UNIVERSITÄT SALZBURG

UNIVERSITY of SALZBURG
Department of Kinesiology

Symposium

“Sleep and (gross-) motor learning”

06/12 – 07/12/2017

University of Salzburg / Austria

Keynotes:

Genevieve Albouy – University of Leuven

Wolfgang Schöllhorn - University of Mainz

Philippe Peigneux - University of Bruxelles

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Team

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Franziska Shelembe

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Patrick Eibenberger

Michael Hahn

Kathrin Bothe

Janina Edfelder

Konrad Holzner

Juliane Schubert

Sandra Rigler

Ann-Kathrin Jöchner

Welcome Letter

Dear Attendees,

It is our pleasure to welcome you to our symposium, which is organized as a closing event of our interdisciplinary research project *"Sleep and gross-motor learning"* funded by the Austrian Science fund (FWF).

We are glad that all of you have agreed to come to Salzburg and join us for this exciting interdisciplinary symposium! We are looking forward to talks from internationally renowned researchers on the intertwined relationship of sleep, cognition, gross- and fine-motor learning.

The symposium will be held at the University of Salzburg, Faculty of Natural Sciences, Austria, at the "Dekanatssitzungssaal" (A1.033 first floor – see plan page 21).

The meeting will start on Wednesday, 6th of December, at 09:00am with a short opening session followed by the first talk at 09:15am. The day will be concluded with a dinner starting at 06:00pm at "Zwettlers" and a visit to the Christmas market afterwards.

The scientific part will be continued on Thursday, 07th of December, starting at 9:00am with the first talk. The meeting will be concluded at 12:00 with lunch at the local mensa.

We are looking forward to two exciting and eventful days with inspiring presentations and fruitful discussions on sleep and (gross-)motor learning!

Beside the scientific part we definitely encourage you to stay for the weekend to enjoy the beautiful surroundings, the white alps and great skiing resorts in the near vicinity.

Enjoy the meeting!

Kerstin Hödlmoser & Jürgen Birklbauer

Program - Wednesday, 06/12/2017

09:00 OPENING REMARKS AND INTRODUCTION

Erich Müller
Kerstin Hödlmoser & Jürgen Birklbauer

09:15 Philippe Peigneux

The complex relationships between sleep and learning

10:15 – 10:30 COFFEE BREAK

10:30 Kerstin Hödlmoser

The impact of diurnal sleep on the consolidation of a complex gross motor adaptation task

11:15 Franziska Shelembe

Sleep and cycle: a gross motor adaptation task benefits from sleep and fast spindle activity after training

12:00 – 13:30 LUNCH

13:30 Wolfgang Schöllhorn

Differencial learning and sleep

14:30 – 14:45 COFFEE BREAK

14:45 Johannes Burdack

Positive effects of differential rope skipping on mathematical performance

15:15 Jürgen Birklbauer

Increased EEG alpha activity in a Stroop-like gross-motor task of riding an inverse steering bicycle

18:00 – 20:00 DINNER

Program - Thursday, 07/12/2017

Geneviève Albouy **09:00**

Sleeping on the motor engram:
The multifaceted nature of sleep-related consolidation assessed with neuroimaging

COFFEE BREAK **10:00 – 10:15**

Kathrin Bothe **10:15**

The impact of sleep on complex gross-motor adaptation in adolescents

Michael Hahn **10:45**

Hints for different consolidation processes of complex gross motor skills between adults and adolescents

Marit Petzka **11:15**

Sleep to boost (re-) learning a fine-motor skill

CLOSING AND LUNCH **12:00**

Notes:

The complex relationships between sleep and learning

Philippe Peigneux

UR2NF-Neuropsychology and Functional Neuroimaging Research Unit at CRCN-Center for Research in Cognition and Neurosciences and UNI-ULB Neuroscience Institute Brussels, Belgium

It is now widely recognized that post-training sleep contributes memory consolidation, but how and to what extent ongoing information is processed during wakefulness then during sleep remains disputed. In this talk, I will first give a rapid overview of the different paradigms used to study the complex relationships between sleep and memory processes. I will then address several boundary conditions that can modulate memory consolidation, with a non-exclusive focus on motor-based learning. Potential modulators encompass, amongst others, the developmental status of the sleeper (from childhood to ageing), variations in vigilance status all across the day and developing fatigue, the way information is processed during wakefulness and possibly reinforced during sleep using targeted memory reactivation procedures, and the limits imposed by sleep neurophysiology to the ongoing processing and acquisition of novel information in the sleeping state.

Wednesday, 06/12/2017, 10:30

The impact of diurnal sleep on the consolidation of a complex gross motor adaptation task

Kerstin Hödlmoser

Laboratory for Sleep and Consciousness Research, University of Salzburg, Austria
Centre for Cognitive Neuroscience, University of Salzburg, Austria

Diurnal sleep effects on consolidation of a complex, ecological valid gross motor adaptation task were examined using a bicycle with an inverse steering device. We tested 24 male subjects aged between 20 and 29 years using a between-subjects design. Participants were trained to adapt to the inverse steering bicycle during 45 minutes. Performance was tested before (TEST1) and after (TEST2) training, as well as after a 2h retention interval (TEST3). During retention participants either slept or remained awake. To assess gross motor performance subjects had to ride the inverse steering bicycle 3x30m straight-line and 3x30m through a slalom. Beyond riding time, we sophisticatedly measured performance accuracy (standard deviation of steering angle) in both conditions using a rotatory potentiometer. A significant decrease of accuracy during straight-line riding after nap and wakefulness was shown. Accuracy during slalom riding remained stable after wakefulness but was reduced after sleep. We found that the duration of REM sleep as well as sleep spindle activity are negatively related with gross motor performance changes over sleep. Together these findings suggest that the consolidation of adaptation to a new steering device is not benefiting from a 2h midday nap. We speculate that in case of strongly overlearned motor patterns such as normal cycling diurnal sleep spindles and REM sleep might even help to protect everyday needed skills and to rapidly forget newly acquired, interfering and irrelevant material.

Sleep and cycle: a gross motor adaptation task benefits from sleep and fast spindle activity after training

Franziska Shelembe

Laboratory for Sleep and Consciousness Research, University of Salzburg, Austria
Centre for Cognitive Neuroscience, University of Salzburg, Austria

Sleep has been discussed to consolidate newly acquired motor skills better than time per se. For this study, students learnt a gross motor adaptation task, i.e. riding an inverse steering bicycle, and either slept or stayed awake during the retention interval. Those who slept could maintain their levels of performance, whereas those who stayed awake became significantly more slowly and unstable. Sleep spindle activity (SpA = mean spindle duration * mean spindle amplitude) was increased over the right hemisphere (F4, C4) after learning compared to an adaptation night. Within the sleep group, high activity of fast sleep spindles (13-15 Hz) in the learning night was associated with overnight performance gains. Our results indicate that sleep after training is beneficial to consolidate a gross motor adaptation task compared to wakefulness and that fast sleep spindles play a functional role in the consolidation of gross motor skills.

Wednesday, 06/12/2017, 13:30

Differencial learning and sleep

Wolfgang Schöllhorn
University of Mainz, Germany

Meanwhile the positive effects of variable learning are generally accepted. Nevertheless, the structure of effective variability and its specific effects on our brain are still areas where our knowledge displays big gaps. The theory of differencial learning suggests the model of stochastic resonance for structuring and for a quantitative analysis of all motor learning approaches (Schöllhorn et al 2006; 2009). Thereby all learning interventions are considered to be accompanied by a certain amount of noise that follow a resonance characteristic with an optimum amount of noise for most effective learning. In consequence even fatiguing exercises are considered as sources of noise that foster learning (Aragones et al 2017). Furthermore the theory suggests that the optimum is not only variable for each individual but is also changing by situation. This suggestion is supported by recent findings. Firstly, movement patterns are changing by themselves within a day and on different days without any intervention (Horst et al 2016; Horst et al 2017), and secondly, movement patterns are changing by emotions, music and fatigue (Janssen et al 2008).
On the search for neurophysiological mechanisms of motor learning a comparison of different short term learning approaches revealed specific patterns of EEG brain activation immediately afterwards (Henz et al 2017). Some EEG patterns displayed high similarity with brain activations of meditating people with high content of alpha and theta EEG activation (Henz et al 2016). Because these frequency bands are of importance in certain sleeping phases parallels will be discussed.

Positive effects of differential rope skipping on mathematical performance

Johannes Burdack
University of Mainz, Germany

Meanwhile positive effects of sports on executive functions are commonly accepted. However, chronological aspects in connection with sports method and their effect on mathematical abilities are barely considered. The aim of this study was the mid-term influence of differential rope skipping on mathematical performance applied after math lessons.

In a pre- posttest-design with retention test 26 pupils (13.9 ± 0.69 years) performed a 5 minute differential or repetitive rope skipping program following a 15-minute learning session in mathematics. The intervention comprised three sessions per week and lasted three weeks. Beside the math tests the heart rates were controlled just before rope skipping.

The results revealed a statistically significant difference between both groups for the development of the mathematical performance. From pre- to posttest both groups improved statistically highly significantly. From post- to retentiontest the differential group again improved significantly, while the performance of the classical rope skipping decreased slightly. No statistical differences in the heart rate between the groups were identified.

As there is evidence for an increase in theta frequencies in brain activation after differential training (Henz & Schöllhorn 2017) we assume that post learning differential training affects cognitive learning in a similar way as specific sleep stages do due to the thereby generated brain activity. The results provide evidence for sustainable improvement of cognitive learning performance and efficiency by integrating specifically adapted differential workouts for instance in school, university or in professional life.

Wednesday, 06/12/2017, 15:15

Increased EEG alpha activity in a Stroop-like gross-motor task of riding an inverse steering bicycle

Jürgen Birklbauer
Department of Sport Science and Kinesiology, University of Salzburg, Austria

In order to avoid falling back into an old routine, one has to suppress the retrieval of the previously learned and interfering memory traces that in turn are thought to rely on top-down, inhibitory control processes (Klimesch et al. 2007). A paradigmatic example in a cognitive setting is the stroop task in which alpha oscillations were found to increase amplitudes in prefrontal regions as a function of the degree of interference (Hanslmayr et al. 2008). The aim of our study was to test whether oscillatory alpha activity also amplifies in a relearned gross-motor skill, i.e. riding an inverse steering bike.

We tested 15 right-handed subjects who had become familiar with an inverse-steering bicycle such that they dare to ride the bicycle in normal road traffic. All subjects performed two different riding conditions, i.e. 10 x 30m straight-line riding and 10 x 30m slalom riding. Both conditions were executed twice with both the inverse-steering bicycle and a structurally identical but normal-steering bicycle in a randomized order. EEG data were recorded from 16 electrodes throughout all 30-m-rides and a 3-minute resting conditions with eyes open.

We found significant differences between straight-line and slalom riding as well as between the inverse and normal-steering condition. Task related alpha power changes were significantly more prominent in frontal and occipital regions throughout riding the inverse-steering compared to the normal bicycle. In relation to the straight-line condition alpha power changes were significantly enhanced at frontal sites during riding the slalom.

We interpret the hypothesized EEG alpha power synchronization during inverse steering as a cortical correlate of top-down control to inhibit the retrieval of the habitual and dominant motor memory traces of normal steering. The difference in alpha activity between slalom and straight-line riding may reflect the higher challenge of the slalom task imposing a more intense cognitive load to control the bicycle through the slalom course.

Sleeping on the motor engram: The multifaceted nature of sleep-related consolidation assessed with neuroimaging

Geneviève Albouy
Movement Control and Neuroplasticity Research Group, Movement Sciences Department, KU Leuven, Belgium

While several models of sleep-related memory consolidation have previously associated hippocampal activity with declarative memory, there is now increasing evidence that the hippocampus also plays a crucial role in motor memory. In this presentation, I will review human functional neuroimaging studies demonstrating that the hippocampus is involved in the acquisition and sleep-related consolidation of procedural memories, and motor sequence-based skills in particular. More specifically, I will present evidence that hippocampal activity and its functional interactions with other brain structures, including the striatum in particular, contribute to the initial learning of sequential motor behavior. Interestingly, these early cerebral representations in the hippocampus and striatum can predict subsequent sleep-related memory consolidation processes. I will present recent work offering insights into the respective roles of these structures in motor memory consolidation processes. Altogether, the data I will present indicate that sleep-dependent motor memory consolidation depends upon multiple boundary conditions, including the recruitment of relevant neural substrates (and the hippocampus in particular). I will then conclude my presentation with preliminary results of ongoing research projects aiming at modulating the neurophysiological processes underlying consolidation in order to influence motor behavior.

Thursday, 07/12/2017, 10:15

The impact of sleep on complex gross-motor adaptation in adolescents

Kathrin Bothe
Laboratory for Sleep and Consciousness Research, University of Salzburg, Austria
Centre for Cognitive Neuroscience, University of Salzburg, Austria

Sleep has been shown to facilitate the consolidation of newly acquired motor memories in adults. However, the role of sleep in motor memory consolidation is less clear in children and adolescents. Therefore, we investigated the effects of sleep and wakefulness on a complex gross-motor adaptation task, i.e. riding an inverse steering bicycle. 30 healthy subjects aged between 11 and 14 years (5 female; M=12.47 years, SD= 0.78) were either trained to ride an inverse steering bicycle with supporting wheels (learning condition) or a stationary bicycle ergometer (control condition). Training took place in the morning (wake group, n= 14) or in the evening (sleep group, n=16) and was followed by a 9h retention interval and a subsequent re-test session. Polysomnography (EEG, EMG, EOG) was recorded in the sleep group during adaptation and test nights (control, learning). Slalom cycling performance was assessed by speed (Runtime [s]) and accuracy (standard deviation of steering angle, SDSD [°]) measures. Results showed no evidence for sleep-dependent memory consolidation on a behavioral level. However, analyzing our sleep data, we found an increase in left hemispheric slow spindle activity from control to learning night being associated with overnight performance gains in accuracy. Furthermore, an increase in REM duration was favorable for performance gains in speed. Thus, although not yet detectable on a behavioral level, sleep seemed to play a role in the acquisition of gross-motor skills. Hence, a promising direction for future research might be to focus on the possibility of delayed performance gains in adolescent populations.

Hints for different consolidation processes of complex gross motor skills between adults and adolescents

Michael Hahn

Laboratory for Sleep and Consciousness Research, University of Salzburg, Austria
Centre for Cognitive Neuroscience, University of Salzburg, Austria

The beneficial effect of sleep-dependent memory consolidation on simple fine motor task performance has been well investigated and understood in adult populations. But in contrast to adult populations, younger populations not only often do not show performance gains after sleep but instead show performance gains after wakefulness. Similar to the memory consolidation processes of younger populations, the effect of sleep on complex gross motor skill learning is less investigated and understood, even though gross motor skills are essential for daily life. Our study aimed to fill these gaps in literature by comparing complex gross motor skill learning (i.e. juggling) of adults and adolescents after sleep and wakefulness. Adult (n = 25, 15 male) and adolescent participants (n = 20, 19 male) were divided into sleep and wake groups. In the sleep groups, juggling was learned in the evening and performance was tested before and after a full-night polysomnography. In the wake groups, juggling was learned in the morning and performance was tested before and after a period of wakefulness. Results show that adults maintained their performance after sleep, whereas performance declined after wakefulness. Adolescents however, declined their performance after sleep but maintained their performance after wakefulness, showing the exact opposite pattern to adults. Only in adults fast sleep spindle activity was related to overnight juggling performance changes, a result that could be the starting point to disentangle different memory consolidation processes between adults and adolescents.

Thursday, 07/12/2017, 11:15

Sleep to boost (re-)learning a fine-motor skill

Marit Petzka
Laboratory for Sleep and Consciousness Research, University of Salzburg, Austria
Centre for Cognitive Neuroscience, University of Salzburg, Austria

Relearned fine-motor skills, like typing on a mirrored keyboard, are supposed to require suppression of over-practiced motor skills, like typing on a regular keyboard. Interestingly, performance on the habitual skill often worsens after practicing such an unusual skill. In the following study the impact of sleep on this interfering effect was investigated.

25 males (25.44±4.56 years) had to practice touch typing of words as rapidly and accurately as possible first, on a regular keyboard (4x3min) and then on a mirrored keyboard (12x3min). After 8h of diurnal wakefulness (wake group, n=11) or nocturnal sleep (sleep group, n=14) the fine-motor performance was assessed on the regular and afterwards on the mirrored keyboard. Fine-motor performance was measured by the number of correctly typed letters per 30s.

Subjects in the sleep group showed a significant decrease in regular typing speed after nocturnal sleep whereas mirrored typing did not change. For subjects in the wake group we found a significant deterioration in mirrored typing but no change in regular typing. Furthermore, we could demonstrate a significant correlation (r_{14}=0.644, p=0.013) between fast (13-15Hz) sleep spindle number during sleep stage N2 and overnight gains in mirrored typing. The results indicate an increased retroactive interference during regular keyboard typing after sleep which may occur because of a more effective consolidation of the mirrored keyboard typing skill during sleep in comparison to wakefulness. Additionally, we provide further evidence that fast sleep spindle number during N2 promotes re-learning of a fine-motor skill.

Thursday, 07/12/2017, 12:00

Concluding words

Kerstin Hödlmoser & Jürgen Birklbauer
Laboratory for Sleep, Cognition and Consciousness Research, University of Salzburg
Centre for Cognitive Neuroscience, University of Salzburg

Thursday, 07/12/2017, 12:00

Lunch

Notes

Maps

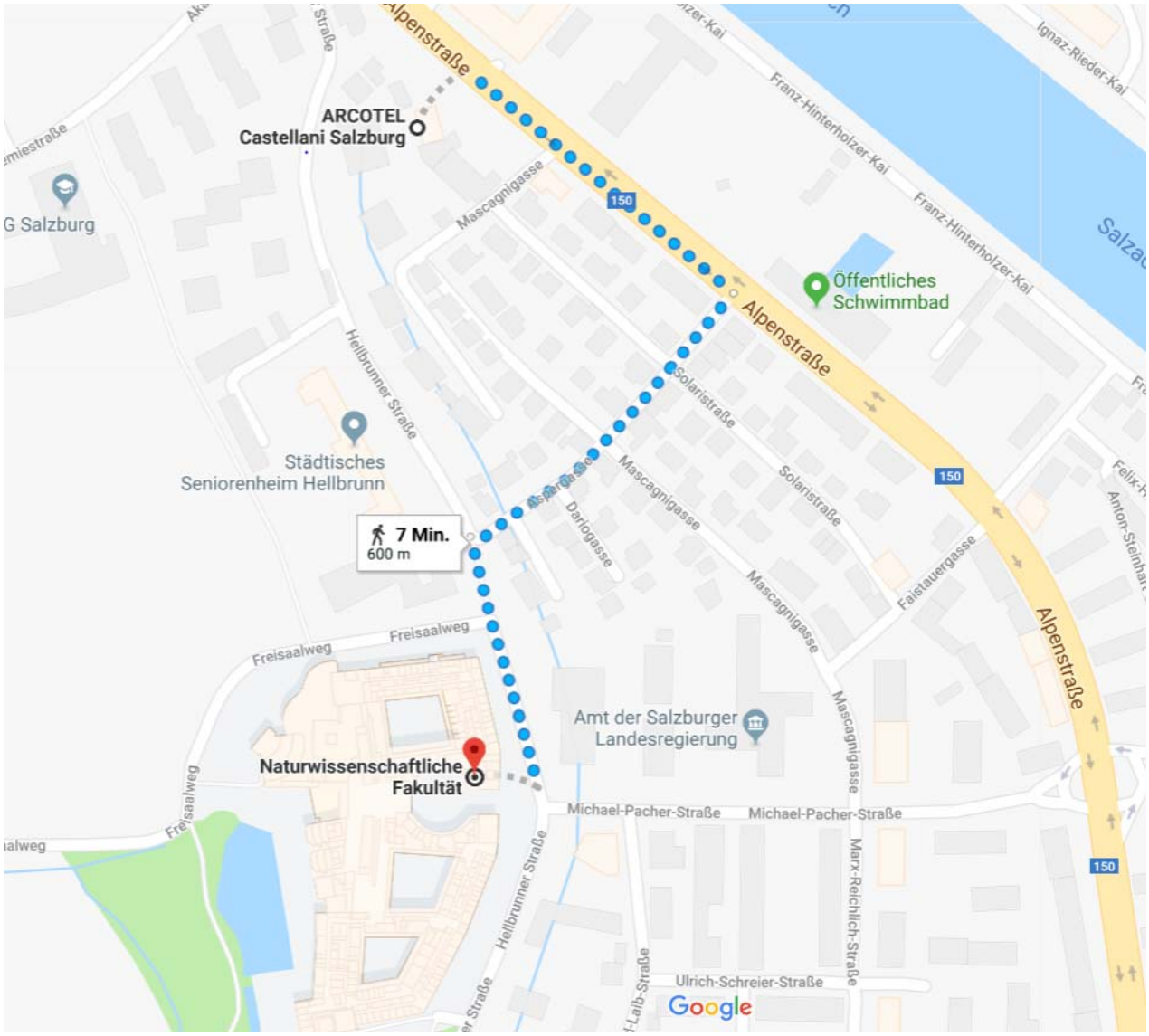
From the train station to your hotel

Hotel Castellani
Alpenstraße 6
5020 Salzburg
Phone: +43 (0) 662 20600

Maps

From Hotel Castellani to the Faculty of Natural Sciences

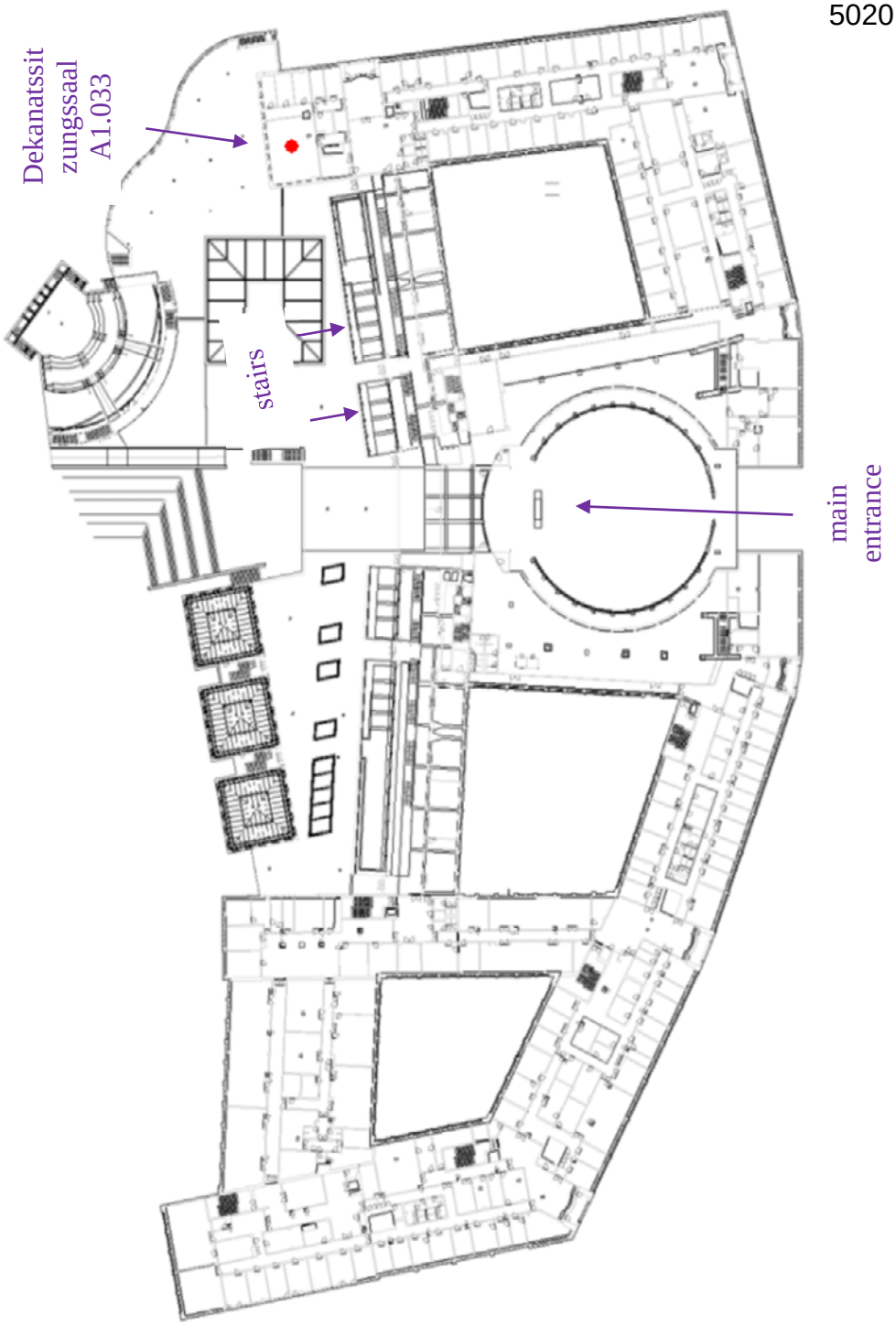
Hellbrunner Str. 34
5020 Salzburg



Maps

Room A1.033 Dekanatssitzungssaal

1st floor
Hellbrunner Str. 34
5020 Salzburg



Maps

From Hotel Castellani to ZWETTLERS

Kaigasse 3
5020 Salzburg
Phone: +43 (0) 662 844199
www.zwettlers.com

Notes

Symposium Information

1. Venue

University of Salzburg
Faculty of Natural Sciences
Hellbrunner Str. 34
5020 Salzburg
Austria

Room A1.033
Dekanatssitzungssaal
1st floor
(find a plan on page 21)

Sleep lab team ☎: +43 (0) 650 5983523

2. Information for speakers

Please ensure that you are available in the seminar room at least ten minutes before the start of your session (please check the program above for more details on the time schedule). It is recommended that all speakers load their PowerPoint slides on the computer at least 2 hours prior to the start of the session. You may also send your presentations to **Ann-Kathrin Jöchner:** ann.joechner@stud.sbg.ac.at in advance.
Preferably, all presentations should be in PowerPoint (the computer is running Windows 10 and PowerPoint 2013). To avoid compatibility issues, we would kindly like to ask you to convert presentations prepared on a Mac to PDF. If this is not possible, please be prepared to use your own Mac for the presentation. We would appreciate if the keynote speakers prepared a talk for a maximum of 45 min + 15 min discussion. All other speakers are expected to prepare a talk for a maximum of 20 min + 10 min discussion.

3. Refreshments and meals

Coffee, tea and water will be served during the coffee breaks. Lunch can be ordered in the local MENSA. Dinner on the 6th of December (18:00-20:00) will take place at ZWETTLERS in the city center of Salzburg. Please find information for the dinner on page 22. After dinner it might be nice to visit the famous, beautiful “Christkindlmarkt” in the city for a hot “Glühwein” or “Punsch”.

3. WIFI

Wifi is available throughout the University and will be free to all delegates:

user: *sleep*
password: *motor*