e.g., due to online teaching, the use of online conferencing tools for work meetings and socializing, or the consumption of entertainment media) likely had a significant impact on this zeitgeber (Bertrand et al., 2022; Oliveira et al., 2021; Saxena et al., 2021; Sexton-Radek, 2021).
Second, the decline in physical activity may have had a dual effect. There are zeitgebers that are driven by the metabolic processes that follow physical activity at a molecular level (for example the skeletal muscle core-clock; Gabriel and Zierath, 2019, 2022). These may have been disrupted by the reduction in activity (Oliveira et al., 2021). The time that had previously been spent on physical activity had to be replaced by other activities. An example of a replacement activity could be the use of digital media, which in turn could have had a further negative impact on the light-dependent zeitgeber.

Third, negative emotions (e.g., worry) and psychological problems caused by the pandemic have been shown to lead to changes in circadian rhythms (S. Chen et al., 2022; Ono, Souza, et al., 2020). Therefore, no general conclusion could be drawn regarding changes in circadian rhythms following lockdown measures.
The decisive factors seemed to be (1) the restrictiveness of the lockdown measures (e.g., whether the population was allowed to leave the house for activities such as outdoor sports, thus ensuring exposure to daylight), (2) the level and timing of the population's exposure to short-wavelength blue light, and (3) the emotional and psychological status of the population.
During data collection for the first study, the COVID-19 measures in Germany were described as moderate in a European comparison (Plümper & Neumayer, 2022). The measures were largely decided by on a federal level (with phases of nationwide requirements depending on the number of infections), which is why the stringency varied greatly. Bavaria maintained the most severe restrictions in Germany, which did not allow the population to leave their homes during the day with certain exceptions. In Baden-Württemberg, where the sample for the first study was collected, the population was allowed to leave the house until 8 p.m., when a curfew was imposed. This difference could be of considerable importance for the interpretation of the results obtained. Current literature suggests that the circadian rhythms of the first study sample did not change because the subjects were allowed to spend time and exercise outdoors. Therefore, they may have had sufficient exposure to daylight to have stabilized the light-dependent zeitgeber.
As the study did not ask about the psychological status and the use of electronic devices emitting short-wavelength blue light, it was not possible to make reliable statements about these factors. However, since lectures were held digitally during the lockdown, it is likely that the use of these devices has increased.
The results suggest that the stringency of the lockdown measures in Baden-Württemberg was not sufficient to destabilize the MSFsc. As the measures in neighboring Bavaria were more stringent and the population was generally not allowed to leave home (only under much more restrictive conditions), it is possible that a change in the MSFsc could have been observed in Bavarian samples.

10.1.4 Daytime Sleepiness

Daytime sleepiness can be caused by a variety of factors, including poor SQ, too little sleep, or a sleep schedule that does not match the biological timing. It can be seen as a measurable facet of alertness (dimension of sleep health; (Buysse, 2014; Wallace et al., 2021)). In the second study, daytime sleepiness was found to be reduced using the PDSS. So far, no other studies were published in literature using the PDSS with young adult samples collected during the COVID-19 pandemic for comparison.
Santos and Louzada (2022) showed a reduction in daytime sleepiness during lockdown in an adolescent sample using this questionnaire. The subjects got enough sleep and the need for naps decreased. Reduced wake-up pressure was discussed as the cause. The reduction in daytime sleepiness was consistent with the results in other adolescent samples using self-developed questions (see e.g., Gruber et al., 2020; Socarras et al., 2021). In contrast to their adolescent sample and contradicting the findings in the second study, Socarras et al. (2021) did not demonstrate reduced daytime sleepiness in their young adults sample. This led to the assumption of an age-related effect and that situational and inter-individual experiences during the pandemic played a role in this difference (Socarras et al., 2021).

Further conflicting results were shown in a young adults sample using a sleep diary with reported naps to measure daytime sleepiness. Smit et al. (2021) compared data from students in the online semester with data from students who had taken the same courses face-to-face in the previous semester. The 'online sample' had later sleep times, lower sleep efficiency, more IST and less nocturnal sleep but more daytime sleep. The authors discussed that it may not be the poor quality of sleep at night that led to more daytime sleep. Rather, fewer constraints during the day (due to asynchronous learning arrangements) may have led to more opportunities for daytime sleep, which in turn affected nocturnal sleep and led to poorer SQ.

This assumption of Smit et al. (2021) was supported by the third and fourth studies. The third study reported that STR did not depend on the work environment. This rules out the possibility that for example more opportunities for socially acceptable daytime sleep (at home versus onsite) results in more daytime sleep. Otherwise, a difference in the regularity of sleep timing would be expected between the HOG and OG, based on the conclusion that more daytime sleep leads to more IST. The fourth study showed that evening oriented subjects working from home split their working hours more compared to morning oriented peers. Fewer time constraints led them to take more breaks, which they may have used to sleep during the day. Both studies support the hypothesis that external temporal regulators are the main determinants of reported outcomes.

However, differences in data collection methods must be considered when comparing the results. In the sample in the second study, daytime sleepiness was examined using the PDSS, which is designed to assess sleepiness at different times of the day, focusing on the morning and different learning-related activities. Four of the eight PDSS items ask about the first half of the day, one asks about the second half of the day and three ask about the whole day. Generally, the PDSS is concerned with subjective perceptions of sleepiness, but not with the extent to which sleepiness actually leads to daytime sleep. Given the positive changes in SJL in this sample, it is reasonable to expect a decrease in the daytime sleepiness score based on the PDSS. The synchronization of biological and social rhythms is likely to have improved the sleepiness of the evening oriented participants in the first half of the day, leading to a better score on the questionnaire.

The PDSS does not ask about the frequency of daytime sleep. Therefore, although the perception of daytime sleepiness has improved, no statement about whether the amount of daytime sleep has remained stable or changed could be made. In contrast, as an extended consequence of daytime sleepiness, Smit et al. (2021) collected data on actual daytime sleep. Their data show an increased incidence of daytime sleep, which may have led to negative effects on sleep health.

Dai et al. (2021) showed that a regular schedule of naps of appropriate duration could reduce negative emotions caused by acute pandemic stress. The authors reported that maintaining pre-pandemic daytime sleep schedules may improve individuals' negative emotionality, learning/work efficiency, and reduce the use of electronic devices. Together the results of Dai et al. (2021) and Smit et al. (2021) suggest that a regular schedule of naps of an appropriate length can have positive effects on health. Negative effects on health are more likely, if naps are irregular, too frequent or too long.

Considering daytime sleepiness as a facet of alertness as dimension of sleep health, it appears that the lockdown had a twofold effect on students. First, it allowed them to adapt their sleep schedule to their biological needs, thereby reducing subjectively rated daytime sleepiness. Second, according to Smit et al. (2021) it led to a loss of external regulation of schedules, resulting in more opportunities for daytime sleep and therefore more actual daytime sleep. Both facets may depend on the perceived pandemic stress. With regard to napping as a consequence of daytime sleepiness, it appears that it could have positive effects on, for example, negative emotionality, provided it is taken appropriately and regularly.

10.1.5 Sleep Timing Regularity

Smit et al. (2021) suggested that nocturnal SQ suffered from daytime sleep during lockdown. This may have also affected STR. The authors showed that around 50% of participants experienced changes in STR, with 23.1% reporting more regular sleep and 24.4% reporting less regular sleep. The authors concluded that IST was caused by more opportunities for daytime sleep due to asynchronous learning arrangements. Similar conclusions were reached in the second study. Here it was shown that increased flexibility in lecture times was followed by increased flexibility in bed and rise times, and thus increased IST. As an extension of these findings, the third study examined whether the work environment was a predictor of IST, given that the sample in the second study was spatially flexible. No effect was found, supporting the hypothesis that increased flexibility in lecture times results in increased IST.

Bertrand et al. (2022) reported increased IST in 48% of their sample, using a self-rated ten-point Likert scale to determine STR from very irregular to very regular. Ong et al. (2021) showed reduced differences in sleep timing between weekdays and weekends, but the standard deviations of bedtimes and wake times increased significantly from the pre-pandemic period to the restriction period and again to the lockdown period. In both studies, it was discussed that the lockdown measures provided more time for sleep and reduced extrinsic factors that enforce a daily rhythm (e.g., commute time, physical activity). These findings support the results of the second study.

In contrast, Wright et al. (2020) showed that STR improved by about 12 min in a sample of university students during lockdown, using standard deviations of sleep timing parameters (bedtimes, midpoints of sleep, rise times) to quantify the changes. Rezaei and Grandner (2021) confirmed a reduction in sleep timing variability during lockdown in comparison to normal values using fitbit data in a US sample. Ramírez-Contreras et al. (2022) used clock times, SJL, and eating jetlag as markers to show more regularity in sleep and eating routines. They surveyed a sample of students in a hybrid learning environment (face-to-face and online). Bottary et al. (2023) presented data from a predominantly female US sample at five different time points (pre-pandemic, 'pandemic 1-4'). Their results suggest that STR depends on the severity of social restrictions, with more severe restrictions accounting for more regular sleep timing.

As for non-healthy samples, studies analyzing data from COVID-19 patients showed increased IST, which may be associated with symptom severity and residual sequelae (see Alzueta et al., 2022; Jackson et al., 2022). Alzueta et al. (2022) showed a greater decrease in all dimensions of sleep health (including STR) with increasing severity of symptoms after a COVID-19 infection. Their findings were supported by Jackson et al. (2022), who showed that IST increased significantly after hospitalization for COVID-19.

With regard to (healthy) student samples, the reported results seem inconclusive. Smit et al. (2021) showed both increased and decreased STR in almost equal numbers of subjects, Wright et al. (2020) and Ramírez-Contreras et al. (2022) showed increased sleep timing regularity, while the sample in the second study showed increased IST depending on the flexibility of lecture times.

Measurement methods may account for the differences in results between studies. In the second study, STR was assessed by the variability of clock time dependent sleep parameters in relation to the flexibility of lecture times. Ramírez-Contreras et al. (2022) used SJL and eating jetlag as measures of timing regularity. The sample of Wright et al. (2020) (as well as the one considered in the third study) was examined using standard deviations of bed and rise times as measure of STR. The data from Smit et al. (2021) were extracted from a participant report, but the factors to be considered were not previously specified by the authors. Smit et al. (2021) concluded that the participants addressed the changes in their sleep patterns that were most salient in their individual experiences. As a result, it was not possible to make reliable statements about how many participants were actually affected by changes in sleep timing, or whether these subjective experiences corresponded to objective values. Generally, for most of these samples self-reported sleep log data were used. These may have benefited from the additional collection of an objective measure, as subjective sleep reports can generally be inaccurate (Ferreira-Souza et al., 2023). Furthermore, it has been shown that the perception of sleep onset and wake time was significantly impaired during lockdown by comparing subjective and objective data (measured by actigraphy; He et al., 2021). Therefore, the use of subjective reports to calculate sleep timing variability in these studies may have introduced bias.

Another important discriminator that may explain the differences in results appears when the environmental conditions of the samples are compared. Wright et al. (2020) found increased STR during the lockdown compared to pre-pandemic levels. The second study showed that STR depended on the flexibility of lecture times. This suggests that the results differ because the second study examined a relationship, whereas Wright et al. (2020) presented absolute values. While this is true, another salient difference is the variation in the implementation of restriction measures.

The students examined by Wright et al. (2020) were taught online with spatial flexibility. Lectures were held synchronously according to the previous schedule, with no temporal flexibility. The third study presented evidence that spatial flexibility did not predict reduced STR. In contrast, the temporal flexibility associated with asynchronous learning arrangements was shown to predict increased IST in the second study. Therefore, although the results of the second study and Wright et al. (2020) differ, they are not contradictory. Based on the results of the first three studies of this thesis, the following changes would have been expected for the sample studied by Wright et al. (2020): later sleep times, longer sleep duration, less SJL (accompanied by a positive effect on STR due to decreasing weekday/ weekend differences) and no IST (due to the lack of temporal flexibility in the online teaching setting). These differences were indeed demonstrated by the authors. Therefore, the results of Wright et al. (2020) can be considered as supporting data.

In summary, the regularity of students' sleep schedules in lockdown may depend on whether regular schedules are imposed by external regulatory factors. The current literature shows that the extent of the influence of these external factors depends on which preventive measures are taken and how they are implemented.

10.1.6 Further Pandemic Effects on Sleep Health

Three objectively assessable dimensions of sleep health (duration, timing, regularity) and one that can be examined using subjective or objective evaluation (alertness) have already been considered here (Buysse, 2014; Wallace et al., 2021). The dimensions not considered so far (efficiency, satisfaction/quality) can be measured objectively and subjectively (Buysse, 2014; Wallace et al., 2021). An assessment of these were part of the second and third studies, but only to a limited extent.

Sleep satisfaction or subjective SQ and sleep efficiency were assessed as facets of the PSQI used in the second study. No changes were found between pre-pandemic and pandemic data. In comparison, the literature suggests that perceived SQ scores decreased as the pandemic progressed (O'regan et al., 2021; Scarpelli et al., 2022; Souza et al., 2021), with lower satisfaction with BPN being a possible reason (Tavernier et al., 2019). In terms of objectively measured SQ, similar results have been obtained using actigraphy, as summarized in a review by Ferreira-Souza et al. (2023).
As for sleep efficiency, Ong et al. (2021) reported that it was only minimally affected by lockdown measures. In addition, sleep efficiency was addressed in the third study by comparing two samples in different working environments (onsite/remote) using actigraphy as an objective measure. No effects of working environment on sleep efficacy were found. Intra-individual differences were reported in the respective groups when comparing weekdays and weekends, but without clinical relevance. Pre-pandemic levels of sleep efficiency were not assessed. Therefore, no comparison between pre-pandemic and pandemic sleep efficiency was possible.

10.1.7 Summarizing Thoughts on the Discussion of the Pandemic Influences on Sleep Parameters

As the pandemic progressed, the prevalence of sleep problems increased (for a systematic review and meta-analysis see Jahrami et al., 2021). A major determinant of these developments is the impact on mental health, which has become more apparent. The increased stress and anxiety led to poorer sleep health (see e.g., O'regan et al., 2021; Souza et al., 2021). However, the facets of sleep that depend on the restrictiveness of social timing (duration, timing, regularity) improved with lockdown. This highlights the different causes of the positive and negative effects, and suggests that the positive effects on sleep health that followed changes in social timing could be maintained after the pandemic by changing social norms and expectations.

10.2 Pandemic Influences on Performance Components

This section discusses the results on chronotype and personality dependent performance components.

10.2.1 Influences on Adherence to Work Phase Routines

The number of work interruptions reportedly increased during the pandemic, resulting in more frequent deviations from the normal work routine, emotional exhaustion and lower performance (Leroy et al., 2021). In the fourth study evening types took more and longer breaks, resulting in more work periods of shorter duration, while morning types maintained their routine working hours. This was seen as a result of the lack of external regulatory factors, and may reflect reduced work performance in evening oriented participants.
Work is generally more efficient with fewer interruptions (Jett & George, 2003). Although interruptions can have positive effects, depending on the frequency, duration, stimulation and information/supervision that can be gained from it (Jett & George, 2003). For example, positive effects of breaks include feelings of refreshment or increased creativity. However, breaks interrupt the workflow, and excessive breaks lead to procrastination (Jett & George, 2003), which again has been shown to be detrimental to creativity (Lim et al., 2017). Therefore, the shorter duration of work periods and the more frequent and longer breaks shown by evening types may indicate increased procrastination. This would be consistent

with research on chronotype and procrastination: Przepiórka et al. (2019) showed EV to be a positive predictor of procrastination, along with low self-efficacy and low self-control. MA, in turn, has been shown to correlate negatively with avoidant procrastination (Díaz-Morales et al., 2008).

Findings from student samples in lockdown associated academic procrastination (delaying academic tasks against better judgement; Svartdal et al., 2020) with low perceived competence in self-regulated learning (Pelikan et al., 2021). Low self-regulation has been associated with EV (Owens et al., 2016). In addition, academic procrastination has been linked to problematic social media (Latipah et al., 2021) and internet use (Tezer et al., 2020), which is has also been related to EV (Rigó et al., 2023). Subjective well-being has been shown to decrease (for a review, see Arifiana et al., 2020) and negative emotionality has been shown to increase (Wang et al., 2022) as academic procrastination increases. EV has been related to all three of these variables (negative relationship with well-being: Jankowski, 2012; positive relationship with negative emotionality: Carciofo, 2020a; positive relationship with academic procrastination: Hess et al., 2000). EV has also been correlated with impaired mental health (Staller & Randler, 2021c), which has been further linked to academic procrastination (Eisenbeck et al., 2019).

Two factors discussed in the context of a possible biological cause of the relationship between these variables and EV are: (1) exposure to natural light versus artificial light and (2) poor sleep quality. Due to their sleep rhythm, evening types are exposed to less natural light and more artificial light than their morning oriented peers (Goulet et al., 2007). This could have direct effects on emotionality and mood through neurobiological processes (Blume et al., 2019). With regard to sleep, poor SQ has been shown to have a significant impact on well-being (Zhai et al., 2018). Prior to the pandemic, evening types were consistently confronted with SJL and poor sleep health (Merikanto et al., 2012; Wittmann et al., 2006), which may mediate this effect. However, some research groups have argued that negative emotionality may be associated with low levels of MA rather than EV itself (see e.g., Carciofo, 2020b; Konttinen et al., 2014; Putilov, 2018).

A gender imbalance in the MA and EV subsamples would be another possible explanation for the results. Lee et al. (2022) showed that traditional gender roles were reinforced during the COVID-19 pandemic. The authors found that family interruptions during work were rated significantly more negatively for men, and they received less support from colleagues than women. As a result of how the environment reacted, women may have taken on more of these family related tasks, which may have caused them more frequent interruptions. These findings were further supported by Leroy et al., 2021, who showed that there was a gender imbalance in the increase in interruptions, unpaid labor (e.g., childcare and household chores), emotional labor, and work-life balance. Women reported being significantly more burdened in comparison to their pre-pandemic work and in comparison to men. However, it seems unlikely that this is an explanation for the results of the fourth study, since the majority of the sample were students and only about 20% reported living with children, making family interruptions or child care responsibilities less likely, for example.

In summary, the behavior 'more and/or longer breaks' shown by the evening oriented participants in the fourth study is likely to be induced by a lack of external regulatory factors and may be associated with a deterioration in learning and work performance. A possible explanation could be a relationship with procrastination. EV has been related to procrastination, as well as to low self-regulation, problematic online activities, poor mental health, negative emotionality, negative mood and poor SQ, which again strengthens the link to procrastination (Arifiana et al., 2020; Carciofo, 2020a; Díaz-Morales et al., 2008; Eisenbeck et al., 2019; Hess et al., 2000; Jankowski, 2012; Owens et al., 2016; Pelikan et al., 2021; Przepiórka et al., 2019; Staller and Randler, 2021c; Wang et al., 2022).

10.2.2 Influences on Creativity in Problem-Solving Approaches

Evening types have been shown to be impaired in their creativity in developing problem-solving approaches during the pandemic-induced changes (Study 4). The link between problem-solving, intrinsic motivation and SDT may be a crucial cause for this impediment.
In the fifth study it was shown that EV did not correlate with the satisfaction of any BPN, but rather with the frustration of BPN autonomy. Morning orientation was correlated with satisfied BPN competence. No other correlations were found with BPN satisfaction or frustration. The BPNSFS means of the fifth study sample are comparable to those of the pandemic sample of Müller et al. (2021). This suggests that the values are within the expected range. Müller et al. (2021) showed that students' BPN satisfaction was significantly lower during the pandemic, while their BPN frustration increased compared to before the pandemic. The authors also showed that both intrinsic motivation and identified regulation were reduced, while introjected and external regulation were increased during pandemic online learning (Müller et al., 2021). Thus, in the fourth study sample, these needs may also have been unmet, resulting in lower intrinsic motivation, which in turn is associated with lower problem-solving success (Song & Grabowski, 2006).
The differences in BPN satisfaction between morning and evening oriented individuals shown in the fifth study could be attributed to, for example, the threshold at which they perceived them to be satisfied. Morning types are generally conscientious (as shown in the fourth and fifth studies; and in the literature, see e.g., Adan et al., 2012). They may see their past successes as the result of this conscientious approach to work, and trust that the tasks they are given are within their ability to accomplish. Conscientiousness may therefore raise the confidence in their own competence, which may lower the threshold for satisfying BPN competence. Evening types are not characterized by conscientiousness (as shown in the fourth and fifth studies; Adan et al., 2012). This same confidence in their own competence may not be available to them, resulting in a higher threshold for satisfying BPN competence compared to morning type peers. They may feel overwhelmed by the new environment and possible new problems that they are being challenged to solve.
A similar situation may have arisen in relation to BPN autonomy. Given the link with time perspective, evening oriented individuals may be more likely to experience frustration in BPN autonomy than morning oriented peers. EV has been shown to relate to a present-fatalistic time perspective (Díaz-Morales et al., 2008). Present fatalism describes the belief that life is determined by chance rather than the free will of the living individual. The relationship between evening orientation and this time perspective suggests that a high threshold may be required to satisfy their BPN autonomy. This finding is further supported by the association of this time perspective with procrastination, as well as EV with procrastination (Díaz-Morales et al., 2008). Morning types, in turn, have been shown to have a futuristic time perspective (Díaz-Morales et al., 2008), which is seen as an influencing factor in the negative relationship between MA and procrastination (Díaz-Morales et al., 2008). The negative correlation of morning orientation with procrastination (Díaz-Morales et al., 2008) and the positive correlation with self-regulation (Owens et al., 2016) and self-efficacy (Study 5) may lead to conditions in which they have more resources to protect them from a frustrated BPN autonomy.

Another possible explanation lies in the influence of the environment (e.g., characteristics of problems or resources) on creativity as a problem-solving approach (Amabile, 1983; Cromwell et al., 2018). Uncertainty is defined as fluctuations of possible problems or resources (Cohen & Cromwell, 2021). In situations where the individual is faced with great uncertainty about both the problem and the solution, the abundance of possibilities leads to a lack of orientation about where to direct efforts, resulting in reduced creativity (Chua & Iyengar, 2008; Schwartz, 2009). In terms of Big Five personality associated with an individual's chronotype, there may be a link with the feeling of being overwhelmed and the reduced creativity in uncertain times.

Evening types have been reported to be associated with openness, as shown in the fourth study and in the literature (see e.g., Adan et al., 2012; Staller & Randler, 2021c). They may therefore be more likely to incorporate peer perspectives into the problem-solving process. The lack of, or difficulty in, incorporating other perspectives due to the social restrictions could have led to a sense of reduced creativity. In this context, collaboration with peers may have been a resource for evening oriented individuals, and the limited contact may therefore have been experienced as a fluctuation of this resource. This, together with the new problems created by the unprecedented situation, may have resulted in high uncertainty due to fluctuations in both problems and resources. A feeling of being overwhelmed and reduced creativity may have followed (Chua & Iyengar, 2008; Schwartz, 2009). Morning orientation again correlated with conscientiousness and agreeableness in this sample. Consistent with these personality traits, morning types have been shown to be more compliant with COVID-19 measures (Li, 2022), which may have led to rapid adaptation to the new situation. Morning orientation does not correlate with openness, as shown in the literature (Adan et al., 2012). Moreover, in the fourth study, morning orientation was negatively related to openness. Therefore, in contrast to the evening types who experienced a loss of the resource 'peer support', morning types may have experienced a gain of the resource 'solitude'. The solitude of this new environment may have enhanced their creativity in developing problem-solving approaches. This could mean that the morning types did not experience negative fluctuations in the resource of peer support and were therefore less at risk of being overwhelmed and having their creativity reduced (Chua & Iyengar, 2008; Schwartz, 2009).

Krammer et al. (2020) examined students' experiences during the lockdown in terms of the beneficial and obstructive aspects of online teaching. Contact with teachers and fellow students was found to be beneficial when implemented well, but a barrier when implemented poorly. This supports the findings of Machtmes and Asher (2000) who showed that two-way interaction between teachers and students is a positive asset to the online teaching process. Depending on chronotype, students may have felt that the learning process was less effective because of the loss of interaction with lecturers and peers. This may have led to a decrease in creativity in problem-solving, if the things to be learned are seen as problems to be solved and the exchange as a resource (fluctuations in both problems and resources → high uncertainty). This line of reasoning supports the notion that evening types need peer support for effective problem-solving and may explain why morning types experience fewer losses in creativity, as discussed in the fourth study. Differences between chronotypes in self-rated creativity in developing problem-solving approaches may have had a multidimensional cause. These may have included high uncertainty due to fluctuations in both problems and resources during the pandemic, and the relationship between chronotype SDT, motivation, procrastination and time perspective.

10.2.3 Influences of the Chronotype on Organizational Citizenship Behavior

In the fourth study, morning orientation was positively related to the OCB scales of conscientiousness, civic virtue, and in-role behavior, as well as the Big Five scales of conscientiousness and agreeableness. The latter two have also been related to MA in the literature (see e.g., Adan et al., 2012) and have been shown to promote positive organizational behavior (Kumar et al., 2009). In addition, MA was negatively related to neuroticism and openness (Study 4). Evening orientation did not show a positive relationship with any of the OCB facets, but was negatively related to conscientiousness and in-role behavior. Regarding the Big Five scales, the results for EV seem to be more contradictory. In this sample, it was positively related to openness and negatively related to conscientiousness. The relationship with openness is supported by the literature (see e.g., Adan et al., 2012). Furthermore, openness has been shown to act as a positive trait for organizational behavior (Abu Elanain, 2007). In the literature, EV has been associated with neuroticism (Adan et al., 2012), which has been shown to act as a detrimental measure for OCB (Kumar et al., 2009), but this relationship was not replicated here.
The findings on chronotype and OCB are consistent with those of Waleriańczyk et al. (2020). The authors showed that EV was a predictor of low levels of OCB, controlling for age and gender. In line with the conclusions of Waleriańczyk et al. (2020), the fourth study also suggested that morning types may be more invested in their professional lives. This indicates that the relationship between chronotype and OCB may have implications for academic performance. These findings may also be supported by the results of the fifth study. In this study, morning orientation was correlated with satisfied BPN competence. By feeling competent, morning oriented individuals are likely to have self-confidence and self-assurance regarding their professional tasks. Through this attitude toward themselves, they may anticipate a positive response from those around them toward them and their work, leading to a sense of being valued by the environment. As a result, there may be a greater willingness to take on additional volunteer tasks, which may explain the relationship between MA and OCB civic virtue. As for the correlation of EV and OCB conscientiousness and in-role behavior, a similar reasoning may apply. In general, OCB refers to work behaviors that are performed voluntarily and without expectation of reward (Staufenbiel, 2000; Staufenbiel & Hartz, 2000). A high level of intrinsic motivation is required to engage in these behaviors, with work autonomy being one of the facilitating factors (Pritchard & Payne, 2002). Frustrated BPN autonomy may lead to a lack of this motivation in evening oriented individuals. Furthermore, in the sample of the fourth study, EV was negatively correlated with conscientiousness, a variable that is strongly positively related to OCB: conscientiousness/in-role behavior. Thus, frustrated BPN autonomy, together with the negative relationship with conscientiousness, may explain the negative correlations between EV and OCB: conscientiousness/in-role behavior.
Moreover, SQ was shown to relate to OCB but only when controlling for chronotype effects (Barnes et al., 2013). This further suggests that OCB and chronotype may also be related. Therefore Guarana et al. (2021) investigated the effects of blue light filtering glasses on sleep quality, quantity and chronotype, as well as work-related variables such as OCB. The authors concluded that blue light reduction improved sleep quality and quantity, which in turn improved work-related variables (Guarana et al., 2021). In general, they interpreted their results as that late chronotypes benefited more from the intervention and showed that although some results were not significant, notable differences were observed (Guarana et al., 2021). The relationship between chronotype and OCB was not significant in their sample contrary to the results in the fourth study.

The existing literature on the relationship between chronotype and OCB is small and insufficient to draw reliable conclusions. Rather, what can be inferred from these studies is that there appears to be a relationship between chronotype, personality and behavioral outcomes in the context of professional life. These may consequently have an impact on performance. Combined, the results suggest that this research question should receive more attention in the future.

10.2.4 Influences of Chronotype and Personality on Academic Self-Regulation

There is much debate about the relevance of chronotype to education. Some research groups proposed a direct link between academic performance and chronotype (for a meta-analysis see Preckel et al., 2011), others concluded that it is not the chronotype per se that is responsible for the influence on academic performance, but the consequences of the socially imposed schedules (see e.g., Roeser et al., 2013). One of the most discussed reasons for these associations is the lack of sleep in evening types. Apart from serious biological consequences such as loss of cognitive function (McCoy & Strecker, 2011; Walker, 2008), also performance-related consequences such as attention problems (see e.g., Fallone et al., 2005) have been shown to follow sleep deprivation. The results of the fourth study suggest that evening orientation is related to personality traits that may be followed by low levels of OCB. This may be another aspect that leads to poor academic performance in evening oriented students. MA is not only associated with less sleep deprivation and daytime sleepiness, but also with higher functional performance attitude, leading to better academic performance (Randler & Frech, 2006, 2009).

In the fifth study MA was positively related to vitality, self-efficacy, satisfied BPN competence, and conscientiousness. Vitality and conscientiousness were further related to each other, strengthening the link to MA. The results regarding MA and vitality are supported by a small body of literature (see e.g., Gulec et al., 2013; Prieto et al., 2012). In addition, Martinek et al. (2021) related vitality to satisfied BPN competence (which was also related to MA in the fifth study). With regard to self-efficacy, the literature is sparse and inconclusive. For example, Przepiórka et al. (2019) found no correlation between chronotype and self-efficacy, while Nicholson et al. (2022) found self-efficacy to be positively correlated with MA and negatively correlated with EV. In addition, Rivers (2021) correlated conscientiousness and agreeableness with self-efficacy, while Audet et al. (2021) correlated conscientiousness and openness with self-efficacy. The fifth study replicated the relationships between MA and conscientiousness with self-efficacy. Agreeableness and openness were not related to chronotype or self-efficacy.

EV was correlated with frustrated BPN autonomy in this sample. This relationship may be strengthened by the aforementioned association with the present-fatalistic time perspective (Díaz-Morales et al., 2008). Which suggests that the threshold for not being frustrated and much less satisfied with BPN autonomy may be quite high for evening type students. They may not have understood why certain tasks were required or why they were meaningful, resulting in frustrated BPN autonomy. This assumption is further supported by the results of Li (2022), who showed that individuals high in EV were less compliant with COVID-19 measures than their peers high in MA. Contrary to the results of the fourth study and the literature (see e.g., Adan et al., 2012), no relationship was found between EV and the Big Five variables of openness and neuroticism. Yet, openness and neuroticism did show correlations with other variables tested. Openness was positively correlated with self-efficacy in this sample, replicating the findings of Karwowski et al. (2013) on creative self-efficacy and contradicting the findings of Thoms et al. (1996) who found no relationship between openness and self-efficacy in self-managed work groups. Neuroticism was negatively related to self-efficacy, vitality and satisfied BPN competence and positively with frustrated BPN competence and relatedness in this sample, consistent with the literature (see e.g., self-efficacy: Karwowski et al., 2013; Şimşek and Koydemir, 2013).

Students' BPN satisfaction was generally found to be impaired during the pandemic. Martinek et al. (2021) reported that the technological resources available in online learning affected the satisfaction of all three BPN. Perceived task overload was also associated with lower levels of BPN satisfaction and higher levels of BPN frustration (Martinek et al., 2021). Students' levels of BPN satisfaction were significantly lower during the pandemic, while their levels of BPN frustration increased compared to before the pandemic (Müller et al., 2021). However, Holzer et al. (2021) showed that the satisfaction of BPN competence was the strongest predictor of students' well-being. This may reinforce the findings on MA and satisfied BPN competence, as well as the discussed relationship between MA and well-being. It may further indicate a high level of well-being among the morning oriented individuals in this sample, which would support the fourth study's hypothesis that morning oriented individuals thrive in an environment of solitude.

Only one other sample could be identified in which the relationship of chronotype with BPN satisfaction was examined. Tavernier et al. (2019) bidirectionally assessed the BPN satisfaction in relation to various subjective sleep variables and chronotype at two time points. They found no correlation between chronotype and BPN satisfaction but showed that BPN satisfaction and MA were correlated same directional with the tested variables. The authors concluded that fostering BPN satisfaction is a relevant starting point for promoting the tested sleep characteristics in students (Tavernier et al., 2019). This may provide some support for the reported relationships of MA with BPN satisfaction in the fifth study, suggesting beneficial properties of morning orientation on learning outcomes in unprecedented and stressful situations. Nevertheless, it is important to note that the sample of the study by Tavernier et al. (2019) differs significantly from the sample in the fifth study in that it was not collected during the pandemic. The pandemic can be described as a traumatic event of massive proportions (Horesh & Brown, 2020), suggesting that coping with this situation was a major component of students' everyday lives. For the sample in the fifth study, the pandemic may have created an environment in which the effects of chronotype on BPN satisfaction and frustration were visible that would otherwise be masked, or these may have been trauma responses that only occur in a traumatic environment.

Regarding the various facets of motivation examined in the fifth study, no correlations with chronotype were found in this sample, although the literature suggests otherwise. For example, Horzum et al. (2014) showed significantly higher academic motivation scores in online learning scenarios for morning oriented students than for their evening oriented peers. Roeser et al. (2013) showed that chronotypes differed in their intrinsic motivation to learn, but not in their attitudes towards performance situations. Morning types showed a positive orientation towards learning goals, whereas evening types showed a more negative orientation and a refusal to work (Roeser et al., 2013). Furthermore, Arbabi et al. (2015) showed that MA was positively related to learning objectives as a facet of motivation, while EV was more correlated with avoidance performance objectives and work avoidance as two other facets of motivation. In support of these findings, Escribano and Díaz-Morales (2016) showed a relationship between morning orientation and higher learning and performance goals compared to evening orientation. The characteristics discussed here suggest a more difficult transition to online learning for evening types during the pandemic, which required many students to become more self-regulated. Therefore, chronotype may be an inter-individual difference that is relevant for the success of online learning, complementing the research of Zhao et al. (2005). The authors showed inter-individual differences on the part of the lecturer (e.g., type of interaction or media involvement) and learner (e.g., content area studied, students prior education, or level of instruction) determine success in online teaching scenarios.

In a sample of medical students, Tuma et al. (2021) showed that 69% of participants reported problems with their online learning success, such as increased fatigue (compare subsection 10.1.4 and 10.1.5) and loss of interest. They also reported less knowledge gain after online teaching compared to traditional teaching approaches. The authors concluded that the quality of education in online teaching scenarios could be improved through student engagement activities, good preparation and appropriate environmental and technical conditions. The findings presented here may point to unsatisfied BPN and implications on motivation. Student engagement activities may be a way to increase feelings of competence, autonomy and relatedness (compare subsection 10.2.2). By incorporating these more, students may be given an opportunity to satisfy their BPN according to SDT. This suggests that engagement in learning activities, in addition to interaction with peers and lecturers, may be a tool to increase online learning success.

10.2.5 Summarizing Thoughts on the Discussion of the Pandemic Influences on Performance Components

It is important to note that the findings in this thesis relate to a situation that is not normal life, but rather a traumatic situation that has affected many areas of life. Therefore, the results are not readily transferable and will need to be re-examined once the pandemic and the resulting measures and restrictions have ended. What can be said is that the close relationship between chronotype, personality, and learning-related variables influences educational success in stressful situations, deviating from normal life. It is not yet clear at what threshold these differences become apparent, or whether they are universally present, and at what point they require intervention. However, the results reported here suggest that society should at least consider the value of equalizing the educational process for differences in biological characteristics of individuals, such as chronotype and related personality traits.

Chapter 11

Identified Needs for Action in this Thesis

Regarding sleep variables the comparison of the current literature with the findings of this thesis suggests that there is a need to change the stringency of socially predetermined times around which daily life is organized. This would be particularly beneficial for individuals high in EV. The results on sleep and regularity presented in the first four studies lead to the recommendation that social schedules should be delayed to accommodate different chronotypes, but that unrestricted temporal flexibility should not be implemented. Instead, external regulators should impose rigid but later schedules. They help stabilize STR and may further prevent evening types from SWH, which in turn may have positive effects on performance components. Such an adjustment could improve four dimensions of sleep health (duration, timing, alertness, regularity). Spatial flexibility is not a negative determinant of sleep health, but may help to facilitate the implementation of a social timing delay and to enhance performance, as it offers beneficial potential in terms of time management, for example.

Another negative development in terms of performance for individuals high in EV that occurred during the pandemic is the decline in social interactions. The fourth study showed that evening types need to interact with others to feel creative in their problem-solving approaches. This finding is supported by the fifth study, which shows that both morning and evening types are not satisfied with BPN relatedness. The only BPN which was shown to be satisfied is BPN competence in morning types, whereas evening oriented students had not satisfied any BPN, but BPN autonomy was frustrated. To foster BPN, the teaching content could be addressed in three ways. First, the students' competences in this situation should be taken into account, for example, by recognizing possible limitations of cognitive resources due to traumatic experiences. Second, students' understanding of the tasks involved and their necessity should be increased. Third, interaction with lecturers and peers should be integrated, for example as student engagement activities. According to the fourth study, the latter also helps to promote creativity in problem-solving approaches in evening orientated individuals.

An adapted teaching concept for similar situations that incorporates the findings reported here takes into account the biological needs of different chronotypes and has a health-promoting effect. Regarding sleep variables neither early and strict onsite teaching times, as offered before the pandemic, nor models with unrestricted temporal flexibility achieve this objective. In addition, by redesigning the environment to meet BPN, achievement in educational aspects could be promoted.

Chapter 12

Outlook and Unresolved Research Questions

Several unanswered questions and underexplored relationships were identified during the research and literature review conducted for this thesis. First, a shift in sleep timing and circadian stability has been reported in the literature, as assessed by both clock time based, and daytime preference based chronotype measures. Reasons discussed include a shift in social timing or reduced exposure to daylight. Changes in circadian timing during the pandemic lockdown should be meta-analyzed to determine what caused them in some samples and prevented them in others.

Second, a review and meta-analysis of changes in sleep health during the pandemic across all its dimensions should be conducted to prepare for similar situations. Beneficial and detrimental factors should be identified to provide further guidance, for example, to policy makers and employers. This could help them to consider and protect the sleep health and therefore resilience of the populations, which in turn would also benefit their work performance.

Third, chronotype and related variables affect performance parameters in everyday life as well as in stressful or traumatic situations. The resulting behavior may not be consistent in these situations. The findings presented suggest that the setting used for online learning during the pandemic in Germany did not sufficiently support evening oriented individuals. Therefore, to understand where individuals with different chronotypes encounter difficulties and how to support them, the relationship with various performance components should be further explored in both scenarios. In addition, the study designs should be repeated in normal life scenarios to determine whether the results obtained here are a general phenomenon or different stress responses in traumatic situations.

Fourth, it seems useful and necessary to prepare for other possible disaster scenarios by developing a concrete concept for the implementation of online learning, supported by the conclusions of the pandemic research. This should take into account inter-individual personality traits that represent learner diversity (such as chronotype) and provide an environment that offers the necessary support to all. Suggestions were made as to which of the factors studied might continue to be supportive in terms of chronotype and which might be more of a hindrance to successfully navigating such a situation.

Fifth, the literature on chronotype as an influence on performance components is sparse. Here, chronotype was shown to affect several variables related to the participants' professional lives. It is reasonable to assume that similar effects will be observed for other variables. Knowledge about the relationships between chronotype, personality, and performance should therefore be expanded. A possible relationship between chronotype and an individual's perceived potential in work performance, as well as related constructs such as the impostor phenomenon, should be investigated. In addition, the relationship between chronotypes and their respective engagement with their commitments in professional contexts (e.g., as reflected by OCB) should also be explored in more detail.

Literature

Abu Elanain, H. M. (2007). Relationship between personality and organizational citizenship behavior: Does personality influence employee citizenship. *International Review of Business Research Papers*, *3*(4), 31–43. https://www.researchgate.net/publication/265106363_Relationship_between_Personality_and_Organizational_Citizenship_Behavior_Does_Personality_Influence_Employee_Citizenship

ActiGraph. (2013). *Actigraph GT3X+ Manual*. ActiGraphCorp. Pensacola, Florida. Retrieved June 18, 2022, from https://dl.theactigraph.com/gt3xp_wgt3xp_device_manual.pdf

Adan, A., & Almirall, H. (1991). Horne & östberg morningness-eveningness questionnaire: A reduced scale. *Personality and Individual Differences*, *12*(3), 241–253. https://doi.org/10.1016/0191-8869(91)90110-W

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., & Randler, C. (2012). Circadian typology: A comprehensive review. *Chronobiology International*, *29*(9), 1153–1175. https://doi.org/10.3109/07420528.2012.719971

Adisa, T. A., Antonacopoulou, E., Beauregard, T. A., Dickmann, M., & Adekoya, O. D. (2022). Exploring the impact of covid-19 on employees' boundary management and work–life balance. *British Journal of Management*, *33*(4), 1694–1709. https://doi.org/10.1111/1467-8551.12643

Ahn, Y. M., Chang, J., Joo, Y. H., Kim, S. C., Lee, K. Y., & Kim, Y. S. (2008). Chronotype distribution in bipolar I disorder and schizophrenia in a Korean sample. *Bipolar Disorders*, *10*(2), 271–275. https://doi.org/10.1111/j.1399-5618.2007.00573.x

Alzueta, E., Perrin, P. B., Yuksel, D., Ramos-Usuga, D., Kiss, O., Iacovides, S., de Zambotti, M., Cortes, M., Olabarrieta-Landa, L., Arango-Lasprilla, J. C., & Baker, F. C. (2022). An international study of post-COVID sleep health. *Sleep Health*, *8*(6), 684–690. https://doi.org/10.1016/j.sleh.2022.06.011

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology*, *45*(2), 357–376. https://doi.org/10.1037/0022-3514.45.2.357

Arbabi, T., Vollmer, C., Dörfler, T., & Randler, C. (2015). The influence of chronotype and intelligence on academic achievement in primary school is mediated by conscientiousness, midpoint of sleep and motivation. *Chronobiology International*, *32*(3), 349–357. https://doi.org/10.3109/07420528.2014.980508

Arifiana, I. Y., Rahmawati, H., Hanurawan, F., Eva, N., et al. (2020). Stop academic procrastination during covid 19: Academic procrastination reduces subjective well-being. *KnE Social Sciences*, *4*(15), 312–325. https://doi.org/10.18502/kss.v4i15.8220

Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of Personality and Social Psychology*, *73*(2), 345–368. https://doi.org/10.1037/0022-3514.73.2.345

Arrona-Palacios, A., Rebolledo-Mendez, G., Escamilla, J., Hosseini, S., & Duffy, J. (2022). Effects of COVID-19 lockdown on sleep duration, sleep quality and burnout in faculty members of higher education in Mexico. *Ciência & Saúde Coletiva*, *27*(8), 2985–2993. https://doi.org/10.1590/1413-81232022278.04322021

Au, J., & Reece, J. (2017). The relationship between chronotype and depressive symptoms: A meta-analysis. *Journal of Affective Disorders*, *218*, 93–104. https://doi.org/10.1016/j.jad.2017.04.021

Audet, É. C., Levine, S. L., Metin, E., Koestner, S., & Barcan, S. (2021). Zooming their way through university: Which big 5 traits facilitated students' adjustment to online courses during the covid-19 pandemic. *Personality and Individual Differences*, *180*, 110969. https://doi.org/10.1016/j.paid.2021.110969

Bareeqa, S. B., Ahmed, S. I., Samar, S. S., Yasin, W., Zehra, S., Monese, G. M., & Gouthro, R. V. (2021). Prevalence of depression, anxiety and stress in china during COVID-19 pandemic: A systematic review with meta-analysis. *The International Journal of Psychiatry in Medicine*, *56*(4), 210–227. https://doi.org/10.1177/0091217420978005

Barnes, C. M., Ghumman, S., & Scott, B. A. (2013). Sleep and organizational citizenship behavior: The mediating role of job satisfaction. *Journal of Occupational Health Psychology*, *18*(1), 16–26. https://doi.org/10.1037/a0030349

Bazzani, A., Bruno, S., Frumento, P., Cruz-Sanabria, F., Turchetti, G., & Faraguna, U. (2021). Sleep quality mediates the effect of chronotype on resilience in the time of COVID-19. *Chronobiology International*, *38*(6), 883–892. https://doi.org/10.1080/07420528.2021.1895199

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How Does Distance Education Compare With Classroom Instruction? A Meta-Analysis of the Empirical Literature. *Review of Educational Research*, *74*(3), 379–439. https://doi.org/10.3102/00346543074003379

Bertrand, L., Schröder, C., Bourgin, P., Maruani, J., Atoui, Y., d'Ortho, M.-P., Lejoyeux, M., & Geoffroy, P. A. (2022). Sleep and circadian rhythm characteristics in individuals from the general population during the French COVID-19 full lockdown. *Journal of Sleep Research*, *31*(2), e13480. https://doi.org/10.1111/jsr.13480

Biss, R. K., & Hasher, L. (2012). Happy as a lark: Morning-type younger and older adults are higher in positive affect. *Emotion*, *12*(3), 437–441. https://doi.org/10.1037/a0027071

Blume, C., Garbazza, C., & Spitschan, M. (2019). Effects of light on human circadian rhythms, sleep and mood. *Somnologie*, *23*(3), 147–156. https://doi.org/10.1007/s11818-019-00215-x

Blume, C., Schmidt, M. H., & Cajochen, C. (2020). Effects of the COVID-19 lockdown on human sleep and rest-activity rhythms. *Current Biology*, *30*(14), R795–R797. https://doi.org/10.1016/j.cub.2020.06.021

Boivin, D. B., & Boudreau, P. (2014). Impacts of shift work on sleep and circadian rhythms. *Pathologie Biologie*, *62*(5), 292–301. https://doi.org/10.1016/j.patbio.2014.08.001

Borisenkov, M. F., Popov, S. V., Smirnov, V. V., Gubin, D. G., Petrov, I. M., Vasilkova, T. N., Solovieva, S. V., Martinson, E. A., Pecherinka, A. A., Dorogina, O. I., & Symaniuk, E. E. (2022). Associations among sleep-wake rhythm characteristics, time perspective and psycho-emotional state during COVID-19 isolation. *Biological Rhythm Research*, *53*(11), 1770–1781. https://doi.org/10.1080/09291016.2022.2041289

Bottary, R., Fields, E. C., Kensinger, E. A., & Cunningham, T. J. (2022). Age and chronotype influenced sleep timing changes during the first wave of the COVID-19 pandemic. *Journal of Sleep Research*, *31*(2), e13495. https://doi.org/10.1111/jsr.13495

Bottary, R., Fields, E. C., Ugheoke, L., Denis, D., Mullington, J. M., & Cunningham, T. J. (2023). Changes in Sleep Regularity and Perceived Life Stress across the COVID-19 Pandemic: A Longitudinal Analysis of a Predominately Female United States Convenience Sample. *Clocks & Sleep*, *5*(1), 1–9. https://doi.org/10.3390/clockssleep5010001

Bouwmans, M. E. J., Bos, E. H., Hoenders, H. J. R., Oldehinkel, A. J., & de Jonge, P. (2017). Sleep quality predicts positive and negative affect but not vice versa. An electronic diary study in depressed and healthy individuals. *Journal of Affective Disorders*, *207*, 260–267. https://doi.org/10.1016/j.jad.2016.09.046

Bundesministerium für Inneres und Heimat (BMI) & Bundesministerium für Gesundheit (BMG). (2020). Krisenstab am 10.03.2020. Retrieved August 9, 2022, from https://www.bundesgesundheitsministerium.de/presse/pressemitteilungen/2020/1-quartal/krisenstab-bmg-bmi-sitzung-5.html

Bundesregierung. (2020). Videokonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 28. Oktober 2020. Retrieved August 9, 2022, from https://www.bundesregierung.de/breg-de/themen/buerokratieabbau/videokonferenz-der-bundeskanzlerin-mit-den-regierungschefinnen-und-regierungschefs-der-laender-am-28-oktober-2020-1805248

Bundesregierung. (2021a). Infektionsschutzgesetz - Das regelt die bundeseinheitliche Notbremse. Retrieved August 9, 2022, from https://www.bundesregierung.de/breg-de/themen/coronavirus/bundesweite-notbremse-1888982

Bundesregierung. (2021b). Videoschaltkonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 18. November 2021. Retrieved January 13, 2023, from https://www.bundesregierung.de/resource/blob/974430/1982598/defbdff47daf5f177586a5d34e8677e8/2021-11-18-mpk-data.pdf?download=1

Buysse, D. J. (2014). Sleep health: Can we define it? Does it matter? *Sleep*, *37*(1), 9–17. https://doi.org/10.5665/sleep.3298

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Caci, H., Robert, P., & Boyer, P. (2004). Novelty seekers and impulsive subjects are low in morningness. *European psychiatry*, *19*(2), 79–84. https://doi.org/10.1016/j.eurpsy.2003.09.007

Carciofo, R. (2020a). Morningness–eveningness and affect: The mediating roles of sleep quality and metacognitive beliefs. *Sleep and Biological Rhythms*, *18*(1), 17–26. https://doi.org/10.1007/s41105-019-00238-9

Carciofo, R. (2020b). Morning affect, eveningness, and amplitude distinctness: Associations with negative emotionality, including the mediating roles of sleep quality, personality, and metacognitive beliefs. *Chronobiology International*, *37*(11), 1565–1579. https://doi.org/10.1080/07420528.2020.1798978

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of personality and social psychology*, *67*(2), 319–333. https://doi.org/10.1037/0022-3514.67.2.319

Cellini, N., Canale, N., Mioni, G., & Costa, S. (2020). Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. *Journal of sleep research*, *29*(4), e13074. https://doi.org/10.1111/jsr.13074

Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., Van der Kaap-Deeder, J., Duriez, B., Lens, W., Matos, L., Mouratidis, A., Ryan, R. M., Sheldon, K. M., Soenens, B., Van Petegem, S., & Verstuyf, J. (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion*, *39*(2), 216–236. https://doi.org/10.1007/s11031-014-9450-1

Chen, S., Huang, T., Huang, Y., Nie, C., Liang, J., Ma, H., Liu, X., Xu, Y., & Guo, J. (2022). A Population-Level Analysis of Changes in Circadian Rhythms and Sleep and Their Association with Negative Emotions during the Outbreak of COVID-19 in China. *COVID*, *2*(4), 450–463. https://doi.org/10.3390/covid2040032

Chirkov, V., Ryan, R. M., Kim, Y., & Kaplan, U. (2003). Differentiating autonomy from individualism and independence: A self-determination theory perspective on internalization of cultural orientations and well-being. *Journal of personality and social psychology*, *84*(1), 97–110. https://doi.org/10.1037/0022-3514.84.1.97

Chua, R. Y.-J., & Iyengar, S. S. (2008). Creativity as a Matter of Choice: Prior Experience and Task Instruction as Boundary Conditions for the Positive Effect of Choice on Creativity. *The Journal of Creative Behavior*, *42*(3), 164–180. https://doi.org/10.1002/j.2162-6057.2008.tb01293.x

Cohen, A. K., & Cromwell, J. R. (2021). How to Respond to the COVID-19 Pandemic with More Creativity and Innovation. *Population Health Management*, *24*(2), 153–155. https://doi.org/10.1089/pop.2020.0119

Cole, R., Kripke, D., Gruen, W., Mullaney, D., & Gillin, J. (1992). Automatic sleep/wake identification from wrist activity. *Sleep*, *15*(5), 461–469. https://doi.org/10.1093/sleep/15.5.461

Corr, P. J. (2008). Reinforcement sensitivity theory (RST): Introduction. In *The reinforcement sensitivity theory of personality* (pp. 1–43). Cambridge University Press. https://doi.org/10.1017/CBO9780511819384.002

Costa, G., Pickup, L., & Di Martino, V. (1988). Commuting–a further stress factor for working people: Evidence from the European Community. II. An empirical study. *International archives of occupational and environmental health*, *60*(5), 377–385. https://doi.org/10.1007/bf00405674

Costa, P. T., & McCrae, R. R. (2008). The Revised Neo Personality Inventory (NEO-PI-R). In *The SAGE handbook of personality theory and assessment* (pp. 179–198). Sage Publications, Ltd. https://doi.org/10.4135/9781849200479.n9

Cromwell, J. R., Amabile, T. M., & Harvey, J.-F. (2018). An integrated model of dynamic problem solving within organizational constraints. In *Explorations in creativity research, individual creativity in the workplace* (pp. 53–81). Academic Press, Elsevier.

Dai, W., Zhou, J., Li, G., Zhang, B., & Ma, N. (2021). Maintaining normal sleep patterns, lifestyles and emotion during the COVID-19 pandemic: The stabilizing effect of daytime napping. *Journal of Sleep Research*, *30*(4), e13259. https://doi.org/10.1111/jsr.13259

Deci, E. L., & Ryan, R. M. (2013). An introduction: Motivation theories, the organismic approach, self-determination theory: An overview. In *Intrinsic Motivation and Self-Determination in Human Behavior* (pp. 3–10). Springer New York, NY. https://doi.org/10.1007/978-1-4899-2271-7

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews*, *14*(3), 179–189. https://doi.org/10.1016/j.smrv.2009.10.004

Díaz-Morales, J. F. (2007). Morning and evening-types: Exploring their personality styles. *Personality and Individual Differences*, *43*(4), 769–778. https://doi.org/10.1016/j.paid.2007.02.002

Díaz-Morales, J. F., Ferrari, J. R., & Cohen, J. R. (2008). Indecision and avoidant procrastination: The role of morningness—eveningness and time perspective in chronic delay lifestyles. *The journal of general psychology*, *135*(3), 228–240. https://doi.org/10.3200/GENP.135.3.228-240

Díaz-Morales, J. F., & Sánchez-López, P. M. (2008). Morningness-eveningness and anxiety among adults: A matter of sex/gender? *Personality and Individual Differences*, *44*(6), 1391–1401. https://doi.org/10.1016/j.paid.2007.12.007

Didikoglu, A., Walker, B., Maharani, A., Pendleton, N., Canal, M. M., Payton, A., Gibson, J., & Brown, T. (2022). Associations between chronotype and employment status in a longitudinal study of an elderly population. *Chronobiology International*, *39*(8), 1118–1131. https://doi.org/10.1080/07420528.2022.2071158

Dinmohamed, A. G., Visser, O., Verhoeven, R. H. A., Louwman, M. W. J., Nederveen, F. H. v., Willems, S. M., Merkx, M. A. W., Lemmens, V. E. P. P., Nagtegaal, I. D., & Siesling, S. (2020). Fewer cancer diagnoses during the COVID-19 epidemic in the Netherlands. *The Lancet Oncology*, *21*(6), 750–751. https://doi.org/10.1016/S1470-2045(20)30265-5

Doucet, A., Netolicky, D., Timmers, K., & Tuscano, F. J. (2020). *Thinking about pedagogy in an unfolding pandemic: An independent report on approaches to distance learning during COVID19 school closures* (Vol. 2). Education International & UNESCO. Retrieved August 9, 2022, from https://issuu.com/educationinternational/docs/2020_research_covid-19_eng

Drezno, M., Stolarski, M., & Matthews, G. (2019). An in-depth look into the association between morningness–eveningness and well-being: Evidence for mediating and moderating effects of personality. *Chronobiology International*, *36*(1), 96–109. https://doi.org/10.1080/07420528.2018.1523184

Duggan, K. A., Friedman, H. S., McDevitt, E. A., & Mednick, S. C. (2014). Personality and Healthy Sleep: The Importance of Conscientiousness and Neuroticism. *PLOS ONE*, *9*(3), e90628. https://doi.org/10.1371/journal.pone.0090628

Eisenbeck, N., Carreno, D. F., & Uclés-Juárez, R. (2019). From psychological distress to academic procrastination: Exploring the role of psychological inflexibility. *Journal of Contextual Behavioral Science*, *13*, 103–108. https://doi.org/10.1016/j.jcbs.2019.07.007

Emborg, H.-D., Carnahan, A., Bragstad, K., Trebbien, R., Brytting, M., Hungnes, O., Byström, E., & Vestergaard, L. S. (2021). Abrupt termination of the 2019/20 influenza season following preventive measures against covid-19 in denmark, norway and sweden. *Eurosurveillance*, *26*(22), 2001160. https://doi.org/10.2807/1560-7917.ES.2021.26.22.2001160

Escribano, C., & Díaz-Morales, J. F. (2016). Are achievement goals different among morning and evening-type adolescents? *Personality and Individual Differences*, *88*, 57–61. https://doi.org/10.1016/j.paid.2015.08.032

Evans, M. D., Kelley, P., & Kelley, J. (2017). Identifying the best times for cognitive functioning using new methods: Matching university times to undergraduate chronotypes. *Frontiers in human neuroscience*, *11*(188). https://doi.org/10.3389/fnhum.2017.00188

Eysenck, H. J., & Eysenck, S. B. (1963). Eysenck personality inventory. *Journal of Clinical Psychology*. https://doi.org/10.1037/t02711-000

Fabbian, F., Zucchi, B., De Giorgi, A., Tiseo, R., Boari, B., Salmi, R., Cappadona, R., Gianesini, G., Bassi, E., Signani, F., Raparelli, V., Basili, S., & Manfredini, R. (2016). Chronotype, gender and general health. *Chronobiology International*, *33*(7), 863–882. https://doi.org/10.1080/07420528.2016.1176927

Facer-Childs, E. R., Campos, B. M., Middleton, B., Skene, D. J., & Bagshaw, A. P. (2019). Circadian phenotype impacts the brain's resting-state functional connectivity, attentional performance, and sleepiness. *Sleep*, *42*(5), zsz033. https://doi.org/10.1093/sleep/zsz033

Facer-Childs, E. R., Hoffman, D., Tran, J. N., Drummond, S. P., & Rajaratnam, S. M. (2021). Sleep and mental health in athletes during COVID-19 lockdown. *Sleep*, *44*(5), zsaa261. https://doi.org/10.1093/sleep/zsaa261

Fallone, G., Acebo, C., Seifer, R., & Carskadon, M. A. (2005). Experimental Restriction of Sleep Opportunity in Children: Effects on Teacher Ratings. *Sleep*, *28*(12), 1561–1567. https://doi.org/10.1093/sleep/28.12.1561

Ferreira-Souza, L. F., Julianelli-Peçanha, M., Coelho-Oliveira, A. C., da Silva Bahia, C. M. C., Paineiras-Domingos, L. L., Reis-Silva, A., Moura-Fernandes, M. C., Trindade-Gusmão, L. C., Taiar, R., da Cunha Sá-Caputo, D., Rapin, A., & Bernardo-Filho, M. (2023). Impacts of COVID-19 Pandemic on Sleep Quality Evaluated by Wrist Actigraphy: A Systematic Review. *Journal of Clinical Medicine*, *12*(3), 1182. https://doi.org/10.3390/jcm12031182

Florea, C., Topalidis, P., Hauser, T., Angerer, M., Kurapov, A., Beltran Leon, C. A., Soares Brandão, D., & Schabus, M. (2021). Sleep during COVID-19 lockdown: A cross-cultural study investigating job system relevance. *Biochemical Pharmacology*, *191*, 114463. https://doi.org/10.1016/j.bcp.2021.114463

Gabriel, B. M., & Zierath, J. R. (2019). Circadian rhythms and exercise — re-setting the clock in metabolic disease. *Nature Reviews Endocrinology*, *15*(4), 197–206. https://doi.org/10.1038/s41574-018-0150-x

Gabriel, B. M., & Zierath, J. R. (2022). Zeitgebers of skeletal muscle and implications for metabolic health. *The Journal of physiology*, *600*(5), 1027–1036. https://doi.org/10.1113/JP280884

Gao, C., & Scullin, M. K. (2020). Sleep health early in the coronavirus disease 2019 (COVID-19) outbreak in the United States: Integrating longitudinal, cross-sectional, and retrospective recall data. *Sleep Medicine*, *73*, 1–10. https://doi.org/10.1016/j.sleep.2020.06.032

Gassman-Pines, A., Ananat, E. O., Fitz-Henley II, J., & Leer, J. (2022). Effect of daily school and care disruptions during the covid-19 pandemic on child behavior problems. *Developmental psychology*, *58*(8), 1512–1527. https://doi.org/10.1037/dev0001373

Genta, F. D., Neto, G. B. R., Sunfeld, J. P. V., Porto, J. F., Xavier, A. D., Moreno, C. R. C., Lorenzi-Filho, G., & Genta, P. R. (2021). Covid-19 pandemic impact on sleep habits, chronotype, and health-related quality of life among high school students: A longitudinal study. *Journal of Clinical Sleep Medicine*, *17*(7), 1371–1377. https://doi.org/10.5664/jcsm.9196

Ghislandi, S., Muttarak, R., Sauerberg, M., & Scotti, B. (2020). News from the front: Estimation of excess mortality and life expectancy in the major epicenters of the COVID-19 pandemic in Italy. *MedRxiv*, 2020.04.29.20084335. https://doi.org/10.1101/2020.04.29.20084335

Giampietro, M., & Cavallera, G. M. (2007). Morning and evening types and creative thinking. *Personality and Individual Differences*, *42*(3), 453–463. https://doi.org/10.1016/j.paid.2006.06.027

Giglio, L. M. F., Magalhães, P. V. S., Andersen, M. L., Walz, J. C., Jakobson, L., & Kapczinski, F. (2010). Circadian preference in bipolar disorder. *Sleep and Breathing*, *14*(2), 153–155. https://doi.org/10.1007/s11325-009-0301-3

Gist, M. E. (1987). Self-efficacy: Implications for organizational behavior and human resource management. *The Academy of Management Review*, *12*(3), 472–485. https://doi.org/10.5465/amr.1987.4306562

Goldstein, D., Hahn, C. S., Hasher, L., Wiprzycka, U. J., & Zelazo, P. D. (2007). Time of day, intellectual performance, and behavioral problems in Morning versus Evening type adolescents: Is there a synchrony effect? *Personality and Individual Differences*, *42*(3), 431–440. https://doi.org/10.1016/j.paid.2006.07.008

Gorgol, J., Waleriańczyk, W., & Stolarski, M. (2022). The moderating role of personality traits in the relationship between chronotype and depressive symptoms. *Chronobiology International*, *39*(1), 106–116. https://doi.org/10.1080/07420528.2021.1979995

Gottholmseder, G., Nowotny, K., Pruckner, G. J., & Theurl, E. (2009). Stress perception and commuting. *Health economics*, *18*(5), 559–576. https://doi.org/10.1002/hec.1389

Goulet, G., Mongrain, V., Desrosiers, C., Paquet, J., & Dumont, M. (2007). Daily Light Exposure in Morning-Type and Evening-Type Individuals. *Journal of Biological Rhythms*, *22*(2), 151–158. https://doi.org/10.1177/0748730406297780

Gruber, R., Saha, S., Somerville, G., Boursier, J., & Wise, M. S. (2020). The impact of COVID-19 related school shutdown on sleep in adolescents: A natural experiment. *Sleep Medicine*, *76*, 33–35. https://doi.org/10.1016/j.sleep.2020.09.015

Guarana, C. L., Barnes, C. M., & Ong, W. J. (2021). The effects of blue-light filtration on sleep and work outcomes. *Journal of Applied Psychology*, *106*(5), 784–796. https://doi.org/10.1037/apl0000806

Gulec, M., Selvi, Y., Boysan, M., Aydin, A., Oral, E., & Aydin, E. F. (2013). Chronotype effects on general well-being and psychopathology levels in healthy young adults. *Biological Rhythm Research*, *44*(3), 457–468. https://doi.org/10.1080/09291016.2012.704795

Gunawardane, K. C., Custance, D. M., & Piffer, D. (2011). Evidence of Sexual Selection for Evening Orientation in Human Males: A Cross Cultural Study in Italy and Sri Lanka. *Interdisciplinary Bio Central*, *3*(4), 1–8. https://doi.org/10.4051/ibc.2011.3.4.0013

Harantová, V., Hájnik, A., Kalašová, A., & Figlus, T. (2022). The effect of the covid-19 pandemic on traffic flow characteristics, emissions production and fuel consumption at a selected intersection in slovakia. *Energies*, *15*(6), 2020. https://doi.org/10.3390/en15062020

He, L., Zhao, W., Gao, Y., Gao, X., & Lei, X. (2021). The effect of COVID-19 lockdowns on sleep time perception: Comparing actigraphy and sleep diary measures. *International Journal of Psychophysiology*, *167*, 86–93. https://doi.org/10.1016/j.ijpsycho.2021.07.001

Heissel, A., Pietrek, A., Flunger, B., Fydrich, T., Rapp, M. A., Heinzel, S., & Vansteenkiste, M. (2018). The Validation of the German Basic Psychological Need Satisfaction and Frustration Scale in the Context of Mental Health. *European Journal of Health Psychology*, *25*(4), 119–132. https://doi.org/10.1027/2512-8442/a000017

Hess, B., Sherman, M. F., & Goodman, M. (2000). Eveningness predicts academic procrastination: The mediating role of neuroticism. *Journal of Social Behavior and Personality*, *15*(5), 61. Retrieved April 18, 2022, from https://www.proquest.com/scholarly-journals/eveningness-predicts-academic-procrastination/docview/1292313737/se-2

Hidalgo, M. P., & Caumo, W. (2002). Sleep disturbances associated with minor psychiatric disorders in medical students. *Neurological Sciences*, *23*(1), 35–39. https://doi.org/10.1007/s100720200021

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O'Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*, *1*(1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Holzer, J., Lüftenegger, M., Korlat, S., Pelikan, E., Salmela-Aro, K., Spiel, C., & Schober, B. (2021). Higher Education in Times of COVID-19: University Students' Basic Need Satisfaction, Self-Regulated Learning, and Well-Being. *AERA Open*, *7*, 233285842110031. https://doi.org/10.1177/23328584211003164

Horesh, D., & Brown, A. D. (2020). Traumatic stress in the age of covid-19: A call to close critical gaps and adapt to new realities. *Psychological Trauma: Theory, Research, Practice, and Policy*, *12*(4), 331–335. https://doi.org/10.1037/tra0000592

Horzum, M. B., Önder, İ., & Beşoluk, Ş. (2014). Chronotype and academic achievement among online learning students. *Learning and Individual Differences*, *30*, 106–111. https://doi.org/10.1016/j.lindif.2013.10.017

Huang, T., Mariani, S., & Redline, S. (2020). Sleep irregularity and risk of cardiovascular events: The multiethnic study of atherosclerosis. *Journal of the American College of Cardiology*, *75*(9), 991–999. https://doi.org/10.1016/j.jacc.2019.12.054

Jackson, C., Stewart, I., Plekhanova, T., Cunningham, P., Hazel, A. L., Al-Sheklly, B., Aul, R., Bolton, C. E., Chalder, T., Chalmers, J. D., et al. (2022). The effects of sleep disturbance on dyspnoea and impaired lung function following covid-19 hospitalisation: A prospective multi-centre cohort study. *medRxiv*, 2022.12.13.22283391. https://doi.org/10.1101/2022.12.13.22283391

Jagiellowicz, J., Aron, A., & Aron, E. N. (2016). Relationship between the temperament trait of sensory processing sensitivity and emotional reactivity. *Social Behavior and Personality: an international journal*, *44*(2), 185–199. https://doi.org/10.2224/sbp.2016.44.2.185

Jahrami, H., BaHammam, A. S., Bragazzi, N. L., Saif, Z., Faris, M., & Vitiello, M. V. (2021). Sleep problems during the COVID-19 pandemic by population: A systematic review and meta-analysis. *Journal of Clinical Sleep Medicine*, *17*(2), 299–313. https://doi.org/10.5664/jcsm.8930

Jankowski, K. S. (2012). Morningness/eveningness and satisfaction with life in a Polish sample. *Chronobiology International*, *29*(6), 780–785. https://doi.org/10.3109/07420528.2012.685671

Jankowski, K. S. (2016). Morningness-eveningness and depressive symptoms: Test on the components level with CES-D in Polish students. *Journal of Affective Disorders*, *196*, 47–53. https://doi.org/10.1016/j.jad.2016.02.015

Jerusalem, M., & Schwarzer, R. (1986). Selbstwirksamkeit. *Skalen zur Befindlichkeit und Persönlichkeit*, *5*, 15–28.

Jett, Q. R., & George, J. M. (2003). Work interrupted: A closer look at the role of interruptions in organizational life. *Academy of management Review*, *28*(3), 494–507. https://doi.org/10.5465/amr.2003.10196791

Ji, L., Wallace, M. L., Master, L., Schade, M. M., Shen, Y., Derby, C. A., & Buxton, O. M. (2023). Six multidimensional sleep health facets in older adults identified with factor analysis of actigraphy: Results from the einstein aging study. *Sleep Health*, *9*(5), 758–766. https://doi.org/10.1016/j.sleh.2023.03.002

Kahn, M., Sheppes, G., & Sadeh, A. (2013). Sleep and emotions: Bidirectional links and underlying mechanisms. *International Journal of Psychophysiology*, *89*(2), 218–228. https://doi.org/10.1016/j.ijpsycho.2013.05.010

Karwowski, M., Lebuda, I., Wisniewska, E., & Gralewski, J. (2013). Big five personality traits as the predictors of creative self-efficacy and creative personal identity: Does gender matter? *The Journal of Creative Behavior*, *47*(3), 215–232. https://doi.org/10.1002/jocb.32

Kasaeian, A., Weidenauer, C., Hautzinger, M., & Randler, C. (2019). Reproductive success, relationship orientation, and sexual behavior in heterosexuals: Relationship with chronotype, sleep, and sex. *Evolutionary Psychology*, *17*(3), 1474704919859760. https://doi.org/10.1177/1474704919859760

Kelley, P., Lockley, S. W., Foster, R. G., & Kelley, J. (2015). Synchronizing education to adolescent biology: 'let teens sleep, start school later'. *Learning, Media and Technology*, *40*(2), 210–226. https://doi.org/10.1080/17439884.2014.942666

Kivelä, L., Papadopoulos, M. R., & Antypa, N. (2018). Chronotype and psychiatric disorders. *Current sleep medicine reports*, *4*, 94–103. https://doi.org/10.1007/s40675-018-0113-8

Klassen, R. M., Perry, N. E., & Frenzel, A. C. (2012). Teachers' relatedness with students: An underemphasized component of teachers' basic psychological needs. *Journal of Educational Psychology*, *104*(1), 150–165. https://doi.org/10.1037/a0026253

Knutson, K. L., & Von Schantz, M. (2018). Associations between chronotype, morbidity and mortality in the UK Biobank cohort. *Chronobiology International*, *35*(8), 1045–1053. https://doi.org/10.1080/07420528.2018.1454458

Kolomeichuk, S. N., Randler, C., Shabalina, I., Fradkova, L., & Borisenkov, M. (2016). The influence of chronotype on the academic achievement of children and adolescents – evidence from Russian Karelia. *Biological Rhythm Research*, *47*(6), 873–883. https://doi.org/10.1080/09291016.2016.1207352

Konttinen, H., Kronholm, E., Partonen, T., Kanerva, N., Männistö, S., & Haukkala, A. (2014). Morningness–eveningness, depressive symptoms, and emotional eating: A population-based study. *Chronobiology International*, *31*(4), 554–563. https://doi.org/10.3109/07420528.2013.877922

Korman, M., Tkachev, V., Reis, C., Komada, Y., Kitamura, S., Gubin, D., Kumar, V., & Roenneberg, T. (2020). COVID-19-mandated social restrictions unveil the impact of social time pressure on sleep and body clock. *Scientific Reports*, *10*(1), 22225. https://doi.org/10.1038/s41598-020-79299-7

Korman, M., Tkachev, V., Reis, C., Komada, Y., Kitamura, S., Gubin, D., Kumar, V., & Roenneberg, T. (2022). Outdoor daylight exposure and longer sleep promote wellbeing under COVID-19 mandated restrictions. *Journal of sleep research*, *31*(2), e13471. https://doi.org/10.1111/jsr.13471

Kotov, R., Gamez, W., Schmidt, F., & Watson, D. (2010). Linking "big" personality traits to anxiety, depressive, and substance use disorders: A meta-analysis. *Psychological bulletin*, *136*(5), 768–821. https://doi.org/10.1037/a0020327

Krammer, G., Pflanzl, B., & Matischek-Jauk, M. (2020). Aspekte der Online-Lehre und deren Zusammenhang mit positivem Erleben und Motivation bei Lehramtsstudierenden: Mixed-method Befunde zu Beginn von COVID-19. *Zeitschrift für Bildungsforschung*, *10*(3), 337–375. https://doi.org/10.1007/s35834-020-00283-2

Krarti, M., & Aldubyan, M. (2021). Review analysis of covid-19 impact on electricity demand for residential buildings. *Renewable and Sustainable Energy Reviews*, *143*, 110888. https://doi.org/10.1016/j.rser.2021.110888

Kumar, K., Bakhshi, A., & Rani, E. (2009). Linking the 'Big Five'personality domains to Organizational citizenship behavior. *International journal of Psychological studies*, *1*(2), 73–81. https://doi.org/10.5539/ijps.v1n2p73

Kylili, A., Afxentiou, N., Georgiou, L., Panteli, C., Morsink-Georgalli, P.-Z., Panayidou, A., Papouis, C., & Fokaides, P. A. (2020). The role of remote working in smart cities: Lessons learnt from covid-19 pandemic. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1–16. https://doi.org/10.1080/15567036.2020.1831108

Lan, A., Kotler, D., Kronfeld-Schor, N., Stukalin, Y., & Einat, H. (2022). Changes in sleep patterns of college students in Israel during COVID-19 lockdown, a sleep diaries study. *Sleep and biological rhythms*, *20*(2), 309–314. https://doi.org/10.1007/s41105-021-00371-4

Landesregierung: Baden-Württemberg. (2020). Pressemitteilung. Landesweite Schließung von Schulen und Kindergärten. Retrieved July 9, 2022, from https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/landesweite-schliessung-von-schulen-und-kindergaerten/

Lange, L., & Randler, C. (2011). Morningness-eveningness and behavioural problems in adolescents. *Sleep and Biological Rhythms*, *9*(1), 12–18. https://doi.org/10.1111/j.1479-8425.2010.00478.x

Latipah, E., Adi, H. C., & Insani, F. D. (2021). Academic Procrastination of High School Students During the Covid-19 Pandemic: Review from Self-Regulated Learning and the Intensity of Social Media. *Dinamika Ilmu*, *21*(2), 293–308. https://doi.org/10.21093/di.v21i2.3444

Lázár, A. S., Slak, A., Lo, J. C.-Y., Santhi, N., von Schantz, M., Archer, S. N., Groeger, J. A., & Dijk, D.-J. (2012). Sleep, diurnal preference, health, and psychological well-being: A prospective single-allelic-variation study. *Chronobiology International*, *29*(2), 131–146. https://doi.org/10.3109/07420528.2011.641193

Lee, S. S., Chao, M. M., & He, H. (2022). When family interrupted work: The implications of gendered role perception in the face of covid-19. *Journal of Social Issues*, 1–17. https://doi.org/10.1111/josi.12504

Leone, M. J., Sigman, M., & Golombek, D. A. (2020). Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. *Current Biology*, *30*(16), R930–R931. https://doi.org/10.1016/j.cub.2020.07.015

Leroy, S., Schmidt, A. M., & Madjar, N. (2021). Working from home during COVID-19: A study of the interruption landscape. *Journal of Applied Psychology*, *106*(10), 1448–1465. https://doi.org/10.1037/apl0000972

Li, H. (2022). Normal lark, deviant owl: The relationship between chronotype and compliance with COVID-19 mitigation measures. *Chronobiology International*, *39*(11), 1524–1532. https://doi.org/10.1080/07420528.2022.2123276

Lim, J.-W., Phang, J.-Y., Low, M.-Y., & Tan, C.-S. (2017). Procrastination is detrimental to undergraduate students' self-rated creativity: The mediating role of state anxiety. *Creativity. Theories–Research-Applications*, *4* (1), 99–115. https://doi.org/10.1515/ctra-2017-0005

Lipnevich, A. A., Credè, M., Hahn, E., Spinath, F. M., Roberts, R. D., & Preckel, F. (2017). How distinctive are morningness and eveningness from the Big Five factors of personality? A meta-analytic investigation. *Journal of Personality and Social Psychology*, *112* (3), 491–509. https://doi.org/10.1037/pspp0000099

Machtmes, K., & Asher, J. W. (2000). A meta-analysis of the effectiveness of telecourses in distance education. *American Journal of Distance Education*, *14* (1), 27–46. https://doi.org/10.1080/08923640009527043

Maestripieri, D. (2014). Night owl women are similar to men in their relationship orientation, risk-taking propensities, and cortisol levels: Implications for the adaptive significance and evolution of eveningness. *Evolutionary Psychology*, *12* (1), 147470491401200111. https://doi.org/10.1177/147470491401200111

Marelli, S., Castelnuovo, A., Somma, A., Castronovo, V., Mombelli, S., Bottoni, D., Leitner, C., Fossati, A., & Ferini-Strambi, L. (2021). Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *Journal of neurology*, *268*, 8–15. https://doi.org/10.1007/s00415-020-10056-6

Martinek, D., Carmignola, M., Müller, F. H., Bieg, S., Thomas, A., Eckes, A., Großmann, N., Dittrich, A.-K., & Wilde, M. (2021). How can students feel more vital amidst severe restrictions? Psychological needs satisfaction, motivational regulation and vitality of students during the coronavirus pandemic restrictions. *European Journal of Investigation in Health, Psychology and Education*, *11* (2), 405–422. https://doi.org/10.3390/ejihpe11020030

McCoy, J. G., & Strecker, R. E. (2011). The cognitive cost of sleep lost. *Neurobiology of learning and memory*, *96* (4), 564–582. https://doi.org/10.1016/j.nlm.2011.07.004

Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers college record*, *115* (3), 1–47. https://doi.org/10.1177/016146811311500307

Mecacci, L., & Rocchetti, G. (1998). Morning and evening types: Stress-related personality aspects. *Personality and individual Differences*, *25* (3), 537–542. https://doi.org/10.1016/S0191-8869(98)00087-7

Merikanto, I., Kronholm, E., Peltonen, M., Laatikainen, T., Lahti, T., & Partonen, T. (2012). Relation of chronotype to sleep complaints in the general Finnish population. *Chronobiology International*, *29* (3), 311–317. https://doi.org/10.3109/07420528.2012.655870

Merikanto, I., Lahti, T., Puolijoki, H., Vanhala, M., Peltonen, M., Laatikainen, T., Vartiainen, E., Salomaa, V., Kronholm, E., & Partonen, T. (2013). Associations of chronotype and sleep with cardiovascular diseases and type 2 diabetes. *Chronobiology International*, *30* (4), 470–477. https://doi.org/10.3109/07420528.2012.741171

Merkel, A., Söder, M., & Tschentscher, P. (2020). Pressekonferenz von Bundeskanzlerin Merkel, Ministerpräsident Söder und dem Ersten Bürgermeister Tschentscher im Anschluss an das Gespräch mit den Regierungschefinnen und Regierungschefs der Länder am 06.05.2020: retrieved August 9, 2022, from https://www.bundesregierung.de/breg-de/aktuelles/pressekonferenzen/pressekonferenz-von-bundeskanzlerin-merkel-ministerpraesident-soeder-und-dem-ersten-buergermeister-tschentscher-im-anschluss-an-das-gespraech-mit-den-regierungschefinnen-und-regierungschefs-der-laender-1751050

Ministerpräsidentenkonferenz. (2020a). MPK-Beschluss: Beschluss der Bundeskanzlerin und der Regierungschefinnen und Regierungschefs der Länder vom 22. März 2020. Retrieved July 9, 2022, from https://www.bmi.bund.de/SharedDocs/downloads/DE/veroeffentlichungen/2020/corona/hinweis-einschraenkung-soziale-kontakte.html

Ministerpräsidentenkonferenz. (2020b). MPK-Beschluss: Telefonkonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 13. Dezember 2020. Retrieved August 9, 2022, from https://www.bundesregierung.de/resource/blob/997532/1827366/69441fb68435a7199b3d3a89bff2c0e6/2020-12-13-beschluss-mpk-data.pdf

Ministerpräsidentenkonferenz. (2020c). MPK-Beschluss: Telefonschaltkonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 15. April 2020. Retrieved July 9, 2022, from https://www.bundesregierung.de/resource/blob/973812/1744226/bcf47533c99dc84216eded8772e803d4/2020-04-15-beschluss-bund-laender-data.pdf

Ministerpräsidentenkonferenz. (2020d). MPK-Beschluss: Telefonschaltkonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 30. April 2020. Retrieved July 9, 2022, from https://www.bundesregierung.de/resource/blob/975226/1749804/d3e2fa884ba9ac2b743192d27dc12aea/2020-04-30-beschluss-bund-laender-data.pdf?download=1

Ministerpräsidentenkonferenz. (2020e). MPK-Beschluss: Videoschaltkonferenz der Bundeskanzlerin mit den Regierungschefinnen und Regierungschefs der Länder am 19. Januar 2021. Retrieved August 9, 2022, from https://www.bundesregierung.de/resource/blob/974430/1840868/1c68fcd2008b53cf12691162bf20626f/2021-01-19-mpk-data.pdf?download=1

Modig, K., Ahlbom, A., & Ebeling, M. (2021). Excess mortality from COVID-19: Weekly excess death rates by age and sex for Sweden and its most affected region. *European journal of public health*, *31*(1), 17–22. https://doi.org/10.1093/eurpub/ckaa218

Monk, T. H., Buysse, D. J., Kennedy, K. S., Potts, J. M., DeGrazia, J. M., & Miewald, J. M. (2003). Measuring sleep habits without using a diary: The sleep timing questionnaire. *Sleep*, *26*(2), 208–212.

Müller, F. H., Thomas, A. E., Carmignola, M., Dittrich, A.-K., Eckes, A., Großmann, N., Martinek, D., Wilde, M., & Bieg, S. (2021). University students' basic psychological needs, motivation, and vitality before and during COVID-19: A self-determination theory approach. *Frontiers in psychology*, *12*, 775804. https://doi.org/10.3389/fpsyg.2021.775804

Muro, A., Gomà-i-Freixanet, M., & Adan, A. (2012). Circadian typology and sensation seeking in adolescents. *Chronobiology International*, *29*(10), 1376–1382. https://doi.org/10.3109/07420528.2012.728665

Negriff, S., Dorn, L. D., Pabst, S. R., & Susman, E. J. (2011). Morningness/eveningness, pubertal timing, and substance use in adolescent girls. *Psychiatry Research*, *185*(3), 408–413. https://doi.org/10.1016/j.psychres.2010.07.006

Nicholson, L., Mullan, B., & Liddelow, C. (2022). Investigating the role of morningness/eveningness in physical activity engagement. *Health Psychology and Behavioral Medicine*, *10*(1), 1003–1019. https://doi.org/10.1080/21642850.2022.2136183

Novianti, R., & Garzia, M. (2020). Parental engagement in children's online learning during covid-19 pandemic. *Journal of Teaching and Learning in Elementary Education (Jtlee)*, *3*(2), 117–131. https://doi.org/10.33578/jtlee.v3i2.7845

Núñez, J. L., & León, J. (2016). The Mediating Effect of Intrinsic Motivation to Learn on the Relationship between Student's Autonomy Support and Vitality and Deep Learning. *The Spanish Journal of Psychology*, *19*, E42. https://doi.org/10.1017/sjp.2016.43

Oliveira, G. F., Marin, T. C., Apolinário, N., Rosa-Silva, J., Azevêdo, L., Ceciliato, J., Silva-Batista, C., & Brito, L. C. (2021). Association of morningness–eveningness preference with physical activity during the COVID-19 pandemic social distancing: A cross-sectional survey in Brazil: Circadian rhythm, physical activity and isolation. *Chronobiology International*, *38*(10), 1432–1440. https://doi.org/10.1080/07420528.2021.1931276

Ong, J. L., Lau, T., Massar, S. A., Chong, Z. T., Ng, B. K., Koek, D., Zhao, W., Yeo, B. T., Cheong, K., & Chee, M. W. (2021). COVID-19-related mobility reduction: Heterogenous effects on sleep and physical activity rhythms. *Sleep*, *44*(2), zsaa179. https://doi.org/10.1093/sleep/zsaa179

Ono, B. H. V. S., Souza, J. C., et al. (2020). Sleep and immunity in times of COVID-19. *Revista da Associação Médica Brasileira*, *66*(2), 143–147. https://doi.org/10.1590/1806-9282.66.S2.143

O'regan, D., Jackson, M. L., Young, A. H., & Rosenzweig, I. (2021). Understanding the impact of the COVID-19 pandemic, lockdowns and social isolation on sleep quality. *Nature and science of sleep*, *13*, 2053–2064. https://doi.org/10.2147/NSS.S266240

Ottoni, G. L., Antoniolli, E., & Lara, D. R. (2012). Circadian preference is associated with emotional and affective temperaments. *Chronobiology International*, *29*(6), 786–793. https://doi.org/10.3109/07420528.2012.679329

Owens, J. A., Dearth-Wesley, T., Lewin, D., Gioia, G., & Whitaker, R. C. (2016). Self-regulation and sleep duration, sleepiness, and chronotype in adolescents. *Pediatrics*, *138*(6), e20161406. https://doi.org/10.1542/peds.2016-1406

Pancani, L., Marinucci, M., Aureli, N., & Riva, P. (2021). Forced social isolation and mental health: A study on 1,006 Italians under COVID-19 lockdown. *Frontiers in psychology*, *12*, 663799. https://doi.org/10.3389/fpsyg.2021.663799

Partonen, T. (2015). Chronotype and health outcomes. *Current Sleep Medicine Reports*, *1*, 205–211. https://doi.org/10.1007/s40675-015-0022-z

Pelikan, E. R., Lüftenegger, M., Holzer, J., Korlat, S., Spiel, C., & Schober, B. (2021). Learning during COVID-19: The role of self-regulated learning, motivation, and procrastination for perceived competence. *Zeitschrift für Erziehungswissenschaft*, *24*(2), 393–418. https://doi.org/10.1007/s11618-021-01002-x

Pfeifer, C. (2018). An empirical note on commuting distance and sleep during workweek and weekend. *Bulletin of Economic Research*, *70*(1), 97–102. https://doi.org/10.1111/boer.12121

Piffer, D. (2010). Sleep patterns and sexual selection: An evolutionary approach. *Mankind Quarterly*, *50*(4), 361–375. https://doi.org/10.46469/mq.2010.50.4.6

Piquero, A. R., Jennings, W. G., Jemison, E., Kaukinen, C., & Knaul, F. M. (2021). Domestic violence during the COVID-19 pandemic-Evidence from a systematic review and meta-analysis. *Journal of criminal justice*, *74*, 101806. https://doi.org/10.1016/j.jcrimjus.2021.101806

Plümper, T., & Neumayer, E. (2022). Lockdown policies and the dynamics of the first wave of the sars-cov-2 pandemic in europe. *Journal of European Public Policy*, *29*(3), 321–341. https://doi.org/10.1080/13501763.2020.1847170

Preckel, F., Lipnevich, A. A., Schneider, S., & Roberts, R. D. (2011). Chronotype, cognitive abilities, and academic achievement: A meta-analytic investigation. *Learning and Individual Differences*, *21*(5), 483–492. https://doi.org/10.1016/j.lindif.2011.07.003

Prieto, P. D., Díaz-Morales, J. F., Barreno, C. E., Mateo, M. J. C., & Randler, C. (2012). Morningness-eveningness and health-related quality of life among adolescents. *The Spanish journal of psychology*, *15*(2), 613–623. https://doi.org/10.5209/rev_SJOP.2012.v15.n2.38872

Pritchard, R. D., & Payne, S. C. (2002). Performance management practices and motivation. In *The new workplace* (pp. 219–244). John Wiley & Sons, Ltd. https://doi.org/https://doi.org/10.1002/9780470713365.ch12

Przepiórka, A., B\textbackslashlachnio, A., & Siu, N. Y.-F. (2019). The relationships between self-efficacy, self-control, chronotype, procrastination and sleep problems in young adults. *Chronobiology International*, *36*(8), 1025–1035. https://doi.org/10.1080/07420528.2019.1607370

Putilov, A. A. (2018). Associations of depression and seasonality with morning-evening preference: Comparison of contributions of its morning and evening components. *Psychiatry research*, *262*, 609–617. https://doi.org/10.1016/j.psychres.2017.09.054

Radchikova, N. P., & Odintsova, M. A. (2021). Assessment of the covid-19 pandemic situation: Data from two countries with different security measures taken by authorities (belarus and russia). *Data in Brief*, *35*, 106917. https://doi.org/10.1016/j.dib.2021.106917

Rahafar, A., Randler, C., Castellana, I., & Kausch, I. (2017). How does chronotype mediate gender effect on Dark Triad? *Personality and Individual Differences*, *108*, 35–39. https://doi.org/10.1016/j.paid.2016.12.002

Raman, S., & Coogan, A. N. (2022). Effects of societal-level COVID-19 mitigation measures on the timing and quality of sleep in Ireland. *Sleep Medicine*, *91*, 179–184. https://doi.org/10.1016/j.sleep.2021.02.024

Ramírez-Contreras, C., Zerón-Rugerio, M. F., & Izquierdo-Pulido, M. (2022). Life before and after COVID-19: The 'New Normal' Benefits the Regularity of Daily Sleep and Eating Routines among College Students. *Nutrients*, *14*(2), 351. https://doi.org/10.3390/nu14020351

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of research in Personality*, *41*(1), 203–212.

Rammstedt, B., Kemper, C., Klein, M. C., Beierlein, C., & Kovaleva, A. (2013). Eine kurze skala zur messung der fünf dimensionen der persönlichkeit: Big-five-inventory-10 (BFI-10). *Methoden, Daten, Analysen (mda)*, *7*(2), 233–249.

Randler, C. (2008a). Differences between smokers and nonsmokers in morningness-eveningness. *Social Behavior and Personality: an international journal*, *36*(5), 673–680. https://doi.org/10.2224/sbp.2008.36.5.673

Randler, C. (2008b). Morningness–eveningness and satisfaction with life. *Social Indicators Research*, *86*, 297–302. https://doi.org/10.1007/s11205-007-9139-x

Randler, C. (2009). Proactive people are morning people. *Journal of Applied Social Psychology*, *39*(12), 2787–2797. https://doi.org/10.1111/j.1559-1816.2009.00549.x

Randler, C., Baumann, V. P., & Horzum, M. B. (2014). Morningness–eveningness, Big Five and the BIS/BAS inventory. *Personality and Individual Differences*, *66*, 64–67. https://doi.org/10.1016/j.paid.2014.03.010

Randler, C., Díaz-Morales, J. F., Rahafar, A., & Vollmer, C. (2016). Morningness–eveningness and amplitude–development and validation of an improved composite scale to measure circadian preference and stability (MESSi). *Chronobiology international*, *33*(7), 832–848.

Randler, C., Ebenhoeh, N., Fischer, A., Hoechel, S., Schroff, C., Stoll, J. C., Vollmer, C., & Piffer, D. (2012). Eveningness is related to men's mating success. *Personality and Individual Differences*, *53*(3), 263–267. https://doi.org/10.1016/j.paid.2012.03.025

Randler, C., Faßl, C., & Kalb, N. (2017). From Lark to Owl: Developmental changes in morningness-eveningness from new-borns to early adulthood. *Scientific reports*, *7*(1), 1–8. https://doi.org/10.1038/srep45874

Randler, C., & Frech, D. (2006). Correlation between morningness – eveningness and final school leaving exams. *Biological Rhythm Research*, *37*(3), 233–239. https://doi.org/10.1080/09291010600645780

Randler, C., & Frech, D. (2009). Young people's time-of-day preferences affect their school performance. *Journal of Youth Studies*, *12*(6), 653–667. https://doi.org/10.1080/13676260902902697

Randler, C., Schredl, M., & Göritz, A. S. (2017). Chronotype, sleep behavior, and the big five personality factors. *Sage Open*, *7*(3), 2158244017728321. https://doi.org/10.1177/2158244017728321

Randler, C., Stadler, L., Vollmer, C., & Diaz-Morales, J. F. (2012). Relationship between depressive symptoms and sleep duration/chronotype in women. *Journal of Individual Differences*, *33*(3), 186–191. https://doi.org/10.1027/1614-0001/a000089

Randler, C., & Weber, V. (2015). Positive and negative affect during the school day and its relationship to morningness–eveningness. *Biological Rhythm Research*, *46*(5), 683–690.

Reeve, J. (2018). Chapter 5: Extrinsic Motivation and Internalization & Chapter 6: Psychological Needs. In *Understanding Motivation and Emotion* (pp. 98–151). John Wiley & Sons.

Reutrakul, S., & Knutson, K. L. (2015). Consequences of circadian disruption on cardiometabolic health. *Sleep medicine clinics*, *10*(4), 455–468. https://doi.org/10.1016/j.jsmc.2015.07.005

Rezaei, N., & Grandner, M. A. (2021). Changes in sleep duration, timing, and variability during the COVID-19 pandemic: Large-scale Fitbit data from 6 major US cities. *Sleep Health*, *7*(3), 303–313. https://doi.org/10.1016/j.sleh.2021.02.008

Rigó, A., Tóth-Király, I., Magi, A., Eisinger, A., Griffiths, M. D., & Demetrovics, Z. (2023). Morningness-Eveningness and Problematic Online Activities. *International Journal of Mental Health and Addiction*, 1–21. https://doi.org/10.1007/s11469-023-01017-x

Rivers, D. J. (2021). The role of personality traits and online academic self-efficacy in acceptance, actual use and achievement in Moodle. *Education and Information Technologies*, *26*(4), 4353–4378.

Roberts, A., Rogers, J., Mason, R., Siriwardena, A. N., Hogue, T., Whitley, G. A., & Law, G. R. (2021). Alcohol and other substance use during the COVID-19 pandemic: A systematic review. *Drug and alcohol dependence*, *229*, 109150. https://doi.org/10.1016/j.drugalcdep.2021.109150

Roberts, R. E., Roberts, C. R., & Duong, H. T. (2009). Sleepless in adolescence: Prospective data on sleep deprivation, health and functioning. *Journal of adolescence*, *32*(5), 1045–1057. https://doi.org/10.1016/j.adolescence.2009.03.007

Rodriguez-Leor, O., Cid-Álvarez, B., Ojeda, S., Martín-Moreiras, J., Rumoroso, J. R., López-Palop, R., Serrador, A., Cequier, A., Romaguera, R., Cruz, I., et al. (2020). Impact of the COVID-19 pandemic on interventional cardiology activity in Spain. *REC Interv Cardiol*, *2*(2), 82–9. https://doi.org/10.24875/RECICE.M20000123

Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Merrow, M. (2004). A marker for the end of adolescence. *Current biology*, *14*(24), R1038–R1039. https://doi.org/10.1016/j.cub.2004.11.039

Roenneberg, T., Wirz-Justice, A., & Merrow, M. (2003). Life between clocks: Daily temporal patterns of human chronotypes. *Journal of biological rhythms*, *18*(1), 80–90. https://doi.org/10.1177/0748730402239679

Roeser, K., Meule, A., Schwerdtle, B., Kübler, A., & Schlarb, A. A. (2012). Subjective sleep quality exclusively mediates the relationship between morningness-eveningness preference and self-perceived stress response. *Chronobiology International*, *29*(7), 955–960. https://doi.org/10.3109/07420528.2012.699124

Roeser, K., Schlarb, A. A., & Kübler, A. (2013). The chronotype-academic performance model (cam): Daytime sleepiness and learning motivation link chronotype and school performance in adolescents. *Personality and Individual Differences*, *54*(7), 836–840. https://doi.org/10.1016/j.paid.2012.12.021

Rome, O., Sinai, L., Sevitt, R., Meroody, A., Nadolne, M., Shilco, P., Jacobs, G. P., Shterenshis, M., Sosnow, A., Foonberg, M., et al. (2021). Owls and larks do not exist: Covid-19 quarantine sleep habits. *Sleep medicine*, *77*, 177–183. https://doi.org/10.1016/j.sleep.2020.09.003

Ruffing, S., Hahn, E., Spinath, F. M., Brünken, R., & Karbach, J. (2015). Predicting students' learning strategies: The contribution of chronotype over personality. *Personality and Individual Differences*, *85*, 199–204. https://doi.org/10.1016/j.paid.2015.04.048

Russo, P. M., Leone, L., Penolazzi, B., & Natale, V. (2012). Circadian preference and the big five: The role of impulsivity and sensation seeking. *Chronobiology International*, *29*(8), 1121–1126. https://doi.org/10.3109/07420528.2012.706768

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of social and clinical psychology*, *29*(1), 95–122. https://doi.org/10.1521/jscp.2010.29.1.95

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, *25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Ryan, R. M., & Deci, E. L. (2017). The Six Mini-Theories of Self-Determination Theory & Motivation and Human Developement in Families, Schools and Societies. In *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness* (pp. 319–555). The Guilford Press A Division of Guilford Publications, Inc. New York.

Ryan, R. M., & Frederick, C. (1997). On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. *Journal of Personality*, *65*(3), 529–565. https://doi.org/10.1111/j.1467-6494.1997.tb00326.x

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and emotion*, *30*, 344–360. https://doi.org/10.1007/s11031-006-9051-8

Ryff, C. D., Singer, B. H., & Dienberg Love, G. (2004). Positive health: Connecting well–being with biology. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *359*(1449), 1383–1394. https://doi.org/10.1098/rstb.2004.1521

Santos, J. S., & Louzada, F. M. (2022). Changes in adolescents' sleep during COVID-19 outbreak reveal the inadequacy of early morning school schedules. *Sleep Science*, *15*(Spec 1), 74–79. https://doi.org/10.5935/1984-0063.20200127

Saxena, R., Parmar, N., Kaur, P., & Allen, T. (2021). Effect of screen-time on sleep pattern and dietary habits among college-going students in COVID-19 pandemic. *Indian Journal of Community Health*, *33*(1), 65–74. https://doi.org/10.47203/IJCH.2021.v33i01.009

Saxvig, I. W., Pallesen, S., Sivertsen, B., Hysing, M., Evanger, L. N., & Bjorvatn, B. (2022). Sleep during COVID-19-related school lockdown, a longitudinal study among high school students. *Journal of Sleep Research*, *31*(2), e13499. https://doi.org/10.1111/jsr.13499

Scarpelli, S., Zagaria, A., Ratti, P.-L., Albano, A., Fazio, V., Musetti, A., Varallo, G., Castelnuovo, G., Plazzi, G., & Franceschini, C. (2022). Subjective sleep alterations in healthy subjects worldwide during COVID-19 pandemic: A systematic review, meta-analysis and meta-regression. *Sleep Medicine*, *100*, 89–102. https://doi.org/10.1016/j.sleep.2022.07.012

Schmeer, K. K., Singletary, B., Purtell, K. M., & Justice, L. M. (2023). Family disruption and parenting during the covid-19 pandemic. *Journal of Family Issues*, *44*(1), 112–138. https://doi.org/10.1177/0192513X211042852

Schneider, A.-M., & Randler, C. (2009). Daytime sleepiness during transition into daylight saving time in adolescents: Are owls higher at risk? *Sleep medicine*, *10*(9), 1047–1050. https://doi.org/10.1016/j.sleep.2008.08.009

Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychological bulletin*, *143*(6), 565–600. https://doi.org/10.1037/bul0000098

Schwartz, B. (2009). Why we suffer. In *The paradox of choice: Why more is less, revised edition* (pp. 99–220). HarperCollins Publishers.

Scott, S. R., Rivera, K. M., Rushing, E., Manczak, E. M., Rozek, C. S., & Doom, J. R. (2021). "I hate this": A qualitative analysis of adolescents' self-reported challenges during the covid-19 pandemic. *Journal of Adolescent Health*, *68*(2), 262–269. https://doi.org/10.1016/j.jadohealth.2020.11.010

Sexton-Radek, K. (2021). Young Adult Sleep Health during COVID-19 Pandemic. *Health*, *13*(4), 369–377. https://doi.org/10.4236/health.2021.134030

Shin, J.-E., & Kim, J. K. (2018). How a good sleep predicts life satisfaction: The role of zero-sum beliefs about happiness. *Frontiers in psychology*, *9*, 1589. https://doi.org/10.3389/fpsyg.2018.01589

Şimşek, Ö. F., & Koydemir, S. (2013). Linking metatraits of the big five to well-being and ill-being: Do basic psychological needs matter? *Social Indicators Research*, *112*, 221–238. https://doi.org/10.1007/s11205-012-0049-1

Sinha, M., Pande, B., & Sinha, R. (2020). Association of mid sleep time and social jetlag with psychosocial behaviour of Indian population during COVID-19 lockdown. *Journal of Public Health Research*, *9*(4), 1870. https://doi.org/10.4081/jphr.2020.1870

Smit, A. N., Juda, M., Livingstone, A., U, S. R., & Mistlberger, R. E. (2021). Impact of COVID-19 social-distancing on sleep timing and duration during a university semester. *PloS one*, *16*(4), e0250793. https://doi.org/10.1371/journal.pone.0250793

Smolewska, K. A., McCabe, S. B., & Woody, E. Z. (2006). A psychometric evaluation of the Highly Sensitive Person Scale: The components of sensory-processing sensitivity and their relation to the BIS/BAS and "Big Five". *Personality and Individual Differences*, *40*(6), 1269–1279. https://doi.org/10.1016/j.paid.2005.09.022

Socarras, L. R., Potvin, J., & Forest, G. (2021). COVID-19 and sleep patterns in adolescents and young adults. *Sleep Medicine*, *83*, 26–33. https://doi.org/10.1016/j.sleep.2021.04.010

Song, H.-D., & Grabowski, B. L. (2006). Stimulating intrinsic motivation for problem solving using goal-oriented contexts and peer group composition. *Educational Technology Research and Development*, *54*(5), 445–466. https://doi.org/10.1007/s11423-006-0128-6

Souza, L. F. F. d., Paineiras-Domingos, L. L., Melo-Oliveira, M. E. d. S., Pessanha-Freitas, J., Moreira-Marconi, E., Lacerda, A. C. R., Mendonça, V. A., Sá-Caputo, D. d. C., & Bernardo-Filho, M. (2021). The impact of COVID-19 pandemic in the quality of sleep by Pittsburgh Sleep Quality Index: A systematic review. *Ciência & Saúde Coletiva*, *26*, 1457–1466. https://doi.org/10.1590/1413-81232021264.45952020

Staller, N., Großmann, N., Eckes, A., Wilde, M., Müller, F. H., & Randler, C. (2021). Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19. *6*, 681840. https://doi.org/10.3389/feduc.2021.681840

Staller, N., Kalbacher, L., & Randler, C. (2022). Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic. *Somnologie*, *26*(2), 98–105. https://doi.org/10.1007/s11818-022-00346-8

Staller, N., Quante, M., Deutsch, H., & Randler, C. (2023). Onsite versus home-office: Differences in sleep patterns according to workplace. *Somnologie*. https://doi.org/10.1007/s11818-023-00408-5

Staller, N., & Randler, C. (2021a). Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. *Somnologie*, *25*(2), 131–137. https://doi.org/10.1007/s11818-020-00277-2

Staller, N., & Randler, C. (2021b). Chronotype dependent choosiness and mate choice. *Personality and Individual Differences*, *168*, 110375. https://doi.org/10.1016/j.paid.2020.110375

Staller, N., & Randler, C. (2021c). Relationship Between Big Five Personality Dimensions, Chronotype, and DSM-V Personality Disorders. *Frontiers in Network Physiology*, *1*, 729113. https://doi.org/10.3389/fnetp.2021.729113

Staller, N., & Randler, C. (2022). Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany. *Biological Rhythm Research*, *53*(10), 1612–1625. https://doi.org/10.1080/09291016.2021.1988207

Staller, N., Randler, C., Weigel, M., & Schredl, M. (2023). Chronotype and sensory-processing sensitivity: A cross-sectional survey. *Chronobiology International*. https://doi.org/10.1080/07420528.2023.2204158

Staufenbiel, T. (2000). Antezedentien und konsequenzen freiwilligen arbeitsengagements. *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO)*, *31*, 169–183. https://doi.org/10.1007/s11612-000-0016-1

Staufenbiel, T., & Hartz, C. (2000). Organizational citizenship behavior: Entwicklung und erste Validierung eines Messinstruments. *Diagnostica*, *46*(2), 73–83. https://doi.org/10.1007/s11612-000-0016-1

Stevenson, J. C., Johann, A., Akram, A., Allen, S., & Akram, U. (2022). Diurnal Preference and Correlates of Multidimensional Perfectionism, Type-D Personality, and Big Five Personality Traits. *Clocks & Sleep*, *4*(3), 466–474. https://doi.org/10.3390/clockssleep4030037

Stukalin, Y., Lan, A., Kronfeld-Schor, N., Shmueli, E., & Einat, H. (2021). Sleep duration during COVID-19 lockdown: Systematic review and meta-analysis. https://doi.org/10.21203/rs.3.rs-778956/v1

Svartdal, F., Dahl, T. I., Gamst-Klaussen, T., Koppenborg, M., & Klingsieck, K. B. (2020). How study environments foster academic procrastination: Overview and recommendations. *Frontiers in Psychology*, *11*(540910). https://doi.org/10.3389/fpsyg.2020.540910

Tavernier, R., Hill, G. C., & Adrien, T. V. (2019). Be well, sleep well: An examination of directionality between basic psychological needs and subjective sleep among emerging adults at university. *Sleep health*, *5*(3), 288–297. https://doi.org/10.1016/j.sleh.2019.02.007

Tegnell, A. (2021). The swedish public health response to covid-19. *Apmis*, *129*(7), 320–323. https://doi.org/10.1111/apm.13112

Tezer, M., Ulgener, P., Minalay, H., Ture, A., Tugutlu, U., & Harper, M. (2020). Examining the relationship between academic procrastination behaviours and problematic internet usage of high school students during the covid-19 pandemic period. *Global Journal of Guidance and Counseling in Schools: Current Perspectives*, *10*(3), 142–156. https://doi.org/10.18844/gjgc.v10i3.5549

Thomas, A. E., Müller, F. H., & Bieg, S. (2018). Entwicklung und Validierung der Skalen zur motivationalen Regulation beim Lernen im Studium (SMR-LS). *Diagnostica*. https://doi.org/10.1026/0012-1924/a000201

Thoms, P., Moore, K. S., & Scott, K. S. (1996). The relationship between self-efficacy for participating in self-managed work groups and the big five personality dimensions. *Journal of organizational Behavior*, *17*(4), 349–362. https://doi.org/10.1002/(SICI)1099-1379(199607)17:4<349::AID-JOB756>3.0.CO;2-3

Tison, G. H., Avram, R., Kuhar, P., Abreau, S., Marcus, G. M., Pletcher, M. J., & Olgin, J. E. (2020). Worldwide effect of COVID-19 on physical activity: A descriptive study. *Annals of internal medicine*, *173*(9), 767–770. https://doi.org/10.7326/M20-2665

Tonetti, L., Natale, V., & Randler, C. (2015). Association between circadian preference and academic achievement: A systematic review and meta-analysis. *Chronobiology international*, *32*(6), 792–801. https://doi.org/10.3109/07420528.2015.1049271

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., McDowell, M., et al. (2008). Physical activity in the United States measured by accelerometer. *Medicine and science in sports and exercise*, *40*(1), 181–188. https://doi.org/10.1249/mss.0b013e31815a51b3

Trott, M., Driscoll, R., Irlado, E., & Pardhan, S. (2022). Changes and correlates of screen time in adults and children during the covid-19 pandemic: A systematic review and meta-analysis. *EClinicalMedicine*, *48*, 101452. https://doi.org/10.1016/j.eclinm.2022.101452

Tsaousis, I. (2010). Circadian preferences and personality traits: A meta-analysis. *European Journal of Personality*, *24*(4), 356–373. https://doi.org/10.1002/per.754

Tsioufis, K., Chrysohoou, C., Kariori, M., Leontsinis, I., Dalakouras, I., Papanikolaou, A., Charalambus, G., Sambatakou, H., Siasos, G., Panagiotakos, D., et al. (2020). The mystery of "missing" visits in an emergency cardiology department, in the era of COVID-19.; a time-series analysis in a tertiary Greek General Hospital. *Clinical Research in Cardiology*, *109*, 1483–1489. https://doi.org/10.1007/s00392-020-01682-1

Tuma, F., Nassar, A. K., Kamel, M. K., Knowlton, L. M., & Jawad, N. K. (2021). Students and faculty perception of distance medical education outcomes in resource-constrained system during COVID-19 pandemic. A cross-sectional study. *Annals of Medicine and Surgery*, *62*, 377–382. https://doi.org/10.1016/j.amsu.2021.01.073

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of psychotherapy integration*, *23*(3), 263–280. https://doi.org/10.1037/a0032359

Vansteenkiste, M., Ryan, R. M., & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. *Motiv Emot*, *44*, 1–31. https://doi.org/10.1007/s11031-019-09818-1

van Weert, H. (2020). After the first wave: What effects did the COVID-19 measures have on regular care and how can general practitioners respond to this? *European Journal of General Practice*, *26*(1), 126–128. https://doi.org/10.1080/13814788.2020.1798156

Vollmer, C., & Jankowski, K. S. (2022). COVID-19-lockdown delayed sleep timing in Tyrolean teachers. *Chronobiology International*, *39*(12), 1601–1610. https://doi.org/10.1080/07420528.2022.2138424

Wahlstrom, K. L. (2016). Later start time for teens improves grades, mood, and safety. *Phi Delta Kappan*, *98*(4), 8–14. https://doi.org/10.1177/0031721716681770

Waleriańczyk, W., Pruszczak, D., & Stolarski, M. (2020). Testing the role of midpoint sleep and social jetlag in the context of work psychology: An exploratory study. *Biological Rhythm Research*, *51*(7), 1026–1043. https://doi.org/10.1080/09291016.2019.1571707

Walker, M. P. (2008). Cognitive consequences of sleep and sleep loss. *Sleep medicine*, *9*(1), 29–34. https://doi.org/10.1016/S1389-9457(08)70014-5

Wallace, M. L., Yu, L., Buysse, D. J., Stone, K. L., Redline, S., Smagula, S. F., Stefanick, M. L., Kritz-Silverstein, D., & Hall, M. H. (2021). Multidimensional sleep health domains in older men and women: An actigraphy factor analysis. *Sleep*, *44*(2), zsaa181.

Wang, Q., Kou, Z., Du, Y., Wang, K., & Xu, Y. (2022). Academic Procrastination and negative emotions among adolescents during the COVID-19 pandemic: The Mediating and buffering effects of online-shopping addiction. *Frontiers in Psychology*, *12*, 789505. https://doi.org/10.3389/fpsyg.2021.789505

Wesley, K. L., Cooper, E. H., Brinton, J. T., Meier, M., Honaker, S., & Simon, S. L. (2022). A national survey of US adolescent sleep duration, timing, and social jetlag during the COVID-19 pandemic. *Behavioral Sleep Medicine*, *21*(3), 291–303. https://doi.org/10.1080/15402002.2022.2086871

Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social Jetlag: Misalignment of Biological and Social Time. *Chronobiology International*, *23*(1-2), 497–509. https://doi.org/10.1080/07420520500545979

Wolfson, A. R., & Carskadon, M. A. (2003). Understanding adolescent's sleep patterns and school performance: A critical appraisal. *Sleep medicine reviews*, *7*(6), 491–506. https://doi.org/10.1016/S1087-0792(03)90003-7

World Health Organization. (2020a). COVID 19 Public Health Emergency of International Concern (PHEIC). Global research and innovation forum: Towards a research roadmap. Retrieved June 18, 2022, from https://covid19-evidence.paho.org/handle/20.500.12663/714

World Health Organization. (2020b). WHO director-general's opening remarks at the media briefing on COVID-19. Retrieved June 18, 2023, from https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

Wright, K. P., Linton, S. K., Withrow, D., Casiraghi, L., Lanza, S. M., de la Iglesia, H., Vetter, C., & Depner, C. M. (2020). Sleep in university students prior to and during COVID-19 Stay-at-Home orders. *Current biology*, *30*(14), R797–R798. https://doi.org/10.1016/j.cub.2020.06.022

Wu, Z., & McGoogan, J. M. (2020). Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*, *323*(13), 1239–1242. https://doi.org/10.1001/jama.2020.2648

Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep—a prefrontal amygdala disconnect. *Current biology*, *17*(20), R877–R878. https://doi.org/10.1016/j.cub.2007.08.007

You, M., Laborde, S., Dosseville, F., Salinas, A., & Allen, M. S. (2020). Associations of chronotype, Big Five, and emotional competences with perceived stress in university students. *Chronobiology International*, *37*(7), 1090–1098. https://doi.org/10.1016/j.cub.2007.08.007

Yu, J. H., Yun, C.-H., Ahn, J. H., Suh, S., Cho, H. J., Lee, S. K., Yoo, H. J., Seo, J. A., Kim, S. G., Choi, K. M., et al. (2015). Evening chronotype is associated with metabolic disorders and body composition in middle-aged adults. *The Journal of Clinical Endocrinology & Metabolism*, *100*(4), 1494–1502. https://doi.org/10.1210/jc.2014-3754

Yüceol, N., Urfa, A. M., Pınar, S., & Binici, C. M. (2021). The impact of work-life balance on mental well-being of remote working generation y academicians due to the covid-19 pandemic in turkey. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *43*(2), 266–284. Retrieved March 9, 2023, from https://dergipark.org.tr/tr/download/article-file/2169892

Zaccoletti, S., Camacho, A., Correia, N., Aguiar, C., Mason, L., Alves, R. A., & Daniel, J. R. (2020). Parents' perceptions of student academic motivation during the COVID-19 lockdown: A cross-country comparison. *Frontiers in psychology*, *11*, 592670. https://doi.org/10.3389/fpsyg.2020.592670

Zavada, A., Gordijn, M. C., Beersma, D. G., Daan, S., & Roenneberg, T. (2005). Comparison of the Munich Chronotype Questionnaire with the Horne-östberg's morningness-eveningness score. *Chronobiology International*, *22*(2), 267–278. https://doi.org/10.1081/CBI-200053536

Zhai, K., Gao, X., & Wang, G. (2018). The role of sleep quality in the psychological well-being of final year undergraduatestudents in China. *International journal of environmental research and public health*, *15*(12), 2881. https://doi.org/10.3390/ijerph15122881

Zhao, Y., Lei, J., Lai, B. Y. C., & Tan, H. S. (2005). What makes the difference? A practical analysis of research on the effectiveness of distance education. *Teachers College Record*, *107*(8), 1836–1884. https://doi.org/10.1111/j.1467-9620.2005.00544.x

Zuckerman, M., Porac, J., Lathin, D., & Deci, E. L. (1978). On the importance of self-determination for intrinsically-motivated behavior. *Personality and social psychology bulletin*, *4*(3), 443–446. https://doi.org/10.1177/014616727800400317

Annex

A Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office

Staller, N., & Randler, C. (2021a). Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. *Somnologie*, *25*(2), 131–137. https://doi.org/10.1007/s11818-020-00277-2

Somnologie
Somnology – Current Sleep Research and Concepts

Original studies

Somnologie 2021 · 25:131–137
https://doi.org/10.1007/s11818-020-00277-2
Accepted: 12 October 2020
Published online: 17 November 2020

Naomi Staller · Christoph Randler[1]
[1] Eberhard Karls Universität Tübingen, Tübingen, Germany

Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office

Introduction

The first known case of COVID-19 caused by the novel coronavirus SARS-CoV-2 occurred in the Chinese city Wuhan at the beginning of December 2019 [1]. It has since caused a global pandemic with dramatic consequences for public health, economy, and social life. In order to limit viral transmission and relieve the healthcare system, governments imposed restrictions on their populations. These differed considerably among countries. In Italy for example, a national health emergency was called out on March 10, 2020. Hereafter, the population was placed in social isolation and the Italian territory was locked down until May 3, 2020, when some restrictions were eased [2]. During this period, people were not allowed to leave the house except to take care of the necessities of life (e.g., buying food or medicine) [2]. Contradictorily, the restrictions in Sweden were comparatively mild and mainly relied on voluntary compliance with the Public Health Agency's recommendations [3]. Preschools (students under 6 years old) and compulsory schools (students under 15–16 years old) remained open, while other schools and universities implemented online teaching. All business remained open as long as proper distance between people could be ensured [3]. Outdoor activities (e.g., walking in parks) were unrestricted and encouraged by authorities [3]. Considering the case numbers, the restriction measures in Germany were imposed early [4]. Starting in the middle of March 2020 (hereafter: COVID-19 restriction phase), universities, schools, kindergartens, and not-system-relevant businesses (e.g., beauty salons) were closed. Gatherings were banned, meeting people was allowed in groups of two (or two households) only, in public areas as well as on private property, and a mandatory isolation of people who had been exposed to or currently had COVID-19 was resolved [4].

The uncertain situation and the governmental measures resulted in changes in sleep and sleep timing around the globe. Some research groups showed increasing prevalence of sleep problems (insomnia, sleep loss, poor sleep quality) in healthcare workers and the general population [5–9], while others showed an improvement of sleep health. In India, China, and Italy, people slept later and longer [2, 7, 10, 11]. In a US sample, Gao and Scullin [9] showed improved sleep parameters even though the perceived view of participants differed partly. Leone et al. [12] showed a decrease of social jetlag in an Argentinian sample.

Sleep deprivation related to late chronotypes was a major problem before the COVID-19 restriction phase, resulting in a state of social jetlag for evening-oriented people [13]. A person's circadian timing depends on exogenous timekeepers (e.g., light cycle) and endogenous timekeepers (e.g., suprachiasmatic nucleus [SCN]; social/environmental timekeepers) [14]. One of those influencing timekeepers is social pressure due to work and school timing [15, 16]. To adapt to the given times, evening-oriented types sleep less than morning types during the week, which leads to a greater morning sleepiness and need for sleep [17]. Contrarily, they show later bed-/rise times and longer times in bed at the weekend [17]. The accumulated sleep debt leads to serious illness [13]. The discrepancy between the internal biological clock and the actual sleep timing due to social factors defines the state of social jetlag. With less social pressure following flexible working hours and home office, the circumstances might be health beneficial in terms of living with the circadian rhythm for evening-oriented people. Under normal circumstances, people have a daily routine which includes fixed events throughout the day (waking up, eating, working, social contacts, sports, etc.). With several of those altered due to the current circumstances, a change in sleep timing might follow. For example, a person wakes early in the morning. Later that day the person watches a movie instead of training soccer in the evening due to social isolation/restrictions. The exposure to blue light at night results in suppression of melatonin and lack of fatigue. Consequently, sleep onset is later than usual. This results in either a reduced sleep duration (waking up at the usual time) or a delayed wake up time. While working in home office, a person does not need to wake up for work at the same time as before (e.g., because the way to work is omitted), and hence rises later to get the same amount of sleep. The daily routine and, in turn, the sleep timing shifts.

It is important to pay attention to sleep during the COVID-19 pandemic because sleep plays a major part in sustainable health. Good night sleep (consisting of sleep duration/quality and timing) is essential to build resilience and cope with the primary and secondary effects of disease [8]. We hypothesized that sleep timing and therefore overall sleep in evening-oriented people during the changed circumstances is more in line with their biological needs and thus beneficial to health.

Methods

Setting

This study was carried out by the Department of Biology, Eberhard Karls University Tübingen, Tübingen, Germany. Data were collected in accordance with the Declaration of Helsinki for experiments involving humans approved by the Eberhard Karls University's ethics committee (Faculty for Economics and Social Sciences: nr. A.Z.: A2.5.4-124_kr).

Data collection

We started our anonymous online survey on May 18, 2020, and continued until June 17, 2020. We therefore collected data during the most restrictive phase in Germany. Participants were informed about the study via an electronic mailing list (employees and students of the Eberhard Karls University Tübingen; >20,000 mails) and postings on different social media platforms (Facebook/Instagram). The recruitment text included an online link to the questionnaire. The survey was hosted on an online platform (SoSciSurvey) to fulfil the European Union's data privacy rules and took an average of 12 min ± 5 min (standard deviation, SD) to complete. The theoretical background and study goals but not the hypothesis were declared. We explicitly informed about the voluntariness of the participation, the option to stop the data collection at any point without consequences, and that participation would not be remunerated. The recruitment text was available in German only and formal consent was inquired in advance. The total number of evaluable cases amounted to 681.

Demographic data

Age, sex, household size, number of children in the household, profession,

Abstract · Zusammenfassung

Somnologie 2021 · 25:131–137 https://doi.org/10.1007/s11818-020-00277-2

N. Staller · C. Randler

Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office

Abstract

Background and objective. In this study, we researched the effects of the COVID-19 restriction measures on the sleep health of $N=681$ German residents (mean age: 28.63 years, SD: 10.49 years).
Methods. The data were collected with an anonymous online survey composed of validated questionnaires and additional questions to quantify changed circumstances during the pandemic. Data were collected from May 18 to June 17, 2020, while governmental restrictions were imposed in Germany. We exclusively analysed participants working in home office during this time.
Results. Participants woke up about 1 hour later during the COVID-19 restriction phase, while going to bed at almost the same time as before. During the week, participants slept about an hour longer, while sleep at weekends did not differ significantly. Social jetlag decreased from 1:39 ± 1:00 to 0:49 ± 0:42 min in our sample. The number of children in the household was a significant factor predicting sleep timing. Participants with children living in the same household slept longer and sleep onset was later.
Conclusion. In terms of sleep behaviour and, consequently, sleep health, participants benefited from the transition to home office. They were able to adapt their waking and working hours better to their biological rhythm, which reduced social jetlag.

Keywords

Circadian preference · Morningness–eveningness stability scale improved · New ways of working · Social jetlag · Distant learning

Änderungen der Schlafzeiten und des Chronotyps aufgrund der COVID-19-Maßnahmen und der Umstellung auf Home-Office

Zusammenfassung

Hintergrund und Zielsetzung. In dieser Arbeit beleuchteten die Autoren die Auswirkungen der COVID-19-Restriktionsmaßnahmen auf die Schlafgesundheit von $n=681$ in Deutschland lebenden Personen (mittleres Alter: 28,63 Jahre, Standardabweichung, SD: 10,49 Jahre). Es wird explizit auf die Veränderungen des Schlafverhaltens der Probanden eingegangen und Stellung zu gesundheitswirksamen Aspekten bezogen.
Methoden. Die Daten wurden anhand einer anonymisierten Online-Befragung mit mehreren validierten Fragebogen und Zusatzfragen zu den veränderten Schlaf- und Arbeitszeiten erhoben. Die Datenerhebung beschränkte sich auf die Zeit der Phase der COVID-19-Restriktionsmaßnahmen zwischen dem 18. Mai und 17. Juni. Es wurden ausschließlich Personen befragt, die in dieser Zeit im Home-Office arbeiteten.
Ergebnisse. Die Teilnehmer wachten während dieser Phase etwa eine Stunde später auf, gingen jedoch nahezu zur selben Zeit wie vor der Umstellung zu Bett. Unter der Woche schliefen die Teilnehmer ungefähr eine Stunde länger, die Schlaflänge am Wochenende unterschied sich nicht signifikant. Der Social Jetlag verringerte sich in dieser Stichprobe von 1:39 ± 1:00 auf 0:49 ± 0:42 min. Die Anzahl der Kinder im Haushalt war dabei ein erheblicher Einflussfaktor auf die Schlafzeiten: Teilnehmer mit Kindern im Haushalt schliefen länger, und die Einschlafzeit war später.
Schlussfolgerung. In der vorliegenden Untersuchungsstichprobe profitieren die Teilnehmer hinsichtlich ihres Schlafverhaltens, und daraus folgend ihrer Schlafgesundheit, von der Umstellung auf Home-Office. Die Versuchsteilnehmer konnten ihre Wach- und Arbeitszeiten besser ihrem biologischen Rhythmus anpassen, wodurch sich der Social Jetlag verringerte.

Schlüsselwörter

Circadiane Präferenz · „Morningness-Eveningness-Stability-Scale improved" · „New ways of working" · Social Jetlag · Distanzlernen

and the option to work in flexitime were asked for. Profession was later dichotomized into student ($N = 400$) or non-student ($N = 281$). 197 participants were male, 484 were female. Mean age was 28.63 years, SD 10.49 years. $N = 545$ participants noted that there were no children in their household, while $N = 136$ reported one or more children. We explicitly asked for the number of children in the household and not the number of own children, because, for example, students may have travelled back home to their parents during the restriction phase and lived with younger siblings. Thus, children in the household is a better measure than own children, because regardless of relationship (own children/siblings/other cases), children in general may have an impact on sleep during the pandemic.

Questionnaire

The questionnaire used was composed of validated questionnaires concerning chronotype and sleep duration as well as additional questions to quantify changed circumstances during the pandemic. Examined characteristics were chronotype/midpoint of sleep, sleep duration, and COVID-19-induced changes in sleep/work hours.

Chronotype

The Morningness–Eveningness Stability Scale improved (MESSi [18, 19]) and the corrected midpoint of sleep (MSF corrected) were used as separate measures to determine the chronotype. The MESSi is composed of three subscales: the morning affect subscale (MA), the eveningness subscale (EV), and the distinctness subscale (DI). Five items in a 1–5 Likert-format represent each scale. The MA is concerned with the affective facet of the morningness–eveningness trait (M/E; e.g., alertness in the morning: "How alert do you feel during the first half hour after having awakened in the morning?"), while the EV queries feeling/mood, energy level, and learning capacity in the evening (e.g., "In general, how is your energy level in the evening?"). The DI shows the subjectively felt amplitude of diurnal active phases (e.g., "There are moments during the day where I feel unable to do anything" with response options ranging from "totally" to "not at all"). Higher MA or EV scores represent higher morning and evening orientation, respectively, while higher DI values indicate higher daytime fluctuations. MESSi's factorial invariance, structure, and reliability have already been confirmed repeatedly in different languages [18, 20–23]. In addition, actigraphy data corroborated the validity of the MESSi [24]. Cronbach's α in the current study sample was 0.899 for MA, 0.889 for EV, and 0.775 for DI.

Sleep duration

We asked for bed and wake times during the week and at weekends to assess sleep duration and the midpoint of sleep, both during and before the COVID-19 restriction phase. Furthermore, a correction algorithm [25] was used to measure the sleep/wake time differences on work-free days due to social jetlag and to calculate a corrected midpoint of sleep (MSF corrected) for both periods. Average sleep duration was calculated: five times the weekday sleep duration plus two times the weekend sleep duration divided by seven.

Sleep phase delay

To assess the sleep phase delay, we subtracted the prior clock times from the clock times during the COVID-19 restriction phase. This resulted in four clock time differences, which were subjected to a factor analysis (principal component). All loaded onto the same single factor, labelled "delayed sleep phase" (58.9% of the variance explained). Week bedtime delay loaded with 0.833, weekend bedtime delay with 0.770, wake week delay with 0.757, and wake weekend delay with 0.705 onto the factor.

Results

Bedtimes and wake times differed between prior to and during the COVID-19 restriction phase (see **Table 1**), with one exception: there were no significant

Table 1 Sleep parameters before and during the COVID-19 restriction phase

	During COVID-19 (M)	SD	Before COVID-19 (M)	SD	T	Df	*P*-value
Wake week	08:03	01:33	07:08	01:10	17.575	679	<0.001
Wake weekend	09:06	01:31	09:16	01:26	−4.633	676	<0.001
Bed week	23:52	01:30	23:19	01:11	13.072	679	<0.001
Bed weekend	00:27	01:33	00:31	01:28	−1.687	679	0.092
Sleep duration week	08:11	01:01	07:49	01:09	8.784	679	<0.001
Sleep duration weekend	08:39	01:05	08:45	01:12	−2.765	676	0.006
Sleep duration average	08:19	00:57	08:05	00:59	6.86	676	<0.001
MS weekday	03:57	01:26	03:13	01:02:04	17.295	679	<0.001
MS weekend	04:47	01:26	04:53	01:19:29	−3.482	676	0.001
MSFsc	04:36	01:29	04:33	01:20:21	1.385	676	0.167

SD standard deviation; *M* mean; *Df* degrees of freedom; *MS* midpoint of sleep; *MSFsc* midpoint of sleep corrected

differences between weekend bedtimes. The most striking difference occurred in wake times during the week. Participants got up approximately 1 hour later during the COVID-19 restriction phase, while bedtimes remained nearly stable. Sleep duration differed by about 22 min between the two time periods; thus, during the COVID-19 restriction phase, people slept on average nearly half an hour longer on weekdays, while there was no significant difference (about 6 min) on weekends. Average sleep duration was about 15 min longer. Midpoint of sleep (MS) on weekdays was about 45 min later, while midpoint of sleep on weekends was a few minutes earlier. When the correction algorithm was applied (MSFsc) to gain an unbiased chronotype measurement from clock times, we found no differences between prior to and during the COVID-19 restriction phase ($p = 0.167$). Social jetlag decreased from 1:39 ± 1:00 to 0:49 ± 0:42 min. The participants in our study slept longer and on weekdays later, while their social jetlag decreased and the corrected midpoint of sleep remained stable.

We found differences in the correlations between sleep parameters and the MESSi prior to and during the COVID-19 restriction phase (see **Table 2**). Prior to the restriction phase MA had a positive relationship to sleep duration, while EV related negatively (not significant) to it. During the restriction phase sleep duration during the week and at the weekend was negatively correlated to the MA facet as well as the EV facet. The DI scale was positively correlated with both variables during the COVID-19 restriction phase and with the sleep duration on weekends beforehand. The relationships between midpoint of sleep on weekdays and weekends/average sleep duration/corrected midpoint of sleep as well as wake up and bedtimes prior to and during the COVID-19 restriction phase retained their direction of effect in almost all variables. Only the average sleep duration during the COVID-19 restriction phase was significantly negatively correlated with MA even though it showed a positive relationship (not significant) before the restrictions.

Concerning the sleep phase delay, which is a compound measure of bedtimes' and wake times' delay on weekdays and at weekends, we found a significant influence of MA/EV and children living in the household (**Table 3**). There were no effects of gender, age, and occupation. Thus, the sleep phase delay affected all participants similarly and moved the sleep phase to later clock times.

Regarding the number of children in households, we found a significant sleep phase shift in participants living with children (**Table 3**; **Fig. 1**), who slept longer and in whom sleep onset was later. Expectedly, MA was negatively ($r = -0.285$, $p < 0.001$) and EV positively ($r = 0.266$, $p < 0.001$) related to the sleep phase delay. Thus, circadian preference was a predictor of the sleep phase delay.

Discussion

Participants working in home office slept longer and later during the COVID-19 restriction phase than before. The working situation participants were faced with compares partly to a modern approach to ways of working called "new ways of working" (NWW) [26]. Implementing NWW has the goal of creating temporal and spatial flexibility and thus accomplishing building work environments that focus on innovation and productivity while reducing costs [27]. The work situation in our sample was spatially flexible for every participant and temporally flexible for the majority. For those who had a certain temporal constraint, the omission of commuting times resulted in an additive time scope. NWW is proposed as a way to improve work time control and therefore allow employees to adjust their work to their private life [28] and biological needs (e.g., chronotype [13]). Our results are in line with these hypotheses. The significant changes in sleep–wake schedules and sleep duration after a prolonged phase of home office can be interpreted as an approach to participants' own intrinsic sleep–wake rhythm. Results of morningness–eveningness's relation to sleep phase delay confirm again that evening-oriented people benefitted from remote working during the COVID-19 restriction phase. These participants were able to adapt their sleep–wake cycle to their own internal clock rather than to work start times. In morning-oriented people, this delay is inevitably shorter because the work start times fit their biological clocks better. Nevertheless, most participants benefited from the changed working situation in terms of sleep health. Gao and Scullin [9] showed comparable results in a US sample. Leone et al. [12] published the effects on social jetlag in the only other study so far. The reported results correspond to ours.

Table 2 Correlational analysis of sleep parameters before and during the COVID-19 restriction phase and the MESSi

	MA	EV	DI
Sleep duration week COVID-19	−0.099*	−0.106**	0.153**
Sleep duration week before	0.088*	−0.226**	0.054
Sleep duration weekend COVID-19	−0.107**	−0.095*	0.095*
Sleep duration weekend before	−0.113**	−0.045	0.157**
MS weekday COVID-19	−0.519**	0.574**	0.125**
MS weekday before	−0.327**	0.421**	0.007
MS weekend COVID-19	−0.542**	0.575**	0.102**
MS weekend before	−0.512**	0.560**	0.092*
Sleep duration average COVID-19	−0.111**	−0.113**	0.149**
Sleep duration average before	0.033	−0.201**	0.097*
MSFsc COVID-19	−0.520**	0.554**	0.111**
MSFsc before	−0.443**	0.499**	0.057
Wake week COVID-19	−0.514**	0.497**	0.166**
Wake week before	−0.243**	0.259**	0.032
Wake weekend COVID-19	−0.550**	0.509**	0.130**
Wake weekend before	−0.519**	0.497**	0.151**
Bed week COVID-19	−0.463**	0.585**	0.067
Bed week before	−0.328**	0.477**	−0.020
Bed weekend COVID-19	−0.465**	0.566**	0.061
Bed weekend before	−0.414**	0.523**	0.018

MA morning affect; *EV* eveningness; *DI* distinctness; *MS* midpoint of sleep; *MSFsc* midpoint of sleep corrected
$^{*}p < 0.05$; $^{**}p < 0.01$

Table 3 Predictor variables of sleep phase delay. Univariate general linear model with sleep phase delay (compound measure, see text)

Source of variation	Df	RMS	F	Sig	Partial eta-squared
Corrected model	11	7.739	8.718	<0.001	0.125
Constant	1	0.102	0.115	0.734	0.000
Age	1	0.002	0.003	0.958	0.000
MA	1	12.441	14.015	<0.001	0.021
EV	1	10.911	12.292	<0.001	0.018
DI	1	1.219	1.373	0.242	0.002
Sex	1	0.085	0.095	0.758	0.000
Profession	1	0.126	0.141	0.707	0.000
No. children	1	6.487	7.307	0.007	0.011
Sex * profession	1	0.001	0.001	0.970	0.000
Sex * no. children	1	1.450	1.634	0.202	0.002
Profession * no. children	1	0.049	0.055	0.814	0.000
Sex * profession * no. children	1	0.388	0.437	0.509	0.001

Df degrees of freedom; *RMS* root mean square; *MA* morning affect; *EV* eveningness; *DI* distinctness

Since schools in Germany implemented online teaching instead of attendance classes, students had a prolonged time scope in the morning lacking commuting times. Additionally, many schools started online teaching later. Therefore, students had to get up later in the morning, similar to their parents'/caregivers' working situation. When controlling for the number of children in participants' households, sleep phase delay increased. Our results show clearly that the negative effects of early school start times impact parents and caregivers as well as children. In general, the obtained results were comparable to other studies. Sinha et al. [10] showed that sleep onset and wake-up times were significantly delayed, with an average delay of sleep onset by 38 min and wake-up time by 51 min, irrespective of age and gender in an Indian sample [10]. Chinese and Italian people slept later and longer than usual during the COVID-19 quarantine phase [7, 11]. In another Italian sample similar results were found, but the impact of the delay in bedtime and in wake-up time was more pronounced in students [2]. These authors used a comparably structured sample with students and university staff. However, in our study, we found no differences between the groups (student versus non-student), despite a slightly higher sample size.

Furthermore, we found changes in the midpoint of sleep during the week as well as the weekend when comparing prior to and during the COVID-19 restriction phase. Only Leone et al. [12] have discussed this aspect in an Argentinian sample so far. One of the most intriguing results concerning the clock-based chronotype (midpoint of sleep corrected) was that the measurement method was not sensitive to sleep time changes during the restriction phase. This suggests that smaller changes in sleep–wake schedules do not necessarily reflect a general change in chronotype as a clock-based measure. However, Leone et al. [12] reported a shift toward a later midpoint of sleep (corrected) in their Argentinian sample. In addition, the circadian preference as measured by the MEQ [12] did not change between the two periods. This supports our findings that daytime preference, as well as the clock time-based measured chronotype, is stable. Otherwise, the validity of the clock time-based chronotype should be questioned. However, our data clearly support the corrected midpoint of sleep as a stable measure. Furthermore, the scales of the MESSi loaded onto the clock times as expected, both prior to and during the pandemic with a similar strength (**Table 2**). This provides additional validity for this newly developed measure.

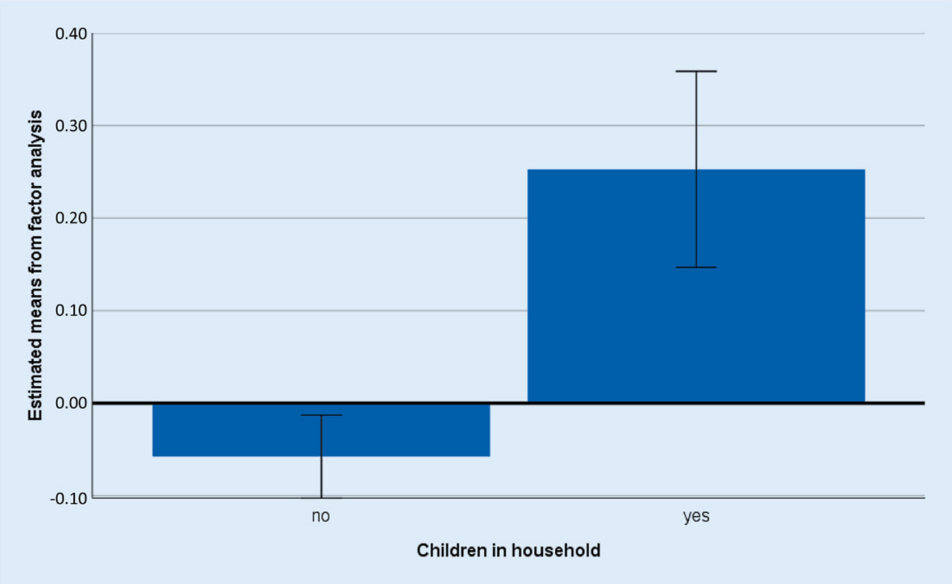


Fig. 1 ◀ Sleep phase change in participants with and without children in the household. Estimated marginal means derived from the factor analysis

Limitations and strengths

One limitation of this study is the retrospective design. While the data on sleep–wake behaviour during the COVID-19 restriction phase were collected simultaneously, the data concerning the prior period were collected in retrospect. Furthermore, due to focusing on alterations following a change to home office, data might be biased. The recruitment might be limiting, since people who felt a change in sleep timing due to the altered work setting might be more interested in participating in the study than others. Another limiting factor is the high number of students taking part in the survey. Even though students' learning environment changed to a home office situation too (e.g., classes were held online), the transferability to working in home office may not be given. In addition, the sample was non-representative (more than half of the participants had an academic background being students) and relatively unbalanced, with about twice as many females as males.

Conclusion

In this study sample, sleep duration and sleep timing improved during the COVID-19 restriction phase. In addition, social jetlag regressed, which is beneficial to a healthy sleep and overall health. We could show that sleep duration during the week in evening-oriented participants in fact increased, while it decreased in morning-oriented participants. Overall, the sleep parameters changed positively in this sample. This study again shows that the social pressure following strict working hours is not target oriented in terms of health for a significant part of the population.

Corresponding address

Prof. Dr. Christoph Randler
Eberhard Karls Universität Tübingen
Tübingen, Germany
christoph.randler@uni-tuebingen.de

Funding. Open Access funding enabled and organized by Projekt DEAL.

Compliance with ethical guidelines

Conflict of interest. N. Staller and C. Randler declare that they have no competing interests.

Data were collected in accordance with the Declaration of Helsinki for experiments involving humans approved by the Eberhard Karls University's ethics committee (Faculty for Social Sciences and Economics: nr. A.Z.: A2.5.4-124_kr).

References

1. Wu Z, McGoogan JM (2020) Characteristics of and important lessons from the coronavirus disease 2019 (CoVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 323(13):1239–1242
2. Marelli S, Castelnuovo A, Somma A, Castronovo V, Mombelli S, Bottoni D, Ferini-Strambi L (2020) Impact of CoVID-19 lockdown on sleep quality in university students and administration staff. J Neurol. https://doi.org/10.1007/s00415-020-10056-6
3. Hensvik L, Skans O (2020) CoVID-19 Crisis Response Monitoring: Sweden
4. Stafford N (2020) Covid-19: Why Germany's case fatality rate seems so low. BMJ. https://doi.org/10.1136/bmj.m1395
5. Lai J, Simeng M, Wang Y et al (2020) Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. Jama Netw Open 3(3):e203976
6. Zhang C, Yan L, Liu S et al (2020) Survey of insomnia and related social psychological factors among medical staffs involved with the 2019 novel coronavirus disease outbreak. Front Psychiatry. https://doi.org/10.3389/fpsyt.2020.00306
7. Cellini N, Canale N, Mioni G, Costa S (2020) Changes in sleep pattern, sense of time and digital media

use during COVID-19 lockdown in Italy. J Sleep Res. https://doi.org/10.1111/jsr.13074
8. Morin CM, Carrier J, Bastien C, Godbout R (2020) Sleep and circadian rhythm in response to the COVID-19 pandemic. Can J Public Health. https://doi.org/10.17269/s41997-020-00382-7
9. Gao C, Scullin MK (2020) Sleep health early in the coronavirus disease 2019 (COVID-19) outbreak in the United States: integrating longitudinal, cross-sectional, and retrospective recall data. Sleep Med 73:1–10
10. Sinha M, Pande B, Sinha R (2020) Impact of COVID-19 lockdown on sleep-wake schedule and associated lifestyle related behavior: a national survey. J Public Health Res. https://doi.org/10.4081/jphr.2020.1826
11. Lee PH, Marek J, Nálevka P (2020) Crowdsourced smartphone data reveal altered sleep/wake pattern in quarantined Chinese during the COVID-19 outbreak. Chronobiol Int. https://doi.org/10.1080/07420528.2020.1792486
12. Leone MJ, Sigman M, Golombek DA (2020) Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. Curr Biol 30(16):R930–R931
13. Wittmann M, Dinich J, Merrow M, Roenneberg T (2006) Social jetlag: misalignment of biological and social time. Chronobiol Int 23(1-2):497–509
14. Koukkari WL, Sothern RB (2007) Introducing biological rhythms: A primer on the temporal organization of life, with implications for health, society, reproduction, and the natural environment. Springer, New York
15. Roenneberg T (2012) Internal time: chronotypes, social jet lag, and why you're so tired. Harvard University Press, Cambridge, MA, USA
16. Roenneberg T, Allebrandt KV, Merrow M, Vetter C (2012) Social jetlag and obesity. Curr Biol 22(10):939–943
17. Taillard J, Philip P, Bioulac B (1999) Morningness/eveningness and the need for sleep. J Sleep Res 8(4):291–295
18. Randler C, Díaz-Morales JF, Rahafar A, Vollmer C (2016) Morningness–eveningness and amplitude–development and validation of an improved composite scale to measure circadian preference and stability (MESSi). Chronobiol Int 33(7):832–848
19. Díaz-Morales JF, Randler C, Arrona-Palacios A, Adan A (2017) Validation of the MESSi among adult workers and young students: General health and personality correlates. Chronobiol Int 34(9):1288–1299
20. Díaz-Morales JF, Randler C (2017) Spanish adaptation of the morningness-eveningness-stability-scale improved (MESSi). Span J Psychol. https://doi.org/10.1017/sjp.2017.21
21. Rahafar A, Randler C, Díaz-Morales JF, Kasaeian A, Heidari Z (2017) Cross-cultural validity of morningness-eveningness stability scale improved (MESSi) in Iran, Spain and Germany. Chronobiol Int 34(2):273–279
22. Rodrigues PF, Vagos P, Pandeirada JN, Marinho PI, Randler C, Silva CF (2018) Initial psychometric characterization for the Portuguese version of the Morningness-Eveningness-Stability-Scale improved (MESSi). Chronobiol Int 35(11):1608–1618
23. Tomažič I, Randler C (2020) Slovenian adaptation of the Morningness-Eveningness-Stability Scales improved (MESSi). Biol Rhythm Res 51(3):453–459
24. Faßl C, Quante M, Mariani S, Randler C (2019) Preliminary findings for the validity of the Morningness–Eveningness-Stability Scale improved (MESSi): correlations with activity levels and personality. Chronobiol Int 36(1):135–142
25. Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Merrow M (2004) A marker for the end of adolescence. Curr Biol 14(24):R1038–R1039
26. Baane R, Houtkamp P, Knotter M (2011). Het nieuwe werken ontrafeld: Over bricks, bytes & behavior (New ways of working unraveled: About bricks, bytes and behavior). Tijdschr HRM 1:7–23
27. Nijp HH, Beckers DG, van de Voorde K, Geurts SA, Kompier MA (2016) Effects of new ways of working on work hours and work location, health and job-related outcomes. Chronobiol Int 33(6):604–618
28. Nijp HH, Beckers DG, Kompier MA, van den Bossche SN, Geurts SA (2015) Worktime control access, need and use in relation to work–home interference, fatigue, and job motivation. Scand J Work Environ Health. https://doi.org/10.5271/sjweh.3504

B Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic

Staller, N., Kalbacher, L., & Randler, C. (2022). Impact of pandemic lockdown on learning behaviour and sleep quality in German students: Results of an online survey before and during the pandemic. *Somnologie*, *26*(2), 98–105. https://doi.org/10.1007/s11818-022-00346-8

Somnologie 2022 · 26:98–105
https://doi.org/10.1007/s11818-022-00346-8
Accepted: 11 March 2022
Published online: 5 April 2022

Impact of pandemic lockdown on learning behaviour and sleep quality in German students

Results of an online survey before and during the pandemic

Naomi Staller · Lisa Kalbacher · Christoph Randler
Department of Biology, Eberhard Karls University, Tübingen, Germany

Abstract

Background: This study addresses the effects of the coronavirus disease 19 (COVID-19) restriction measures on sleep and bedtime habits of $N=637$ German university students.
Methods: The questionnaire was distributed online during two different time periods in 2020 (February 27–March 21) and in 2021 (February 27–March 27). The first data collection phase was immediately before the first strict lockdown to contain the COVID-19 pandemic in Germany, and the second data collection phase was during the second lockdown. The survey was composed of validated questionnaires and additional questions regarding the changes in sleep/bedtimes and the status of lectures during the lockdown phase.
Results: The average Pediatric Daytime Sleepiness Scale (PDSS) score in the sample decreased during the lockdown phase, corresponding to the fact that students were less burdened with daytime sleepiness. Moreover, the sample had earlier rise and earlier bedtimes on free days during the lockdown period. Furthermore, the increase in flexible learning times brought about by the pandemic negatively impacted the students' lifestyle and increased irregularities in sleeping habits.
Conclusion: Significant changes in sleeping patterns seem to be attributable to the pandemic lockdown as found in this self-reported student survey. While daytime sleepiness decreased and earlier overall bedtimes were noted, the impact on the irregularity of sleeping and learning patterns seems to be the most notable finding, as this affects overall quality of life and learning performance. Further studies are needed to validate these findings.

Keywords
Teleworking · Questionnaire · Social isolation · Severe acute respiratory syndrome coronavirus 2 · Coronavirus disease 19

Scan QR code & read article online

With the spread of the novel coronavirus disease (COVID-19) in December 2019, a global pandemic developed, forcing governments worldwide to enforce restrictions in order to contain further dissemination. In Germany, the federal government opted for a strict lockdown, closing schools and universities, retail outlets, restaurants, sports venues, and many other economic areas. The first lockdown began on 22 March 2020, with initial economic sector easing measures coming into force on 4 May 2020. On 15 June 2020, these were introduced in almost every economic area. The summer of 2020 passed, for the most part, without rising infection figures. However, the figures rose again rapidly in autumn, first resulting in a "lockdown light" (04.11.–13.12.2020) and later in a complete lockdown (commencing 13.12.2020, with the possibility of relaxations decided in the "*Bundes-Notbremse*"—a national plan for crisis management starting 23.04.2021—with a general end to the lockdown on 30.06.2021).

The increased restriction of public life and social contact led to the population finding itself in a state of social isolation. Remote working (termed "home office" in Germany) is seen as an important factor in limiting personal contacts, which on a secondary level results in containment of transmission risks and thus of infection [1]. Therefore, the government recommended the switch to working from home for industry/business, and implemented this directly in areas under the direction of the federal and state governments (e.g., schools and universities). In accordance with these provisions, restrictions on university and school classroom teaching were imposed, which were subsequently abolished in favour of digital teaching from home. This change in lecturing (online classes ranging from fixed schedules to on-demand courses) and the additional closure of associated buildings (e.g., libraries) forced students to study almost exclusively from home. This resulted in some profound secondary changes, such as commuting time falling away and a lack of exchange with teachers and fellow students.

In this novel situation, students were confronted with subjectively perceived and physiologically measurable behavioural changes, accompanied by changes in habits such as eating habits (e.g. [2]), sleeping habits (e.g. [3, 4]) and exercise levels (e.g. [5, 6]). In this study, we investigate the relationship between sleep times on weekdays/at weekends and teaching times (measured on a scale ranging from "fixed learning times" to "on-demand learning"), as well as possible changes in social jetlag—defined as the discrepancy between the internal biological clock and the actual sleep timing due to social factors [7]—because of the pandemic. The present sample contains data from two sampling periods. The first before the lockdown and the second during the lockdown. This distinguishes the present results from those of Staller and Randler (2020) [4], as the data of their study were collected retrospectively. Furthermore, the influence of lecture status (measured on a scale ranging from "fixed learning times" to "on-demand learning") on sleep parameters was examined here for the first time. The focus of the study was to investigate the following hypotheses: the more flexible the teaching times, the more flexible the bed- and wake-up times during the pandemic. Therefore, students live more in line with their chronotype and, as a consequence, social jetlag decreases.

Methods

Data collection

This study was carried out by the Department of Biology, Eberhard Karls University, Tübingen, Germany. The study sample comprises students of the University of Tübingen. The questionnaire was provided in German language only and distributed online during two different time periods in 2020 (February 27–March 21) and 2021 (February 27–March 27). The first data collection phase was directly before the first strict lockdown to contain the COVID-19 pandemic in Germany, and the second data collection phase was during the second lockdown. Participants were made aware of the study via mailing lists and official university platforms. The background of the study was clarified, and the voluntary and anonymous nature of participation was pointed out up front. In addition, the participants were made aware that they would not suffer any disadvantages if they terminated the survey prematurely and that participation would not be remunerated. The survey was hosted on the SoSciSurvey online platform, which fulfils the European Union's data privacy standards. Data were collected from a total of $N = 637$ (male: 191; female: 445; other: 8) participants; first data collection $N = 312$, second data collection $N = 325$.

Questionnaires

In addition to collecting data on demographics and the highest educational qualification (type, year and state in which the qualification was obtained), the survey was compiled from validated questionnaires (Morningness–Eveningness Stability Scale improved, MESSi; Pittsburgh Sleep Quality Index, PSQI; Sleep timing questionnaire, STQ; Pediatric Daytime Sleepiness Scale, PDSS). Furthermore, the participants provided information on the current status of lectures "type of teaching cur-

Table 1 Descriptive statistics of the study sample. Only independent datasets were analysed, which is why $N = 398$ datasets were excluded from the analysis

	N	Mean	Standard deviation
Morning affect	637	2.959	0.996
Eveningness	637	3.146	1.016
Distinctness	637	3.660	0.842
PSQI score	637	0.590	0.400
PDSS score	632	3.130	0.553
STQ score	632	4.679	2.042
Rise times weekdays	622	7:23	1:06
Rise times free days	575	9:16	1:34
Bedtime weekdays	608	23:11	1:12
Bedtime free days	618	00:21	1:31
Midpoint of sleep weekdays	599	3:17	0:59
Midpoint of sleep free days	572	4:49	1:27
Midpoint of sleep corrected	560	4:34	1:22
Sleep duration week	599	8:12	1:07
Sleep duration free days	572	8:54	1:04
Average sleep duration	560	8:23	0:57
Social jetlag	560	1:31	1:01

PSQI Pittsburgh Sleep Quality Index, *PDSS* Paediatric Daytime Sleepiness Scale, *STQ* Sleep timing questionnaire

rently offered" twice, but coded slightly differently in each case, to form a scale (1: If you worked remotely from home in the past 2 months, how often did this follow a fixed schedule with set times? Exclusively/a lot/medium/little/not at all; 2: If you worked remotely from home in the past 2 months, how often was this based to on-demand events? Exclusively/a lot/medium/little/not at all). Also, participants were asked whether they had completed the survey at both survey times. Participants for whom this circumstance applied were excluded from the analysis ($N = 398$). The reasoning was that the survey took place anonymously and the datasets of this linked sample could not have been combined as dependent datasets. Therefore, independent datasets were analysed. The questionnaire took an average of 11.29 min to complete with a standard deviation of 4.76 min.

Morningness–Eveningness Stability Scale improved

In this study we used the MESSi to assess participants' morningness–eveningness. The questionnaire is separated into three subscales—the morning affect subscale (MA), the eveningness subscale (EV) and the distinctness subscale (DI). Each subscale consists of five questions in a 1–5 Likert format. The MA queries the affective facet (e.g., "How alert do you feel during the first half hour after awakening in the morning?"), the EV collects data on the overall physical and mental situation in the evening (e.g., "In general, how is your energy level in the evening?"), while DI is looking into the amplitude of active phases (e.g., "There are moments during the day where I feel unable to do anything."). Higher values on the subscales indicate participants being more prone to those facets (MA → prone to morningness/EV → prone to eveningness/DI → higher daytime fluctuations of active phases). The MESSi questionnaire has been validated in various studies (factorial invariance, structure, reliability in different languages, e.g., [8–12]; and by actigraphy [13]). Cronbach's α in the current sample was 0.891 for MA, 0.870 for EV and 0.759 for DI.

Pittsburgh Sleep Quality Index

The PSQI is a self-reported inventory that measures various sleep variables in a retrospective design considering the past 4 weeks. It is used in clinical and non-clinical settings and includes 19 self-rated and 5 externally rated questions. The latter are not included in the quantitative evaluation. The PSQI is divided into seven sections: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications and daytime dysfunction over the past month (e.g., "During the past month, how often have you had trouble sleeping because you cannot get to sleep within 30 min?"). The sum of the 1–4 Likert scale leads to a classification from "good" sleepers to "poor" sleepers [14]. The current study investigated the frequency of sleep disturbances (eight items) and performed an assessment of overall sleep quality (1 item). Cronbach's α in the current sample was 0.642.

Sleep timing questionnaire

The STQ consists of 18 items asking for the individual bed and awakening times on weekdays and at weekends, the stability of these schedules, and the frequency and length of night awakenings. It was developed to provide a precise picture of a person's typical sleep rhythm [15]. Sleep technicians can thus adjust the timing of polysomnographic examinations to the specific needs and habits of the patient [16]. It is more time efficient than a sleep diary format. As we had already collected sleep quality aspects, we only asked for variation individual bed and awakening times on weekdays or at weekends and, in addition, calculated the length of sleep. Cronbach's α in the current sample was 0.831.

Paediatric Daytime Sleepiness Scale

The PDSS is a questionnaire originally introduced in English [17] and translated into German by Schneider and Randler (2009) [18]. It queries the daytime sleepiness of students. The questionnaire contains eight items of which two are clearly related to a school or learning environment. All questions are asked in a 1–5 Likert format, with one question being reverse coded. The total score of the questionnaire is obtained by adding up the answer scores. Cronbach's α of this scale was 0.808 in this sample.

Table 2 *T*-test for independent groups (before vs. during the pandemic) assessing the influence of timepoint on chronotype and sleep variables

Pandemic		*N*	Mean	Standard deviation	Standard error of the mean	T	Df	*P*-value	Cohen's d
Morning affect	Before	312	2.885	1.006	0.057	−1.833	635	0.067	−0.145
	During	325	3.030	0.983	0.055	–			–
Eveningness	Before	312	3.190	0.997	0.056	1.081	635	0.280	0.086
	During	325	3.103	1.033	0.057	–			–
Distinctness	Before	312	3.724	0.834	0.047	1.887	635	0.060	0.150
	During	325	3.599	0.847	0.047	–			–
PSQI score	Before	312	0.574	0.383	0.022	−0.973	635	0.331	−0.077
	During	325	0.605	0.415	0.023	–			–
PDSS score	Before	312	3.075	0.586	0.033	−2.505	630	0.012*	−0.199
	During	320	3.184	0.514	0.029	–			–
STQ score	Before	312	4.763	1.969	0.111	1.021	630	0.307	0.081
	During	320	4.597	2.111	0.118	–			–
Rise times weekdays	Before	306	7:15	1:02	0:03	−2.941	620	0.003**	−0.236
	During	316	7:30	1:08	0:03	–			–
Rise times free days	Before	280	9:28	1:36	0:05	3.038	573	0.002**	0.253
	During	295	9:04	1:31	0:05	–			–
Bedtime weekdays	Before	297	23:14	1:11	0:04	0.995	606	0.320	0.081
	During	311	23:08	1:13	0:04	–			–
Bedtime free days	Before	300	24:30	1:29	0:05	2.494	616	0.013*	0.201
	During	318	24:12	1:32	0:05	–			–
Midpoint of sleep weekdays	Before	294	3:14	0:57	0:03	−1.254	597	0.210	−0.103
	During	305	3:20	1:02	0:03	–			–
Midpoint of sleep free days	Before	279	5:00	1:27	0:05	2.936	570	0.003**	0.246
	During	293	4:39	1:26	0:05	–			–
Midpoint of sleep corrected	Before	274	4:40	1:20	0:04	1.798	558	0.073	0.152
	During	286	4:28	1:24	0:05	–			–
Sleep duration week	Before	294	8:01	1:07	0:03	−3.863	597	<0.001***	−0.315
	During	305	8:22	1:05	0:03	–			–
Sleep duration free days	Before	279	8:56	1:05	0:03	0.644	570	0.520	0.054
	During	293	8:52	1:03	0:03	–			–
Average sleep duration	Before	274	8:16	0:55	0:03	−3.036	558	0.003**	−0.257
	During	286	8:30	0:58	0:03	–			–
Social jetlag	Before	274	1:45	1:03	0:03	5.537	558	<0.001***	0.467
	During	286	1:17	0:55	0:03	–			–

Df degrees of freedom, *PSQI* Pittsburgh Sleep Quality Index, *PDSS* Pediatric Daytime Sleepiness Scale, *STQ* Sleep timing questionnaire
$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Habitual sleep–wake variables

We collected bedtimes and rise times on weekdays and free days to calculate sleep duration, midpoint of sleep and social jetlag. Sleep duration (SD) results from the difference between sleeping and waking times and is summed up to average sleep duration ($SD_{average}$) as follows:

$$SD_{\text{average}} = \frac{5xSD_{\text{workdays}} + 2xSD_{\text{freedays}}}{7}$$

The term midpoint of sleep (MS) refers to the clock time-based midpoint between sleep onset and awakening. Since bedtime and waking times differ measurably between weekdays and weekend days/days off, the term social jetlag was coined [7]. Social jetlag quantifies the difference between the midpoint of sleep on weekdays compared to the midpoint of sleep on days off. Accordingly, we use an algorithm to correct the midpoint of sleep ($MS_{freedays\ corrected}$) and to include the weekend oversleep in the analysis [19]:

$$MS_{\text{freedays corrected}} = MS_{\text{freedays}} - 0.5x\left(\frac{SD_{\text{freedays}} - (5xSD_{\text{workdays}} + 2xSD_{\text{freedays}})}{7}\right)$$

Table 3 Spearman's rho rank-order correlation coefficients for the interaction of the variables "fixed lecture time" and "on-demand lectures" with chronotype and sleep variables

Spearman's rho		Regression factor
Morning affect	Correlation coefficient	−0.111
	Significance (two-tailed)	0.066
	N	276
Eveningness	Correlation coefficient	0.074
	Significance (two-tailed)	0.222
	N	276
Distinctness	Correlation coefficient	0.025
	Significance (two-tailed)	0.678
	N	276
PSQI score	Correlation coefficient	−0.058
	Significance (two-tailed)	0.336
	N	276
PDSS score	Correlation coefficient	−0.112
	Significance (two-tailed)	0.064
	N	272
STQ score	Correlation coefficient	0.145*
	Significance (two-tailed)	0.017*
	N	271
Rise time weekdays	Correlation coefficient	0.160**
	Significance (two-tailed)	0.008**
	N	269
Rise time free days	Correlation coefficient	0.156*
	Significance (two-tailed)	0.013*
	N	252
Bedtime weekdays	Correlation coefficient	0.165**
	Significance (two-tailed)	0.007**
	N	266
Bedtime free days	Correlation coefficient	0.172**
	Significance (two-tailed)	0.005**
	N	271
Midpoint of sleep weekdays	Correlation coefficient	0.182**
	Significance (two-tailed)	0.003**
	N	261
Midpoint of sleep free days	Correlation coefficient	0.181**
	Significance (two-tailed)	0.004**
	N	251
Midpoint of sleep corrected	Correlation coefficient	0.171**
	Significance (two-tailed)	0.007**
	N	245
Sleep duration weekdays	Correlation coefficient	−0.030
	Significance (two-tailed)	0.631
	N	261

Statistics

Data analysis was performed using SPSS 27.0 (IBM, Armonk, NY, USA). Examined characteristics were "status of lectures", MESSi, STQ, PDSS, PSQI and self-reported sleep variables. As not all participants filled in all questions, the exact sample size is always given for the calculations; thus, *N* and degrees of freedom may differ.

Results

Descriptive statistics are presented in **Table 1**.

We carried out *t*-tests to assess the influence of measurement timepoint (before vs. during the pandemic). These tests showed an influence on sleep duration on weekdays, average sleep duration, midpoint of sleep on free days, social jetlag, and PDSS scores (**Table 2**). Further, differences existed in rise times, and in free day bedtimes (**Table 2**).

Furthermore, we assessed the relationship of the type of instruction offered to students during the pandemic with chronotype and sleep variables. In the questionnaire, the participants answered the question "type of teaching currently offered (status of lectures)" twice, but the questions were reverse coded to each other. We linked these two variables via an exploratory factor analysis (principal component, varimax rotation) with the residuals saved as factor scores (regression factor 1, **Table 3**). "Fixed schedule" loaded positively while "on-demand events" loaded negatively on the scale. A high positive value of the residuals (regression factor) corresponds to a flexible schedule.

Discussion

The aim of this study was to investigate the changes in sleeping and learning behaviour attributable to the pandemic lockdown. There were three main findings that can be summarized as follows:

1. The average PDSS score in the sample decreased during the lockdown phase, corresponding to the fact that students were less burdened with daytime sleepiness.
2. On free days, students had earlier rising times and earlier bedtimes during the lockdown period.
3. The increase in flexible learning times brought on by the pandemic negatively impacted students' lifestyle and increased irregularities in sleeping habits.

The decrease in the average PDSS score during the lockdown period is in line with the results of the rise times during the

Table 3 (Continued)		
Spearman's rho		**Regression factor**
Sleep duration free days	Correlation coefficient	−0.094
	Significance (two-tailed)	0.137
	N	251
Average sleep duration	Correlation coefficient	−0.028
	Significance (two-tailed)	0.659
	N	245
Social jetlag	Correlation coefficient	0.032
	Significance (two-tailed)	0.620
	N	245

PSQI Pittsburgh Sleep Quality Index, *PDSS* Paediatric Daytime Sleepiness Scale, *STQ* Sleep timing questionnaire
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

week. Our data demonstrate that students rose later by an average of 15 min on weekdays during the lockdown period. Taken together with the trend toward earlier rise times on free days (on average 24 min earlier compared to the pre-lockdown period), this indicates that the students were able to align their schedules more with their internal biological rhythm. In sum, this led to a decline in social jetlag by 28 min. Students increased their sleep duration during the week by 21 min on average. Their average sleep duration (weekdays + free days) increased by 14 min. Similar results in the investigation of altered sleep timing were also shown in, e.g., Italian [3], another German [4], North American [20, 21], Chinese [22] and Singaporean [23] cohorts. For example, Ong et al. (2021) [23] reported a reduction in weekday–weekend difference in social jetlag of 50 min. Accordingly, the lockdown and the subsequent changes in getting up times attributable to (1) the flexible teaching schedule and (2) the elimination of commuting times enabled the majority of students to reduce their sleep deficit during the week. Therefore, students may have already been well-rested at an earlier time during the weekend and, subsequently, rose earlier without the need to compensate for the weekday sleep deficit. This is further strengthened by the results of a large US survey on sleep times and their relationship to waking activities. Here, it was shown that the second largest reciprocal relationship to sleep (after work time) was found for travel time including commuting times [24] (for conflicting results and an alternate interpretation see Putilov, 2021; [25]).

In addition to earlier rise times on free days, students also had later bedtimes (on average by 18 min), which complements the results of the midpoint of sleep on free days (on average 21 min later) well. Several explanations which fit into the chain of reasoning are possible. For example, the earlier bedtime and the earlier midpoint of sleep on weekends may be due to the fact that leisure activities were severely restricted during the lockdown. In some areas, people were no longer allowed to leave their homes in the evening due to strict curfews. Moreover, severe contact restrictions were enforced, which is why the reception of visitors also declined sharply. The significant decline in leisure opportunities and the general stay-at-home attitude may have prompted the shift in bedtimes during the lockdown. These results advocate a state of social isolation in the sample group [26]. A less likely explanation would be that students spent less time commuting during the pandemic, leaving more time for personal leisure (if working hours remained the same), conveying the impression of an improved work–life balance. In consequence, they might have been more likely to rest more in themselves and able to go to bed earlier, including at the weekends. The exact reasons remain speculative and would need to be verified by further studies on the psychological effects of lockdown.

The evaluation of the status of lectures in the lockdown subsample showed effects on all clock time-dependant sleep parameters. The results of the factor analysis suggested that the subjects' lifestyle regularity changed negatively due to flexible learning times. The results support the hypothesis that if the subjects were able to choose their own times for getting up and going to bed due to flexible learning times, the irregularity in their sleep timing would increase. This may negatively impact sleep rhythm and has been associated with serious health issues in the long-term course [27]. Work itself is a strong frame for daytime organization (see also [23]). This reflects the disadvantages of flexible learning times. However, in contrast to fixed learning times (which tend to stabilise lifestyle regularity), flexible learning times give subjects the opportunity to adapt their sleep and waking times to their own biological rhythm and thus reduce social jetlag. Taken together, our results show an increase in lifestyle irregularity, which has a negative effect on sleep timing on one hand, and a positive effect on an individual's personal sleep rhythm and sleep timing due to a reduction of social jetlag on the other. The data on the PSQI score prior to and during the pandemic did not change significantly, showing that even though the lockdown influenced sleep-dependent variables, participants reported no effect on their sleep quality or the amount of sleep disturbances. A possible explanation for this result is that these opposing influencing factors (increased lifestyle irregularity/decreased social jetlag) cancel each other out. However, the method used here to assess sleep quality (facet on sleep quality of the PSQi score) consists only of a single item that is also self-reported (vs. e.g., physiological measurements). To confirm the discussed effect, further studies with a broader spectrum of survey methods for sleep quality should be connected.

These results show that the consequences of the lockdown must be considered in a multilayered manner. In principle, more flexible lecture times help students to organise their everyday life to be more in line with their own chronotype. This leads to cultivating a healthier sleep and less suffering from the consequences of social jetlag, such as depression [28]. However, during the lockdown, not only did the university environment have to be restructured with immense restrictions, but also all other facets of everyday life. The students thus lost a large part of the structure and regularity in their everyday lives. A higher irregularity in life, however, leads to poorer sleep due to a poorer sleep rhythm. We conclude that the most health-promoting version of the lecture offer may be a hybrid model combining fixed lecture times, where questions can be clarified, and an on-demand offer.

Strengths and limitations

The strengths of this research are that the data were collected during the actual experience before or during the lockdown and the subjects did not have to provide retrospective assessments. Limitations are mainly the self-assessment questionnaire design of the study, which was not backed up by peer assessment or physiological data.

Since the anonymity of the participants of this study was preserved, we did not encode the participants, so we could not precisely track individual changes in sleep habits before and during the pandemic.

Conclusion

Significant changes in sleeping patterns seem to be attributable to the pandemic lockdown, as found in this self-reported student survey. While daytime sleepiness decreased and earlier overall bedtimes were noted, the impact on the irregularity of sleeping and learning patterns seems to be the most notable finding, as this affects overall quality of life and learning performance. Further studies are needed to validate these findings.

Corresponding address

Naomi Staller
Department of Biology, Eberhard Karls University
72076 Tübingen, Germany
naomi.staller@uni-tuebingen.de

Funding. Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest. N. Staller, L. Kalbacher and C. Randler declare that they have no competing interests.

The data basis of the present study is an online ques onnaire that was collected completely anonymously, no personal data was requested and there was no physical or mental stress or decep on, which is why no ethics approval needs to be obtained under German law.

References

1. Burdorf A, Porru F, Rugulies R (2020) The COVID-19 (Coronavirus) pandemic: consequences for occupational health. Scand J Work Environ Health 46(3):229–230
2. Quaresma MVLS, Marques CG, Magalhães ACO, Santos DRVT (2021) Emotional eating, binge eating, physical inactivity, and vespertine chronotype are negative predictors of dietary practices during COVID-19 social isolation: A Cross-Sectional Study. Nutrition. https://doi.org/10.1016/j.nut.2021.111223
3. Cellini N, Canale N, Mioni G, Costa S (2020) Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. J Sleep Res 29(4):e13074
4. Staller N, Randler C (2020) Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. Somnologie. https://doi.org/10.1007/s11818-020-00277-2
5. Ingram J, Maciejewski G, Hand CJ (2020) Changes in diet, sleep, and physical activity are associated with differences in negative mood during COVID-19 lockdown. Front Psychol 11:2328
6. Martínez-de-Quel Ó, Suárez-Iglesias D, López-Flores M, Pérez CA (2021) Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: a longitudinal study. Appetite 158:105019
7. Wittmann M, Dinich J, Merrow M, Roenneberg T (2006) Social jetlag: misalignment of biological and social time. Chronobiol Int 23(1–2):497–509
8. Randler C, Díaz-Morales JF, Rahafar A, Vollmer C (2016) Morningness—eveningness and amplitude—development and validation of an improved composite scale to measure circadian preference and stability (MESSi). Chronobiol Int 33(7):832–848
9. Díaz-Morales JF, Randler C (2017) Spanish adaptation of the morningness-eveningness-stability-scale improved (MESSi). Span J Psychol. https://doi.org/10.1017/sjp.2017.21
10. Rahafar A, Randler C, Díaz-Morales JF, Kasaeian A, Heidari Z (2017) Cross-cultural validity of morningness-eveningness stability scale improved (MESSi) in Iran, Spain and Germany. Chronobiol Int 34(2):273–279
11. Rodrigues PF, Vagos P, Pandeirada JN, Marinho PI, Randler C, Silva CF (2018) Initial psychometric characterization for the Portuguese version of the Morningness-Eveningness-Stability-Scale improved (MESSi). Chronobiol Int 35(11):1608–1618
12. Tomažič I, Randler C (2020) Slovenian adaptation of the Morningness-Eveningness-Stability Scales improved (MESSi). Biol Rhythm Res 51(3):453–459
13. Faßl C, Quante M, Mariani S, Randler C (2019) Preliminary findings for the validity of the Morningness—Eveningness-Stability Scale improved (MESSi): correlations with activity levels and personality. Chronobiol Int 36(1):135–142
14. Buysse DJ, Reynolds CF III, Monk TH, Berman SR, Kupfer DJ (1989) The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 28(2):193–213. https://doi.org/10.1016/0165-1781(89)90047-4
15. Monk TH, Buysse DJ, Kennedy KS, Potts JM, DeGrazia JM, Miewald JM (2003) Measuring sleep habits without using a diary: the sleep timing questionnaire. Sleep 26(2):208–212
16. Shahid A, Wilkinson K, Marcu S, Shapiro CM (2011) Sleep Timing Questionnaire (STQ). In: Shahid A, Wilkinson K, Marcu S, Shapiro C (eds) STOP, THAT and one hundred other sleep scales. Springer, New York https://doi.org/10.1007/978-1-4419-9893-4_86
17. Drake C, Nickel C, Burduvali E, Roth T, Jefferson C, Badia P (2003) The pediatric daytime sleepiness scale (PDSS): sleep habits and school outcomes in middle-school children. Sleep 26(4):455–458
18. Schneider AM, Randler C (2009) Daytime sleepiness during transition into daylight saving time in adolescents: are owls higher at risk? Sleep Med 10(9):1047–1050
19. Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Merrow M (2004) A marker for the end of adolescence. Curr Biol 14(24):R1038–R1039
20. Wright KP Jr, Linton SK, Withrow D, Casiraghi L, Lanza SM, de la Iglesia H, Depner CM (2020) Sleep in university students prior to and during COVID-19 stay-at-home orders. Curr Biol 30(14):R797–R798
21. Gao C, Scullin MK (2020) Sleep health early in the coronavirus disease 2019 (COVID-19) outbreak in the United States: integrating longitudinal, cross-sectional, and retrospective recall data. Sleep Med 73:1–10
22. Li Y, Qin Q, Sun Q, Sanford LD, Vgontzas AN, Tang X (2020) Insomnia and psychological reactions during the COVID-19 outbreak in China. J Clin Sleep Med 16(8):1417–1418
23. Ong JL, Lau T, Massar SA, Chong ZT, Ng BK, Koek D, Chee MW (2021) COVID-19-related mobility reduction: heterogenous effects on sleep and physical activity rhythms. Sleep 44(2):zsaa179
24. Basner M, Fomberstein KM, Razavi FM, Banks S, William JH, Rosa RR, Dinges DF (2007) American time use survey: sleep time and its relationship to waking activities. Sleep 30(9):1085–1095
25. Putilov AA (2021) Sleep during "lockdown" highlighted the need to rethink the concept of weekend catch-up sleep. Sleep Breath. https://doi.org/10.1007/s11325-021-02492-z
26. Galea S, Merchant RM, Lurie N (2020) The mental health consequences of COVID-19 and physical

distancing: the need for prevention and early intervention. JAMA Intern Med 180(6):817–818
27. Huang T, Mariani S, Redline S (2020) Sleep irregularity and risk of cardiovascular events: the multi-ethnic study of atherosclerosis. J Am Coll Cardiol 75(9):991–999. https://doi.org/10.1016/j.jacc.2019.12.054
28. Islam Z, Hu H, Akter S, Kuwahara K, Kochi T, Eguchi M, Kurotani K, Nanri A, Kabe I, Mizoue T (2020) Social jetlag is associated with an increased likelihood of having depressive symptoms among the Japanese working population: the Furukawa Nutrition and Health Study. Sleep 43(1):zsz204. https://doi.org/10.1093/sleep/zsz204

Zusammenfassung

Auswirkungen eines pandemiebedingten Lockdowns auf Lernverhalten und Schlafqualität bei deutschen Studierenden. Ergebnisse einer Online-Umfrage vor und während der Pandemie

Hintergrund: In dieser Studie untersuchten die Autoren die Auswirkungen und nachfolgenden Veränderungen der COVID-19-Restriktionsmaßnahmen („coronavirus disease 2019") auf die Schlaf- und Schlafenszeitgewohnheiten von $n = 637$ deutschen Universitätsstudierenden.
Methoden: Der Fragebogen wurde online zu 2 verschiedenen Zeitpunkten verteilt: 2020 (27. Februar bis 21. März) und 2021 (27. Februar bis 27. März). Die erste Datenerhebungsphase wurde unmittelbar vor der ersten strengen Abriegelung zur Eindämmung der COVID-19-Pandemie in Deutschland durchgeführt, die zweite Datenerhebungsphase fand während der zweiten Abriegelung statt. Die Erhebung setzte sich aus validierten Fragebögen und zusätzlichen Fragen zu den Veränderungen der Schlaf-/Bettgehzeiten und dem Stand der Vorlesungen während der Abriegelungsphase zusammen.
Ergebnisse: Der Durchschnittswert der Pediatric Daytime Sleepiness Scale (PDSS) in der Stichprobe sank während der Schließungsphase, was darauf hindeutet, dass die Studierenden weniger durch Tagesschläfrigkeit belastet waren. Außerdem stand die Stichprobe an freien Tagen während der Schließungsphase früher auf und ging früher ins Bett. Darüber hinaus wirkte sich die durch die Pandemie bedingte Zunahme flexibler Lernzeiten negativ auf den Lebensstil der Studierenden aus und führte zu mehr Unregelmäßigkeiten in den Schlafgewohnheiten.
Schlussfolgerungen: Wie aus der Selbstauskunft der Studierenden hervorgeht, scheinen signifikante Veränderungen im Schlafverhalten auf die Pandemiesperrung zurückzuführen zu sein. Während die Tagesschläfrigkeit abnahm und insgesamt frühere Schlafenszeiten festgestellt wurden, scheint die Auswirkung auf die Unregelmäßigkeit der Schlaf- und Lerngewohnheiten das bemerkenswerteste Ergebnis zu sein, da dies die allgemeine Lebensqualität und die Lernleistung beeinflusst. Weitere Studien sind erforderlich, um diese Ergebnisse zu validieren.

Schlüsselwörter
Telearbeit · Fragebogen · Soziale Isolierung · „Severe acute respiratory syndrome coronavirus type 2" · „Coronavirus disease 2019"

C Onsite versus home-office: differences in sleep patterns according to workplace

Staller, N., Quante, M., Deutsch, H., & Randler, C. (2023). Onsite versus home-office: Differences in sleep patterns according to workplace. *Somnologie*. https://doi.org/10.1007/s11818-023-00408-5

Somnologie
Somnology – Current Sleep Research and Concepts

Somnologie
https://doi.org/10.1007/s11818-023-00408-5
Accepted: 13 April 2023

Onsite versus home-office: differences in sleep patterns according to workplace

Naomi Staller[1] · Mirja Quante[2] · Helen Deutsch[2] · Christoph Randler[1]
[1] Department of Biology, University of Tuebingen, Tuebingen, Germany
[2] Department of Neonatology, University of Tuebingen, Tuebingen, Germany

Abstract

Background and objective: This study aimed to evaluate the sleep patterns of students and employees working onsite versus those working from home during the COVID-19 pandemic using actigraphy.
Methods: A total of 75 students/employees (onsite: $N = 40$, home-office: $N = 35$; age range: 19–56 years; 32% male; 42.7% students, 49.3% employees) were studied between December 2020 and January 2022 using actigraphy, a sleep diary, and an online questionnaire assessing sociodemographics and morningness–eveningness. Independent-sample *t*-tests, paired-sample tests, and a multivariate general linear model adjusting for age (fixed factors: sex and work environment) were applied.
Results: Overall, onsite workers had significantly earlier rise times (7:05 [SD: 1:11] versus 7:44 [1:08] hours) and midpoints of sleep (2:57 [0:58] versus 3:33 [0:58] hours) on weekdays compared to home-office workers. Sleep efficiency, sleep duration, variability of sleep timing, and social jetlag did not differ between the groups.
Discussion: Home-office workers showed a delay in sleep timing that did not affect any other sleep parameters such as sleep efficiency or nighttime sleep duration. The work environment had only marginal impact on sleep patterns and thus sleep health in this sample. Sleep timing variability did not differ between groups.

Keywords
Actigraphy · Coronavirus disease 2019 pandemic · Sleep hygiene · Remote working · Circadian rhythm

Supplementary Information

The online version of this article (https://doi.org/10.1007/s11818-023-00408-5) contains supplementary material 1 and 2, which is available to authorized users.

Supplementary material online – scan QR code

Sleep is critical for regular functioning of physical and mental health in humans [1]. It is important for maintaining long-term health through physical/cerebral functioning (sleep deprivation causes, e.g., an increased prevalence of noncommunicable diseases such as obesity [2] or cardiovascular problems [3]), and short term health by, e.g., minimizing the risk of traffic accidents related to drowsiness [4, 5].

With the onset of the coronavirus disease 2019 (COVID-19) pandemic, mental stress increased enormously due to fears about the future, about relatives, or about one's own health. Since stress and anxiety have a strong negative impact on sleep, some research groups have reported a deterioration in sleep health (see [6] for a review). In addition, increased workloads in some professions (e.g., medical staff) have also taken their toll, leading to more sleep problems and poorer sleep health [6].

The pandemic changed the professional situation of students and employees. Remote working (hereinafter also referred to as the situation of students studying at home) as well as the closure of many business sectors (e.g., body-related services) affected everyday life, including sleep. It was shown that the shift to remote working and the associated later work start allowed participants to adjust their sleep times to their own circadian rhythm. As a result, students and employees were able to synchronize their biological and social clocks, thereby improving sleep

Published online: 06 June 2023

health (e.g., [7–15]). In addition to the positive effects of synchronizing social and biological timing, on-demand teaching has been shown to lead to a loss of sleep timing regularity [14], which, in turn, can have negative effects on sleep and overall health (e.g., [16, 17]). In contrast, Ramírez-Contreras and colleagues [18] reported that the hybrid system of virtual and face-to-face activity was beneficial for students in terms of sleep regularity and eating habits, resulting in longer sleep duration on weekdays and reductions in sleep deprivation. Furthermore, increased screen time due to remote working may also have disrupted and delayed sleep onset due to more blue light exposure (e.g., [19, 20]) and less outdoor light exposure [21]. However, increased time spent outdoors in home-office workers has also been reported [22]. So far, there are few data on the effect of the working environment on sleep patterns during the COVID-19 pandemic in Germany.

The present study builds on the preliminary data and literature available and compares the sleep patterns of participants in two different working environments. We hypothesized later/more irregular sleep timing and midpoints of sleep, longer nighttime sleep duration, worse sleep efficiency, and less social jetlag (SJL) in home-office compared to onsite-working students/employees.

Methods

Setting

This study was approved by the Eberhard Karls University's ethics committee (Faculty of Economics and Social Sciences: no. A.Z.: A2.5.4-157_ns).

Data collection

Data were collected from December 14, 2020, to January 18, 2022. Participants were recruited through university mailing lists and social media postings (Facebook, Instagram, WhatsApp). The study included a questionnaire that was available online on the SoSciSurvey platform (https://www.soscisurvey.de/). This hosting platform complies with European Union data protection regulations. Potential study participants were informed about the voluntary nature of participation, the possibility to stop data collection at any time without consequences, and the study compensation of 25 € in cash. Informed consent was obtained before data collection began. Exclusion criteria were shiftwork, participants who planned to travel across time zones during data collection, and participants who were not fluent in German.

Variables and instruments

Participants reported information on their demographics (such as the work environment ("working onsite," hereafter: "onsite group"; and "working from home," hereafter: "home-office group"), age, sex, number of children in their household, occupation), details of their sleep behavior, and a morningness–eveningness questionnaire (the Morningness–Eveningness Stability Scale improved [MESSi]).

MESSi

The MESSi consists of three subscales: morning affect (MA), eveningness (EV), and distinctness (DI). MA is designed to measure the affective component of morning orientation, while EV measures the affective component of evening orientation. In comparison to the diurnal changes measured by the MA and EV subscales, the DI subscale measures fluctuating changes in the expression of MA and EV [23].

Actigraphy

Participants were asked to wear an ActiGraph (GT3X+, ActiGraph, Pensacola, FL, USA) for 7 consecutive days in order to measure sleep–wake patterns. The device is worn on the nondominant wrist similar to a wristwatch. At the end of the measurement week, participants returned their ActiGraphs and the data were downloaded using the accompanying software (ActiLife). Activity counts were collected in 1-min epochs over a continuous period of 1 week (7 × 24 h). Any recordings that did not meet the minimum requirements of a) at least 10 h of valid signal during waking hours and b) a total of at least 4 valid days were excluded. Sleep–wake patterns were scored manually using the ActiLife software as described by Mitchell and colleagues [24]. Briefly, sleep onset and offset times were identified by diary report and observation of a sharp decrease/increase in activity. If there were discrepancies of more than 30 min between the sleep diary report and the decrease/increase in activity counts measured by the ActiGraph, sleep phases were determined visually based on the activity changes. We used the Cole–Kripke algorithm to estimate sleep and wake periods [25]. Non-wearing times were determined using the Troiano algorithm and compared with the sleep diary [26].

Sleep diary

Participants completed a sleep diary during the week of actigraphic monitoring. Participants were asked to note bedtimes, naps during the day, awakenings during the night (duration and frequency), and times when the ActiGraph was taken off (e.g., to take a shower).

Midpoint of sleep as a measure of chronotype

As a second measure of chronotype the corrected midpoint of sleep (MSFsc) as proposed by Roenneberg and colleagues was used [27]. This chronotype measure is based on clock time but adjusts for average individual sleep need [28]. It was shown to be a stable measure of chronotype during the COVID-19 pandemic in a similar German sample from Baden-Württemberg [13]. Throughout this manuscript the abbreviation "MPOS" represents "midpoint of sleep," while in the following formula, "SDu" stands for "average sleep duration":

$$
\begin{aligned}
MSFsc &= \mathrm{MPOS}_{\mathrm{weekend}} \\
&-0.5\times(SDu_{\mathrm{weekend}} \\
&-(5\times SDu_{\mathrm{workdays}} + 2\times SDu_{\mathrm{weekend}}) \div 7)
\end{aligned}
$$

Social jetlag

SJL is a parameter to describe the discrepancy between a person's social and biological clocks due to circadian preferences [29]. Weekend sleep patterns are thought to reflect the internal biological

Table 1 Demographics: onsite versus home-office group				
Variable		**Overall ($N=75$)**	**Onsite group ($N=40$)**	**Home-office group ($N=35$)**
Age, years, mean (SD)		28.2 (7.7)	30.3 (8.7)*	25.8 (5.6)*
Sex, ***N*** (%)	Male	24 (32.0)	15 (37.5)	9 (25.7)
	Female	51 (68.0)	25 (62.5)	26 (74.3)
Children in household, ***N*** (%)	Yes	5 (6.7)	4 (10.0)	1 (2.9)
	No	70 (93.3)	36 (90.0)	34 (97.1)
Profession, ***N*** (%)	Student	32 (42.7)	9 (22.5)*	23 (65.7)*
	Employee	37 (49.3)	25 (62.5)	12 (34.3)
	Not specified	6 (8.0)	6 (15.0)	–
Morningness, mean (SD)		3.37 (0.79)	3.41 (0.77)	3.32 (0.82)
Eveningness, mean (SD)		3.01 (0.86)	2.97 (0.83)	3.07 (0.90)
Distinctness, mean (SD)		3.31 (0.71)	3.35 (0.71)	3.27 (0.72)
Sleep time variability—bedtimes, mean (SD), max/min [h]		0.87 (0.45), 0.17/2.32	0.92 (0.45), 0.17/2.32	0.83 (0.43), 0.2/2.07
Sleep time variability—rise times, mean (SD), max/min [h]		0.95 (0.43), 0.2/2.1	0.93 (0.45), 0.2/1.9	0.95 (0.43), 0.25/2.1

SD standard deviation
*Significant differences between onsite and home-office ($p < 0.05$)

clock, whereas weekday sleep patterns reflect the social clock. SJL is calculated by subtracting the midpoint of sleep on workdays from the midpoint of sleep on days off:

$$SJL = \mathrm{MPOS}_{\mathrm{weekend}} - M\mathrm{POS}_{\mathrm{workdays}}$$

Sleep efficiency

Sleep efficiency is calculated by dividing the amount of time spent asleep (in minutes) by the total amount of time in bed (in minutes).

Sleep time variability

The variability in sleep times was compared between the groups. This was done by calculating the standard deviation of sleep times for each participant and using this to calculate a group mean. The result shows the average standard deviation of sleep times and is considered the variability of sleep timing in the group.

Statistical analyses

We further analyzed the actigraphy data using pyActigraphy [30], an open-source Python actigraphy analysis and visualization framework. In addition, averages of various sleep parameters were calculated for each subject using the Python data analysis library Pandas [31]. To calculate time averages after midnight, e.g., sleep onset time and midpoint of sleep, we added 24 h to times below an appropriate pivot element before calculating the mean, and then subtracted 24 h afterwards, if necessary. The software and a detailed description are available as open source at https://github.com/spuetz/actigraphy.git. Statistical analysis of the actigraphy and questionnaire data was performed using SPSS 29.0 software (IBM Corp., Armonk, NY, USA). Independent-sample *t*-tests and paired-sample tests were calculated to compare inter-and intra-individual differences. Furthermore, a multivariate general model was calculated with sex and work environment as fixed factors and age as a covariate to control the reliability of the *t*-tests. Kolmogorov–Smirnov and Shapiro–Wilk tests were used to test the normal distribution of the MSFsc variable. Levine tests indicated that equal variances could be assumed. Pearson's chi-squared test was used for descriptive group comparisons.

Results

Descriptive group statistics are presented in **Table 1**. Exploratory data analysis was performed to identify outliers in the age variable, as this variable has a strong influence on other variables. Outlier limits were defined as ±3 standard deviations from the mean value. Two cases were excluded in each group. This reduced the original sample size from $N=79$ to $N=75$. Overall, the home-office group was significantly younger than the onsite group. Significantly more participants were students in the home-office group compared to the onsite group. We did not see any difference between groups regarding children in the household or chronotype. The sleep timing variability did not differ between the groups. In terms of intra-individual differences in the variability of sleep times, the onsite group had the lowest standard deviation of 0.17 h for bedtimes and also the highest of 2.32 h. For rise times, the minimum and maximum were 0.2 h and 2.07 h (**Table 1**). In the home-office group, the minimum for bedtime was 0.2 h and the maximum was 1.9 h, while the rise times were 0.25 h and 2.1 h respectively (see **Table 1**).

Comparisons of sleep patterns are shown in **Table 2**. No differences were seen in total time in bed, sleep efficiency, and total sleep time on weekdays, weekends, and all days. The home-office group went to bed, reached the midpoint of sleep, and got up significantly later than the onsite group on weekdays. Interestingly, sleep parameters did not differ between groups at weekends. Also, the variability of sleep timing (standard deviations of sleep timing, **Table 1**) did not differ between the groups. Both groups showed a SJL of about 1 h, which was not significantly different. In addition, there was no difference in chronotype measured by the MESSi scales MA/EV/DI (**Table 1**) or MSFsc (**Table 2**) between the two groups. For both the onsite and home-office groups, the Kolmogorov–Smirnov test and the Shapiro–Wilk test indicated a normal distribution of the MSFsc.

As age differed significantly between the onsite and home-office groups (30.3 versus 25.8 years, $p=0.01$), a multivariate general linear model adjusting for age was applied (fixed factors: sex and work environment) (**Table 3**).

In comparison with the independent-sample test (**Table 2**), the general linear model confirmed the significant findings. The only exception was the variable

Table 2 Comparison of onsite versus home-office groups regarding sleep patterns

Characteristic	Onsite group (N = 40)			Home-office group (N = 35)			p-value
	Mean	SD	Std. error mean	Mean	SD	Std. error mean	
Average total time in bed (all days), h	7.65	0.78	0.2	7.73	0.77	0.2	0.636
Average total time in bed (workdays), h	7.55	0.92	0.22	7.63	0.87	0.22	0.685
Average total time in bed (weekend), h	7.90	1.12	0.28	8.00	1.02	0.28	0.695
Average total sleep time (all days), h	6.92	0.8	0.12	6.93	0.68	0.1	0.899
Average total sleep time (workdays), h	6.83	0.83	0.12	6.82	0.77	0.12	0.980
Average total sleep time (weekend), h	7.15	1.28	0.2	7.23	0.88	0.15	0.723
Average sleep efficiency (all days), %	90.4	0.05	0.01	89.9	0.05	0.01	0.605
Average efficiency (workdays), %	90.5	0.04	0.01	89.5	0.05	0.01	0.331
Average efficiency (weekend), %	90.1	0.09	0.01	90.7	0.05	0.01	0.738
Average bedtime (all days)	23:43	0.97	0.15	00:16	1.08	0.18	0.023*
Average bedtime (workdays)	23:28	0.98	0.15	00:07	1.05	0.17	0.008*
Average bedtime (weekend)	00:21	1.3	0.2	00:45	1.33	0.22	0.197
Average midpoint of sleep all days	3:14	0.92	0.13	3:48	1.0	0.17	0.015*
Average midpoint of sleep workdays	2:57	0.97	0.15	3:33	0.97	0.15	0.009*
Average midpoint of sleep weekend	3:59	1.17	0.18	4:25	1.18	0.2	0.122
Average corrected midpoint of sleep	3:51	1.27	0.2	4:17	1.28	0.22	0.158
Average rise time (all days)	7:25	1.0	0.15	8:01	1.05	0.17	0.014*
Average rise time (workdays)	7:05	1.18	0.18	7:44	1.13	0.18	0.019*
Average rise time (weekend)	8:17	1.12	0.17	8:47	1.2	0.2	0.068
Social Jetlag, h	1.03	1.02	0.15	0.87	0.72	0.12	0.403

SD standard deviation
*Significant differences between onsite and home-office ($p < 0.05$)

"average rise time workdays," which was no longer significant in the general linear model.

Sleep parameters on weekdays were also compared with weekend days to investigate intra-individual differences within each group using paired-sample *t*-tests (**Table 4**). Intra-individual differences were found in both the onsite and home-office groups. The sleep parameters of the onsite group differed significantly between weekdays and weekend days with regard to sleep efficiency, bedtime, total sleep time, rise time, and midpoint of sleep. The home-office group differed in the same sleep parameters except for total sleep time.

Onsite workers had a higher sleep efficiency on weekdays compared to weekends, while home-office workers had a higher sleep efficiency on weekends compared to weekdays. Average bedtime and midpoint of sleep were significantly later at weekends compared to weekdays for both groups.

Discussion

In summary, it was found that onsite workers had significantly earlier sleep timing and midpoints of sleep on weekdays compared to home-office workers, whereas there were no clinically meaningful differences regarding sleep efficiency, sleep duration, and variability in sleep timing. Importantly, also SJL did not differ between the groups. The results of the group comparison showed that the onsite group was significantly older than the home-office group. The group means differed by 4.5 years. This age difference is particularly important when considering the present results. Chronotype, as an individual difference trait, is subject to changes in expression over the course of a person's life [32]. While young children tend to be morning types, this tendency changes strongly during adolescence [32]. Adolescents show a distinct delay in chronotype, peaking at the age of 20 years [27]. With the end of adolescence, the daytime preference shifts again and begins to advance. Roenneberg and colleagues [27] showed a continuous advancement of chronotype from the age of 20 until about 65 years. There is also a steeper regression line between the ages of 20 and 45 years than between 45 and 65 years. Most adults do not belong to an extreme chronotype and are therefore described as neither type [32]. In the sample of Randler and colleagues [32], a distribution of 21.1% evening, 71.7% neither, and 7.2% morning type was reported for the 26-year-old subjects. Among the 30-year-old subjects, 11.9% were classified as evening type, 74.8% as neither, and 13.3% as morning type. This means that the 30-year-old subjects were 9.2% less likely to be classified as evening type than the 26-year-old subjects. As the average age of the present sample groups differed by about 4.5 years (mean 25.8 years in home-office, mean 30.3 years in onsite), it could be assumed that also the chronotypes differ significantly from each other. Participants in the home-office group may therefore be more evening oriented, reflecting a higher proportion of evening types in this group than in the onsite group.

In this study two different measures of chronotype were used (MSFsc: clock time-based measure, MESSi: continu-

Table 3 Results of the general linear model controlling for age as a covariate

Dependent variable		F	*p*-value	Estimated marginal means	
				Mean	Std. error
Average total time in bed (all days), h	Onsite	0.006	0.938	7.65	0.13
	Home-office			7.63	0.13
Average total time in bed (workdays), h	Onsite	0.068	0.795	7.57	0.15
	Home-office			7.52	0.17
Average total time in bed (weekend), h	Onsite	0.147	0.702	7.83	0.18
	Home-office			7.93	0.2
Average total sleep time (all days), h	Onsite	0.258	0.613	6.88	0.12
	Home-office			6.80	0.13
Average total sleep time (workdays), h	Onsite	0.575	0.451	6.82	0.13
	Home-office			6.67	0.15
Average total sleep time (weekend), h	Onsite	0.042	0.837	7.05	0.18
	Home-office			7.12	0.20
Average efficiency (all days), %	Onsite	0.511	0.477	0.90	0.008
	Home-office			0.89	0.008
Average efficiency (workdays), %	Onsite	1.183	0.280	0.90	0.007
	Home-office			0.89	0.008
Average efficiency (weekend), %	Onsite	0.006	0.940	0.90	0.012
	Home-office			0.90	0.013
Average bedtime (all days)	Onsite	5.034	0.028*	23:51	00:10
	Home-office			00:23	00:11
Average bedtime (workdays)	Onsite	7.225	0.009*	23:37	00:10
	Home-office			00:15	00:11
Average bedtime (weekend)	Onsite	1.615	0.208	00:26	00:13
	Home-office			00:50	00:14
Average midpoint of sleep all days	Onsite	4.522	0.037*	03:21	00:09
	Home-office			03:50	00:10
Average midpoint of sleep workdays	Onsite	5.022	0.028*	03:04	00:09
	Home-office			03:35	00:10
Average midpoint of sleep weekend	Onsite	2.103	0.151	04:01	00:11
	Home-office			04:27	00:13
Average corrected midpoint of sleep	Onsite	1.362	0.247	03:55	00:13
	Home-office			04:17	00:14
Average rise time (all days)	Onsite	4.338	0.041*	07:32	00:10
	Home-office			08:03	00:11
Average rise time (workdays)	Onsite	3.528	0.064	07:14	00:11
	Home-office			07:45	00:12
Average rise time (weekend)	Onsite	3.173	0.079	08:18	00:12
	Home-office			08:49	00:13
Social jetlag, h	Onsite	0.179	0.673	0.95	0.15
	Home-office			0.85	0.17

Means of squares are given as a decimal number
*Significant differences between onsite and home-office

ous morningness-eveningness measure). The analysis of the MSFsc and the MESSi showed no significant differences between the groups. Therefore, the expression of chronotype did not differ between the groups.

Regarding the MSFsc variable, Roenneberg and colleagues [33] described a comparable shape and width of the distribution in all age groups, with a varying mean value. Graphical comparison of the group histograms (see Supplement 1) with the expected values ([33], $N \geq 55{,}000$) showed that the distribution in the home-office group had a similar shape. In the onsite group, two equally high peaks existed, one at 3:00 a.m. and one at 4:30 a.m., showing the shape of the distribution to be different from the reference. In the sample of Roenneberg and colleagues [33], the 26-year-old subjects showed peaks at around 4:45 a.m. compared to 4:17 a.m. for the home-office group. For the 30-year-old participants, Roenneberg and colleagues [33] reported an average MSFsc of approximately 4:30 a.m., compared to 3:51 a.m. for the onsite group. Taken together, these two discrepancies led us to consider the MSFsc of the onsite group to be unrepresentative.

In summary, a) the expected distribution of chronotype based on the age groups of the samples and b) the finding that the distribution of chronotype in the onsite group cannot be considered representative suggest that the chronotypes of the groups can generally be expected to differ. The younger group would normally have a higher prevalence of evening types/more pronounced eveningness, although this was not the case in the present samples.

Increased eveningness is associated with a higher risk of SJL. SJL has repeatedly been shown to be particularly detrimental to public health (e.g., cardiovascular outcomes, psychiatric disorders, obesity [34]). However, softer factors such as productivity at work are also significantly affected by SJL. To test whether the measured SJL in the home-office group was within the expected range, the results were compared to an earlier sample of the authors' research group [13]. In that study, only people who worked in home-office during the COVID-19 pandemic had been surveyed. The mean age of the sample was reported to be ~ 28.6 years (SD: ~ 10.5 years), which was not different compared to the sample of the present study ($p = 0.11$; Supplement 2). With regard to SJL, the means of the present home-office group (0.80, SD: 0.73 h) and the previous sample (0.82; SD: 0.70 h) were also not significantly different ($p = 0.87$; Supplement 2). Furthermore, the chronotype within the two groups measured by MSFsc did not

Table 4 Intra-individual differences between sleep parameters on weekdays versus weekends						
Characteristic	Onsite group ($N=40$)			Home-office group ($N=35$)		
	Mean	SD	p-value	Mean	SD	p-value
Average total time in bed	−0.33	1.30	0.208	−0.35	1.10	0.058
Average total sleep time	−0.32	1.28	0.037*	−0.40	0.97	0.063
Average efficiency	0.004	0.07	< 0.001*	−0.01	0.04	< 0.001*
Average bedtime	−0.87	1.03	< 0.001*	−0.63	0.75	< 0.001*
Average midpoint of sleep	−1.03	1.02	< 0.001*	−0.87	0.72	< 0.001*
Average rise time	−1.20	1.30	0.026*	−1.05	1.05	< 0.001*

SD standard deviation
*Significant differences between weekdays and weekend days ($p<0.05$)

differ ($p=0.21$; Supplement 2). It can therefore be assumed that the SJL in the present sample is representative for this age group working from home. In another sample of the same age who were not working from home, the SJL was almost 1 h higher (1.78 h) compared to the present sample with 0.8 h [35]. It could be postulated that the implementation of home-office might potentially be beneficial for young people to reduce SJL. The onsite group had an average SJL of 1.03 h, which was also compared to other samples in the current literature. As no age-matching sample could be found in the literature, the present results were compared to slightly younger and older samples. Both showed a meaningful but equal age difference compared to the present sample. Interestingly, the SJL (1.4 ± 1.0, [36]; 1.33 ± 0.88 h, [37]) of the two studies did not significantly differ ($p=0.42$, $t=0.78$, $df=727$, Standard Error of Difference (SED) = 0.09). Therefore, these results were used as representative reference values for SJL in the current sample. Even the value closer to the current study [37] differed significantly from the SJL reported herein ($p=0.04$, $t=2.07$, $df=637$, $SED=0.15$; Supplement 2). This led to the conclusion that the SJL of the onsite group cannot be considered representative, as it was significantly below the expected range.

Although the SJL of the present two study groups were not significantly different, there was a tendency towards lower SJL in the home-office group. This tendency was reinforced by an overrepresentation of low SJL in the onsite group, while the home-office group showed more similar values to age-comparable samples. Therefore, the current results suggest that working from home might help to reduce SJL.

The present study differs from the authors' previous studies which examined only home-office participants and not two samples in different working environments. As spatial flexibility, in addition to temporal flexibility [14], may play a role in the increasing irregularity of students' sleep schedules, a possible relationship was investigated here.

The sleep timing of the two groups on workdays differed significantly. The home-office group went to bed later and also got up later. However, both groups had similar fluctuations regarding sleep timing variability and no difference in overall nightly sleep duration. Thus, home-office had no negative influence on sleep variability and duration in this sample. There was also no influence of spatial flexibility/working environment on the loss of sleep duration/regularity observed. Instead, data support the hypothesis that the ability to work with unrestricted temporal flexibility is the main influencing factor of the increased sleep timing regularity in students, as discussed in one of the authors' previous studies [14] by excluding another possible influencing factor.

Sleep efficiency did not differ between the two groups. However, a difference within the groups could be detected. In the onsite group, sleep efficiency was higher on weekdays than at weekends. The opposite was true for the home-office group, where sleep efficiency was higher at weekends. The reason for this could be explained by the way the sleep efficiency variable is calculated. On weekdays, participants in the onsite group could have either gotten up immediately after waking up (e.g., because of the increased pressure to get up on time in order to commute to work compared to the weekend) or gone straight to sleep after going to bed (e.g., because of the increased exhaustion from onsite work with probably fewer breaks compared to the weekend). This would explain the high ratio of total sleep time to time in bed, which corresponds to a higher sleep efficiency. At the weekend, on the other hand, they may have stayed in bed even longer although they were already awake, or it took longer for them to fall asleep, resulting in lower sleep efficiency. In contrast, the opposite was true for the home-office group, with a higher sleep efficiency at weekends compared to weekdays. Although statistically significant, this effect was small and not clinically meaningful.

Conclusion

In summary, it was found that home-office workers had a delay in sleep timing that did not have a clinically meaningful effect on any other sleep parameter such as sleep efficiency or nightly sleep duration. Compared to values in the current literature, SJL seemed to be reduced in the home-office group. Overall, the work environment had only marginal impact on sleep patterns and thus sleep health in this sample. Sleep timing variability did not differ between groups.

Limitations and strengths

Strengths of the study were the objective data collection via actigraphy and the assessment of different sleep variables covering sleep quantity, quality, and circadian patterns. The results of the study were limited by the fact that the sample was relatively small and there was a significant age difference between the groups. In addition, students were overrepresented in the home-office group. Moreover, although the data were collected during the same seasons, which reduces seasonal effects, they were collected over a long period of time, this may have influenced the data in terms of the evolution of the pandemic (different severity of lockdown regimes, psychological effects due to different familiarity and understanding).

Zusammenfassung

Vor Ort vs. Home-Office: Unterschiede im Schlafverhalten je nach Arbeitsort

Hintergrund und Ziel: In dieser Studie wurde das Schlafverhalten von Studierenden und Angestellten, die während der COVID-19-Pandemie vor Ort oder von zu Hause aus arbeiteten, aktigraphisch untersucht.
Methoden: Untersucht wurden 75 Studierende/Angestellte (vor Ort: $N = 40$, Home-Office: $N = 35$, Alter: 19–56 Jahre, 32 % männlich, 42,7 % Studierende, 49,3 % Angestellte) zwischen Dezember 2020 und Januar 2022 mittels Aktigraphie, Schlaftagebuch und Online-Fragebogen zur Erfassung von soziodemographischen Daten und Morningness-Eveningness. Verwendet wurden *t*-Tests für unabhängige Stichproben, Tests für gepaarte Stichproben sowie ein altersbereinigtes multivariates allgemeines lineares Modell (feste Faktoren: Geschlecht und Arbeitsumgebung).
Ergebnisse: Insgesamt standen die Vor-Ort-Arbeitenden an Wochentagen signifikant früher auf (7:05 [SD 1:11] vs. 7:44 [1:08] Stunden) und hatten einen signifikant früheren Schlafmittelpunkt (2:57 [0:58] vs. 3:33 [0:58] Stunden) als die im Home-Office-Arbeitenden. Schlafeffizienz, Schlafdauer, Schlafvariabilität und sozialer Jetlag unterschieden sich nicht zwischen den Gruppen.
Diskussion: Im Home-Office arbeitende Teilnehmende zeigten eine Verzögerung des Schlafzeitpunkts, die sich nicht auf andere Schlafparameter, wie Schlafeffizienz oder nächtliche Schlafdauer, auswirkte. Die Arbeitsumgebung hatte in dieser Stichprobe nur einen geringen Einfluss auf das Schlafverhalten und damit auf die Schlafgesundheit. Die Variabilität der Schlafzeiten unterschied sich nicht zwischen den Gruppen.

Schlüsselwörter
Aktigraphie · COVID-19 Pandemie · Schlafhygiene · Remote-Arbeit · Zirkadianer Rhythmus

Corresponding address

Naomi Staller
Department of Biology, University of Tuebingen
Tuebingen, Germany
naomi.staller@uni-tuebingen.de

Funding. Open Access funding enabled and organized by Projekt DEAL.

Declarations

Conflict of interest. N. Staller, M. Quante, H. Deutsch, and C. Randler declare that they have no competing interests.

For this article no studies with animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

References

1. Ramar K, Malhotra RK, Carden KA et al (2021) Sleep is essential to health: an American Academy of Sleep Medicine position statement. J Clin Sleep Med 17(10):2115–2119
2. Sun W, Huang Y, Wang Z, Yu Y, Lau A, Ali G, Shan G (2015) Sleep duration associated with body mass index among Chinese adults. Sleep Med 16(5):612–616
3. Sabanayagam C, Shankar A (2010) Sleep duration and cardiovascular disease: results from the National Health Interview Survey. Sleep 33(8):1037–1042
4. Hillman DR, Lack LC (2013) Public health implications of sleep loss: the community burden. Med J Aust 199:S7–S10
5. Philip P, Chaufton C, Orriols L, Lagarde E, Amoros E, Laumon B, Sagaspe P (2014) Complaints of poor sleep and risk of traffic accidents: a population-based case-control study. Plos One 9(12):e114102
6. Lin YN, Liu ZR, Li SQ, Li CX, Zhang L, Li N, Li QY (2021) Burden of sleep disturbance during COVID-19 pandemic: a systematic review. NSS 13:933
7. Conroy DA, Hadler NL, Cho E, Moreira A, MacKenzie C, Swanson LM, Goldstein CA (2021) The effects of COVID-19 stay-at-home order on sleep, health, and working patterns: a survey study of US health care workers. J Clin Sleep Med 17(2):185–191
8. Hallman DM, Januario LB, Mathiassen SE, Heiden M, Svensson S, Bergström G (2021) Working from home during the COVID-19 outbreak in Sweden: effects on 24-h time-use in office workers. Bmc Public Health 21(1):1–10
9. Hirschwald B, Sun Y, Nold A, Bochmann F (2022) Personal factors influencing daytime sleepiness. Zbl Arbeitsmed: 1–7. https://doi.org/10.1007/s40664-022-00459-9
10. Korman M, Tkachev V, Reis C, Komada Y, Kitamura S, Gubin D, Roenneberg T (2020) COVID-19-mandated social restrictions unveil the impact of social time pressure on sleep and body clock. Sci Rep 10(1):1–10
11. Leone MJ, Sigman M, Golombek DA (2020) Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. Curr Biol 30(16):R930–R931
12. Raman S, Coogan AN (2022) Effects of societal-level COVID-19 mitigation measures on the timing and quality of sleep in Ireland. Sleep Med 91:179–184
13. Staller N, Randler C (2021) Changes in sleep schedule and chronotype due to COVID-19 restrictions and home office. Somnologie 25:131–137. https://doi.org/10.1007/s11818-020-00277-2
14. Staller N, Kalbacher L, Randler C (2022) Impact of pandemic lockdown on learning behaviour and sleep quality in German students. Somnologie 26:98–105. https://doi.org/10.1007/s11818-022-00346-8
15. Vollmer C, Jankowski KS (2022) COVID-19-lockdown delayed sleep timing in Tyrolean teachers. Chronobiol Int 39(12):1601–1610
16. Khan S, Duan P, Yao L, Hou H (2018) Shiftwork-mediated disruptions of circadian rhythms and sleep homeostasis cause serious health problems. Int J Genomics 2018. https://doi.org/10.1155/2018/8576890
17. Huang T, Mariani S, Redline S (2020) Sleep irregularity and risk of cardiovascular events: the multi-ethnic study of atherosclerosis. J Am Coll Cardiol 75(9):991–999
18. Ramírez-Contreras C, Zerón-Rugerio MF, Izquierdo-Pulido M (2022) Life before and after COVID-19: the 'new normal'benefits the regularity of daily sleep and eating routines among college students. Nutrients 14(2):351
19. Nestler S, Böckelmann I (2022) Einfluss der Bildschirmzeit auf die Schlafqualität Studierender. Somnologie: 1–8. https://doi.org/10.1007/s11818-022-00357-5
20. Saxena R, Parmar N, Prabhleen K, Allen T (2021) Effect of screen-time on sleep pattern and dietary habits among college-going students in COVID-19 pandemic. Indian J Community Health 33:1
21. Korman M, Tkachev V, Reis C, Komada Y, Kitamura S, Gubin D, Roenneberg T (2022) Outdoor daylight exposure and longer sleep promote wellbeing under COVID-19 mandated restrictions. J Sleep Res 31(2):e13471
22. Randler C, Tryjanowski P, Jokimäki J, Kaisanlahti-Jokimäki ML, Staller N (2020) SARS-CoV2 (COVID-19) Pandemic lockdown influences nature-based recreational activity: The case of birders. IJERPH 17(19):7310
23. Randler C, Díaz-Morales JF, Rahafar A, Vollmer C (2016) Morningness–eveningness and amplitude–development and validation of an improved composite scale to measure circadian preference and stability (MESSi). Chronobiol Int 33(7):832–848
24. Mitchell JA, Quante M, Godbole S, James P, Hipp JA, Marinac CR, Kerr J (2017) Variation in actigraphy-

estimated rest-activity patterns by demographic factors. Chronobiol Int 34(8):1042–1056
25. Cole RJ, Kripke DF, Gruen W, Mullaney DJ, Gillin JC (1992) Automatic sleep/wake identification from wrist activity. Sleep 15(5):461–469
26. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M (2008) Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc 40(1):181
27. Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Merrow M (2004) A marker for the end of adolescence. Curr Biol 14(24):R1038–R1039
28. Zavada A, Gordijn MC, Beersma DG, Daan S, Roenneberg T (2005) Comparison of the Munich chronotype questionnaire with the Horne-Öst-berg's morningness-eveningness score. Chronobiol Int 22(2):267–278
29. Wittmann M, Dinich J, Merrow M, Roenneberg T (2006) Social jetlag: misalignment of biological and social time. Chronobiol Int 23(1–2):497–509
30. pyActigraphy (2022) https://www.researchgate.net/publication/355770176_pyActigraphy_Open-source_python_package_for_actigraphy_data_visualization_and_analysis. Accessed 12 Nov 2022
31. McKinney W (2012) Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. O'Reilly Media, Inc
32. Randler C, Faßl C, Kalb N (2017) From Lark to Owl: developmental changes in morningness-eveningness from new-borns to early adulthood. Sci Rep 7(1):1–8
33. Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn M, Merrow M (2007) Epidemiology of the human circadian clock. Sleep Med Rev 11(6):429–438
34. Caliandro R, Streng AA, van Kerkhof LW, van der Horst GT, Chaves I (2021) Social jetlag and related risks for human health: A timely review. Nutrients 13(12):4543
35. Randler C, Vollmer C, Kalb N, Itzek-Greulich H (2019) Breakpoints of time in bed, midpoint of sleep, and social jetlag from infancy to early adulthood. Sleep Med 57:80–86
36. Choi SJ, Joo EY, Hong SB (2016) Sleep–wake pattern, chronotype and seizures in patients with epilepsy. Epilepsy Res 120:19–24
37. Hayes JF, Schumacher LM, Lanoye A, LaRose JG, Tate DF, Espeland MA, Wing RR (2022) Persistent, high levels of social jetlag predict poor weight outcomes in a weight gain prevention study for young adults. J Behav Med 45(5):794–803

D Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany

Staller, N., & Randler, C. (2022). Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany. *Biological Rhythm Research*, *53*(10), 1612–1625. https://doi.org/10.1080/09291016.2021.1988207

BIOLOGICAL RHYTHM RESEARCH
2022, VOL. 53, NO. 10, 1612–1625
https://doi.org/10.1080/09291016.2021.1988207

Taylor & Francis
Taylor & Francis Group

ORIGINAL REPORT

OPEN ACCESS Check for updates

Chronotype and organizational citizenship behavior during the COVID-19 restriction phase in Germany

Naomi Staller and Christoph Randler

Department of Biology, Eberhard Karls University Tübingen, Tübingen, Germany

ABSTRACT

Here, we researched the effects of the COVID-19 restriction measures on learning/work-related characteristics (working hours, creativity in problem-solving approaches/organizational citizenship behavior (OCB)) depending on chronotype of N = 681 German residents (mean age: 28.63 years, SD: 10.49 years). The data were collected with an online questionnaire from 18 May to 17 June 2020, during the most restrictive phase in Germany. We analyzed participants studying/working in home offices only. Morningness showed positive, while eveningness showed negative correlations to OCB. Morning types worked their usual working times, while evening types took more and longer breaks. In remote work, morning types felt more creative developing problem-solving approaches, while evening types reported the opposite. Our results suggest that remote working is not beneficial for evening types when performance components are concerned, even though they can choose their working time freely which benefits their biological rhythm. This study should be repeated with workers on a large scale to confirm these results.

ARTICLE HISTORY
Received 17 August 2021
Accepted 28 September 2021

KEYWORDS
Big Five; new ways of working; home office; remote working; morningness–eveningness

1. Introduction

Since the first known infection with the novel coronavirus induced disease COVID-19 in December 2019 (Wuhan, China), a global pandemic developed (Wu and McGoogan 2020). The consequences for the health system, economy and social life were immense. To stop the spreading, governments (starting with China) imposed restrictions and ultimately lockdowns on the populations. In Europe, the measures differed considerably. Italy called out a national health emergency and locked down the whole Italian territory beginning 10 March 2020. Until 3 May 2020, the population was placed in social isolation (Marelli et al. 2020). In Sweden, the measures mainly relied on voluntary compliance with the Public Health Agency's recommendations (Hensvik and Skans 2020). In Germany restriction measures were set starting in the middle of March. From this point on, universities, schools, kindergartens, and non-essential businesses were closed. This resulted in a shift to home office and distant learning practices. The sudden changes in lifestyle had various physiological (e.g. absence of sport and leisure activities: Randler et al. 2020) and psychological consequences (e.g. altered sleep: e.g. Staller & Randler 2020).

CONTACT Naomi Staller naomi.staller@uni-tuebingen.de Department of Biology, Eberhard Karls Universität Tübingen, Institut Didaktik Der Biologie Auf Der Morgenstelle, Tübingen, Germany

Studies concerning sleep health during the global COVID-19 pandemic reported changes in contrary ways. Following increasing depression, anxiety and future uncertainty, many people faced sleep disturbances like insomnia, sleep loss, and poor sleep quality (Lai et al. 2020; Zhang et al. 2020; Cellini et al. 2020). For others, the change in sleep wake cycle due to working from home and the abolition of commuting times resulted in positive alterations of sleep parameters (Gao and Scullin 2020; Sinha et al. 2020; Leone et al. 2020; Cellini et al. 2020; Staller & Randler 2020). The latter findings support a modern approach to working called "New Ways of Working" (NWW) (Baane et al. 2011).

NWW as a concept tries to create work environments that are temporal and spatially flexible and focus on innovation and productivity while reducing costs (Nijp et al. 2016). It is proposed as a way to improve work time control by adjusting work to private life (Gajendran and Harrison 2007; Nijp et al. 2015) and biological needs (e.g., chronotype (Wittmann et al., 2006). Further advantages related to NWW are improved motivation due to autonomy (Pritchard and Payne 2003), cost reduction, increased efficiency and information sharing following digitalization and adapted use of office space (Peponis et al. 2007; Demerouti et al. 2014) as well as reduced commuting time/ costs and resulting decrease of environmental pollution (Manoochehri and Pinkerton 2003). Negative aspects of NWW might be the lack of collegial support and exchange (Halford 2005), increased stress due to the feeling of responsibility, loss of structure as well as missing boundaries between work and private life (Lundberg and Cooper 2010; Allvin et al. 2011; Mazmanian et al. 2013; Demerouti et al. 2014). Nevertheless, NWW is designed to influence the work output in a positive manner. The changes that the COVID-19 pandemic has brought about have enabled many people to integrate the NWW concept at least partially into their everyday lives.

This changeover was followed by decreasing social jetlag due to the temporal flexibility, underlining the positive adjusting effects of NWW (Staller & Randler 2020). In another study Staller et al. (2021) reported altered motivational regulation in biology teaching students, depending on chronotype and Big Five personality characteristics during the restriction phase in Germany. Herein it was concluded that the NWW concept might be more suitable for morning types and not/not very beneficial for evening types when only learning/working is concerned (not considering improved biological factors). It was stated that these relationships should be studied further.

The chronotype is a personality trait, which cannot be influenced externally (Tsaousis 2010) but changes during the lifespan (Randler et al. 2017). Morning types get up earlier and go to bed earlier than evening types and reach their peak performance earlier during the day (Adan et al. 2012). This trait has a biological basis, which can be measured by questionnaires, hormones, or daily fluctuations of the body temperature (see Adan et al. 2012, for a review). In general, women are more morning oriented than men (Randler and Engelke 2019), children are more morning oriented, while a shift toward eveningness occurs during puberty, and back to morningness at the end of puberty (Randler et al. 2017). The relationship of morningness to different personality dimensions, for example, agreeableness and conscientiousness, has been replicated repeatedly (see, e.g. Tsaousis 2010; Adan et al. 2012). Among others, these personality characteristics mark an important influencing factor of working success, since, for example, they correlate to constructs, which regard an employee's contribution to the employing company's success (performance components, e.g. Organizational Citizenship Behavior (OCB)). Therefore, the circadian preference might be an understudied influencing factor of learning/working success and work models like NWW. Hence, to achieve the best possible results in learning/working, the chronotype's influences should be explored more in relation to work success variables.

To measure the subjective assessment of participants' own involvement to their learning/working duties we used the conduct of Organizational Citizenship Behavior in its German version from Staufenbiel and Hartz (2000). OCB has increasingly become a subject of organizational psychological research (see Staufenbiel 2000 for an overview). The construct was originally created to resolve the contradiction between the belief that there is a positive correlation of job satisfaction and performance, on the one hand, and empirical data, on the other hand (Organ 1988). Organ (1988) assumed the way of measuring the performance may be inadequate for the expected results because of the small influence employees have to this value. He named other factors like technology or workflows as potentially limiting. If, instead, performance components such as OCB are surveyed, higher correlations with job satisfaction result (see meta-analysis from Organ and Ryan 1995). Important definition criteria of the OCB construct are voluntary helpfulness with absence of any reward, and that the employee's behavior must be conducive to the effectiveness of the organization (Organ 1988). Based on this definition, related constructs can be delimited. For example, the conduct of prosocial organizational behavior (Brief and Motowidlo 1986) also includes behavior that is formally required, such as helping customers. Personality dimensions that are favorable for OCB were also linked to morningness (e.g. conscientiousness, agreeableness, see, e.g. Tsaousis 2010; Adan et al. 2012). Further aspects of individual differences that are both relevant for circadian preference and OCB are, for example, proactivity. This characteristic was identified as an important factor for workplace success. Randler (2009) reported that proactivity was related to morningness, while procrastination was related to eveningness (Díaz-Morales et al. 2008).

NWW should benefit evening types from a biological viewpoint because they can choose their work start times freer in concordance with their intrinsic biological rhythms, which results in lower social jetlag. However, in terms of performance components, we hypothesize NWW is less beneficial for evening types, because they need collegial support and default structure more than morning types. Morning types in comparison have more favorable personality characteristics, such as higher conscientiousness, to succeed in learning/working settings with less supervision. Here we examine how work-related characteristics (e.g. creativity in problem-solving approaches) are affected by the home office orders and how these changes relate to circadian preference.

2. Methods

2.1. Data collection

This study was performed in accordance with the Declaration of Helsinki for experiments involving humans, approved by the ethics committee of the faculty for economy and social sciences of the Eberhard Karls university Tuebingen (Nr. A.Z.: A2.5.4–124_kr). The Data was collected during the most restrictive phase in Germany, from 18 May 2020 until 17 June 2020. Participants were recruited through an online link to the survey they received via Mail (electronic mailing list) or postings on different social media platforms (Facebook/Instagram). Data collection was limited to a single point in time (when the respondents visited the questionnaire via the link). The survey was hosted on an online platform (SoSciSurvey), fulfilling the European Union's data privacy rules. On average, it took 12 min ± 5 min (SD) to complete the questionnaire. Formal consent was inquired in advance. Participants were informed about the theoretical background and study goals (not the hypothesis), voluntariness of the participation, the option to stop the data collection at any point without consequences, and that participation will not be remunerated. The total number of evaluable cases amounts to 681.

2.2. Questionnaire

2.2.1. Demographic data

We asked for age (mean: 28.63 SD: 10.49), sex (n = 197 males; n = 484 females), household size, number of children living in participants' household during the lockdown measures, profession and the option of flex time working. We later dichotomized the answers to "profession" into student (N = 400) and non-student (N = 281). N = 545 participants reported no children in their household, while N = 136 stated one or more. We explicitly asked for the number of children in the household (not the number of own children) because students may live with their families and consequently younger siblings during the lockdown measures. Thus, "children in the household" is a better measure than "own children", because children in general may impair quality of learning/ working/ sleeping regardless of relationship (own children/siblings/ other cases).

2.2.2. Organizational citizenship behavior

OCB is usually measured using external assessment questionnaires. The first and a frequently used questionnaire originated from Smith et al. (1983), using 16 items assigned to the personality characteristics "altruism" and "conscientiousness" (Staufenbiel and Hartz 2000). It was later revised by Organ (1988), who added three more dimensions of personality characteristics (sportsmanship, civic virtue, courtesy; Staufenbiel and Hartz 2000). Although the instruments of the group around Podsakoff & MacKenzie (see, e.g. Podsakoff et al. 1990; MacKenzie et al. 1991), using these five personality characteristics (altruism, conscientiousness, sportsmanship, civic virtue, courtesy), found the largest distribution, no questionnaire has gained general acceptance in American research (Staufenbiel and Hartz 2000). Hence, as no questionnaire was suitable for translation, Staufenbiel and Hartz (2000) developed a new questionnaire for German research. Items from the existing OCB-instruments were selected which met the following criteria: (1) broad coverage of the five OCB-subscales, (2) not too specific to individual areas of activity, (3) clear compliance with Organs (1988) definition of OCB (Staufenbiel and Hartz 2000). Of the five facets (altruism, conscientiousness, sportsmanship, civic virtue, courtesy) the facet "courtesy" was not empirically supported and therefore deleted in the new German questionnaire (Staufenbiel and Hartz 2000). For the other four facets, the five items that loaded the highest on the factor and showed lowest cross loading were selected (Staufenbiel and Hartz 2000). Additionally, the scale of "in-role behavior" of Williams and Anderson (1991) was used. Therefore, the questionnaire has a five-factor structure (altruism, conscientiousness, sportsmanship, civic virtue, in-role behavior) with every factor being represented with five items. The five-factor model showed a χ^2 of 640,5 ($p < 0.001$), df of 265 and CFI of 0.91 (Staufenbiel and Hartz 2000). The questionnaire is available in external- or self- assessment form. Here, we used the self-assessment version. Staufenbiel and Hartz (2000) proposed a confirmatory factor analysis to assess the fit of the data structure. In our current sample, we found an RMSEA of 0.053, with the CI ranging from 0.049 to 0.057, and a PClose of 0.111, suggesting a good fit of our data with the theoretical construct.

2.2.3. Additional freeform questions concerning the working behavior during the home office phase

We asked for changes in creativity in the development of problem-solving approaches and working hours additionally to the OCB questionnaire. These questions aim to address the main changes that occurred due to the transfer from workplace/university to home office: (1) the lack of collegial support → other perspectives and approaches help to find creative problem-solving strategies; (2) the possibility of a freer allocation of time, which can improve the ability to concentrate, but can also provide distractions. A freeform design questionnaire was used to uncover these changes: (1) Do you find it easier/equal/ more difficult to develop creative solutions and solve problems in your home office? Describe. (2) Do you split your working hours more than usual (e.g. more/longer breaks) or do you work as usual? Describe. The answers were later grouped in (1) 1 = easier/2 = equal/3 = more difficult; (2) 1 = same working hours/2 = more and/or longer breaks.

2.2.4. Chronotype

In this study, we used circadian preference as a measure of chronotype. This differs from the clock-based measurement of chronotype, such as the MCTQ (Roenneberg et al. 2003), but in fact, both measures are closely related (and are correlated with each other with an $r = 0.73$; Zavada et al. 2005). In the present study, we used the Morningness-Eveningness Stability Scale improved (MESSi; Randler et al. 2016; Díaz-Morales et al. 2017) to determine circadian preference. The MESSi consists of three subscales represented by five items each, the Morning Affect (MA), Eveningness (EV) and Distinctness (DI). Each of those queries a delimited facet of the M/E trait. MA deals with the energy level in the morning (e.g. "How alert do you feel during the first half hour after having awakened in the morning?") while EV is concerned with the situation in the evening (e.g. "In general, how is your energy level in the evening?"). The DI subscale asks for changes in active phases during the day (e.g. "There are moments during the day where I feel unable to do anything."). High scores in the MA or EV subscale indicate high orientation toward this facet, while high DI scores represent higher daytime fluctuations. MESSi's validity has already been confirmed repeatedly in different languages, using a broad spectrum of methods (Díaz-Morales and Randler 2017; Rahafar et al. 2017; Rodrigues et al. 2018; Faßl et al. 2019; Tomažič and Randler 2020) and is used on a global scale (see, e.g. Arrona-Palacios (2020) for a Mexican sample). Cronbach's α in the current sample was 0.899 for MA, 0.889 for EV, and 0.775 for DI.

Table 1. Correlation matrix chronotype and Big Five personality dimensions.

		Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness
MA	r	0.075	.123**	.272**	−.183**	−.079*
	P	0.052	0.001	<0.001	<0.001	0.039
EV	r	0.026	−0.038	−.182**	−0.052	.102**
	P	0.502	0.327	<0.001	0.176	0.008
DI	r	−.104**	−.107**	−.234**	.341**	.086*
	P	0.007	0.005	<0.001	<0.001	0.025

MA = Morningness; EV = Eveningness; DI = Distinctness¸** denotes $p < 0.01$; * denotes $p < 0.05$

2.2.5. Big Five personality

To measure Big Five personality dimensions, we used the German short version of the Big Five inventory (BFI-10; Rammstedt and John 2007; Rammstedt et al. 2013). This scale is based on the BFI-44 (Benet-Martínez and John 1998) and shortened to a 10-item questionnaire. Two items represent each personality dimension (extraversion, agreeableness, openness, neuroticism, and conscientiousness) with one item per dimension reverse coded. The items are answered in a five-point-Likert format. The BFI-10 showed a clear five factor structure and good external validity (Rammstedt and John 2007). Extraversion, Neuroticism, and Conscientiousness had average correlations with the BFI-44 scales of .89, .86, and .82, while Agreeableness and Openness had .74 and .79. In our sample, the correlation between the two items was 0.666 for Extraversion, 0.482 for Neuroticism, 0.298 for Conscientiousness, 0.157 for Agreeableness, and 0.452 for Openness.

3. Results

The independent predictor variables circadian preference and Big Five personality dimensions were related with each other (see Table 1). Morningness was positively associated with agreeableness and conscientiousness, and negatively with neuroticism and openness. Eveningness, in turn, was negatively related to conscientiousness, but positively to openness. Distinctness was positively related to neuroticism and openness but negatively to extraversion, conscientiousness and agreeableness.

The correlation matrix between OCB and work-related characteristics on one side and personality/circadian preference on the other showed that morningness was positively related to conscientiousness, civic virtue, and in-role behavior (see Table 2). Furthermore, morningness related positively to creativity in problem-solving approaches and negatively to splitting working hours (see Table 3). Eveningness correlated negatively to conscientiousness, in-role behavior (see Table 2) as well as creativity and positively to splitting working hours (see Table 3).

4. Discussion

4.1. Chronotype and Big Five

In our sample, we replicated the relationship of morningness to conscientiousness and agreeableness as well as of eveningness to openness (compare Tonetti et al. 2009; Adan et al. 2012). We failed to replicate a connection of eveningness to extraversion and

Table 2. Correlation matrix of chronotype and Big Five Personality dimensions with OCB-variables.

		OCB altruism	OCB conscientiousness	OCB sportsmanship	OCB civic virtue	in-role behavior
Morning Affect	r	0.052	.291**	0.066	.092*	.184**
	P	0.173	0.001	0.084	0.016	0.001
Eveningness	r	0.015	−.189**	0.003	0.001	−.092*
	P	0.693	0.001	0.942	0.97	0.017
Distinctness	r	−.098*	−.123**	−.184**	−.187**	−.168**
	P	0.01	0.001	0.001	0.001	0.001
Extraversion	r	.264**	−0.024	0.075	.284**	.086*
	P	0.001	0.535	0.051	0.001	0.025
Agreeableness	r	.244**	0.061	.301**	0.006	0.01
	P	0.001	0.112	0.001	0.876	0.786
Conscientiousness	r	.200**	.334**	.163**	.258**	.412**
	P	0.001	0.001	0.001	0.001	0.001
Neuroticism	r	−.168**	0.035	−.270**	−.242**	−.155**
	P	0.001	0.368	0.001	0.001	0.001
Openness	r	.148**	−0.026	0.056	.111**	0.01
	P	0.001	0.492	0.145	0.004	0.797

OCB = Organizational Citizenship Behavior; ** denotes p < 0.01; * denotes p < 0.05

Table 3. Correlations of chronotype and Big Five Personality dimensions with the additional freeform questions concerning the working behavior during the home office phase.

		creative problem solving approaches	splitting working hours
Morning Affect	r	.082*	−.123**
	P	0.036	0.002
Eveningness	r	−.086*	.114**
	P	0.028	0.004
Distinctness	r	0.063	.142**
	P	0.109	0.001
Extraversion	r	0.039	−0.023
	P	0.324	0.559
Agreeableness	r	0.004	−0.05
	P	0.927	0.211
Conscientiousness	r	0.012	−0.073
	P	0.759	0.064
Neuroticism	r	.078*	−0.029
	P	0.048	0.459
Openness	r	−0.063	−0.021
	P	0.108	0.59

** denotes p < 0.01; * denotes p < 0.05

neuroticism but showed a negative correlation of eveningness to conscientiousness and morningness to neuroticism and openness. This might be due to the method determining the chronotype. Here, we used the MESSi to examine the chronotype. The MESSi is a rather new questionnaire, which was created to challenge the disadvantages of clock time-based questionnaires and to provide a consistent Likert-scale rating from 1 to 5, which is not available in most previous chronotype questionnaires (Di Milia et al. 2013). Further, the MESSi portrays chronotype in three dimensions rather than only one (for discussion, see Randler et al. 2016). Even so, to confirm these results further, it would be useful to replicate the study design with a standard instrument to assess circadian preference.

4.2. Chronotype and OCB

The results of both morning and evening types in the Big Five personality dimension "conscientiousness" were in accordance with the results of the OCB-variable "conscientiousness". Morning types showed a positive relationship to the OCB "conscientiousness", while evening types showed a negative one. This was strengthened further by the correlation of Big Five conscientiousness to OCB conscientiousness. Moreover, morningness related positively to the variables OCB "civic virtue" and "in-role behavior", without relating to an OCB variable negatively. Eveningness correlated negatively to in-role behavior, not relating positively to one of the OCB variables. Morningness showed a positive while eveningness showed a negative connection to OCB and therefore conduct at the workplace. These results show that morning types invest more energy in job/studies than evening types do. This adds another point of view to the considerations on why evening types show worse academic performance than morning types throughout their whole education (compare Randler and Frech 2006; Arbabi et al. 2015; Tonetti et al. 2015; Kolomeichuk et al. 2016). Because of the socially demanded working hours and school starting times, evening types live with a sleep deprivation during the week, which is called social jetlag (Wittmann et al. 2006). Their internal biological clock differs from the social clock. So far, this was a main reason believed to cause worse academic performance in schools and universities not least because the differences in success of university students were mitigated by the level of free time allocation and therefore social jetlag (Tonetti et al. 2015). Here we show that evening types invest less in their job and educational duties on a self-aware level, which might be another important reason. However, since we have not received an OCB evaluation from participants' supervisors to reconcile the self-assessment and external assessment data, the results could also be interpreted differently. Evening types might feel not having reached their full potential yet, feeling capable of investing more and achieving better results. They therefore may have assessed themselves as not meeting the expected standards.

4.3. Chronotype and changes in working behavior during the restriction phase

The OCB questionnaire in our survey queried the self-assessment of one's general work behavior, not limited to the home office phase. We therefore additionally asked for changes in creativity in the development of problem-solving approaches and working hours during the restriction phase to specifically address possible alterations.

Morningness was positively correlated, while eveningness was negatively correlated with creative problem-solving approaches. Both relationships might be explained by the lack of colleagues around to engage with. For morning types who are less open (Big Five personality dimension) this change might be beneficial as far as work-related creativity is concerned, because they can concentrate on their own thinking and do not have to consider other arguments into their problem-solving approach. Therefore, they might feel less held back by others, which results in a higher self-assessed rating of creativity of problem-solving approaches. Evening types, in contrast, are more open (Big Five personality dimension) and may relate more on conversations and brainstorming with colleagues to build strategies for problem solving. Therefore, they might feel less creative during home office because of the lack of input from others. In contrast, Giampietro and Cavallera (2007) found evening types to be more likely to use divergent thinking strategies and show creative thinking than morning types.

When splitting working hours are concerned, morningness showed a negative while eveningness showed a positive correlation. Morning types by themselves are on an advantage by socially demanded working hours and school starting times. Their usual working hours therefore might be beneficial followed by no need to change them. Furthermore, morning types are more conscientious, proactive, and behaving according to the OCB criteria, which might raise the desire to fulfill the expected availability. Eveningness, on the other hand, relates negatively to conscientiousness and positively to procrastination. Evening types, therefore, may take more breaks because they procrastinate and have no remorse because of this (Díaz-Morales et al. 2008).

4.4. Big Five and OCB

Agreeableness and conscientiousness as two of the Big Five personality dimensions are well-known predictors of OCB (Organ and Ryan 1995; Ilies et al. 2009). Here, we could show the Big Five personality dimension "conscientiousness" to correlate with all OCB measures and in-role behavior on a highly significant level. Agreeableness was shown to relate to OCB altruism and sportsmanship also highly significant. Together with Emotional Stability, which is understood as the opposite of neuroticism in the Big Five personality dimension, these three characteristics are clustered as socially desirable behavior (Chiaburu et al. 2011). This might be explained by the responsible behavior (conscientiousness), sensitivity in dealing with others (agreeableness) and the absence of negatively directed emotions (emotional stability as opposite of neuroticism) (Chiaburu et al. 2011). Here, we could show every OCB scale and the in-role behavior except for OCB conscientiousness to negatively correlate to neuroticism (which can be understood as correlating positively to emotional stability). In our sample, neuroticism was the best predictor of OCB (all scales combined) second only to conscientiousness, while agreeableness showed to only relate to two scales. Extraversion and openness, on the other hand, are assigned as qualities of dynamic tendencies and proactivity (Chiaburu et al. 2011). Openness is associated with learning orientation and curiosity and extraversion with dominance, while both relate to proactivity (Chiaburu et al. 2011). In our sample, extraversion correlates with the OCB scales of altruism and civic virtue as well as in-role behavior, which underlines the based characteristics, which are accounted to it (dominance/proactivity). The proactivity as a dynamic tendency might guide extraverted employees to help new colleagues during the training period (altruism), while the dominance facet might account for civic virtue. They might want to be leading and first, therefore showing personal initiative. Openness related to OCB altruism and civic virtue as well, which is also in line with this argument. Employees scoring high on the openness scale might be curious and want to be involved with new colleagues or problems of others. The learning orientation facet of openness might reflect in civic virtue since this scale, for example, appoints to constantly upgrading their qualifications or voluntarily taking on additional tasks

5. Conclusion

NWW benefits evening types in terms of biological necessities (internal biological rhythm; decrease of social jetlag). When performance components are concerned, the relationships to the Big Five personality dimensions as well as the OCB scales suggest evening types needing the personal contact to colleagues more than morning types. The analysis of the changes during the restriction phase underlines this connection further. Morning types, on the other hand, might have benefitted from the transition to home office.

6. Limitations and strengths

Our results are very important for employers and companies because they have the potential to increase an employee's work productivity by improving the work performance components. By implementing the results presented here, suitable working conditions can be tailored to the personality of the employee without incurring additional costs for the employer. To further confirm these results, this experiment should be repeated with workers on a large scale, since we here examined only N = 281 workers. The low number of workers but high number of students may be a limitation of the study execution or more specific for transferability to the working population. Although universities implemented distance learning, the transferability to working in home office may not be given. Furthermore, the sample was non-representative of the German population since the sample size is relatively small and most participants had an academic background. In addition, the sample was relatively unbalanced with about twice as many respondents being female. The recruitment might be limiting as well, since consciously perceived changes in sleep timing or productivity at work could have been accompanied by an increased interest in participation. Another limitation may be the self-assessed study design. Also, participants' attribution of changes in their productivity to external (changes due to the pandemic) rather than internal factors (changes due to altered supervision) may be problematic (data might be biased). A better alternative to challenge the latter two limitations would be having the participants' productivity assessed by a supervisor, which still does not guarantee objective data.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Naomi Staller http://orcid.org/0000-0002-9851-9681
Christoph Randler http://orcid.org/0000-0002-7357-2793

References

Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. 2012. Circadian typology: a comprehensive review. Chronobiol Int. 29(9):1153–1175. doi:10.3109/07420528.2012.719971.

Allvin M, Aronsson G, Hagström T, Johansson G, Lundberg U. 2011. Work without boundaries: psychological perspectives on the new working life. West Sussex (UK): John Wiley & Sons, Ltd.

Arbabi T, Vollmer C, Dörfler T, Randler C. 2015. The influence of chronotype and intelligence on academic achievement in primary school is mediated by conscientiousness, midpoint of sleep and motivation. Chronobiol Int. 32(3):349–357. doi:10.3109/07420528.2014.980508.

Arrona-Palacios A. 2020. Sleep habits, circadian preferences and substance use in a Mexican population: the use of the morningness-eveningness-stability-scale improved (MESSi). Chronobiol Int. 37:111–122. doi:10.1080/07420528.2019.1688339.

Baane R, Houtkamp P, Knotter M. 2011. Het nieuwe werken ontrafeld: over bricks, bytes & behavior (new ways of working unraveled: about bricks, bytes and behavior). Tijdschr Voor HRM. 1:7–23.

Benet-Martínez V, John OP. 1998. Los cinco grandes across cultures and ethnic groups: multitrait-multimethod analyses of the big five in Spanish and english. J Pers Soc Psychol. 75 (3):729. doi:10.1037/0022-3514.75.3.729.

Brief AP, Motowidlo SJ. 1986. Prosocial organizational behaviors. Academy of Management Review. 11(4):710–725. doi:10.5465/amr.1986.4283909.

Cellini N, Canale N, Mioni G, Costa S. 2020. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. J Sleep Res. E13074. doi:10.1111/jsr.13074.

Chiaburu DS, Oh I-S, Berry CM, Li N, Gardner RG. 2011. The five-factor model of personality traits and organizational citizenship behaviors: a meta-analysis. Journal of Applied Psychology. 96 (6):1140–1166. doi:10.1037/a0024004.

Demerouti E, Derks D, Ten Brummelhuis LL, Bakker AB. 2014. New ways of working: impact on working conditions, work-family balance, and well-being. In: Karunka C, Hoonakker P, editors. The impact of ICT on quality of working life. Berlin: Springer Science; p. 123–141. https://doi.org/10.1007/978-94-017-8854-0_8.

Di Milia L, Adan A, Natale V, Randler C. 2013. Reviewing the psychometric properties of contemporary circadian typology measures. Chronobiol Int. 30(10):1261–1271. doi:10.3109/07420528.2013.817415.

Díaz-Morales JF, Ferrari JR, Cohen JR. 2008. Indecision and avoidant procrastination: the role of morningness—eveningness and time perspective in chronic delay lifestyles. J Gen Psychol. 135 (3):228–240. doi:10.3200/GENP.135.3.228-240.

Díaz-Morales JF, Randler C. 2017. Spanish adaptation of the morningness-eveningness-stability-scale improved (MESSi). Span J Psychol. 20. doi:10.1017/sjp.2017.21.

Díaz-Morales JF, Randler C, Arrona-Palacios A, Adan A. 2017. Validation of the MESSi among adult workers and young students: general health and personality correlates. Chronobiol Int. 34 (9):1288–1299. doi:10.1080/07420528.2017.1361437.

Faßl C, Quante M, Mariani S, Randler C. 2019. Preliminary findings for the validity of the morningness–eveningness-stability scale improved (MESSi): correlations with activity levels and personality. Chronobiol Int. 36(1):135–142. doi:10.1080/07420528.2018.1519570.

Gajendran RS, Harrison DA. 2007. The good, the bad, and the unknown about telecommuting: meta-analysis of psychological mediators and individual consequences. J Appl Psychol. 92:1524–1541. doi:10.1037/0021-9010.92.6.1524.

Gao C, Scullin MK. 2020. Sleep health early in the coronavirus disease 2019 (COVID-19) outbreak in the United States: integrating longitudinal, cross-sectional, and retrospective recall data. Sleep Med. 73:1–10. doi:10.1016/j.sleep.2020.06.032.

Giampietro M, Cavallera GM. 2007. Morning and evening types and creative thinking. Pers Individ Dif. 42(3):453–463. doi:10.1016/j.paid.2006.06.027.

Halford S. 2005. Hybrid workspace: respatialisations of work, organisation and management. New Technology, Work, and Employment. 20:19–33. doi:10.1111/j.1468-005X.2005.00141.x.

Hensvik L, Skans O. 2020. Covid-19 crisis response monitoring: Sweden: IZA Country Report.

Ilies R, Fulmer IS, Spitzmuller M, Johnson MD. 2009. Personality and citizenship behavior: the mediating role of job satisfaction. Journal of Applied Psychology. 94(4):945. doi:10.1037/a0013329.

Kolomeichuk SN, Randler C, Shabalina I, Fradkova L, Borisenkov M. 2016. The influence of chronotype on the academic achievement of children and adolescents–evidence from Russian Karelia. Biol Rhythm Res. 47(6):873–883. doi:10.1080/09291016.2016.1207352.

Lai J, Simeng M, Wang Y. 2020. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. JAMA Network Open. 3(3):e203976. doi:10.1001/jamanetworkopen.2020.3976.

Leone MJ, Sigman M, Golombek DA. 2020. Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. Current Biology. 30(16):R930–R931. doi:10.1016/j.cub.2020.07.015.

Lundberg U, Cooper CL. 2010. The science of occupational health: stress, psychobiology and the new world of work. Oxford (UK): Wiley-Blackwell.

MacKenzie SB, Podsakoff PM, Fetter R. 1991. Organizational citizenship behavior and objective productivity as determinants of managerial evaluations of salespersons' performance. Organ Behav Hum Decis Process. 50(1):123–150. doi:10.1016/0749-5978(91)90037-T.

Manoochehri G, Pinkerton T. 2003. Managing telecommuters: opportunities and challenges. Am Bus Review. 21:9–16.

Marelli S, Castelnuovo A, Somma A, Castronovo V, Mombelli S, Bottoni D, Ferini-Strambi L. 2020. Impact of CoVID-19 lockdown on sleep quality in university students and administration staff. J Neurol. 1–8. doi:10.1007/s00415-020-10056-6.

Mazmanian M, Orlikowski WJ, Yates J. 2013. The autonomy paradox: the implications of mobile email devices for knowledge professionals. Organ Sci. 24(5):1337–1357. doi:10.1287/orsc.1120.0806.

Nijp HH, Beckers DG, Kompier MA, van den Bossche SN, Geurts SA. 2015. Worktime control access, need and use in relation to work–home interference, fatigue, and job motivation. Scand J Work Environ Health. 347–355. doi:10.5271/sjweh.3504.

Nijp HH, Beckers DG, van de Voorde K, Geurts SA, Kompier MA. 2016. Effects of new ways of working on work hours and work location, health and job-related outcomes. Chronobiol Int. 33 (6):604–618. doi:10.3109/07420528.2016.1167731.

Organ DW. 1988. Organizational citizenship behavior: the good soldier syndrome. Lexington (MA): Lexington Books.

Organ DW, Ryan K. 1995. A meta-analytic review of attitudinal and dispositional predictors of organizational citizenship behavior. Pers Psychol. 48(4):775–802. doi:10.1111/j.1744-6570.1995.tb01781.x.

Peponis J, Bafna S, Bajaj R, Bromberg J, Congdon C, Rashid M, Warmels S, Yan Z, Zimring C. 2007. Designing space to support knowledge work. Environ Behav. 39:815–840. doi:10.1177/0013916506297216.

Podsakoff PM, MacKenzie SB, Moorman RH, Fetter R. 1990. Transformational leader behaviors and their effects on followers' trust in leader, satisfaction, and organizational citizenship behaviors. Leadersh Q. 1(2):107–142. doi:10.1016/1048-9843(90)90009-7.

Pritchard RD, Payne SC. 2003. Performance management practices and motivation. In: Holman D, Wall TD, Clegg CW, Sparrow P, Howard A, editors. The new workplace: a guide to the human impact of modern working practices. UK (West Sussex):Wiley & Sons; p. 219–244. https://doi.org/10.3109/07420528.2016.1167731. (2003).

Rahafar A, Randler C, Díaz-Morales JF, Kasaeian A, Heidari Z. 2017. Cross-cultural validity of morningness-eveningness stability scale improved (MESSi) in Iran, Spain and Germany. Chronobiol Int. 34(2):273–279. doi:10.1080/07420528.2016.1267187.

Rammstedt B, John OP. 2007. Measuring personality in one minute or less: a 10-item short version of the big five inventory in English and German. J Res Pers. 41(1):203–212. doi:10.1016/j.jrp.2006.02.001.

Rammstedt B, Kemper CJ, Klein MC, Beierlein C, Kovaleva A. 2013. A short scale for assessing the big five dimensions of personality: 10 item big five inventory (BFI-10). Methods, Data, Analyses. 7 (2):17. doi:10.12758/mda.2013.013.

Randler C. 2009. Proactive people are morning people. J Appl Soc Psychol. 39(12):2787–2797. doi:10.1111/j.15591816.2009.00549.x.

Randler C, Díaz-Morales JF, Rahafar A, Vollmer C. 2016. Morningness–eveningness and amplitude–development and validation of an improved composite scale to measure circadian preference and stability (MESSi). Chronobiol Int. 33(7):832–848. doi:10.3109/07420528.2016.1171233.

Randler C, Engelke J. 2019. Gender differences in chronotype diminish with age: a meta-analysis based on morningness/chronotype questionnaires. Chronobiol Int. 36(7):888–905. doi:10.1080/07420528.2019.1585867.

Randler C, Faßl C, Kalb N. 2017. From Lark to Owl: developmental changes in morningness-eveningness from new-borns to early adulthood. Sci Rep. 7(1):45874. doi:10.1038/srep45874.

Randler C, Frech D. 2006. Correlation between morningness–eveningness and final school leaving exams. Biol Rhythm Res. 37(3):233–239. doi:10.1080/09291010600645780.

Randler C, Tryjanowski P, Jokimäki J, Kaisanlahti-Jokimäki ML, Staller N. 2020. SARS-CoV2 (COVID-19) pandemic lockdown influences nature-based recreational activity: the case of birders. Int J Environ Res Public Health. 17(19):7310. doi:10.3390/ijerph17197310.

Rodrigues PF, Vagos P, Pandeirada JN, Marinho PI, Randler C, Silva CF. 2018. Initial psychometric characterization for the Portuguese version of the morningness-eveningness-stability-scale improved (MESSi). Chronobiol Int. 35(11):1608–1618. doi:10.1080/07420528.2018.1495646.

Roenneberg T, Wirz-Justice A, Merrow M. 2003. Life between clocks: daily temporal patterns of human chronotypes. J Biol Rhythms. 18(1):80–90. doi:10.1177/0748730402239679.

Sinha M, Pande B, Sinha R. 2020. Impact of COVID-19 lockdown on sleep-wake schedule and associated lifestyle related behavior: a national survey. J Public Health Res. 9(3). doi:10.4081/jphr.2020.1826.

Smith CAODWNJP, Organ DW, Near JP. 1983. Organizational citizenship behavior: its nature and antecedents. Journal of Applied Psychology. 68(4):653. doi:10.1037/0021-9010.68.4.653.

Staller & Randler. 2020. Changes in sleep schedule and chronotype due to CoVID-19 restrictions and home office. Somnologie. doi:10.1007/s11818-020-00277-2.

Staller N, Großmann N, Eckes A, Wilde M, Müller FH, Randler C. 2021, Jun. Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19. In Frontiers in Education (Vol. 6, p. 238). Frontiers.

Staufenbiel T. 2000. Antezedentien und Konsequenzen freiwilligen Arbeitsengagements. Gruppe Interaktion Organisation Zeitschrift für Angewandte Organisationspsychologie (GIO). 31 (2):169–183. doi:10.1007/s11612-000-0016-1.

Staufenbiel T, Hartz C. 2000. Organizational Citizenship Behavior: entwicklung und erste Validierung eines Messinstruments. Diagnostica. doi:10.1026/0012-1924.46.2.73.

Tomažič I, Randler C. 2020. Slovenian adaptation of the morningness-eveningness-stability scales improved (MESSi). Biol Rhythm Res. 51(3):453–459. doi:10.1080/09291016.2018.1535539.

Tonetti L, Fabbri M, Natale V. 2009. Relationship between circadian typology and big five personality domains. Chronobiol Int. 26(2):337–347. doi:10.1080/07420520902750995.

Tonetti L, Natale V, Randler C. 2015. Association between circadian preference and academic achievement: a systematic review and meta-analysis. Chronobiol Int. 32(6):792–801. doi:10.3109/07420528.2015.1049271.

Tsaousis I. 2010. Circadian preferences and personality traits: a meta-analysis. European Journal of Personality: Published for the European Association of Personality Psychology. 24(4):356–373. doi:10.1002/per.754.

Williams LJ, Anderson SE. 1991. Job satisfaction and organizational commitment as predictors of organizational citizenship and in-role behaviors. J Manage. 17(3):601–617. doi:10.1177/014920639101700305.

Wittmann M, Dinich J, Merrow M, Roenneberg T. 2006. Social jetlag: misalignment of biological and social time. Chronobiol Int. 23(1–2):497–509. doi:10.1080/07420520500545979.

Wu Z, McGoogan JM. 2020. Characteristics of and important lessons from the coronavirus disease 2019 (CoVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese center for disease control and prevention. Jama. 323(13):1239–1242. doi:10.1001/jama.2020.2648.

Zavada A, Gordijn MC, Beersma DG, Daan S, Roenneberg T. 2005. Comparison of the Munich chronotype questionnaire with the horne-östberg's morningness-eveningness score. Chronobiol Int. 22(2):267–278. doi:10.1081/CBI-200053536.

Zhang C, Yan L, Liu S. 2020. Survey of insomnia and related social psychological factors among medical staffs involved with the 2019 novel coronavirus disease outbreak. Frontiers in Psychiatry. doi:10.3389/fpsyt.2020.00306.

E Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19

Staller, N., Großmann, N., Eckes, A., Wilde, M., Müller, F. H., & Randler, C. (2021). Academic self-regulation, chronotype and personality in university students during the remote learning phase due to COVID-19. *6*, 681840. https://doi.org/10.3389/feduc.2021.681840

frontiers in Education

ORIGINAL RESEARCH
published: 30 June 2021
doi: 10.3389/feduc.2021.681840

Check for updates

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

Naomi Staller[1]*, Nadine Großmann[2], Alexander Eckes[3], Matthias Wilde[2], Florian H. Müller[4] and Christoph Randler[1]

[1]Department for Didactics of Biology, Eberhard Karls University Tübingen, Tübingen, Germany, [2]Department for Didactics of Biology, Bielefeld University, Bielefeld, Germany, [3]Osnabrück University, Osnabrück, Germany, [4]University Klagenfurt, Klagenfurt, Austria

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)

OPEN ACCESS

Edited by:
Daniela Conti,
Sheffield Hallam University,
United Kingdom

Reviewed by:
Luca Corazzini,
Ca' Foscari University of Venice, Italy
Concetta De Pasquale,
University of Catania, Italy

****Correspondence:***
Naomi Staller
naomi.staller@uni-tuebingen.de

Specialty section:
This article was submitted to Educational Psychology, a section of the journal Frontiers in Education

Received: *17 March 2021*
Accepted: *15 June 2021*
Published: *30 June 2021*

Citation:
Staller N, Großmann N, Eckes A, Wilde M, Müller FH and Randler C (2021) Academic Self-Regulation, Chronotype and Personality in University Students During the Remote Learning Phase due to COVID-19. Front. Educ. 6:681840. doi: 10.3389/feduc.2021.681840

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.

FUNDING

This project is part of the "Qualitätsoffensive Lehrerbildung", a joint initiative of the Federal Government and the *Länder*, which aims to improve the quality of teacher training. The programme is funded by the Federal Ministry of Education and Research (funding code: 01JA1908). The authors are responsible for the content of this publication.

ACKNOWLEDGMENTS

We acknowledge support by Open Access Publishing Fund of University of Tübingen.

REFERENCES

Ackerman, P. L., Bowen, K. R., Beier, M. E., and Kanfer, R. (2001). Determinants of Individual Differences and Gender Differences in Knowledge. *J. Educ. Psychol.* 93 (4), 797–825. doi:10.1037//0022-0663.93.4.79710.1037/0022-0663.93.4.797

Ackerman, P. L., and Heggestad, E. D. (1997). Intelligence, Personality, and Interests: Evidence for Overlapping Traits. *Psychol. Bull.* 121 (2), 219–245. doi:10.1037/0033-2909.121.2.219

Adan, A., and Almirall, H. (1991). Horne & Östberg Morningness-Eveningness Questionnaire: A Reduced Scale. *Personal. Individual Differences* 12 (3), 241–253. doi:10.1016/0191-8869(91)90110-W

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., and Randler, C. (2012). Circadian Typology: A Comprehensive Review. *Chronobiology Int.* 29 (9), 1153–1175. doi:10.3109/07420528.2012.719971

Arbabi, T., Vollmer, C., Dörfler, T., and Randler, C. (2015). The Influence of Chronotype and Intelligence on Academic Achievement in Primary School Is Mediated by Conscientiousness, Midpoint of Sleep and Motivation. *Chronobiology Int.* 32 (3), 349–357. doi:10.3109/07420528.2014.980508

Assor, A., Vansteenkiste, M., and Kaplan, A. (2009). Identified versus Introjected Approach and Introjected Avoidance Motivations in School and in Sports: The Limited Benefits of Self-worth Strivings. *J. Educ. Psychol.* 101 (2), 482–497. doi:10.1037/a0014236

Baane, R., Houtkamp, P., and Knotter, M. (2011). Het Nieuwe Werken Ontrafeld: Over Bricks, Bytes & Behavior (New Ways of Working Unraveled: About Bricks, Bytes and Behavior). *Tijdschr. Voor HRM* 1, 7–23.

Bandura, A. (1997). *Self-efficacy: The Exercise of Control*. New York, NY: W. H. Freeman and Company.

Benet-Martínez, V., and John, O. P. (1998). Los Cinco Grandes across Cultures and Ethnic Groups: Multitrait-Multimethod Analyses of the Big Five in Spanish and English. *J. Personal. Soc. Psychol.* 75 (3), 729–750. doi:10.1037/0022-3514.75.3.729

Borkenau, P., and Ostendorf, F. (2008). *NEO-FFI: NEO-Fünf-Faktoren-Inventar nach Costa und McCrae*. 2nd ed.. Göttingen, Germany: Manual, Hogrefe.

Budde, J. (2008). Jungen, Männlichkeit und Schule [Boys, masculinity, and school]. In *Bildungsministerium für Bildung und Forschung Bildungs(miss)erfolge von Jungen und Berufswahlverhalten bei Jungen/männlichen Jugendlichen*, (pp. 39–45). Bonn, Berlin, Germany.

Cellini, N., Canale, N., Mioni, G., and Costa, S. (2020). Changes in Sleep Pattern, Sense of Time and Digital media Use during COVID-19 Lockdown in Italy. *J. Sleep Res.* 29. doi:10.1111/jsr.13074

Chamorro-Premuzic, T., and Furnham, A. (2005). Intellectual Competence. *Psychol.* 18 (6), 352–354.

Chamorro-Premuzic, T., and Furnham, A. (2006). Intellectual Competence and the Intelligent Personality: A Third Way in Differential Psychology. *Rev. Gen. Psychol.* 10 (3), 251–267. doi:10.1037/1089-2680.10.3.251

Corazzini, L., D'Arrigo, S., Millemaci, E., and Navarra, P. (2020). The Influence of Personality Traits on University Performance: Evidence from Italian Freshmen

Students. Venice, Italy: University Ca'Foscari of Venice, *Dept. Of Economics Research Paper Series No*, 19. doi:10.2139/ssrn.3764500
Costa, P. T., and McCrae, R. R. (1995). Domains and Facets: Hierarchical Personality Assessment Using the Revised NEO Personality Inventory. *J. Pers Assess.* 64, 21–50. doi:10.1207/s15327752jpa6401_2
Demerouti, E., Derks, D., Ten Brummelhuis, L. L., and Bakker, A. B. (2014). "New Ways of Working: Impact on Working Conditions, Work-Family Balance, and Well-Being," in *The Impact of ICT on Quality of Working Life*. Editors C. Karunka and P. Hoonakker (Berlin, Germany: Springer), 123–141. doi:10.1007/978-94-017-8854-0_8
Demirhan, E., Randler, C., and Horzum, M. B. (2016). Is Problematic mobile Phone Use Explained by Chronotype and Personality?. *Chronobiology Int.* 33 (7), 821–831. doi:10.3109/07420528.2016.1171232
Deniz, M. E., and Satici, S. A. (2017). The Relationships between Big Five Personality Traits and Subjective Vitality. *An Psicol-spain* 33 (2), 218–224. doi:10.6018/analesps.33.2.261911
DeYoung, C. G., Hasher, L., Djikic, M., Criger, B., and Peterson, J. B. (2007). Morning People Are Stable People: Circadian Rhythm and the Higher-Order Factors of the Big Five. *Personal. Individual Differences* 43, 267–276. doi:10.1016/j.paid.2006.11.030
Di Milia, L., Adan, A., Natale, V., and Randler, C. (2013). Reviewing the Psychometric Properties of Contemporary Circadian Typology Measures. *Chronobiology Int.* 30 (10), 1261–1271. doi:10.3109/07420528.2013.817415
Dietze, J., Gehlhaar, K.-H., and Klepel, G. (2005). "Untersuchungen zum Entwicklungsstand von Biologieinteressen bei Schülerinnen und Schülern der Sekundarstufe II [Investigations on the state of development of student interest in biology at the secondary level]," in *Lehr- und Lernforschung in der Biologiedidaktik*. Editors R. Klee, A. Sandmann, and H. Vogt (Innsbruck, Austria: Studien Verlag), 133–145.
Eccles, J. S., and Wigfield, A. (2002). Motivational Beliefs, Values, and Goals. *Annu. Rev. Psychol.* 53 (1), 109–132. doi:10.1146/annurev.psych.53.100901.135153
Fallan, L., and Opstad, L. (2016). Student Self-Efficacy and Gender-Personality Interactions. *Ijhe* 5 (3), 32–44. doi:10.5430/ijhe.v5n3p32
Fleig, D., and Randler, C. (2009). Association between Chronotype and Diet in Adolescents Based on Food Logs. *Eat. Behaviors* 10 (2), 115–118. doi:10.1016/j.eatbeh.2009.03.002
Furnham, A., Chamorro-Premuzic, T., and McDougall, F. (2003). Personality, Cognitive Ability, and Beliefs about Intelligence as Predictors of Academic Performance. *Learn. Individual Differences* 14 (1), 47–64. doi:10.1016/j.lindif.2003.08.002
Furnham, A., and Chamorro-Premuzic, T. (2004). Personality and Intelligence as Predictors of Statistics Examination Grades. *Personal. Individual Differences* 37 (5), 943–955. doi:10.1016/j.paid.2003.10.016
Gajendran, R. S., and Harrison, D. A. (2007). The Good, the Bad, and the Unknown about Telecommuting: Meta-Analysis of Psychological Mediators and Individual Consequences. *J. Appl. Psychol.* 92, 1524–1541. doi:10.1037/0021-9010.92.6.1524
Gao, C., and Scullin, M. K. (2020). Sleep Health Early in the Coronavirus Disease 2019 (COVID-19) Outbreak in the United States: Integrating Longitudinal, Cross-Sectional, and Retrospective Recall Data. *Sleep Med.* 73, 1–10. doi:10.1016/j.sleep.2020.06.032
Gariépy, G., Doré, I., Whitehead, R. D., and Elgar, F. J. (2019). More Than Just Sleeping in: A Late Timing of Sleep Is Associated with Health Problems and Unhealthy Behaviours in Adolescents. *Sleep Med.* 56, 66–72. doi:10.1016/j.sleep.2018.10.029
Goff, M., and Ackerman, P. L. (1992). Personality-intelligence Relations: Assessment of Typical Intellectual Engagement. *J. Educ. Psychol.* 84 (4), 537–552. doi:10.1037/0022-0663.84.4.537
Goldstein, D., Hahn, C. S., Hasher, L., Wiprzycka, U. J., and Zelazo, P. D. (2007). Time of Day, Intellectual Performance, and Behavioral Problems in Morning versus Evening Type Adolescents: Is There a Synchrony Effect?. *Personal. Individual Differences* 42 (3), 431–440. doi:10.1016/j.paid.2006.07.008
Großmann, N., Hofferber, N., Wilde, M., and Basten, M. (2019). Students' Flow-Experience and Quality of Motivation in Biology Lessons – Can the Gender gap Be Reduced by Teaching Behavior?. Manuscript submitted for publication in: *Motivation and Emotion*.
Guay, F., Vallerand, R. J., and Blanchard, C. (2000). On the Assessment of Situational Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS). *Motiv. Emot.* 24 (3), 175–213. doi:10.1023/A:1005614228250
Halford, S. (2005). Hybrid Workspace: Re-spatialisations of Work, Organisation and Management. *New Tech. Work Empl* 20, 19–33. doi:10.1111/j.1468-005X.2005.00141.x
Heissel, A., Pietrek, A., Flunger, B., Fydrich, T., Rapp, M. A., Heinzel, S., et al. (2018). The Validation of the German Basic Psychological Need Satisfaction and Frustration Scale in the Context of Mental Health. *Eur. J. Health Psychol.* 25 (4), 119–132. doi:10.1027/2512-8442/a000017
Horne, J. A., and Östberg, O. (1976). A Self-Assessment Questionnaire to Determine Morningness-Eveningness in Human Circadian Rhythms. *Int. J. Chronobiol* 4, 97–110. doi:10.1111/j.1468-005X.2005.00141.x
Horzum, M. B., Önder, İ., and Beşoluk, Ş. (2014). Chronotype and Academic Achievement Among Online Learning Students. *Learn. Individual Differences* 30, 106–111. doi:10.1016/j.lindif.2013.10.017
Huang, C. (2013). Gender Differences in Academic Self-Efficacy: A Meta-Analysis. *Eur. J. Psychol. Educ.* 28 (1), 1–35. doi:10.1007/s10212-011-0097-y
Hutcheson, G., and Sofroniou, N. (1999). *The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models*. Thousand Oaks: Sage Publications. doi:10.4135/9780857028075
Jerusalem, M., and Schwarzer, R. (1986). "Selbstwirksamkeit [Self-Efficacy]," in Skalen zur Befindlichkeit und Persönlichkeit *(Forschungsbericht 5*. Editor R. Schwarzer (Freie Universität, Institut für Psychologie), 15–28.
John, O. P., Naumann, L. P., and Soto, C. J. (2008). "Paradigm Shift to the Integrative Big Five Trait Taxonomy: History, Measurement, and Conceptual Issues," in *Handbook of Personality: Theory and Research*. Editors O. P. John, R. W. Robins, and L. A. Pervin (New York, NY: The Guilford Press), 114–158.
Jovanovski, D., and Bassili, J. N. (2007). The Relationship between Morningness - Eveningness Preference and Online Learning. *Biol. Rhythm Res.* 38 (5), 355–365. doi:10.1080/09291010600950149
Judge, T. A., Jackson, C. L., Shaw, J. C., Scott, B. A., and Rich, B. L. (2007). Self-efficacy and Work-Related Performance: The Integral Role of Individual Differences. *J. Appl. Psychol.* 92 (1), 107–127. doi:10.1037/0021-9010.92.1.107
Kadzikowska-Wrzosek, R. (2020). Insufficient Sleep Among Adolescents: the Role of Bedtime Procrastination, Chronotype and Autonomous vs. Controlled Motivational Regulations. *Curr. Psychol.* 39 (3), 1031–1040. doi:10.1007/s12144-018-9825-7
Kauderer, S., and Randler, C. (2013). Differences in Time Use Among Chronotypes in Adolescents. *Biol. Rhythm Res.* 44 (4), 601–608. doi:10.1080/09291016.2012.721687
Kerkhof, G. A., and Van Dongen, H. P. A. (1996). Morning-type and Evening-type Individuals Differ in the Phase Position of Their Endogenous Circadian Oscillator. *Neurosci. Lett.* 218 (3), 153–156. doi:10.1016/s0304-3940(96)13140-2
Kirmizi, O. (2015). The Interplay Among Academic Self-Concept, Self-Efficacy, Self-Regulation and Academic Achievement of Higher Education L2 Learners. *Hig* 5 (1), 32–40. doi:10.5961/jhes.2015.107
Kolomeichuk, S. N., Randler, C., Shabalina, I., Fradkova, L., and Borisenkov, M. (2016). The Influence of Chronotype on the Academic Achievement of Children and Adolescents - Evidence from Russian Karelia. *Biol. Rhythm Res.* 47 (6), 873–883. doi:10.1080/09291016.2016.1207352
Komarraju, M., Karau, S. J., and Schmeck, R. R. (2009). Role of the Big Five Personality Traits in Predicting College Students' Academic Motivation and Achievement. *Learn. Individual Differences* 19 (1), 47–52. doi:10.1016/j.lindif.2008.07.001
Leone, M. J., Sigman, M., and Golombek, D. A. (2020). Effects of Lockdown on Human Sleep and Chronotype during the COVID-19 Pandemic. *Curr. Biol.* 30 (16), R930–R931. doi:10.1016/j.cub.2020.07.015
Martela, F., DeHaan, C. R., and Ryan, R. M. (2016). "On Enhancing and Diminishing Energy through Psychological Means," in *Self-regulation and Ego Control*. Editors E. R. Hirt, J. J. Clarkson, and L. Jia (Amsterdam, Netherlands: Elsevier Academic Press), 67–85. doi:10.1016/B978-0-12-801850-7.00004-4
Mayr, J. (2014). "Der Persönlichkeitsansatz in der Forschung zum Lehrerberuf – Konzepte, Befunde und Folgerungen [The personality approach in research on the teaching profession – Concepts, findings and conclusions]," in *Handbuch der Forschung zum Lehrerberuf*. Editors E. Terhart, H. Bennewitz, and M. Rothland (Waxmann), Münster, Germany 189–215.

Moosbrugger, H., and Kelava, A. (2012). *Testtheorie und Fragebogenkonstruktion [Test theory and test instrument design]*. 2nd ed. Berlin: Springer.
Müller, F. H., Palekčić, M., Beck, M., and Wanninger, S. (2006). Personality, Motives and Learning Environment as Predictors of Self-Determined Learning Motivation. *Rev. Psychol.* 12 (2), 75–86.
Nijp, H. H., Beckers, D. G. J., van de Voorde, K., Geurts, S. A. E., and Kompier, M. A. J. (2016). Effects of New Ways of Working on Work Hours and Work Location, Health and Job-Related Outcomes. *Chronobiology Int.* 33 (6), 604–618. doi:10.3109/07420528.2016.1167731
Nijp, H. H., Beckers, D. G., Kompier, M. A., van den Bossche, S. N., and Geurts, S. A. (2015). Worktime Control Access, Need and Use in Relation to Work-home Interference, Fatigue, and Job Motivation. *Scand. J. Work Environ. Health* 41 (4), 347–355. doi:10.5271/sjweh.3504
Nishimura, T., and Suzuki, T. (2016). Basic Psychological Need Satisfaction and Frustration in Japan: Controlling for the Big Five Personality Traits. *Jpn. Psychol. Res.* 58 (4), 320–331. doi:10.1111/jpr.12131
O'Connor, M. C., and Paunonen, S. V. (2007). Big Five Personality Predictors of post-secondary Academic Performance. *Personal. Individual Differences* 43 (5), 971–990. doi:10.1016/j.paid.2007.03.017
Önder, İ., Beşoluk, Ş., İskender, M., Masal, E., and Demirhan, E. (2014). Circadian Preferences, Sleep Quality and Sleep Patterns, Personality, Academic Motivation and Academic Achievement of university Students. *Learn. Individual Differences* 32, 184–192. doi:10.1016/j.lindif.2014.02.003
Pekrun, R., Goetz, T., Titz, W., and Perry, R. P. (2002). Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research. *Educ. Psychol.* 37 (2), 91–105. doi:10.1207/S15326985EP3702_4
Pekrun, R. (1992). Kognition und Emotion in studienbezogenen Lern-und Leistungssituationen: Explorative Analysen [Cognition and emotion in study-related learning and performance situations: Explorative analyses]. *Unterrichtswissenschaft* 20 (4), 308–324.
Poropat, A. E. (2009). A Meta-Analysis of the Five-Factor Model of Personality and Academic Performance. *Psychol. Bull.* 135 (2), 322–338. doi:10.1037/a0014996
Pritchard, R. D., and Payne, S. C. (2003). "Performance Management Practices and Motivation," in *The New Workplace: A Guide to the Human Impact of Modern Working Practices*. Editors D. Holman, T. D. Wall, C. W. Clegg, P. Sparrow, and A. Howard (Hoboken, NJ: Wiley & Sons), 219–244.
Przepiórka, A., Błachnio, A., and Siu, N. Y.-F. (2019). The Relationships between Self-Efficacy, Self-Control, Chronotype, Procrastination and Sleep Problems in Young Adults. *Chronobiology Int.* 36 (8), 1025–1035. doi:10.1080/07420528.2019.1607370
Rammstedt, B., and John, O. P. (2007). Measuring Personality in One Minute or Less: A 10-item Short Version of the Big Five Inventory in English and German. *J. Res. Personal.* 41 (1), 203–212. doi:10.1016/j.jrp.2006.02.001
Rammstedt, B., Kemper, C., Klein, M. C., Beierlein, C., and Kovaleva, A. (2013). Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit: big-five-inventory-10 (BFI-10). *Methoden, Daten, Analysen (mda)* 7 (2), 233–249. doi:10.12758/mda.2013.013
Randler, C., and Engelke, J. (2019). Gender Differences in Chronotype Diminish with Age: a Meta-Analysis Based on Morningness/chronotype Questionnaires. *Chronobiology Int.* 36 (7), 888–905. doi:10.1080/07420528.2019.1585867
Randler, C., and Frech, D. (2006). Correlation between Morningness - Eveningness and Final School Leaving Exams. *Biol. Rhythm Res.* 37 (3), 233–239. doi:10.1080/09291010600645780
Randler, C., Freyth-Weber, K., Rahafar, A., Florez Jurado, A., and Kriegs, J. O. (2016a). Morningness-eveningness in a Large Sample of German Adolescents and Adults. *Heliyon* 2 (11), e00200. doi:10.1016/j.heliyon.2016.e00200
Randler, C. (2013). German Version of the Reduced Morningness-Eveningness Questionnaire (rMEQ). *Biol. Rhythm Res.* 44 (5), 730–736. doi:10.1080/09291016.2012.739930
Randler, C., and Saliger, L. (2011). Relationship between Morningness-Eveningness and Temperament and Character Dimensions in Adolescents. *Personal. Individual Differences* 50, 148–152. doi:10.1016/j.paid.2010.09.016
Randler, C., and Schaal, S. (2010). Morningness-eveningness, Habitual Sleep-Wake Variables and Cortisol Level. *Biol. Psychol.* 85 (1), 14–18. doi:10.1016/j.biopsycho.2010.04.006
Randler, C., Wolfgang, L., Matt, K., Demirhan, E., Horzum, M. B., and Beşoluk, Ş. (2016b). Smartphone Addiction Proneness in Relation to Sleep and Morningness-Eveningness in German Adolescents. *J. Behav. Addict.* 5 (3), 465–473. doi:10.1556/2006.5.2016.056
Reeve, J. (2002). "Self-determination Theory Applied to Educational Settings," in *Handbook of Self-Determination Research*. Editors E. L. Deci and R. M. Ryan (Rochester, NY: University of Rochester Press), 183–203.
Renaud-Dubé, A., Taylor, G., Lekes, N., Koestner, R., and Guay, F. (2010). Adolescents' Motivation toward the Environment: Age-Related Trends and Correlates. *Can. J. Behav. Sci./Revue canadienne des Sci. du comportement* 42 (3), 194–199. doi:10.1037/a0018596
Richardson, M., Abraham, C., and Bond, R. (2012). Psychological Correlates of university Students' Academic Performance: A Systematic Review and Meta-Analysis. *Psychol. Bull.* 138 (2), 353–387. doi:10.1037/a0026838
Roberts, R. E., Roberts, C. R., and Duong, H. T. (2009). Sleepless in Adolescence: Prospective Data on Sleep Deprivation, Health and Functioning. *J. Adolescence* 32 (5), 1045–1057. doi:10.1016/j.adolescence.2009.03.007
Roenneberg, T., Wirz-Justice, A., and Merrow, M. (2003). Life between Clocks: Daily Temporal Patterns of Human Chronotypes. *J. Biol. Rhythms* 18 (1), 80–90. doi:10.1177/0748730402239679
Rothstein, M. G., Paunonen, S. V., Rush, J. C., and King, G. A. (1994). Personality and Cognitive Ability Predictors of Performance in Graduate Business School. *J. Educ. Psychol.* 86 (4), 516–530. doi:10.1037/0022-0663.86.4.516
Ryan, R. M., Bernstein, J. H., and Brown, K. W. (2010). Weekends, Work, and Well-Being: Psychological Need Satisfactions and Day of the Week Effects on Mood, Vitality, and Physical Symptoms. *J. Soc. Clin. Psychol.* 29 (1), 95–122. doi:10.1521/jscp.2010.29.1.95
Ryan, R. M., and Connell, J. P. (1989). Perceived Locus of Causality and Internalization: Examining Reasons for Acting in Two Domains. *J. Personal. Soc. Psychol.* 57 (5), 749–761. doi:10.1037/0022-3514.57.5.749
Ryan, R. M., and Deci, E. L. (2002). "Overview of Self-Determination Theory. An Organismic Dialectical Perspective," in *Handbook of Self-Determination Research*. Editors E. L. Deci and R. M. Ryan (Rochester, NY: University Of Rochester Press), 3–33.
Ryan, R. M., and Deci, E. L. (2017). *Self-determination Theory – Basic Psychological Needs in Motivation, Development, and Wellness*. New York, NY: The Guilford Press.
Ryan, R. M., and Frederick, C. (1997). On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. *J. Personal.* 65 (3), 529–565. doi:10.1111/j.1467-6494.1997.tb00326.x
Ryan, R. M., Rigby, C. S., and Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motiv. Emot.* 30 (4), 344–360. doi:10.1007/s11031-006-9051-8
Şahin, F., and Çetin, F. (2017). The Mediating Role of General Self-Efficacy in the Relationship between the Big Five Personality Traits and Perceived Stress: A Weekly Assessment Study. *Psychol. Stud.* 62 (1), 35–46. doi:10.1007/s12646-016-0382-6
Shimura, A., Hideo, S., Takaesu, Y., Nomura, R., Komada, Y., and Inoue, T. (2018). Comprehensive Assessment of the Impact of Life Habits on Sleep Disturbance, Chronotype, and Daytime Sleepiness Among High-School Students. *Sleep Med.* 44, 12–18. doi:10.1016/j.sleep.2017.10.011
Sinha, M., Pande, B., and Sinha, R. (2020). Impact of COVID-19 Lockdown on Sleep-Wake Schedule and Associated Lifestyle Related Behavior: A National Survey. *J. Public Health Res.* 9 (3). doi:10.4081/jphr.2020.1826
Staller, N., and Randler, C. (2020). Changes in Sleep Schedule and Chronotype Due to CoVID-19 Restrictions and home Office. *Somnologie* 25, 131–137. doi:10.1007/s11818-020-00277-2
Stevens, J. P. (2002). *Applied Multivariate Statistics for the Social Sciences*. 4th ed. Hillsdale: Erlbaum.
Tavernier, R., Hill, G. C., and Adrien, T. V. (2019). Be Well, Sleep Well: An Examination of Directionality between Basic Psychological Needs and Subjective Sleep Among Emerging Adults at university. *Sleep health* 5 (3), 288–297. doi:10.1016/j.sleh.2019.02.007
Ten Brummelhuis, L. L., Bakker, A. B., Hetland, J., and Keulemans, L. (2012). Do new Ways of Working foster Work Engagement?. *Psicothema* 24, 113–120.
Thomas, A. E., Müller, F. H., and Bieg, S. (2018). Entwicklung und Validierung der Skalen zur motivationalen Regulation beim Lernen im Studium (SMR-LS). *Diagnostica* 64 (3), 145–155. doi:10.1026/0012-1924/a000201

Thun, E., Bjorvatn, B., Osland, T., Martin Steen, V., Sivertsen, B., Johansen, T., et al. (2012). An Actigraphic Validation Study of Seven Morningness-Eveningness Inventories. *Eur. Psychol.* 17 (3), 222–230. doi:10.1027/1016-9040/a000097

Tonetti, L., Fabbri, M., and Natale, V. (2009). Relationship between Circadian Typology and Big Five Personality Domains. *Chronobiology Int.* 26, 337–347. doi:10.1080/07420520902750995

Tonetti, L., Natale, V., and Randler, C. (2015). Association between Circadian Preference and Academic Achievement: A Systematic Review and Meta-Analysis. *Chronobiology Int.* 32 (6), 792–801. doi:10.3109/07420528.2015.1049271

Valentine, J. C., Dubois, D. L., and Cooper, H. (2004). The Relation between Self-Beliefs and Academic Achievement: A Meta-Analytic Review. *Educ. Psychol.* 39, 111–133. doi:10.1207/s15326985ep3902_3

Vallerand, R. J., and Ratelle, C. F. (2002). "Intrinsic and Extrinsic Motivation. A Hierarchical Model," in *Handbook of Self-Determination Research.* Editors E. L. Deci and R. M. Ryan (Rochester, NY: University of Rochester Press), 37–63.

Vansteenkiste, M., Ryan, R. M., and Soenens, B. (2020). Basic Psychological Need Theory: Advancements, Critical Themes, and Future Directions. *Motiv. Emot.* 44 (1), 1–31. doi:10.1007/s11031-019-09818-1

Wittmann, M., Dinich, J., Merrow, M., and Roenneberg, T. (2006). Social Jetlag: Misalignment of Biological and Social Time. *Chronobiology Int.* 23 (1-2), 497–509. doi:10.1080/07420520500545979

Zajacova, A., Lynch, S. M., and Espenshade, T. J. (2005). Self-efficacy, Stress, and Academic success in College. *Res. High Educ.* 46, 677–706. doi:10.1007/s11162-004-4139-z

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.