




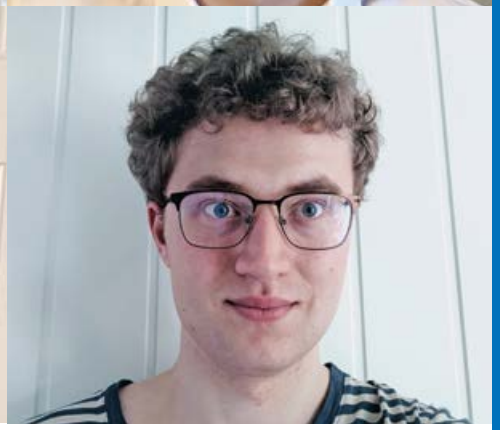


Quintessence

# Project Report **Quintessence**


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|---|---|
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# Preface by Supervisor

Prof. Dr. Hans Förstl

## Caged hunters, bored gatherers

During the pre-COVID era, lectures and seminars represented highly ritualized live gatherings of staff and students celebrating the spirit of science. Nowadays such academic communication is virtually restricted to exchanges in *effigie et verbo absque praesentia*. This is convenient, but a lot of the traditional exercise is lost, including the effort to get up on time, find the way to the lecture rooms, encounter charismatic teachers, meet fellow students in real, have lunch at a given time etc.. Therefore this is a project for both, ongoing studies on-line and the post-COVID period.

Attention has a fast and a hard part. Sharp focusing requires alertness and offers sparks of immediate insight; it is for the genius in ourselves and not always up to the task of an immediate hit right on target. You get the picture (or not). Concentration is for everyone; it is the laborious sustained effort to keep track of content, gather as much information as possible, an effort always bordering on boredom. The text and the reasoning behind the text are studied, and again, and once more if necessary (*repetitio mater studiorum*).

Spirit, “Geist” is fickle and fidgety and notoriously hard to pin down. A domesticated and trained mind may pretend to follow somebody else’s cognitive dance steps for more than a minute or two, the body may sit still on chairs offering limited comfort, eyes and thoughts however will wander vaguely and find consolation in blissful memories and perspectives … whilst authoritative deliberations have long escaped the idle listener.

Attention has to be paid and energy costs are high. Therefore it is of utmost physiological and ecological importance to invest wisely and in harmony with human nature. Astute academic assemblies most modestly make every attempt to deny their very needs, but they respond all the more gratefully if nudged towards invigorating physical exercise, ventilating their strained brains and reinstating fresh supplies of blood, oxygen, glucose, acetylcholine, alertness and stamina.

This study has successfully set out to explore the effects of short intermissions with physical exercise during ninety-minute lectures on subjectively perceived attention. Its results deserve to be considered by students and professors spending long hours in their home offices and also when returning to their traditional chores at a real-world university environment. ■

# Preface by Supervisor

Dr. Susanne Witzgall

## The Struggle for Attention

Our globalized and networked world is flooded by information and images fighting for our attention. Social media platforms are equipped with a special design to foster the constant posting, liking or sharing of content in order to catch one's eye and to increase one's dwelling time. Personalized ads try to allure us and to draw our interest. Attention is perpetually courted and compelled. It has become one of the most important resources and main commodities in contemporary semio-capitalism (Bifo Berardi), which is mainly based on cognitive rather than material labor.

Against this backdrop the project Quintessence which has set itself the goal to improve the individually perceived attentiveness during university lectures, may arouse suspicion in participating in this current fight for a resource becoming seemingly scarcer every day. However, the means employed by this project were rather short intermissions supposed to provide a temporary release from the constant demand for concentration and productive processing of information. Quintessence created a caesura, an abrupt pause in the rhythmic and abundant flows of words, images and data. Its research findings remind us that there are time-based limits in applying the mind to something and that respecting these neuro-cognitive limitations could help to create a more fruitful learning atmosphere. In this context we should also never forget that sometimes the best ideas of artists and scientists alike surface while the mind is in a diffuse mode of non-focusing, a condition of distracted attention. ■

# The Quintessential Break

**Attention is a quintessential ingredient for successful university lectures. But is the classic format at the Technical University Munich (TUM) doing it justice? A simple tweak may offer profound benefits.**

The time is just about 7.45 in the morning, as you leave the house and make your way to the U-Bahn station. You are still tired from yesterday, either from studying, finishing up some work you had left to the last minute to do, or from having gone out with friends. But you knew that you had an 8.30 lecture. In any case, you need to rally. You might get an espresso from a bakery on the way to the train, hoping that this puts you out of your sleepy, wish-you-were-back-in-bed state. You finally enter the train, along with the rest of Munich, and, standing squashed inside a mass of people like a tightly filled can of sardines, you are finally on your way.

Almost every student in their studies at TUM has most certainly experienced the feeling of anticipating a below par lecture, perhaps even on a regular basis. During the last twenty months, team Quintessence, a research group formed by six scholars of the TUM: Junge Akademie (Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig: Year 2019), have undertaken a project to further understand the causes associated with this important issue regarding the classical teaching format at university. Their aim: to develop simple but effective adjustments to the end of improving the lecture experience. You arrive at the main campus of TUM, where you find that you need to hurry if you do not want to miss the beginning of the lecture, because even though the trip from your home to here should never have taken longer than forty-five minutes, today of course it did. Checking your timetable once more, you assure yourself that you are indeed going the right way, to the Carl von Linde lecture theater. As you arrive in the corridor leading up to the hall, you can already hear the distinctive bang of the entrance door as it opens and shuts when people enter, each bang piercing your tired brain through your ears. The lecture has not yet started. You scout the hall for your friends, but the professor just directed an annoyed glance at you, so you simply choose a convenient seat. The lecture hall is now filled with a concert of metallic clunks and jerks, as everybody flaps down their seats and tables, and the lecture begins.

The first ten minutes go quite well. You are taking notes and following the information being presented. But after about fifteen minutes, you can feel that espresso wearing off. After thirty minutes, you are almost back in the state in which you left the house in the morning, only now you must sit still for another hour and try to pay attention to the lecture. The hum of the projector paired with the ventilation system feel like a white noise lullaby, calling you to shut down again. By the time you have reached the second half of the lecture, you are busy enough wrestling with yourself to stay awake, that each lecture slide starts to look the same. Finally, you are elated as the lecturer releases you from quasi-hibernation after ninety minutes. As you leave the lecture hall without any solid grasp of what was discussed in class just now, you cannot help but think that it would have been a better idea to have stayed in bed.

While some of the causes of such an experience are certainly to be attributed to sub-optimal practices of the student (e.g. not getting enough sleep), the lecture format itself may also be contributing its fair share of problems. At least that is the view of team Quintessence, which studied the way students perceive attention in university lectures here at TUM and set out to find interventions which would promise its enhancement.

The team, made up of people with extremely diverse study-backgrounds (chemistry, physics, sports science, management & tech-

nology and mathematics), initially had little scientific domain knowledge in applied psychology, the field in which their project would arguably fall. But an intensive undertaking in literature research together supported by two expert supervisors (Dr. Susanne Witzgall, Akademie der Bildenden Künste, Head of cx Centre for Interdisciplinary Studies, and Prof. Dr. Hans Förstl, Chair for Clinical Psychiatry und Psychotherapy at TUM) and a dedicated tutor (Sebastian Kaltenbach) allowed them to gain an insight into the relevant topics.

Theories and research on attention, especially in the setting of education, are extensive. And while statements like *"You Now Have a Shorter Attention Span Than a Goldfish"* (as once showcased on the cover of Time Magazine) make for a good headline, these kinds of comparisons lack scientific rigor. However, according to the preliminary research of team Quintessence, there exists consensus on certain issues. For example, there seems to be a limit as to how long humans can continuously pay attention to an activity which demands it, as is the case for university lectures. In fact, since the latter half of the twentieth century, it has been well established that effects of attention-loss can already be observed after ten to fifteen minutes for tasks requiring a constant level of significant mental activity. Hence, you should not be surprised if you feel a dip, low or crash after the first quarter hour of a lecture, regardless of having had an espresso before or not. Given that lectures at TUM tend to be administered in ninety-minute blocks, this is seemingly in dissonance with the results from various psychological papers.

In light of this, the team hypothesized that a lecture break could have a significant impact on the perceived attention of the attending students. First validation occurred in the form of two case-studies performed at ETH Zurich and RWTH Aachen. At ETH, the timetable follows a strict regimen of consecutive hour-blocks, consisting of a forty-five minutes class and fifteen minutes break each. Instead, at RWTH a service had been set up by their university sports center, which a lecturer could hire, to perform a five-minute activity break in the middle of class. Both concepts sounded intriguing and had merit, which prompted Quintessence to conduct their own study here at TUM and test their hypotheses. Over the course of seven weeks in November and December 2019, the team tested two different break formats (one passive, one with guided activity) of varied length (five and ten minutes) and across a wide range of faculties and lecture sizes.

The results? Indeed, the team was able to measure positive tendencies in response to the applied measures (see scientific report on pages [164 – 171] for detailed presentation and discussion of methods/results), and while some students expressed concerns about distraction, a majority seems to respond to the introduced measures in a positive way. "I thought the activity break was great. It helped my concentration and made the lecture more relaxed," one participant wrote as anonymous feedback. At the same time, the lecturers who participated have also been generally encouraging about the studies' administration. However, the data has also shown inconsistencies regarding the level to which the measures are effective, offering strong evidence that their effectivity must also be highly dependent on other aspects (e.g. subject taught, the lecturers and their teaching styles, etc.). Thus far, the tested interventions do not significantly factor out these parameters and can therefore not be considered to guarantee improvement of students' perceived attention in a universal lecture setting.

It remains to be seen if the work of team Quintessence will yield the implementation of breaks at TUM as being *quintessential*. In any case, it will most certainly raise awareness about the current lecture practices at TUM. Perhaps the time has come for a shift in teaching culture. ■

# Quintessence

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## Abstract

Attention represents a complex function that is relevant to a multitude of human activities. However, while a lot of research on attention has already been conducted, relatively few studies have focused on university students.

Thus, the primary objective of this study was to investigate the effects of distinct break concepts and durations on the individually perceived attentiveness of university students in lecture contexts. Thereby, a comprehensive approach involving the capture of students' subjective perceptions via a questionnaire and the measurement of several environmental parameters was taken.

We found that breaks, which may or may not involve physical activity, appeared to improve students' individually perceived attentiveness significantly, while longer breaks did not show stronger effects than shorter ones. On the other hand, the magnitude of these effects showed to be context-specific and influenced by diverging environmental conditions. Consequently, despite the necessity of additional research, this analysis contributes to an enhanced understanding of attentiveness in a university context.

## 1. Background

While there are various diverging definitions of the concept of attention [1, 2, 3], the overall scientific consensus appears to suggest that the capacity of prolonged attention (as quantifiable by the measure of "attention spans") is an essential requirement for academic performance. This has been underlined by studies on the implications of attention deficit hyperactivity disorder for school children and adolescents [4, 5, 6]. Consequently, the arising question of how to optimize the potential for attention is intensely debated in educational discussions [7,8].

In this context, a set of studies have provided valuable insight into the factors that influence attention. These include intrinsic ones which solely depend on the individual's inherent physical and psychological characteristics, such as age, intelligence, mental illnesses, circadian rhythms or moods [9, 10, 11, 12, 13]. Extrinsic factors include environmental conditions e.g. noise, light, and also the influence of psychostimulants like coffee and tea [14, 15]. Therefore, it seems plausible that attention spans can be maximized by optimizing the parameters associated with intrinsic and extrinsic factors.

More specifically, the introduction of breaks has been proposed and successfully applied in the past to augment attentiveness of humans in various contexts [16, 17, 18, 19, 20]. However, one important caveat of the above-cited studies is that they usually focus on children, adults or elderly subjects. In contrast, research with regard to the optimization of attentiveness in a university context turns out to be scarce. Moreover, different opinions exist among scientists regarding the optimal length of breaks and whether they should involve physical exercises [21, 22, 23, 24, 25,26].

In light of these issues, we investigated strategies for the improvement of individually perceived attentiveness of university students by assessing different implementation concepts of breaks in lectures. Our comprehensive approach included the testing of various break lengths and activities. It was aimed at resolving some of the remaining controversies concerning the optimal nature of attention-enhancing breaks in university lectures.

## 2. Goals andmethods

### 1.2 Goals

The primary aim of our project was to improve the individually perceived attentiveness of TUM-students in university lectures by 2020. To that end, we investigated the extent to which breaks can constitute implementable measures that augment said attention in university lectures.

In particular, three distinct break concepts (“Treatments”) were considered (see Fig. 1). Treatment I was a “conventional” 90-minute lecture without any break, serving as a control. Whereas, Treatment II featured a break without physical activity of either five or ten minutes, while Treatment III involved a five- or ten-minute break with physical activity.

Possible effects on the students’ individually perceived attentiveness were assessed via a questionnaire-based interrogation. In light of the above-discussed complexity of attention, one central issue in the context of this study was the design of a sum score – i.e. a single scalar that measured the individually perceived attentiveness – to allow a straightforward comparison amongst the

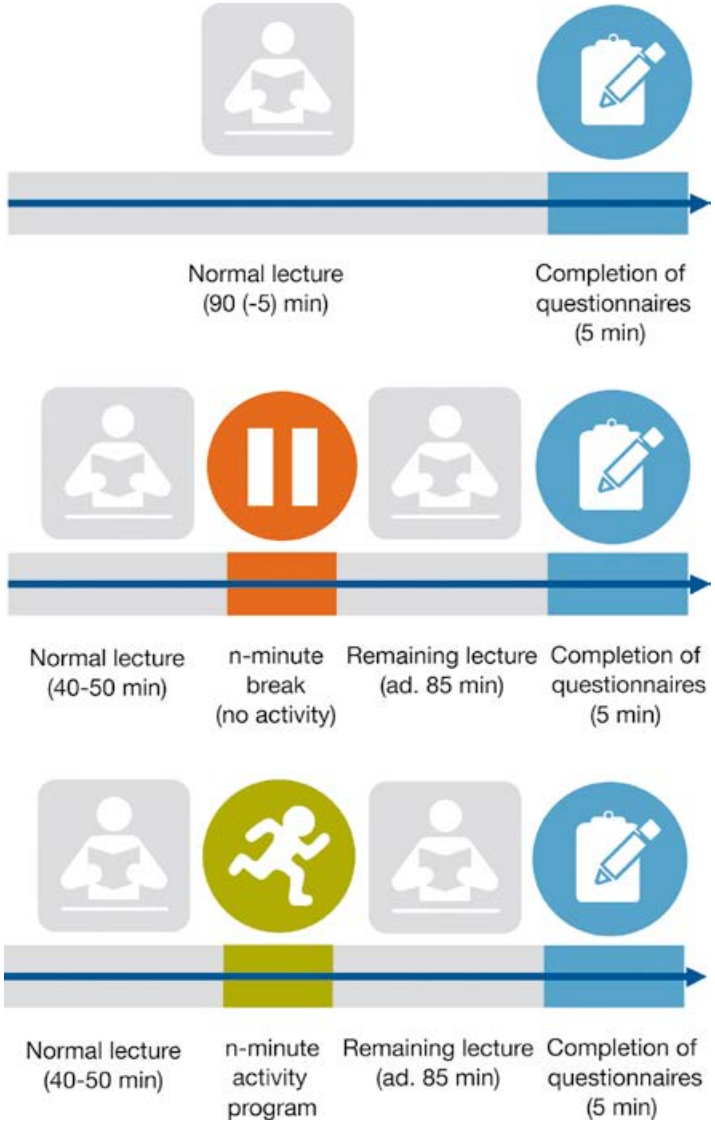



Fig. 1: Scheme describing the three different break concepts (“Treatments”; I-III) analyzed in this study. In each case, students were asked to fill out the respective questionnaire at the very end of the lecture.

three Treatments. Evidently, such a sum score must comprise a many facets of attention in the context of university lectures, e.g. the prevailing environmental conditions, general physical and mental features as well as momentary emotions of the students, and the modality of the presentation of the contents by the lecturer. Thus, the sum score was realized by conceptualizing a questionnaire that included all of the discussed aspects.

The outcomes of this study may have implications for the lecture practices at TUM by serving as a scientific basis for the design of guidelines to optimize the lectures' structure. This appears to be of particular relevance with regard to TUM's Future Learning Initiative which focuses on the development of new concepts to promote dynamic and future- oriented teaching at TUM [27]. More globally, the research presented here contributes to a better understanding of attention – especially in a university context.

### 2.2 Methods

A total of six different 90-minute courses taught on a weekly basis at different scientific faculties were analyzed (see Tab. 1). Each lecture was subjected to the Treatments I, II, and III (in the given order; see Fig. 1) throughout three consecutive weeks. In the case of course 1, the treated lectures were separated by a time interval of two weeks as an exception. The program of Treatment III was invariably led by the professional instructor Christof Wendt using a defined set of stretching and activity exercises of either 5 or 10 minutes length.

To assess the individually perceived attentiveness of students during the observed university lectures, three questionnaires in German language (one per Treatment) were administered. These allowed for surveying the attending students whilst taking into account their age, gender, and semester. The questionnaires comprised items that were each composed of a statement and an associated six-point rating scale reflecting the students' level of agreement. Each questionnaire consisted of the same 14 items which equally contributed to the above-mentioned sum score. Treatment II and III included additional items that were not considered for calculating the sum score. These were incorporated to survey Treatment-specific impressions of the students. For more detailed information concerning the used questionnaires, the reader may refer to[28].

| # | Course title | Lecturer | Date and start time | # of seats of the lecture hall | Ø # of completed questionnaires | Break length (treatment II and III) |
|---|---|---|---|---|---|---|
| 1 | Biotechnologie für Ingenieure | Prof. S. Berensmeier | Tuesday, 2:30 pm | I: 80<br>II and III: 88 | 32 | 5 |
| 2 | Einführung in die Methoden der empirischen Sozialforschung | C. Petz<br>(II: Prof. J. Pfeffer) | Wednesday, 1:15 pm | 188 | 60 | 5 |
| 3 | Bodenordnung und Landentwicklung | Prof.<br>W. de Vries | Friday, 8:00 am | 60 | 12 | 5 |
| 4 | Einführung in die Pädagogik | Prof. F. Mess | Tuesday, 9:45 am | 843 | 228 | 10 |
| 5 | Lineare Algebra für Elektrotechnik | Prof. S. Weltge | Thursday, 3:00 pm | 843 | 234 | 10 |
| 6 | Ernährung, Bewegung und Gesundheit | Dr. T. Schulz | Friday, 10:15 am | 304 | 80 | 10 |

Tab. 1: Overview of the examined university courses including information on the course, the lecturer, the lecture hall, and the number of students attending the lecture. Treatment-specific details denoted by the corresponding identifier of the Treatment (cf. Fig. 1).

Additionally, the environmental conditions prevailing in the lecture hall, i.e. noise, temperature, air humidity, and the concentration of $CO_2$, were consistently probed using an IC-Meter device.

The data analysis was carried out using the statistical programming language R. The source code is accessible at [28]. Approaches of descriptive statistical methods, e.g. box plots and histograms, were used for socio demographic data as well as results of the survey. To allow further deductions, inferential methods, e.g. linear regression modelling and modelling with interaction effects, were used.

## 3. Outcome and Discussion

Within the scope of this study, a total of 512 triplets (belonging to Treatments I, II,and III) of questionnaires were gathered in six different university courses and analyzed with respect to the respective sum score. The collected raw data is shown in Fig. 2 as box-and-whisker-plots. Note, that no statements of statistical significance can be directly derived from the mere visualization of the data. Never the less, a qualitative analysis of those plots serves as an intuitive entry point for the interpretation of the obtained data.

In this context, it is apparent that the interquartile ranges are of comparable order of magnitude (between 8.5 and 14.8) for all courses and Treatments. Given the assumption that the interquartile ranges represent adequate proxies for the variances of the sum score distributions, one can conclude that the latter are also in a similar range. Similarities of variances may indicate that the distributions obtained from courses with small sample sizes (e.g. course 1 and course 3) are still representative. In other words, biases due to small sample sizes can be assumed as negligible. This view is supported by the moderate number of outliers in the box- and-whisker-plots (see Fig.2).

Moreover, we observed a global trend that the sum score median becomes more elevated in case of Treatments II and III as com-

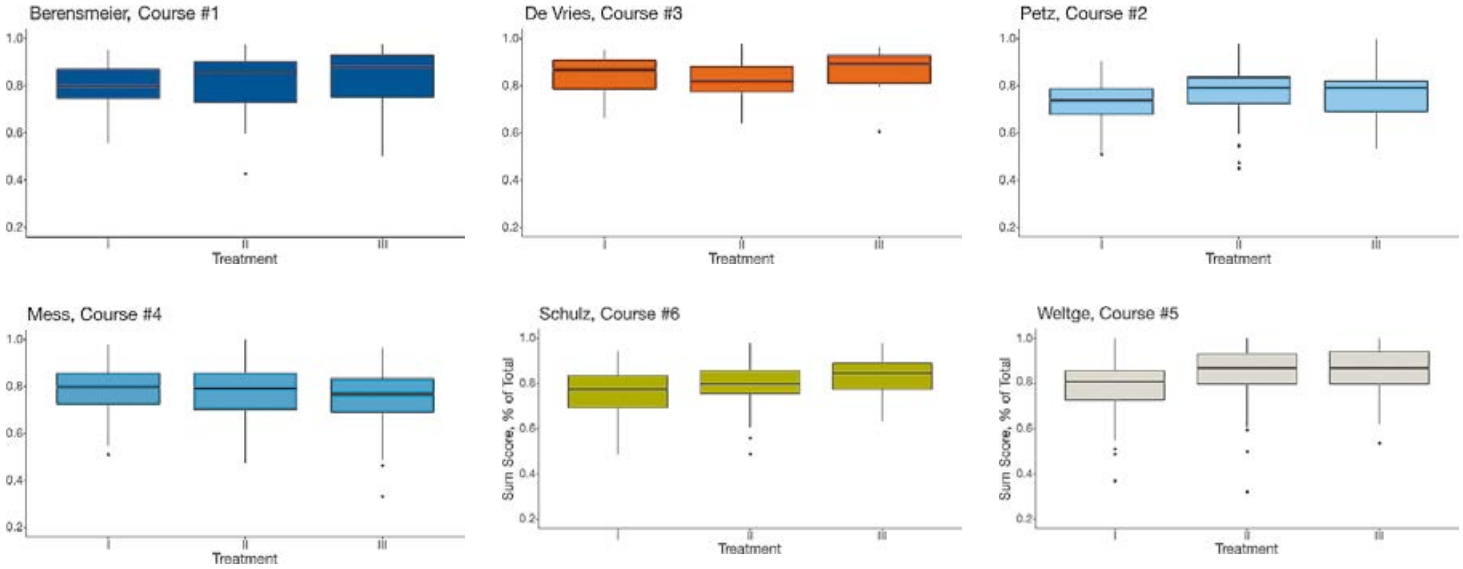



Fig. 2: Box-and-whisker-plots summarising the results of the questionnaire-based survey of different university courses (cf. tab. 1). In each case, the sum score (normalised with respect to the maximal, theoretically achievable sum score) is plotted against the effected Treatment. The median is denoted by a bold black line and the upper resp.lower boundary of the surrounding box signifies the upper resp. lower quartile. The associated whiskers visualise the minimal and maximal values. Circles represent outliers with a distance of at least 1.5 times the interquartile range to the boxes' boundaries. NB: While these plots reflect the obtained raw data and may adumbrate rough tendencies, no significant statements can be deduced from them without further data analysis (see maintext).

pared to Treatment I. This may hint at the efficacy of a passive (Treatment II) or active (Treatment III) break in lectures with regard to improving the individually perceived attentiveness among university students. However, the fact that courses 3 and 4 do not follow this trend stresses the importance of a more rigorous, statistically sound analysis of the data.

Consequently, a linear regression analysis paired with hypothesis tests, particularly t-tests, was carried out to investigate the relationship between the sum score and the Treatments. In principle, this allows to draw conclusions concerning the statistical significance of certain trends. The null-hypothesis assumed that neither the existence, nor the type of break have an effect on the sum score. For sake of simplicity, we additionally assumed that the different courses were sufficiently similar with respect to the parameters of the lectures, such as the lecturer's delivery or environmental conditions. This simplified view enabled treating the different courses and their students as one homogeneous population that forms the basis of our linear regression analysis. While detailed data emerging from this statistical evaluation procedure may be retrieved from [28], core results suggests that the incorporation of a break into a lecture (Treatment II resp. III) is associated with sum scores that are significantly higher as compared to those of break-free lectures (Treatment I; significance level: 1 %; average improvement of the sum score of ca. 2 to 2.5 points, which equals 2.4 to 3.0 percentage points in relative terms). In contrast, Treatment III shows non-significantly higher sum scores than Treatment II. While there is a tendency that breaks with durations of 10 minutes (course 4 to 6)are associated with higher sum scores compared to those of 5 minutes length (course 1 to 3), these differences turn out to benon-significant.

Hence, the combined data suggests that the implementation of a break in the context of a university lecture significantly improves students' individually perceived attentiveness as quantified by the introduced sum score. However, differences between breaks, with respect to activity and duration, appear to be moderate.

Next, it was tested whether the initial assumption of a homogeneous population of courses and students is justifiable. To this end, the collected data was statistically examined with regard to the potential presence of interaction effects, i.e. the presence of other causal variables that have an effect on the discussed relations between Treatment and sum score. This showed that such effects are indeed detectable. For instance, the relation between Treatment and sum score is influenced by the nature of the course. This is reflected in courses 2 and 4 having significantly lower sum scores than others in case of Treatments 1 and 3. The presence of this observed interaction severely challenges the postulate of a homogeneous set of courses and students.

A partial explanation for the previously discussed interaction can be derived from the measurements of prevailing environmental circumstances that were carried out over the course of the studied lectures. While some parameters, such as temperature and humidity, appear almost constant throughout the Treatments, average $CO_2$ concentrations and noise levels exhibit quite drastic differences (see Fig. 3). As the latter two have been shown to affect the attentiveness of humans in earlier studies [29,30], it is reasonable to suggest that fluctuations of these parameters may influence the sum score. For instance, course 2 shows the overall highest $CO_2$ values at Treatment I (see Fig. 3 A), which correlates with a relatively low sum score. Some of the measured $CO_2$ concentration values lie above 690 ppm which has been found to be the threshold above which attentional capacities of students in primary school classes decrease [31]. This implies that there may be room for improvement with regard to the ventilation conditions present in the respective lecture halls at TUM.

Another conclusion that can be drawn from the measured data is that there is no global trend of elevated CO2 concentration or noise levels in case of Treatment III (see Fig. 3). While one might intuitively presume that physical activity is associated with an unfavorable increase in these parameters, this does not become apparent from our measurements.

In addition to other interesting insights, fluctuating environmental parameters may thus provide a plausible explanation for external influences on the relation between Treatment and sum score. However, the origin of these interaction effects cannot be exclusively attributed to fluctuating environmental parameters, but may well arise from other sources, e.g. the lecturer's delivery, the lecture's content or the time at which the lecture is held. This is underlined by the fact that the sum score performance does not always correlate with the values of the environmental parameters. Exemplarily, course 4 exhibits relatively poor sum scores at Treatment III in spite of a low

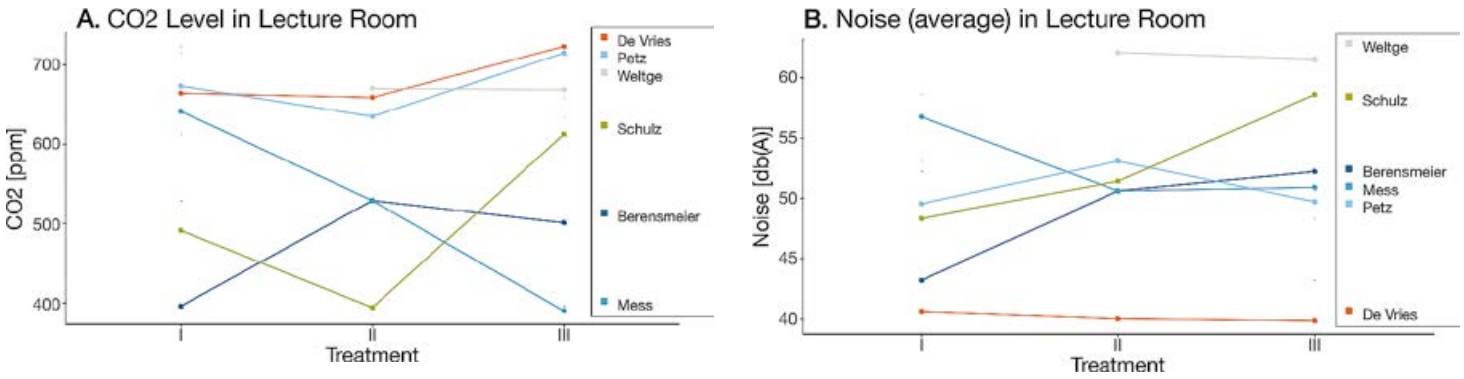



Fig. 3: Line charts visualising selected environmental conditions prevailing in the lecture halls of different university courses (cf. tab. 1) as a function of the respective Treatment. In case of Treatment I of lecture 5, no data is available due to technical issues during the measurement. A) Carbon dioxide concentration (denoted in parts per million). B) Average noise (denoted in A-weighted decibels).

prevailing $CO_2$ concentration (see Fig. 3 A). Therefore, further research may contribute to identifying more of the underlying factors.

## 4. Summary and future goals

In summary, the presented work provides evidence that the introduction of breaks in a lecture context represents an effective tool to enhance the individually perceived attentiveness of university students. It contributes to scientifically underlining the potential benefits of various initiatives promoting the incorporation of breaks into university schedules, such as the “Pausenexpress” project of the German university sports association (ADH) [32].

However, there is one important caveat to the conclusions of this study: As previously mentioned, the assumption of a homogeneous course- and student-base represents a simplification which was underlined by the analysis of interaction effects. In principle, one could explicitly account for these variables by applying more complex models. Expanding the investigated sample size might also help to deduce statistically significant conclusions in spite of an expanded parameter space.

Nevertheless, the obtained results are still valid under the given assumptions and, as such, may serve as a starting point for the creation of guidelines to implement break concepts at TUM. More globally, said guidelines might help to create a more prosperous and stimulating educational environment and thereby contribute to TUM’s ongoing aspiration for better knowledge transfer, as reflected in the TUM: Future Learning Initiative. ■

## References


1. https://www.britannica.com/science/attention. Retrieved March 30,2020.
2. Anderson, J. R. (2005). Cognitive Psychology and Its Implications. (p. 519) Macmillan.
3. Gardner, D. G., Dunham, R. B., Cummings, L. L., & Pierce, J. L. (1989). Focus of attention at work: Construct definition and empirical validation. Journal of Occupational Psychology, 62 (1), 61–77. https://doi.org/10.1111/j.2044-8325.1989.tb00478.x
4. Biederman, J., Nwecorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. American Journal of Psychiatry, 148(5), 564–577. https://doi.org/10.1176/ajp.148.5.564
5. Birchwood, J., & Daley, D. (2012). Brief report: The impact of Attention Deficit Hyperactivity Disorder (ADHD) symptoms on academic performance in an adolescent community sample. Journal of Adolescence, 35 (1), 225–231. https://doi.org/10.1016/j.adolescence.2010.08.011
6. Daley, D., & Birchwood, J. (2010). ADHD and academic performance: why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom? Child: Care, Health and Development, 36 (4), 455–464. https://doi.org/10.1111/j.1365-2214.2009.01046.x
7. https://www.academia.edu/25039190/Managing_Attention_Span_in_the_Digital_Age. Retrieved April 10,2020
8. https://www.telegraph.co.uk/news/2018/05/17/chinese-school-uses-facial-recognition-monitor-student-attention/. Retrieved March 30,2020.
9. Commodari, E., & Guarnera, M. (2008). Attention and aging. Aging Clinical and Experimental Research, 20 (6), 578–584. https://doi.org/10.1007/bf03324887
10. Stankov, L. (1983). Attention and intelligence. Journal of Educational Psychology, 75 (4), 471–490. https://doi.org/10.1037/0022-0663.75.4.471
11. Hanley, M., Khairat, M., Taylor, K., Wilson, R., Cole-Fletcher, R., & Riby, D. M. (2017). Classroom displays – Attraction or distraction? Evidence of impact on attention and learning from children with and withoutautism. Developmental Psychology, 53 (7), 1265–1275. https://doi.org/10.1037/dev0000271
12. Valdez, P., Ramírez, C., García, A., Talamantes, J., Armijo, P., & Borrani, J. (2005). Circadian rhythms in components of attention. Biological Rhythm Research, 36 (1–2), 57–65. https://doi.org/10.1080/09291010400028633
13. Rokke, P. D. ., Arnell, K. M., Koch, M. D., & Andrews, J. T. (2002). Dual-task attention deficits indysphoric mood. Journal of Abnormal Psychology, 111 (2), 370–379. https://doi.org/10.1037/0021-843x.111.2.370
14. Castro-Martínez, J. A., Chavarría Roa, J., Parra Benítez, A., & González, S. (2017). Effects of classroom- acoustic change on the attention level of university students. Interdisciplinaria: Revista de Psicología Y Ciencias Afines, 33 (2). https://doi.org/10.16888/interd.2016.33.2.1
15. McLellan, T. M., Caldwell, J. A., & Lieberman, H. R. (2016). A review of caffeine's effects on cognitive, physical and occupational performance. Neuroscience & Biobehavioral Reviews, 71, 294–312. https://doi.org/10.1016/j.neubiorev.2016.09.001
16. Brauer, M. (2014). An der Hochschule lehren. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642- 42006-1
17. Howie, E. K., Schatz, J., & Pate, R. R. (2015). Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study. Research Quarterly for Exercise and Sport, 86 (3), 217–224. https://doi.org/10.1080/02701367.2015.1039892
18. Bennett, A. (2015). Take five? Examining the impact of microbreak duration, activities, and appraisals on human energy and performance. (Doctoral dissertation). Retrieved from VCU University Archives.

19. Anderson, W. A., & Harrison, B. (1985). Lecture break. Journal of Agronomic Education, 14, 105–108.
20. Dababneh, A. J., Swanson, N., & Shell, R. L. (2001). Impact of added rest breaks on the productivity and well being of workers. Ergonomics, 44 (2), 164–174. https://doi.org/10.1080/00140130121538
21. Howie, E. K., Schatz, J., & Pate, R. R. (2015). Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study. Research Quarterly for Exercise and Sport, 86 (3), 217–224. https://doi.org/10.1080/02701367.2015.1039892
22. Bennett, A. (2015). Take five? Examining the impact of micro break duration, activities, and appraisals on human energy and performance. (Doctoral dissertation). Retrieved from VCU University Archives.
23. Hill, L., Williams, J. H. G., Aucott L., Milne, J., Thomson, J., Greig, J., Munro, V., & Mon-Williams, M. (2010). Exercising attention within the classroom. Developmental Medicine & Child Neurology, 52 (10), 929–934. https://doi.org/10.1111/j.1469-8749.2010.03661.x
24. Schmidt, M., Benzing, V., & Kamer, M. (2016). Classroom-Based Physical Activity Breaks and Children's Attention: Cognitive Engagement Works! Frontiers in Psychology, 7. https://doi.org/10.3389/fpsyg.2016.01474
25. Wilson, A. N., Olds, T., Lushington, K., Petkov, J., & Dollman, J. (2016). The impact of 10-minute activity breaks outside the classroom on male students' on-task behaviour and sustained attention: a randomised crossover design. Acta Paediatrica, 105 (4), e181–e188. https://doi.org/10.1111/apa.13323
26. Osnabrücker Forschungsgruppe (2016). Mittagsfreizeit an Ganztagsschulen. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-11623-1
27. https://www.tum.de/studium/im-studium/future-learning/. Retrieved March 29, 2020.
28. Papazoglou-Hennig, J., Hutschenreiter, S., Huber, D., Hasbach, S., Gandorfer, S., & Frey, D. M. (2020,May 14). Investigation of the effects of different break concepts on the attention of students during university lectures: Supplementary Information (Version 1.0.0). Version 1.0.0. https://doi.org/10.5281/ZENODO.3827961
29. https://www.aerzteblatt.de/nachrichten/102938/Zahl-der-Menschen-mit-drittem-Geschlecht-geringer-als-angenommen. Retrieved April 10,2020.
30. Lazovic, I., M., Stevanovic, Z., M., Jovasevic-Stojanovic, M., V., Zivkovic, M., M., & Banjac, M., J. (2016). Impact of CO2 concentration on indoor air quality and correlation with relative humidity and indoor air temperature in school buildings in Serbia. Thermal Science, 20 (suppl. 1), 297–307. https://doi.org/10.2298/tsci150831173l
31. Fernandes, R. A., Vidor, D. C. G. M., & Oliveira, A. A. de. (2019). The effect of noise on attention and performance in reading and writing tasks. CoDAS, 31 (4). https://doi.org/10.1590/2317-1782/20182017241
32. Coley, D. A., Greeves, R., & Saxby, B. K. (2007). The Effect of Low Ventilation Rates on the Cognitive Function of a Primary School Class. International Journal of Ventilation, 6 (2), 107–112. https://doi.org/10.1080/14733315.2007.11683770
33. https://www.adh.de/projekte/pausenexpress.html. Retrieved April 102020.

## Self Reflection

Looking back on 20 months of active membership in TUM: Junge Akademie, it has been a remarkable experience for every one of us here at team *Quintessence*. Seeing a scientific project unfold, from conception of ideas to preliminary research, fixing our goals and research question, case studies, planning and conducting our own study up to finally reaping the results, has been an incredible journey filled with lots of challenging and interesting turns along the way.

Our team initially formed under the theme “Perception” in November 2018. The formation process was successful, because, even as we were just starting to engage in open brainstorming, there was a clear feeling of confluence regarding our potential project ideas. We were all interested in the concepts of perception, attention, distraction, and concentration from the standpoint of education practices and corresponding effects on society in general. This gave our whole team significant initial motivation and encouragement, which carried over into the first months of our project work, allowing us to quickly isolate more concrete ideas worth pursuing. These included the development of a fact-checking service to contain the spread of misinformation, as well as the idea of creating a framework for improving the teaching setting at university.

Although our team size of six people appeared manageable, the designation of clear roles was extremely helpful for our organization. Especially, clarifying who is the primary responsible for matters of IT (e.g. set up of calendar, cloud storage, file structure), communication with internal or external actors (e.g. website, external partners, TUMJA-headquarters), general planning (e.g. meetings, timeline, work distribution) gave us some basic structure from which we could work off, while still maintaining the necessary flexibility to assign tasks throughout our team in order to deal with surprises, uncertainty, as well as intermittent absence of team members. Frequent and fixed meetings were also extremely beneficial during the first months, where we sat down together at an almost weekly basis to discuss our progress with preliminary research into scientific literature. From the beginning, we also learned the benefits of divide-and-conquer strategies. By often splitting off into smaller focus groups, we would be able to further analyze potential options regarding our procedure, before making important and significant decisions impacting our project.

Hence, by the end of January 2019, we had already reached a point, where we could clearly formulate a primary goal (*improving the individually perceived attentiveness of TUM-students in university lectures by 2020*) and corresponding research question (*How could an implementable concept be constructed such as to improve the individually perceived attention of TUM students in university lectures?*), along with preliminary hypotheses which we were planning to investigate in that regard. At this point we had also consulted our supervisors, who gave very helpful feedback with respect to a first validation of our hypotheses and the next possible steps.

Our organizational framework enabled us to plan two case studies in May and June 2019: one to ETH Zurich and one to RWTH Aachen. There, we wanted to observe and evaluate possible solution strategies to the end of improving attention in lectures. The planning procedure could have been handled a little more efficiently than it occurred, which resulted in slightly higher travel and accommodation cost. Nonetheless, the insights gained from both trips were valuable in mapping out promising implementation concepts for our own project.

With the knowledge taken away from the case studies and further input from our supervisors, as we approached July 2019, we managed to devise a clear concept for the study of lecture-breaks we wanted to conduct. Our plan was ambitious: Not only did we have to successfully organize a partnership with 6 different lecturers to schedule the administration of our study. We also wanted to design our own questionnaire, to assess the effect of the measures we were testing. For the latter, we cannot stress how valuable the input of our supervisors was in deciding the format and content of our survey. Finding the lecturers was not easy, but greatly aided through the connections made possible by TUM: Junge Akademie. The same was true with regard to preparing the administration of the questionnaires through the survey-platform EvaSys.

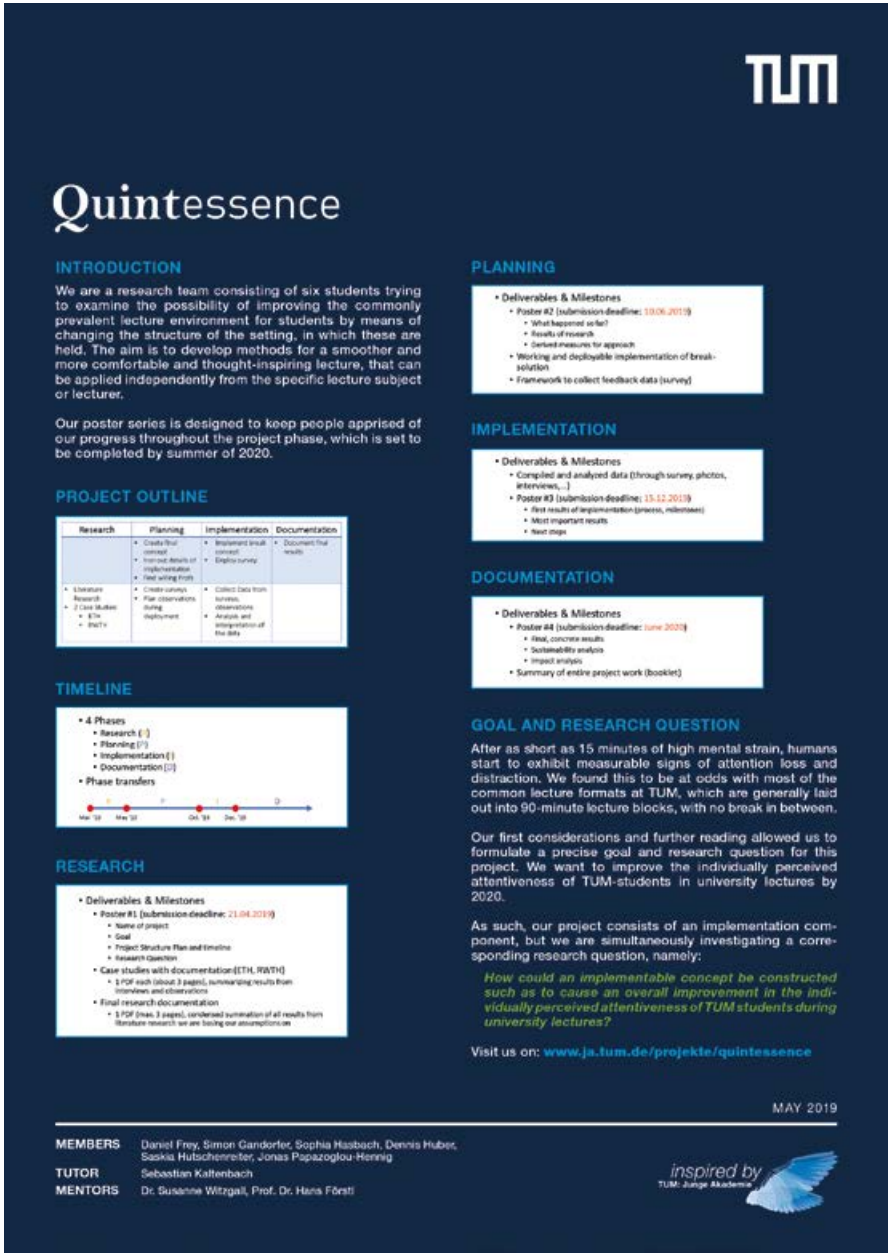
While some last-minute changes in schedule were necessary, but as a result of otherwise meticulous and thorough planning, the overall execution of our study in 7 weeks of November and December 2019 went along very well. However, we were extremely distraught over the fact that we had over-printed hundreds of questionnaires, which remained unused and will now have to be recycled. Admittedly, perhaps an online-based questionnaire would have been better from the perspective of sustainability and environmental concerns, yet we made the decision not to proceed in this way in fear of lower response rates. On the other hand, our study resulted in the test of two different lecture break formats (passive and activity- based) across different lengths (5 and 10 minutes) and yielded over 1000 valid questionnaires, giving rise to more than 10000 relevant data points for the analysis of our specifically devised statistical hypotheses. To our knowledge, it is the first time a study of such scale is being executed within the framework of TUM: Junge Akademie, which goes to show how much is possible in this scholarship program.

Overall, we are very satisfied with the development of our project over these past 20 months. We started out with a very vague set of ideas, which we managed to transform and incorporate into much of the work we completed since then. Certainly, it was an advantage that we were able to organize ourselves very efficiently right from the start, but we were also lucky that none of our plans went incredibly wrong, which allowed for a mostly smooth evolution of the project.

**Acknowledgements**

Our project would not have turned out the way it did without the valued support of our tutor Sebastian Kaltenbach, whose experience in TUM: Junge Akademie was invaluable to our process and whose commitment, attending most of our meetings and workshops, was highly appreciated. Further, we would like to thank our supervisors, Dr. Susanne Witzgall and Prof. Dr. Hans Förstl, for their distinguished perspective and input from their fields, which they both brought to the table. We are also very grateful for the lecturers, who entrusted us with their time to give us the possibility of performing our study in their lectures. We therefore extend many thanks to Prof. Dr. Sonja Berensmeier, Prof. Dr. Walter deVries, Prof. Dr. Filip Mess, Ms. Cindarella Petz, Prof. Dr. Jürgen Pfeffer, Dr. Thorsten Schulz, and Prof. Dr. Stefan Weltge. We are also very grateful for the collaboration with Christof Wendt, who devised and presented the program for all activity breaks. Finally, this entire enterprise would not have been possible without the resources provided by TUM: Junge Akademie, in particular due to the efforts of Maria Hannecker, Peter Finger as well as the entire team, who kept things running in the background as we were allowed to work on our project.

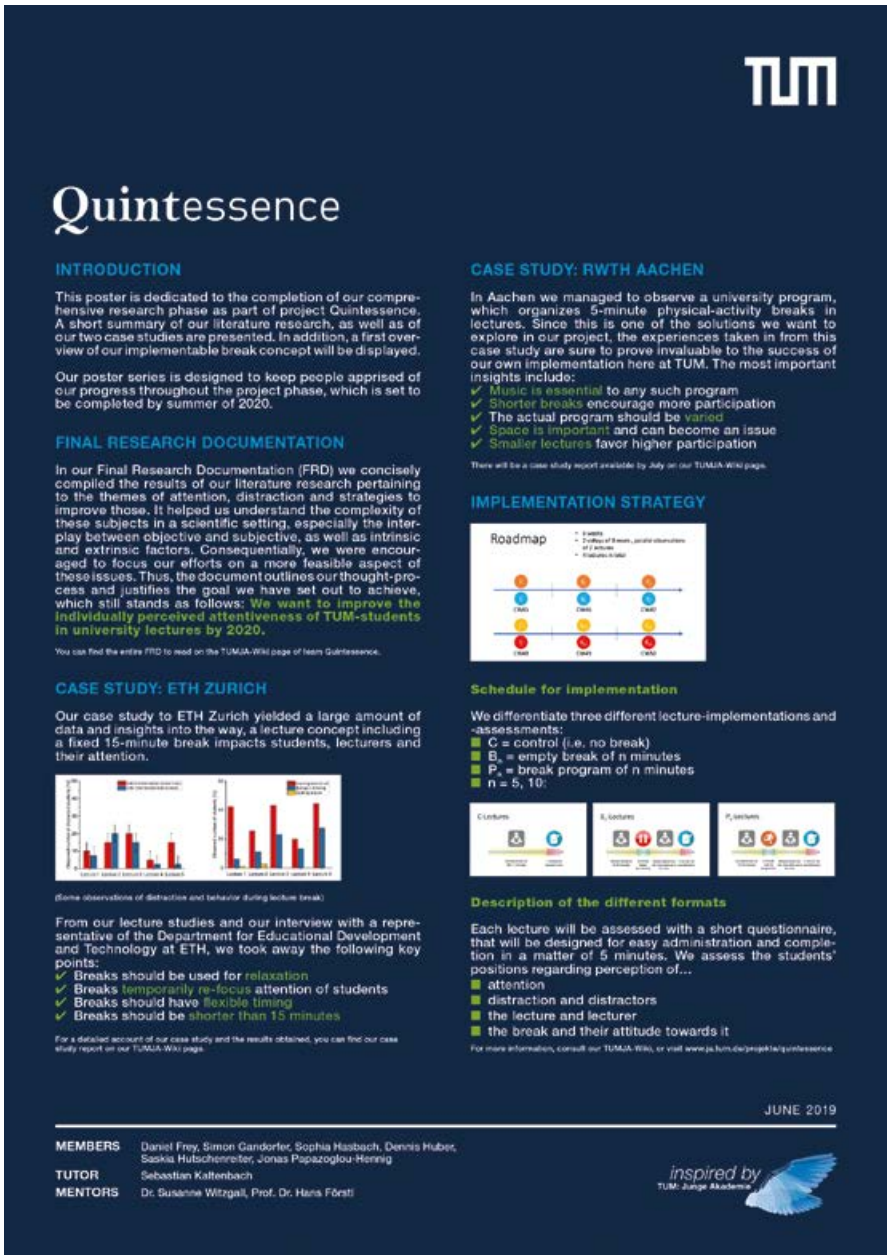
Thank you for this opportunity. ■




POSTER 1: Our team met in November 2019 to discuss the main theme of “Perception” and we soon agreed that, within this field, we were especially interested in questions of human attention span. To find out more about that topic, we first undertook some research. One of the main outcomes of this first research phase was the understanding that, after only about fifteen minutes of intense mental exertion, humans become distracted. After narrowing down the results of our research into different topics, we decided that we wanted to carry out our work within the university environment, partly because this would allow for easy access to sample target groups but, most importantly, because our initial research results strongly contradicted the concept of ninety-minute lecture lengths at most universities. After making this decision, we formulated our project goal: *to improve the individually perceived attentiveness of TUM students in university lectures by 2020.*

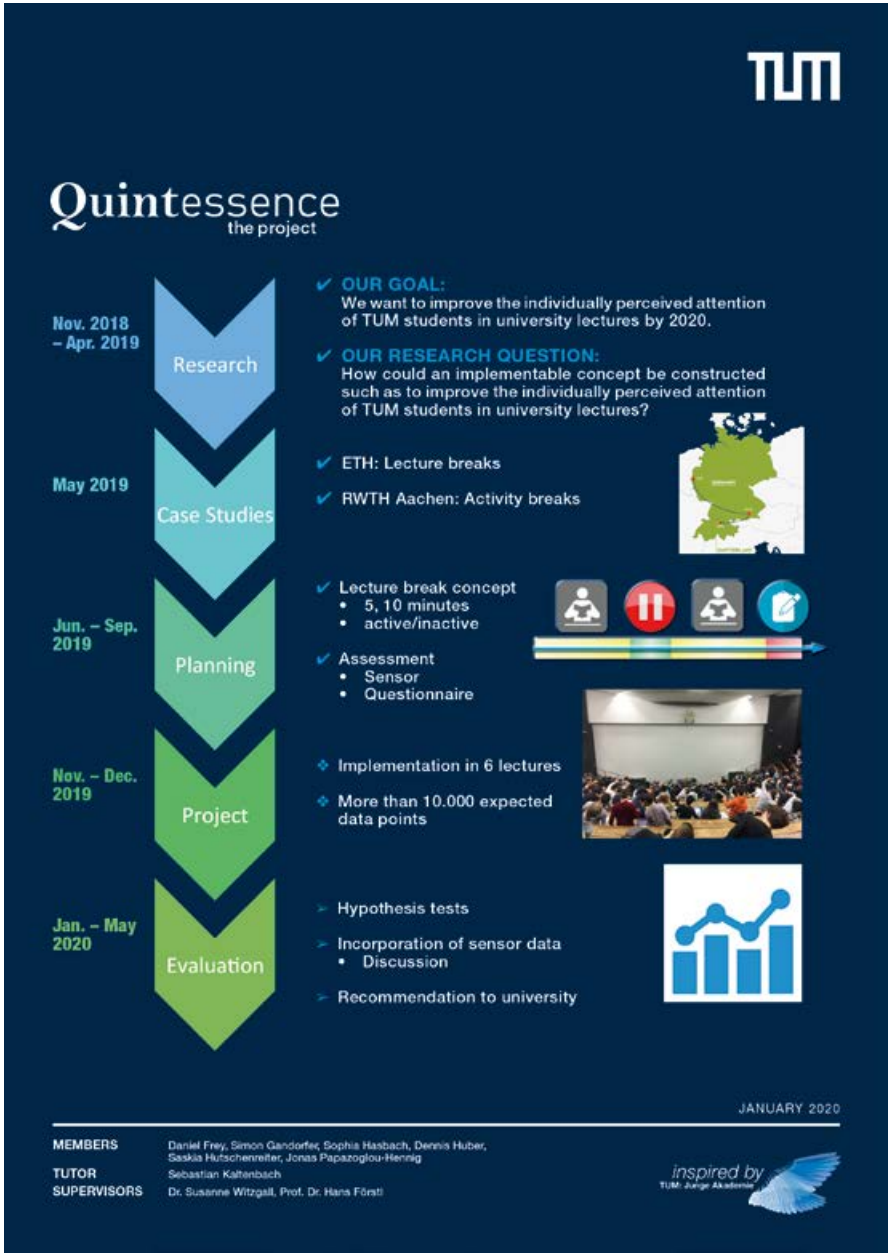
During a second research phase, we then figured that a promising and realistic tool for achieving our goal could be lecture breaks and therefore we decided to test different kinds of lecture breaks against each other. We had some ideas about what different kinds of lecture breaks this could entail, but we left this question open at that stage. However, as a result, we also came up with our scientific research question, that is: *How could an implementable concept be constructed such as to cause an overall improvement in the individually perceived attentiveness of TUM students during university lectures?*

To make sure that we could work efficiently, we then divided our project into four different phases and fixed a time span for each of them: a research phase with two case studies, a planning phase, an implementation phase and a documentation phase. The timetable of the four phases as well as our project goal and research question was our first milestone and can be found on our first poster.




POSTER 2: Up to the time when the second poster had to be finished, we were still mainly occupied with the research phase. We conducted two case studies, one at ETH Zurich, where there are fifteen-minute breaks after forty-five minutes of each ninety-minute lecture, and the other one at RWTH Aachen, where lecturers can book the "Pausenexpress," a physical lecture break offer by the university sports centre.

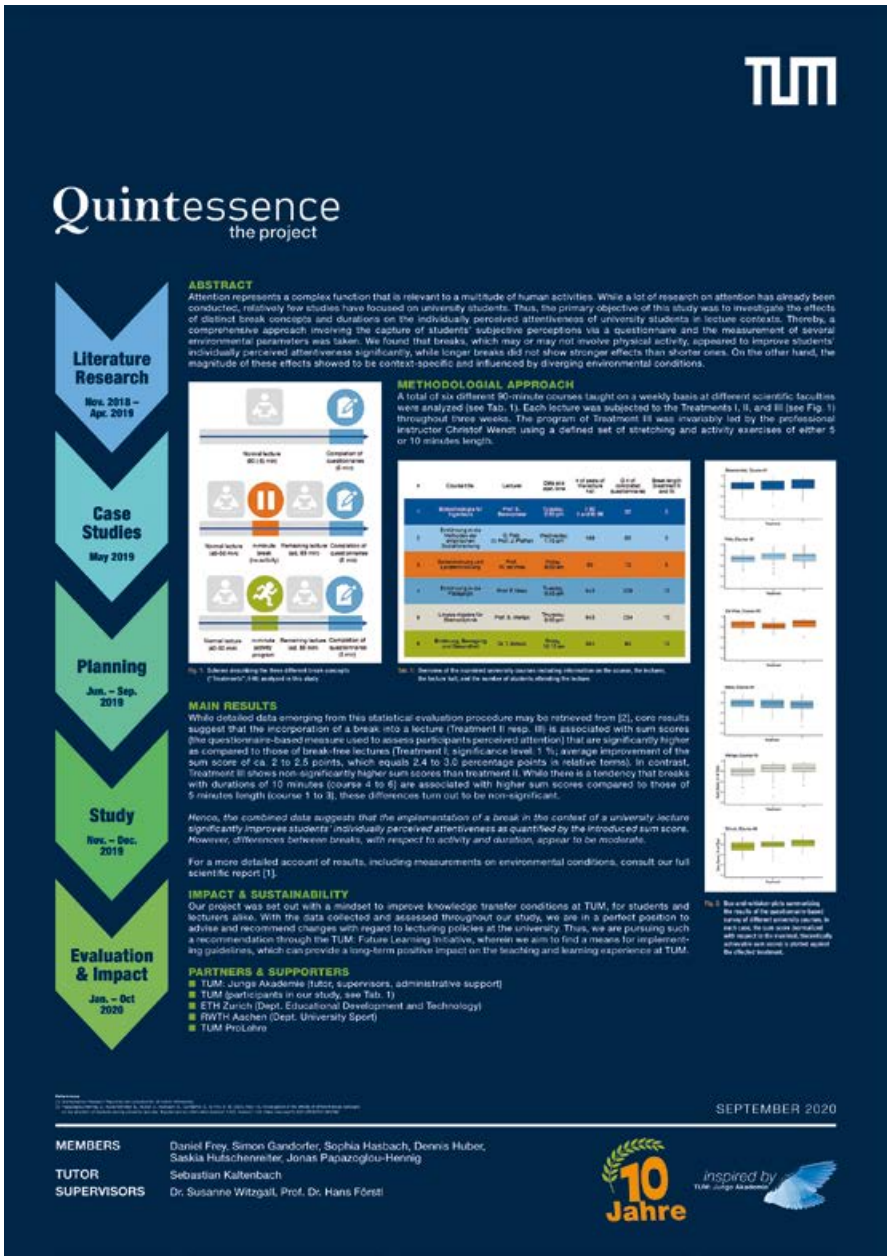
The results of these case studies encouraged us in our decision to use lecture breaks as a tool to improve the individually perceived attentiveness of students. Moreover, we were able to finalize what our lecture break concepts should look like specifically. We decided on two different kinds of breaks: a "normal, empty" break and a physical activity break that should both take place after about the first half of the lecture. Both break concepts were supposed to be tested against a normal lecture with no break in it at all (control). As a learning point arising from the two case studies was that the breaks should be shorter than fifteen minutes, we also decided to test both break concepts with a length of five minutes and ten minutes each. By doing this we also made sure that we had a larger variety of break concepts so that we would have a bigger choice as to the one that works best in the end. To measure individually perceived attentiveness, we decided on using a short questionnaire that assesses the students' positions regarding attention, distraction, the lecture and lecturer as well as the break itself. The specific lecture concepts are presented in detail on poster 2.




POSTER 3: After the research phase was finished, we finally started on planning the concrete implementation. We had already decided on the lecture break concepts, so the main focus here needed to be on how best to make the questionnaire capture relevant data about students' individual attentiveness. Using the results of our research and with the help of our supervisors, we developed twelve items that could be rated from "totally disagree" to "totally agree" and that would provide us with a sum score for each student in each lecture concept. These sum scores could then be statistically tested against each other. We were hoping that twelve items (one A4 page) were enough to get valid results on the one hand but also that, on the other hand, it did not take too long for the participants to fill it out. Also, we managed to borrow a sensor that could measure heat, humidity, $CO_2$ level and volume to be able to assess how far attention depends on these factors, too.

During that time, we also decided on implementing our program through six different lectures delivered three times each, using the two different break concepts and the control in each lecture, with one half of the lectures with five-minute breaks and the other one with ten-minute breaks. We then started writing and talking to lecturers who might support us by letting us implement our concepts in their lectures. Moreover, we found a fitness trainer to help us with the physical activity break.

All in all, during this phase of the project, we tried to make sure that our plans for the implementation phase were as detailed as possible, so that the actual execution of the project would work smoothly and without any problems. On the third poster, we summarized not only the results of this detailed planning phase but also of our whole project so far.




POSTER 4: Shortly after the third poster, we started our six-week implementation phase. We attended each lecture with two of our team members plus the fitness trainer for the physical activity breaks as he carried out the mobility program. As already mentioned, we planned everything in a very detailed manner and therefore there was not much to do for us during this phase except for attending the lectures and making sure that everything worked smoothly there.

As this phase took place shortly before the Christmas holidays, we decided to make a start on evaluating our results only after the holidays. We then assessed our data by testing if there were statistically significant differences between the sum scores (^= attention) of the different concepts and lengths. Also, we tried to figure out how the environmental data related to the sum scores. Our results were promising, and we started documenting them for the project book by splitting the different parts between our team members. On poster 4, we then tried to summarize our goal, our concrete project, our results and what we were hoping to achieve with our project, thus making the poster a brief summary of the key elements of our project. ■