

Impact of Chronotype on Teaching and Learning

William F. Martin

DePaul University, Chicago, IL, USA

Yvette P. Lopez

DePaul University, Chicago, IL, USA

[Abstract] As university stakeholders work to support the academic performance and success of their students, an often omitted consideration is chronotype. Chronotype represents an individual's circadian rhythm that describes the time of day at which a person is able to effectively cope with challenging tasks. While chronotype and time of day are gaining as an area of inquiry in learning research, there is a dearth of research on the intersection of chronotype and education. This article focuses on administrative policies and systems, as well as on the chronotypes of faculty and students in positively influencing undergraduate student academic performance.

[Keywords] academic performance, chronotype, student learning, teaching

Impact of Chronotype on Teaching and Learning

There are a host of contributions to college success. These include academic and non-academic factors (Adams & Blair, 2019). An example of a non-academic factor is self-regulation. Self-regulation is “the voluntary control of attentional, emotional, and behavioral impulses in the service of personally valued goals and standards” (Duckworth & Carlson, 2013, p. 209). Self-regulation is key to academic success (Duckworth & Carlson, 2013; Poropat, 2009).

Self-regulatory capacities are impacted by chronotype. Chronotype is “an expression of individual circadian rhythmicity” (Takahashi et al., 2018, p. 1). More specifically, chronotype is “the measurable manifestation of the biological rhythm describing the time of day at which a person is best able to cope with particularly challenging tasks” (Staller et al., 2021, p. 238). As a result, time management and scheduling influence performance (Baker et al., 2019).

Our focus here is on chronotype and its impact on academic performance. We aim to briefly review the literature on the impact of chronotype on teaching and learning. We begin with a succinct review of chronotype. We then focus on academic policies and systems as they set the context by which faculty and students function. Next, we focus on curricula design, course design, and teaching from the perspective of the faculty. Finally, we turn to class scheduling, assessment scheduling, in-class performance, and studying from the perspective of the student, with a specific focus on undergraduate level students.

Chronotype: A Succinct Review

Our goal is to contribute to the extant literature. Chronotype is a biological construct (Roenneberg et al., 2019). Yet, chronotype has long been conceptualized as a psychological construct or trait (Horn & Ostberg, 1977). Although chronotype is a genetically determined construct, it is influenced by other factors such as schedules (Roenneberg et al., 2019).

There are three chronotypes: early morning, intermediate, and evening (Akram et al., 2018). Morning types get up earlier and go to bed earlier. Their performance, both physically and mentally, peaks during the morning hours (Itzek-Greulich et al., 2016). In contrast, evening types are those who go to bed later and get up later. Their peak performance, both physically and mentally, typically occurs in the late afternoon and evening (Itzek-Greulich et al., 2016).

Upon entering early adulthood, chronotypes are relatively stable due to their genetic basis. Yet, late adolescence is when chronotypes reach their peak with regard to lateness, and this is an overall effect among the adolescent age cohort (Fischer et al., 2017). Therefore, young people (18-19 years) are on average the latest chronotypes in society (Fisher et al., 2017).

Chronotype is related to sleep but independent of sleep duration (Fischer et al., 2017). For example, evening types report lower sleep quality, less sleep, excessive daytime sleepiness, and difficulty falling asleep (Kivela et al., 2018). Prior evidence shows that short sleep duration is empirically associated with lower GPAs (Hershner, 2020). Empirical evidence also shows that sleep consistency affects academic performance more than sleep duration (Hershner, 2020). Therefore, both chronotype and time of day are gaining as an area of inquiry in learning research (Adan et al., 2012). Yet, there is a dearth of research on the intersection of chronotype and education (Itzek-Greulich et al., 2016).

Administrative Perspective

Academic performance is the agenda of higher education administrators. Still, this responsibility is shared by other university stakeholders. Therefore, in alignment with this responsibility, “Institutions and scholars are searching for causes of and solutions to low academic performance” (Baker et al., 2019, p. 522). Relatedly, one of the more complicated decisions confronting school administrators is school start time (Bertsimas et al., 2019). Because chronotype has been shown to predict academic achievement (Arababi et al., 2015; Tonetti et al., 2015), the American Academy of Pediatrics recommends that adolescents begin school no earlier than 8:30 am (Adolescent Sleep Working Group, Committee on Adolescence & Council on School Health, 2014). It is well established that academic performance is lower when classes are not aligned with the internal clocks of students (Williams & Shapiro, 2018). Therefore, early school start times clash with this biological reality (Goldin et al., 2020).

School schedules are also important in the academic performance of university students. The average university undergraduate level student falls within the age range of an older adolescent (Crowley et al., 2018). In a study of 14,894 university students, it was found that course schedules that aligned with the chronotype of students resulted in higher academic performance (Smarr & Schirmer, 2018). Another study of United States Air Force Academy second-semester freshmen resulted in the authors putting forth policy recommendations for academic administrators related to course scheduling, recognizing that “shifting a school’s entire schedule may be expensive or unpopular among administration, teachers, parents, and coaches” (Williams & Shapiro, 2018, p. 167). Regardless, the authors conclude that classes beginning at 9 am or later result in higher academic performance and that the optimal time for learning is in the afternoon (Williams & Shapiro, 2018).

Therefore, the role of administration is critical here as stated by Hammond et al., “while the content and pedagogical knowledge are the foundation of quality teaching, there are a number of administrative, policy, and operational factors that influence instructional behaviors” (2018, p. 1). Instructional technology, faculty support, scheduling, compensation, and faculty-community

all influence teaching quality (Hammond et al., 2018) and, as we determined, so is scheduling. Course scheduling at colleges and universities often takes place at the department or college level based upon the perceived needs of students, faculty availability, and classroom capacity (Sun & Xu, 2018). It is critical that administrators understand the influence that scheduling can have not only on student academic performance, but also on faculty performance as chronotype impacts both students and faculty.

It should be noted that “the consistency or inconsistency by which an instructor is scheduled to teach a given course may impact teaching quality” (Hammond et al., 2018, p. 5). Hence, it is recommended that faculty must be part of the scheduling process, particularly as it relates to their schedules (Hammond et al., 2018). Allowing workers to schedule their work hours is one element of job autonomy (Hackman & Oldham, 1976), which positively influences key factors such as intrinsic motivation, engagement, and work performance (Nahrgrang et al., 2010). The well-being of workers across many industries is positively associated with job control and schedule control (Wheatley, 2017). The well-being of students and their mental health can also be influenced by these decisions. When workplaces and institutions do better to accommodate evening types, it “may ultimately reduce mental health problems within young adults and improve performance” (Walsh et al., 2022, p. 7).

Therefore, it is recommended that colleges/universities adopt sleep-friendly policies and interventions (Hershner, 2020). More specifically, it is important that administrators work to sync work schedules with employee chronotypes, enhance asynchronous instruction, and allow asynchronous examinations (Walsh et al., 2022), all to support the performance of their faculty and students.

Faculty Perspective

Faculty clearly have a role related to the academic performance of undergraduate students. Yet, faculty must manage multiple responsibilities and stressors related to teaching, service, and research (Eagan & Garvey, 2015). Stressors may also include external issues related to family obligations (Eagan & Garvey, 2015). De Souza and colleagues (2014) conclude that “the discussion about school start times originally proposed for adolescents needs to be magnified to teachers, contributing to improvement of sleep habits and life quality in the school environment” (p. 206). We agree.

Worker productivity is partially driven by chronotype and schedules. According to Putilov and colleagues (2021), the approximate distribution of chronotypes in adult populations is as follows: morning type (13%), intermediate type (63%), and evening type (24%). In one study it was found that “morningness workers may improve their work productivity by sleeping earlier, and eveningness workers may improve their work productivity by waking up later” (Shimura et al., 2022, p. 77). In another study, De Souza and colleagues (2018) surveyed university faculty and recommended that, “working only in the afternoon seems to provide better sleep/awake conditions for teachers because they keep the same sleep duration during the week and on the weekend, and they are diagnosed with less daytime sleepiness” (p. 157). Waking times are generally determined by school/work schedules, leaving non-school/workdays more aligned with our chronotype or endogenous rhythms (Wittmann et al., 2006). Hence, individuals tend to sleep longer on non-school/workdays (Goldin et al., 2020).

It is essential that faculty advocate for courses to be scheduled at times that favorably impact teaching and learning outcomes. Specifically, afternoon classes result in higher

performance for both faculty and students. It is also essential that faculty advocate for fewer preparations during any given semester/quarter and advocate for teaching multiple sections during the same day of the week. Research indicates that faculty performance improves when faculty teach the same material as the day progresses (Williams & Shapiro, 2018). Research further indicates that “students in the later repeated sections received higher grades, higher passing rates, and significantly better final exam scores” (Sun & Xu, 2018, p. 290). However, it should be noted that faculty also received worse teaching evaluations (Sun & Xu, 2018), confirming prior research demonstrating that teaching effectiveness is often associated with lower teaching ratings (Kornell & Hausmann, 2016).

Although our primary focus here has been on undergraduate level students, it should be noted that in a qualitative study of adult learners, the benefits of asynchronous online learning were numerous, including achieving overall life balance (Berry & Hughes, 2020). This finding recognizes the three types of boundaries which can result in stress: physical, temporal, and psychological (Cousins & Robey, 2015). These boundaries can exist in all course modalities, including online learning. However, online learning has been shown to *solve* all three (Berry & Hughes, 2020).

Martin and colleagues (2020) describe a concept called *bichronous learning*, which is the “blending of both asynchronous and synchronous online learning, where students can participate in anytime, anywhere learning during the asynchronous parts of the course but then participate in real-time activities for the synchronous sessions.” The evidence demonstrates that “when synchronous communication features are integrated with asynchronous features, the online course is more engaging, increasing learning outcomes, positive attitudes, and retention” (Martin et al., 2020).

Student Perspective

As previously indicated, our focus here is on undergraduate level students. As such, it is important to review the distribution of chronotypes involved with this specific group. Some of these differences involve age and others involve gender. For instance, not all college students are adolescents. Additionally, Roenneberg and colleagues (2007) found that men reach their latest chronotype peak at 19.5 years and women at 21 years.

It is well established that adolescents undergo a later sleep/wake pattern until early adulthood (Crowley et al., 2018). The later the peak, the greater the misalignment between social clocks such as school scheduling and biological clocks (Wittmann et al., 2006). Adolescents experience greater misalignment between the biological clock and the social clock. This misalignment is known as social jet lag. Social jet lag is “misalignment between biological time and sleeping time imposed by social schedules such as school and work times” (Muzni et al., 2021, p. 2). Evening types suffer more from social jet lag than other chronotypes (Roenneberg et al., 2019). Social jet lag has been shown to result in attention and learning deficits according to Smarr and Schirmer (2018).

The implications for undergraduate level students can be substantial. However, unlike secondary school, college/university students have greater control over their schedules (Tonetti et al., 2015). In a meta-analysis across 30 studies and 30,000 subjects, it was demonstrated that evening types have worse school achievement than morning types (Tonetti et al., 2015). Based upon a study exploring the interaction of chronotype and time of day in a science course, the authors recommend that “schools should offer more learning opportunities in the afternoon”

(Itzek-Greulich et al., 2016, p. 189) given the finding that evening types are more motivated and learn better in the afternoon. Yet, morning types do not suffer a decrement in performance so long as the assessment is between 12:45- 3:00 pm (Itzek-Greulich et al., 2016). Therefore, early morning types ought to begin class earlier than evening types (Goldin et al., 2020).

This aligns with several studies of university students that have found that morningness is associated with a future time perspective while eveningness is associated with a present time perspective (Cinan & Dogan, 2013; Stolarski et al., 2013). Future time perspectives influence intended active engagement, influencing GPA (Barnett et al., 2020). This has implications for the way that students approach a course and their overall curriculum.

The impact of chronotype on academic performance has been shown to also depend upon the subject. The relationship is more pronounced among scientific subjects than humanistic/linguistic subjects (Zerbini et al., 2017). Evening types perform better than morning types in language/humanistic subjects scheduled later in the day (Goldin et al., 2020). Math/science performance is higher for early types than evening types during the morning (Goldin et al., 2020).

Late types are disadvantaged if they take exams on scientific materials early in the day (Zerbini et al., 2017). Although morning types may benefit from a synchrony perspective taking classes in the morning, the evidence suggests that morning classes result in a lower GPA (Yeo et al., 2021). Contributing explanations for this finding include higher class absences and lower nocturnal sleep duration (Yeo et al., 2021). Therefore, universities should avoid scheduling early morning classes (Chen et al., 2022).

While the amount of time studying influences academic performance, study habits can moderate this relationship (Nonis & Hudson, 2010). Study habits include factors such as concentrating and scheduling (Nonis & Hudson, 2010). The key is to create a learning environment that optimizes the *synchrony effect*. The synchrony effect occurs when there is alignment between the student's chronotype and the time of day of a class or exam (Ziporyn et al., 2022).

Implications for Administrators, Faculty, and Students

There will almost certainly be issues that administrators, faculty, and students will have to contend with when it comes to fulfilling their respective roles. Table 1 shows both the issues facing administrators, faculty and students along with recommendations for each of the three stakeholder groups.

Table 1*Potential Issues for Each Role and Recommendations*

Potential Issues for Each Role	Potential Recommendations
<u>Administrative</u>	
Leadership	Transformational leadership is needed to build trust with the faculty, staff, and students in committing to the change required.
Shifting of norms, culture, traditions	Get buy-in from the involved stakeholders to support productivity and performance levels.
Needs of students	Ensure degree program course requirements are predominantly available during the 10am-4pm hours.
Faculty availability	Ensure faculty needs are met and matched with class schedules according to their chronotype.
Staff and support staff availability	Ensure staff and support staff needs are met and matched according to their chronotype. Potential for a flex schedule and overlapping shifts.
Classroom capacity	Coordinate availability
Athletics and extracurriculars	Current research suggests optimal athletic performance occurs in the late afternoon-early evening, coinciding with the peak of core body temperature (4pm-8pm).
Transportation	Factor in available train/bus schedules as well as inter-campus shuttle options, if applicable.
Safety/Security	Ensure safety officers/security officers are available on campus during revised hours.
Meeting accreditation requirements	Ensure course requirements continue to meet accreditation requirements.
<u>Faculty</u>	
Faculty availability	Select class schedules according to chronotype, when available.
Competing Roles (e.g., teaching, research, service)	Schedule meetings/courses according to chronotype, when available.
External Responsibilities (e.g., family obligations)	Balance work assignments with external responsibilities.

Student

Work schedule	Students may continue to select a M/W or T/Th course schedule that allows for work on non-class days.
Transportation	Students may have to plan for late afternoon transportation schedules (e.g., bus, train), if applicable.

It is important to emphasize that all stakeholders work to support the academic performance of students and they should consider the influence of chronotypes on academic performance. Administrators consider many factors when scheduling classes (e.g., needs of students, faculty availability, classroom capacity), chronotypes should be one of them.

Research has clearly indicated that chronotypes predict academic achievement (Arababi et al., 2015; Tonetti et al., 2015) and course schedules that align with the chronotypes of students result in higher academic performance (Smarr & Schirmer, 2018). From an administrative perspective, this key factor may aid the administrative agenda of improving academic performance.

From the perspective of faculty, several responsibilities must be managed in the areas of teaching, research, and service. When faculty are allowed the flexibility to conduct these roles during the times of the day in which they are most effective, this too will positively influence their productivity and performance. Faculty members are constantly tasked with demands for creativity, innovation, and superior problem-solving. This can result in high levels of emotional and mental stress (Meyer, 2021). Keeping faculty engaged requires workplace flexibility, conscientiousness, and chronotype consideration (Meyer, 2021).

Finally, from the perspective of undergraduate level students, course schedules that align with the chronotype of students support their potential for achieving higher academic performance (Smarr & Schirmer, 2018). It has further been noted that faculty observe differences in student alertness and focus during certain times of the day (Sun & Xu, 2018). In one study, both faculty and students indicated preference for the 10 am - 4 pm time block (Sun & Xu, 2018). Therefore, it would be in the student's best interest to understand their chronotype and when available, schedule their courses accordingly.

Conclusion

In conclusion, as university stakeholders work to support the academic performance of their students, consideration of the chronotypes of both faculty and students may help university administrators in achieving this particular agenda. Chronotype consideration may also help faculty in their productivity and performance as well as undergraduate students in their academic achievement.

References

Adams, R. V., & Blair, E. (2019). Impact of time management behaviors on undergraduate engineering students' performance. *Sage Open*, 9(1), 2158244018824506.

- 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.
- Adolescent Sleep Working Group, Committee on Adolescence & Council on School Health (2014). School start times for adolescents. *Pediatrics*, 134, 642-649.
- Akram, N., Khan, N., Ameen, M., Mahmood, S., Shamim, K., Amin, M., & Rana, Q. U. A. (2018). Morningness-eveningness preferences, learning approach and academic achievement of undergraduate medical students. *Chronobiology International*, 35(9), 1262-1268.
- Arababi, T., Vollmer, C., Dorfler, 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.
- Baker, R., Evans, B., Li, Q., & Cung, B. (2019). Does inducing students to schedule lecture watching in online classes improve their academic performance? An experimental analysis of a time management intervention. *Research in Higher Education*, 60(4), 521-552.
- Barnett, M. D., Melugin, P. R., & Hernandez, J. (2020). Time perspective, intended academic engagement, and academic performance. *Current Psychology*, 39(2), 761-767.
- Bertsimas, D., Delarue, A., & Martin, S. (2019). Optimizing schools' start time and bus routes. *Proceedings of the National Academy of Sciences*, 116(13), 5943-5948.
- Berry, G. R., & Hughes, H. (2020). Integrating work-life balance with 24/7 information and communication technologies: The experience of adult students with online learning. *American Journal of Distance Education*, 34(2), 91-105.
- Cinan, S., & Dogan, A. (2013). Working memory, mental prospection, time orientation, and cognitive insight. *Journal of Individual Differences*, 34, 159-169.
- Cousins, K., & Robey, D. (2015). Managing work-life boundaries with mobile technologies: An interpretive study of mobile work practices. *Information Technology and People*, 28(1), 34-71.
- Crowley, S. J., Wolfson, A. R., Tarokh, L., & Carskadon, M. A. (2018). An update on adolescent sleep: new evidence informing the perfect storm model. *Journal of Adolescence*, 67, 55-65.
- Crowley, S.J., & Eastman, C.I. (2018). Free-running circadian period in adolescents and adults. *Journal of Sleep Research*, 27(5), e12678. doi: 10.1111/jsr.12678.
- De Souza, J. C. D., Galina, S. D., Almeida, J. C. F. D., Sousa, I. C. D., & Azevedo, C. V. M. D. (2014). Work schedule influence on sleep habits in elementary and high school teachers according to chronotype. *Estudos de Psicologia (Natal)*, 19, 200-209.
- Duckworth, A. L., & Carlson, S. M. (2013). Self-regulation and school success. In B. W. Sokol, F. M. E. Grouzet, & U. Müller (Eds.), *Self-regulation and autonomy: Social and developmental dimensions of human conduct* (pp. 208-230). Cambridge University Press.
- Eagan Jr, M. K., & Garvey, J. C. (2015). Stressing out: Connecting race, gender, and stress with faculty productivity. *The Journal of Higher Education*, 86(6), 923-954.
- Fischer, D., Lombardi, D. A., Marucci-Wellman, H., & Roenneberg, T. (2017). Chronotypes in the US-influence of age and sex. *PloS one*, 12(6).

- Goldin, A. P., Sigman, M., Braier, G., Golombek, D. A., & Leone, M. J. (2020). Interplay of chronotype and school timing predicts school performance. *Nature Human Behaviour*, 4(4), 387-396.
- Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: Test of a theory. *Organizational Behavior and Human Performance*, 16(2), 250–279.
- Hammond, H. G., Coplan, M. J., & Mandernach, B. J. (2018). Administrative considerations impacting the quality of online teaching. *Online Journal of Distance Learning Administration*, 21(4), n4.
- Hershner, S. (2020). Sleep and academic performance: Measuring the impact of sleep. *Current Opinion in Behavioral Sciences*, 33, 51-56.
- Itzek-Greulich, H., Randler, C., & Vollmer, C. (2016). The interaction of chronotype and time of day in a science course: adolescent evening types learn more and are more motivated in the afternoon. *Learning and Individual Differences*, 51, 189-198.
- Kornell, N., & Hausman H. (2016). Do the best teachers get the best ratings? *Frontiers in Psychology*, 7, 570.
- Martin, F., Drew P., & Ritzhaupt, A. (2020). Bichronous Online learning: Blending asynchronous and synchronous online learning. *EDUCAUSE*. September 8. <https://er.educause.edu/articles/2020/9/bichronous-online-learning-blending-asynchronous-and-synchronous-online-learning> .
- Meyer, T. (2021). Exploring chonotype, conscientiousness, workplace flexibility and work overload within the Job Demands-Resources Model. [Doctoral dissertation, Stellenbosch University]. <http://scholar.sun.ac.za/handle/10019.1/109944>
- Muzni, K., Groeger, J. A., Dijk, D. J., & Lazar, A. S. (2021). Self-reported sleep quality is more closely associated with mental and physical health than chronotype and sleep duration in young adults: A multi-instrument analysis. *Journal of Sleep Research*, 30(1), e13152.
- Nonis, S. A., & Hudson, G. I. (2010). Performance of college students: Impact of study time and study habits. *Journal of Education for Business*, 85(4), 229-238.
- Poropat, A. E. (2009). A meta-analysis of the five-factor model of personality and academic performance. *Psychological Bulletin*, 135, 322-338.
- Putilov et al. (2021). Single item chronotyping (SIC), a method to self-assess diurnal types by using 6 simple charts. *Personality and Individual Differences*, 168.
- Roenneberg, T., Pilz, L. K., Zerbini, G., & Winnebeck, E. C. (2019). Chronotype and social jetlag: A (self-) critical review. *Biology*, 8(3), 54.
- Roenneberg, T., Kuehnle, T., Juda, M., Kantemann, T., Allebrandt, K., Gordijn, M., & Merrow, M. (2007) Epidemiology of the human circadian clock. *Sleep Medicine Reviews*, 11, 429-438.
- Shimura, A., Yokoi, K., Sugiura, K., Higashi, S., & Inoue, T. (2022). On workdays, earlier sleep for morningness and later wakeup for eveningness are associated with better work productivity. *Sleep Medicine*, 92, 73-80.
- Smarr, B. L., & Schirmer, A. E. (2018). 3.4 million real-world learning management system logins reveal the majority of students experience social jet lag correlated with decreased performance. *Scientific Reports*, 8, 4793
- 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. *Frontiers in Education*, 6, 238.

- Stolarski, M., Ledziska, M., & Matthews, G. (2013). Morning is tomorrow, evening is today: Relationships between chronotype and time perspective. *Biological Rhythms Research*, 44, 181-196.
- Sun, L., & Xu, X. (2018). The effects of repeated lectures and class time on learning outcomes and teaching evaluations. *Journal of Supply Chain and Operations Management*, 16(3), 278.
- Tonetti, L., Fabbri, M., & Natale, V. (2008). Sex difference in sleep-time preference and sleep need: A cross-sectional survey among Italian pre-adolescents, adolescents, and adults. *Chronobiology International*, 25, 745-759.
- Walsh, N. A., Repa, L. M., & Garland, S. N. (2022). Mindful larks and lonely owls: The relationship between chronotype, mental health, sleep quality, and social support in young adults. *Journal of Sleep Research*, 31(1), e13442.
- Wheatley, D. (2017). Autonomy in paid work and employee subjective well-being. *Work and Occupations*, 44(3), 296-328.
- Williams, K. M., & Shapiro, T. M. (2018). Academic achievement across the day: Evidence from randomized class schedules. *Economics of Education Review*, 67, 158-170.
- Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social jetlag: Misalignment of biological and social time. *Chronobiology International*, 23(1-2), 497-509.
- Yeo, S. C., Lai, C. K., Tan, J., Lim, S., Chandramoghan, Y., & Gooley, J. J. (2021). Large-scale digital traces of university students show that morning classes are bad for attendance, sleep, and academic performance. *BioRxiv*.
<https://doi.org/10.1101/2021.05.14.444124>
- Zerbini, G., van der Vinne, V., Otto, L. K., Kantermann, T., Krijnen, W. P., Roenneberg, T., & Merrow, M. (2017). Lower school performance in late chronotypes: underlying factors and mechanisms. *Scientific Reports*, 7(1), 1-10.
- Ziporyn, T. D., Owens, J. A., Wahlstrom, K. L., Wolfson, A. R., Troxel, W. M., Saletin, J. M., ... & Carskadon, M. A. (2022). Adolescent sleep health and school start times: setting the research agenda for California and beyond: a research summit summary: a research summit summary. *Sleep Health*, 661.