Psychological Impacts of Polyphasic Sleep

Author: Tomáš Votruba

Supervisor: Mgr. Stanislav Ježek, Ph.D.

Brno
2012
I declare that I have worked on this thesis independently, using only the primary and secondary sources listed in the bibliography.

Brno, May 4th 2012

Tomáš Votruba
Acknowledgments

I would like to express sincere gratitude to my supervisor Mgr. Stanislav Ježek, Ph.D. for giving me great insight into single–case experiment study I barely believed to realize as my thesis, for the help with test algorithms, and really enjoyable consultations, to MUDr. Petr Smolík, CSc., MUDr. Miroslav Moráň, and MUDr. Radkin Honzák CSc. for profession medical consultations and critical approach, which helped me to avoid some mistakes, to all polyphasic sleep amateur researchers, who have been a great source of inspiration and motivation to me, and to Mgr. Petr Šaněk for introducing me to this lifetime topic.

Moreover, I would like to thank my friends and mainly flatmates for support, interest and tolerance for my strict daily regime during the whole experiment. Last, but not least, I want to thank to my parents as well as my girlfriend, Lucia Patoprstá, who withstood being woken up at night countless times in previous one and a half years of polyphasic sleep experiments.
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A quote from *Why We Nap* (Stampi, 2002, p. 17) should make it clear: ‘The author would like to caution against misleading interpretations of these conclusions. What is being proposed here is not that polyphasic sleep is preferable to monophasic sleep, nor that everyone should now switch to a multiple napping behaviour ‘panacea’. It appears obvious that quasi-monophasic sleep—monophasic sleep plus occasional naps—is what comes most naturally to the majority of adult humans and few other species. If somewhere in evolution such species have developed the ability to sustain wakefulness for relatively prolonged periods, most likely this ability occurred in response to some sort of important and advantageous adaptive pressure.’
1. Introduction

Modern lifestyle and society has made the time reserved for sleeping marginal, which may lead to many sleep difficulties and disorders such as insomnia or daily fatigue. Disorders may lower the productivity, effectiveness, and well-being, and they are usually artificially fixed by sleeping pills. Fatigue after 8 hours of work, including the travel from and to work, can influence one’s approach to hobbies, well-being and relationships. However, there are also sleep patterns alternative to monophasic sleep, called polyphasic sleep, which can satisfy the need for sleep and ensure a whole productive day as well. It is characteristic for polyphasic sleep to divide the amount of time spent by sleeping into a core sleep and one or more naps. Polyphasic sleep includes many different sleep patterns, which vary by core sleep length, number of naps, and the time intervals, which are usually equidistant. Many studies (i.e., Stampi, 1992, 1989, Carskadon & Dement, 1975, 1977, Stampi & Davis, 1991) focus on the most extreme polyphasic schedule. In the community of amateurs interested in polyphasic sleep, this ultra-short sleep is commonly known as Überman\(^1\) (U) and it is formed by 6 naps lasting altogether 2 hours a day. This sleep schedule is very difficult to keep in the life of an average person for a long time, unless very strict conditions are met. Therefore a schedule Everyman\(^3\) (E3), which suits better to the normal life conditions, was chosen to be employed in practice. This schedule is formed by core sleep\(^2\) 3-hour-long, and 3 naps of 20 min each. This sleep pattern results in the total sleep length of 4 hours. This study compares cognitive and behavioural aspects of monophasic sleep pattern and polyphasic sleep pattern in the context of an all-day productivity, to maximize time period of optimal productivity level.

This thesis focuses on the psychological aspects of a sleep pattern transition, whereas physiological changes like circadian rhythm changes, heart pressure, and weight changes are dealt with only marginally. However, it is still important to bear these factors in mind for they can be connected to changes in sleep pattern as well and because the immunity system and health problems are topics which are questioned by psychology at most. I will present and compare monophasic and polyphasic life approach and all described aspects.

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\(^1\) Originally coined by PureDoxyk as “Uberman’s sleep schedule” (2008). From German Übermensch.

\(^2\) Known also as anchor sleep.
1.1 Why Research this Topic

The main source of my motivation is my profession of freelance PHP programmer, which allows me to decide and set my working hours by myself. This absence of outer control allows me to control my day-time schedule, apart from obligatory school lessons (whose time periods are strictly set). On contrary, an average person’s daytime schedule is limited by the working hours (at least 8 hours), which predetermines them for monophasic sleep patterns.

My goal is to be productive and able to work on paid, unpaid, and personal projects while keeping the same amount of leisure time for activities not related to my work (or earning of money), and to spend my time pursuing my hobbies, engaging in social activities, and relaxing. I want to improve social contact in altruistic approach, by extending time dedicated to dyadic contact, so I would not be tempted to use excuses such as ‘I don’t have time for this, sorry’, and I would be able to help the person. My aim is to internalize this approach and balance with enough work time satisfaction, meaning I would have time to earn money for living and also time in the same amount for social contact.

1.1.1 Expected Benefits

Having more free time could minimize the stress caused by time pressure and deadlines (this often occurs when in the role of freelances and students), lessen stress while solving problems by my awareness of the sufficiency of time and space, reduce health problems connected with stress, and increase the efficiency of solving challenging and difficult tasks (better self-efficacy and self-control). In social relationships, I could develop a more kind, open and altruistic approach to other people, bearing in mind I can give enough time to myself, to my work and to my studies. I can experience time dilatation and perceive time truncation (see My Lifestyle) due to longer vigil period during the day. From the point of self-concept, As far as the self is concerned, self-evolving and self-changing processes would be faster in comparison to processes of those, whose days are relatively shorter. For example, 100 hours of self-development would pass sooner during my practicing the polyphasic schedule than during one’s monophasic schedule with 6 hours of sleep a day. This would bring faster self-esteem improvement, better performance while multitasking, better adaptability due more flexible working memory, precise time management, due to strict sleep pattern, because I would have to plan my time with care. This all would give me greater competence at work and for my studies, which can be from an outside view interpreted as higher intelligence, better abilities or skills with no real changes of those aspects in myself.
1.1.2 Expected Handicaps

Polyphasic sleep can bring many handicaps mainly caused by shorter total sleep duration (in my case 3-hours shorter), mainly lower physical regeneration and physical weakness, especially during transformation from one sleep schedule to another. During this period I could struggle with inferior activity in physical, cognitive and emotional dimensions, for example, lack of alertness, oversensitivity, and confusion. A phenomenon called Immunity fade is also reported: ‘A great deal of polyphasic attempts end up with a cold or influenza, which must reflect the impact of this sleep schedule’ (Wozniack, 2010, para. 4). This is one of the key elements during the adaptation, where I can fail a lot. From behavioural point of view, my resistance to various kinds of persuasion or frauds could lower due to a greater frankness to others, related to altruism mentioned in the previous section. Polyphasic sleep can also affect negatively my long-term memory, cause thinking in more chaotic structures, and inability to perform activities that last longer than 5 hours because of the strict schedule; however rare such activities are, they still pose a failure risk. In that case, I would need either more energy to keep self-concept at same consistency level, or inevitably change self-concept.

3 Reference to U.
2. Polyphasic Sleep

Polyphasic sleep, also called *segmented sleep*, covers all sleep patterns with multiple sleep episodes (SE) a day, contrary to monophasic sleep covering only 1 main SE. Common association or synonym is U sleep schedule (see *Polyphasic Sleep Schedules*), therefore it is important to be clear, which schedule is meant under ‘polyphasic sleep’ in each particular use. It is typical for polyphasic sleep to divide sleep phases to *core/anchor sleep*, a continuous period of sleep during the night, and *nap/power nap*, short sleep episode usually in daytime that lasts on average 30 min depending on specific schedules’ rules. Nap duration includes falling asleep and waking up, sleep itself is shorter (usually 20 min). Naps have to be performed in *equidistance*, which means equal distance from each other, e.g., every 5 hours. It is possible to shift them slightly because some phases could be more vigilant and energetic than others; it depends on individual abilities and needs.

2.1 Polyphasic Sleep in the Nature

Polyphasic sleep is relatively widespread in the animal kingdom. In a recapitulation of phylogeny, human babies also sleep polyphasisically, and gradually lose their nap slots until they become roughly biphasic around the age of one. Human adults, similarly to all great apes, are largely biphasic. Although a majority of westerners\(^4\) do not nap on a regular basis, their alertness shows a slump in alertness in the middle of a subjective day. This slump can consolidate in a short block of sleep in free-running conditions (Stampi, 1992, Campbell, Dawson, & Zulley, 1993). Electroencephalographic (EEG) measurements indicate that humans are basically biphasic (Wozniak, 2005). There is a single powerful drive to sleep during a subjective night and a single dip in alertness in the middle of the subjective day (Monk, 2005). EEG measurements are confirmed by many other physiological variables such as temperature measurements, cortisol levels in the blood, melatonin level in the saliva, levels of other hormones, blood pressure, gene transcription, immune cell activity, subjective alertness, motor activity, and other parameters (Stampi, 2002).

2.2 Polyphasic Sleep Schedules

Polyphasic sleep can be performed in many different ways, from a biphasic schedule, suitable for people with non-flexible life-style, to U or *Dynamion* schedule with very strict

\(^4\) People from America and Western Europe representing group of developed countries
conditions and great time benefit as one gets 2 hours of sleep. *Table 1* shows a list of all strict polyphasic schedules, but there are also possible free schedules (see *Spamayl* bellow).

*Table 1. Strict Polyphasic Schedules with Their Typical Sleep Setting*

<table>
<thead>
<tr>
<th>Schedule Name</th>
<th># Naps (20’)</th>
<th>Core Sleep (hr)</th>
<th>Total Sleep (hr)</th>
<th>Net Benefit (vs. 8 hr)</th>
<th>Nap Schedule Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monophasic</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Biphasic</td>
<td>1</td>
<td>6</td>
<td>6.3</td>
<td>1.7</td>
<td>+/−3 hr</td>
</tr>
<tr>
<td>E2</td>
<td>2</td>
<td>4.5</td>
<td>5.2</td>
<td>2.8</td>
<td>+/−2 hr</td>
</tr>
<tr>
<td>E3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>+/−1 hr</td>
</tr>
<tr>
<td>E4</td>
<td>4 or 5</td>
<td>1.5</td>
<td>2.8</td>
<td>5.2</td>
<td>+/−30 min</td>
</tr>
<tr>
<td>U</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>+/−30 min</td>
</tr>
<tr>
<td>Triphasic</td>
<td>3 * 90’</td>
<td>0</td>
<td>4.5</td>
<td>3.5</td>
<td>—</td>
</tr>
<tr>
<td>Dyxamion</td>
<td>4 * 30’</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>—</td>
</tr>
</tbody>
</table>

This thesis aims to research sleep pattern schedule E3, therefore in sections *Method* and *Discussion* under polyphasic sleep conception of E3 is meant.

### 2.2.1 Spamayl

Recent and a very free type of schedule is SPAMAYL, in full words ‘sleep polyphasically as much as you like’, which means taking naps when a person ‘feels so’, possible in combination with core sleep. Total length differs. This sleep schedule is very popular because of its free regime and because it is easy to attempt after being unsuccessful in other, more strict schedules. Another alternative of free schedules is for example *SL-U* for ‘schedule less’ U.

### 2.2.2 Individual Alternatives

Experiments with polyphasic sleep can be very individual and flexible (see *Figure 1*), i.e., from monophasic 8-hour sleep to 2 hour nap, 3,5 hour core sleep and 1 20 min nap, 6 hours in total (MyZeo, 2010).
2.3 Adaptation Period

The period of transition from one sleep schedule to another is called the adaptation period. For different schedules it has different difficulty and length, and brings different sets of issues. During this period, the subject may feel weak, fatigue, experience sleep deprivation, and perform worse when compared to the baseline. Sbragia attempting U experiment describes how difficult it was to adapt to such a schedule mainly in the first 2–3 weeks, and how he eventually succeeded in adjusting to a 22.5-hour waking day. He vividly explains how, after this initial adaptation period, this schedule appeared natural, and describes the ‘new world’ that he discovered (Stampi, 1992). From another experiment it is also apparent that the gradual transition from monophasic to polyphasic U patterns, carried over several days, played an important role in allowing smooth adaptation to the schedule. The same experience of adaptation to U is reported by Steve Pavlina (2007, para. 2): ‘Adapting to polyphasic sleep took many days, and I felt like a zombie the first week. At one point I just sat on the couch staring at a wall for 90 min, unable to form any thoughts.’ As a comparable example, it is known that following sleep displacement during shift-work or jet-lag studies, full entrainment to a new schedule usually requires a minimum of 3 and an average of 7 days (Folkard, Hume, Minors, Waterhouse, & Watson, 1985). I have experienced that every subsequent adaptation period is weaker and shorter since the body remembers previous attempts and uses adaptation mechanism that proved successful in previous situation, in a faster and more effective way. Every adaptation also depends on subject’s sleep deprivation resistance, conviction and will.

2.4 Research Background

Researching polyphasic sleep is a very complex task as it is a rather unexplored topic. Some of reasons for this could be that there is a great variety of sleep schedules, the methods like
polysomnography or EEG get expensive in connection with the longitudinal condition, and also a huge influence of such experiments on the lives of the test-subjects.

2.4.1 Nap Effect

On polyphasic field, a great number of studies was performed about napping, proving positive effect of nap. A study of behavioural effects of napping has revealed a performance improvement in logical reasoning and digit span, confirmed by significantly higher accuracy of logical reasoning right after the nap (according to 4 after-nap tests in total) when compared to a control group (Takahashi & Arito, 2000); no other differences were significant. In mentioned study, only a 15 min nap was allowed, which is considered too short to provide any sleep effect (Stampi, 2002). Meaningful length of a nap is 20–30 min, which provides enough time to fall sleep and get at least 15 min of sleep. Otherwise real sleep length can be much shorter and the nap could be ineffective or less effective, which happened in above mentioned study with mean SED$^5 = 10.2$ min. Having longer nap period, effect could be more persistent and more long-lasting. Different nap durations can produce different improvements in cognitive performance and alertness, e.g., a 10 min nap can bring improvement right after the nap but this improvement would last a shorter period than the improvement after a 20 min nap. Moreover longer naps can allow more opportunity for slow wave brain activity and for reducing sleep pressure, thereby producing greater waking benefit (Milner & Cote, 2009).

Figure 2. Test Threshold Increase across Test Session

![Figure 2](image)

Note. Adopted from The restorative effect of naps on perceptual deterioration by Mednick et al. (2002).

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$^5$ Sleep Episode Duration
Mednick’s study explored restorative effect of naps on perceptual learning (Mednick et al., 2002) by four tests a day among three groups—a control group, long-nap group (60 min) and short-nap group (30 min). As a result, control groups showed 52% slowing in perceptual processing across the four test session. In test session 3, interstimulus interval (ISI) threshold of the control group increased by 14.1 ms from baseline, short-nap group showed no change and long-nap group showed a decrease by 20.9 ms (see Figure 2).

Sleep patterns of the sample (129 undergraduates) are not described in the study, though based on probability, they were probably monophasic. That could be a reason why the long-nap group was more effective compared to short-nap group, which requires a habitual behaviour and regular repetition to be effective. This supports another study (Milner, Fogel, & Cote, 2006) and indicates that a nap is more effective for habitual nappers than for non-habitual nappers, having less response slowing post-condition compared to baseline, \( t(16) = -2.89 \) (\( p < .01 \)), than the group of non-nappers.

Dinges (1992) compared nap sleep architecture of habitual and non-habitual nappers. Habitual nappers were found to have more Stage 1 and more stage shifts, indicating that non habitual nappers had more consolidated sleep. It can signal that habitual nappers are more sensitive to ultradian rhythms (e.g., biological rhythms with a periodicity shorter than 24 hours), which allows them to fall asleep more easily in the daytime (Schulz, 1993).

A nap can facilitate the learning process that results from an hour spent on training a visual texture discrimination task. Study about this topic (Mednick, Nakayama, & Stickgold, 2003) compared a no-nap control group, a 60-min nap group and a 90-min nap group. No-nap control subjects showed deterioration in performance at 19:00 (13.7 ms longer ISI threshold, \( p < .1 \)), and performed significantly worse than the nap groups (\( p < .05 \)). The deterioration in performance from training to first retest in this group, measured over an 8-hour interval, was similar to that seen in their prior study (Mednick, 2002), which showed 13.8 ms deterioration over a 2-hour interval. This suggests that stimulus exposure rather than inter-test interval produces deterioration in texture discrimination, and that sleep, rather than time, is required to reverse this perceptual deterioration. For nappers, such performance over 24 hours showed as much learning as is normally seen after twice that length of time. Possibly for the same reason mentioned in the study above (non-habitual napping) the 90-min nap group showed significant improvement
(8.4 ms, \( p < .01 \)), whereas the 60-min nap group showed marginal improvement (4.4 ms, \( p < .1 \)). This study shows positive effect of napping, in numbers the difference of 22.1 ms (control group vs. 90-min nap group), which could be important in situations where fast reaction times are required (e.g., car drivers, sportsmen, policemen); however, being of low benefit to an ordinary person. This small difference between groups can be caused by non-habitual practice of napping, therefore I would expect effect grow in repeated naps measurement.

Practical use in the context of car drivers is described by a study (Horne & Reyner, 2007) that examined a nap shorter than 15 min, 150 mg of caffeine in coffee, and a coffee placebo, each given randomly across test sessions to 10 sleepy subjects during a 30-min rest period between two 1-hour-long, monotonous early afternoon drives in a car simulator. Caffeine and a nap significantly reduced driving impairments, subject’s sleepiness, and EEG activity indicating drowsiness. Sleep during naps varied, whereas caffeine produced more consistent effects, which shows there could be individual differences between the effect of and ability to nap. The importance of falling asleep during a nap was indicated by control test, which showed that taking just a break is ineffective.

In recent Berkeley sleep study (Anwar, 2010) 39 healthy young adults were divided into nap and no-nap groups. At 12:00, all the participants were subjected to a rigorous learning task intended to tax the hippocampus, a region of the brain that helps store fact-based memories. Both groups performed at comparable levels. At 14:00, the nap group took a 90-min nap. During new round of learning exercises at 18:00, no-nap group performed worse at learning, in contrast to the nap group, which did markedly better and actually improved in their capacity to learn. Regretfully, Berkeley institute does not report detail information about this study, also adding 30-min and 60-min nap groups might have provided better comparisons. Walker from the same institute discovered that this memory-refreshing process occurs when nappers are engaged in Stage 2 non-REM sleep, which Milner and Cote (2009) describe more in more detail: naps containing Stage 2 sleep improved performance and alertness. Naps containing Stage 1 but not Stage 2 sleep were successful in improving subjective alertness and reducing fatigue but participants experienced performance decrements and showed evidence of decreased objective alertness. Naps with such stage distributions were reported by Hirose & Nagasaka (2003) on eight healthy young adults during a 15-min nap opportunity by examining quantitative EEG.
2.4.2 Longitudinal Design in Sleep Schedule Research

Regrettably, those studies’ designs have no context related to the core sleep or strict napping schedule; on the contrary, non-strict schedule-less biphasic pattern is used. Few studies are focused on influences and development of polyphasic sleep schedule (Campbell, Dawson, & Zulley, 1993, Zulley & Baier, 1988) with total duration 12–14 days in first study, and only 30 hours in second study, which is a key problem concerning the relevance of polyphasic sleep research. Those results can be distorted and may exclude an adaptation period. Moreover, the sample size is too low (8, resp. 12 subjects) to form any conclusions due to low external validity.

U attracted attention of Dr. Claudio Stampi, a founder and a director of the Chronobiology Research Institute in Boston, USA, and also in Rome, Italy, a highly recognized expert in the field of polyphasic sleep research with great life interest in polyphasic sleep. His findings and reports can reach out to other schedules as well, not to such a degree and with lower psychological and physiological demands on conclusions he made. Stampi’s methods are primarily targeted at minimizing sleep deprivation. He has shown that polyphasic sleep can improve cognitive performance in conditions of sleep deprivation as compared with monophasic sleep: Individual sleeping for 30 min every 4 hours, for a daily total of only 3 hours of sleep, subjects performed better and were more alert, compared to when they had 3 hours of uninterrupted sleep. To be specific, Memory and Search Test (MAST) performance showed a slight decrement relative to the baseline throughout days 3–21, followed by an improvement above baseline levels thereafter. Descending subtraction test (DST) performance showed a modest but more prolonged decrement throughout days 3–33, followed by a sharp increase in

Figure 3. Performance During the 48-day U Schedule Experiment Grouped by ‘weeks’ of 6-days each.

Note. Top: Memory and Search Test (MAST); bottom: Descending Subtraction Test (DST). Adopted from Why we nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep by Stampi (1992).
performance above baseline levels immediately after the ad lib sleep day (10 hours of sleep in total). The only significant difference ($p < .05$) was for DST towards the end of the experiment ('week 7, days 36–41) being better than ‘weeks’ 3, 4, 5 and 6 (Stampi, 2002).

In other words, under the conditions of a dramatic sleep reduction, it is more efficient to recharge the sleep ‘battery’ more often (Stampi, 1992). Another research used the sample of 99 yachtsmen during 3 long-distance races (OASTAR: 3000 nautical miles, RBR: 1900 nautical miles and MT: 4300 nautical miles), which took 49, 40 and 20 days to finish. From OASTART 66.5 % competitors performed U with mean sleep episode (SED) ranged between 20 min and 2 hours. It was observed that sailors who attained the highest speed had SEDs between 20 min (the best group) and 1 hour, whereas SEDs of 2 hours or more were associated with an abrupt decline in performance. It can be concluded from the linear regression that the shorter a sailors’ mean sleep episode duration, the better his race results (Stampi, 1989), see Figure 4.

Figure 4. Performance (Mean Handicap Yacht Speed) as a Function of SED (OSTAR).


Another study (Edinger, Marsh, McCall, Erwin, & Liniger, 1990) examined the combined effects of a sleep reduction and exercising in a 146-hour-long marathon tennis match. The players earned 5 min of rest for every hour played (in total 2 hours per day). This rest time was addend up so that they could sleep only once per day: they had a 1-hour-long nap (03:00–04:00) on the
second day of the match, and 2-hour-long nap (03:00–05:00) from the third till the last day of the match. They also showed a gradually increasing tendency toward daytime dozing during the first few days. However, the players differed considerably in their ratings of sleepiness, mood, recovery sleep patterns, and endurance with respect to the demands of the match. Interestingly, players who reported less sleepiness during the marathon were also habitual nappers (biphasic 5-hour core + 90 min nap).

Stampi also presented an example of a successful adaptation to U in 2 studies (Stampi & Davis, 1991, Stampi, Moffitt, & Hoffman, 1990), the first one was undertaken for 19 days (15-min nap every 4 hours), the second one lasted 48 days (30 min every 4 hours), both by a volunteer Sbragia. Confirming his personal observations, performance was not significantly reduced below baseline levels during the experiments. The subject adapted remarkably well to the schedules, both subjectively and objectively. Contrary to usual findings from sleep reduction studies, all sleep stages were proportionately reduced and their percentages were remarkably similar to baseline monophasic sleep.

Wozniack (2010) points out that sleep researches love to compare sleep deprivation to intoxication: both disrupt one’s self-assessment abilities: like an alcoholic who always claims ‘I am not drunk. I am just inebriated’, a sleep deprived person will often say ‘I am fine. I am crisp and alert.’, while their ability to perform mental tasks may be seriously impaired. Also driving when sleep-deprived may be as dangerous as driving while intoxicated. I can report this self-perception while deprived of the sleep; it is important to count with this effect in methodology of self-assessment to prevent distortion of data as much as possible, e.g., by passing test administration or note talking to another person. State of euphoria or mania could be expected. ‘They tend to write about their success at the moment of lucidity or euphoria, while ignoring those brain dead moments as ‘temporary setbacks’, transitory adaptation state, etc.’ (Wozniack, para. 12).
3 Circadian Rhythm, Sleep and Performance

Organization of sleep is closely connected with circadian rhythm. According to Wozniack (2005), there are 2 circadian peaks, in which it is possible to sleep soundly; therefore, naps are ineffective if taken in other than these two periods. Further Wozniack (para. 24) claims: ‘Conceivable, polyphasic sleep might be a relief if the system lost some of its circadian periodicity, however, such a mutation would primarily manifest itself with a difficulty in obtaining a healthy sleep rhythm with a typical refreshing night sleep’. His claims are confirmed by a study on a free-running sleep (Campbell, Dawson, & Zulley, 1993), which says that biphasic sleep is better to keep synchronous circadian rhythms compared to monophasic sleep. Free-nappers (naturally biphasic) showed free-running periods very close to 24 hours with mean 24.01, non-nappers were very close to those reported in traditional free-run studies: 24.78. This 46 min difference can cause serious troubles in day time synchronization, for example a problem with falling asleep, natural postponing time one goes to bed, and forced falling asleep with help of sleep pills. That is why I consider biphasic so important and useful, contrary to monophasic.

3.1 Circadian Rhythm and Temperature

The most well-known circadian rhythm is that of body temperature. This rhythm persists even when the individual has to stay in bed for entire 24 hours, when the physical activity varies, and when fasting is maintained. Pulse rate and blood pressure also peak in approximately the same time as body temperature (Willis, 1990). Generally, human body temperature is lowest when the individual is inactive. Although the activity can make the temperature rise, the temperature follows a specific circadian rhythm (Amin, 2005). Another study conducted by Holland et al. (1985) determined the effects of raised body temperature on reasoning, memory, and mood. Participants were tested for memory registration and recall. Results of this study showed that increase in core temperature was associated with a significant increase in the speed of performing the tests, by 11 and 10 %, respectively.

Another study (Zulley & Campbell, 1985) results indicate that human sleep-wake system is characterized by a polyphasic organization and thus modulated by a circadian influence, which is typical in phase with the circadian oscillation of body temperature. Therefore, same performance in the same day time on polyphasic sleep can be expected as on a monophasic sleep pattern.
3.2 Circadian Rhythm and Performance

Psychological functioning of humans can be influenced by specific varieties of a circadian rhythm, for example by rhythms in the sleep-wake cycle, glucose uptake, core body temperature, neurotransmitter function, heart rate, and circulating hormones. Proper functioning of a human body translates to a physical and mental well-being which, in turn, becomes a determining factor of productivity (Stampi, 1992). A study conducted at the Harvard Medical School in Boston by Dijk et al. (1992) aimed at determining the circadian and sleep-wake dependent aspects of subjective alertness and cognitive performance (Stampi, 1992). The circadian rhythm of core body temperature paralleled the circadian rhythm of alertness and performance. Another study conducted by Johnson et al. (1992) reported that the circadian rhythm of short-term memory varies in parallel with the circadian rhythms of subjective alertness, calculation performance and core body temperature. Johnson et al. suggested that the human circadian pacemaker, which drives the body temperature cycle, is the primary determinant of endogenous circadian variations in subjective alertness and calculation performance as well as in the immediate recall of meaningful material (Stampi, 1992). Coleshaw et al. (1983) studied the effect of lowering body temperature on the memory registration and the speed of reasoning. Aspects of cognitive function were subsequently tested at low core temperature and it was found that the memory registration was impaired progressively when core temperature was lowered under approximately 36.7 °C. Also, at core temperatures of 34–35 °C the impairment caused a loss of approximately 70 % of data that could normally be retained. Finally, on a two-digit calculation test, the speed of performance was impaired by approximately 50 % at a core temperature of 34–35 °C (Stampi, 1992). Amin (2005) studied performance differences of temperature minimums and detected that during the time corresponding to high oral temperatures, participants’ physical performance increased by 9.3 %, and their mental performance increased by 4.6 % compared to the results reported at lower temperatures. Mental performance increased by a greater percentage, in females (5.2) as compared to males (4.07).

To sum up, temperature peak follows circadian curve and cognitive peak. By determining circadian rhythm, I exclude cognitive weak time periods and set peaks suitable for testing. Same cognitive peaks are expected to be observed in polyphasic sleep due to circadian rhythm fixation (Zulley & Campbell, 1985).
3.3 Sleep and Cognitive Abilities

Sleep is believed to play an important role in the memory consolidation and long-term memory creation (Donlea, Thimgan, Suzuki, Gottschalk, & Shaw, 2011), brain plasticity and competing models of sleep-dependent learning (Walker, 2009), immune function, learning, organ function, and productivity (Czeisler & Fryer, 2006). The existence of a connection between sleep quality and quantity and cognitive abilities like alertness, long-term memory, associative memory and working memory is well documented (e.g. Stampi, 1992, Buckhalt, El-Sheikh, & Keller, 2007, Smith-Coggins, Rosekind, Hurd, & Buccino, 1994, Taras & Potts-Datema, 2005). Evidence for a beneficial role of sleep in cognition is rapidly emerging in the cognitive and neuroscience literature (Ellenbogen, 2005).

3.3.1 Long-Term Memory and Memory Consolidation

The role of long-time memory in everyday life is of two kinds. On the one hand, long-term memory allows to access information a person needs to store for a long time to secure a certain stability of the self; for example knowledge acquired in the course of one’s education, relationship structures, information about other people, information about the self, attitudes and experience. On the other hand, long-term memory can hold old and useless information and thus make it more difficult to remember fresh information. One of the earliest human studies (Morris, Williams, & Lubin, 1960) reports the effects of sleep and sleep deprivation on the declarative memory encoding, and indicates that ‘temporal memory’ (memory involved as events occur) was significantly disrupted by a night of pre-training sleep loss. A recent study shows that a memory consolidation during sleep involves a basic selection process determining which of the many pieces of information gathered during the day is sent to the long-term storage. Information relevant to future demands is foremost among those selected for storage (Wilhelm et al., 2011).

3.3.2 Working Memory

Working memory is a system which actively holds information in the mind, thus allowing to perform verbal and nonverbal tasks such as reasoning and comprehension, and to make it available for further information processing (Becker & Morris, 1999). Recent functional imaging studies detected working memory signals in both medial temporal lobe, a brain area strongly associated with long-term memory, and prefrontal cortex, suggesting a strong relationship between working memory and long-term memory (Ranganath & Blumenfeld, 2005).
3.3.3 Short-Term Memory and Alertness

Alertness influences the selection of information, speed of processing, and it is a competitive advantage. In everyday life it is not much trained, except for the people in occupations requiring any kind of a special training—army corps, firemen, or policemen. It was found that the recognition performance was generally impaired for each subject after 24 hours of sleep deprivation. In addition, there was a confirmation of a previously observed increase in the positive skewness of reaction times after wakefulness. Sleep deprivation increases the occurrence of lapses and periods of lowered reactive capacity, which prevent the encoding of items in short-term memory (Polzella, 1975). A study (Kerhof & Dongen, 2011) shows, that subjects deprived of sleep for 36 hours scored significantly lower than control subject, even in a subgroup that received caffeine to overcome non-specific effects of lower alertness.

3.4 A different Research Approach

All findings mentioned above mostly originate from a similar research paradigm—isolate benefits of the sleep by comparing a sleep period to a non-sleep-deprived wake period (Ellenbogen, 2005), or sleep deprived group to sleep non-deprive group, which is basically following comparison: a normal state vs. a handicapped state. Yet, no longitudinal research on specific sleep schedule and monitoring effect on cognitive abilities was conducted. This paradigm would compare a normal state vs. a better state, which can tell more accurately if it is possible to sleep better, ergo to improve one’s cognitive abilities. This thesis focuses on the short-term memory, alertness and working memory. Long-term memory would require more complex procedure caused by a practice effect, and a longer research period. I believe that mentioned abilities can improve on polyphasic sleep compared to monophasic sleep. My opinion is supported by the positive effect of napping (see Research Background).
4. Methods

4.1 Ethics

Shifting the sleep schedule can lead to an artificial shifting or at least a distortion of circadian rhythm, in the same way as a shift work, jet lag or irregular sleeping habits shift it, Besides, it can be one of the reasons of insomnia, and it may cause disorder of the circadian sleep-wake rhythm in general. Disruptions of normal circadian rhythms can also cause depression (Turek & Losee-Olson, 1986), retrograde amnesia (Fekete, Ree, Niesink, & Wied, 1984), they can shift hormonal production of melatonin, serotonin, or affect a regulation of body temperature. Moreover, depression, heart disease, hypertension, irritability, slower reaction times, slurred speech and tremors are connected with sleep deprivation. For those reasons I’ve decided not to expose any subjects to such risk.

4.2 Design

A most common type of research, the Group comparison research, is not possible because of its unethical character: great sample mortality rate is expected in groups under strict circumstances of this research, unless a big motivation is present. In addition, the main motivation for practicing polyphasic sleep should be the inner motivation, not an external motivation such as force of financial reward. For those reasons, I chose a single-case experiment based on basic withdrawal design A-B-A. The reliability of tests of this design would be very high due to persisting changes in sleep pattern and possible shifts in circadian rhythm. Nevertheless, this withdrawal design is not possible because it might cause serious and prolonged difficulties in my sleep (see Ethics), considering 2 changes in research period of 60 days. Therefore, I choose A-B design.

4.2.1 Internal Validity Precautions

As far as possible threats to internal validity are concerned, history must be taken into consideration because setting and location of the testing may influence the outcomes of the testing. The way I deal with this threat is discussed in more detail in Procedure.

Another possible threat can be emotional setting or a current state of mind. On contrary, fatigue and current fitness or freshness are not intervening variables because their influence should be caught by tests. Previous cognitive operations should not be an intervening variable
either because they have almost no influence on napping, which requires relax and calm settings. For example, I am able to work on a school or work project and then take a nap and fall asleep in 5 minutes. The important factor is the actual impression left by an activity (for example, the work can go well or make me feel frustrated), because positive and negative thoughts can influence the level of concentration and tasks practice fluency. A sufficient number of repeated measurements is supposed to balance eventual outliers.

Other possible threat regarding maturation is a practice effect. To eliminate the interference of the practice effect, the results would be carefully observed during a transparent development of data up to the point of a slightly changeable oscillation around a specific static point during the baseline (phase A). If the completion of a test battery would last too long, I might start feeling tired more and more every other test, which could negatively influence my performance. In the original, test battery included ANT (Attention Network Test)\(^6\) which took more than 16 minutes (50 % of the whole test battery duration). I started to feel de-motivated after first 5 days of testing, which corresponded to the process mentioned above. Hence, ANT was excluded from test battery. The final test battery takes approximately 16 minutes to complete and includes multiple breaks, which is sufficient.

### 4.2.2 External Validity Precautions

Being a researcher and a subject in one person can be a very specific source of distortion. Obvious threat to external validity is reactivity of outcome assessment (Kazdin, 1980). Two main threats are to be taken into consideration: my awareness of the experiment, since I am the only subject, and also the tendency to look for and to create data confirming the hypothesis, known as Rosenthal’s effect. This combination poses a major threat which can influence the whole process. To reduce those side effects as much as possible, I took following precautions\(^7\). To separate the role of a tested subject and the role of an evaluating researcher as often as possible, i.e., I asked my thesis supervisor Ježek to evaluate baseline results and to decide when it would be appropriate to move from a phase A to a phase B. Ježek is also the only person who had access to data development graph. I only visited the results page to check briefly if data were recorded successfully. This should have prevented myself from influencing results either negatively (phase A) or positively (phase B) to create data which would seem plausible and which would meet my expectations. The same rule of administrator and subject separation applies for test

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\(^6\) Accessed on http://www.sacklerinstitute.org/users/jin.fan/ant/ANTFirstPage.html. Test author was contacted with more simple version request (<5 min), which could replace origin test, with no response.

\(^7\) Based on discussion with colleague Šipula.
administration as well (e.g., giving test instruction and describing specific proceeding to another person). Because it would be very risky to ensure such a person for a twice-a-day at any circumstances while maintaining his or her professional approach and no interest in test results, tests requiring administration were a priori excluded. Only tests with simple and non-varying instructions are performed. Finally, data result development from phase A to phase B, was separated in order to prevent attempts to perform better or worse according to results of phase A or a previous test.

4.2.3 Test Timing

To determine an ideal time for cognitive test on monophasic sleep cycle (see *Circadian Rhythm and Performance*), I had to measure my daily temperature development. Due to a limited budget and for simple pre-test purposes, professional tools were excluded. I collected data by handle measuring every half an hour during the whole awake daytime in my left armpit for fast accessibility reason. From measured values, I created hourly means to spot a curve and compared them with a theoretic circadian curve (BBC - Science & Nature, 2003). This theoretic curve was examined by amateur experiment with 10 s measure intervals (Adams, 2011) and thus, I consider it reliable. To prevent intervening variables, I performed retest measuring. I used a handle thermometer Thermoval Rapid Flex (Hartmann) and I recorded data to a smart phone HTC task app. Right after waking up cognitive abilities on polyphasic sleep are slowed down, particularly attention and reactance, as well as before sleep. My personal experience judgement is, that first 30 and last 15 min of the phase are very critical (generalized to all phases). Activity requiring cognitive or psychomotorical performance should be shifted to part of the phase. Based upon this experience, the optimal time to test would be middle 2–3 hours.

4.2.4 Pre-test Settings

Securing optimal conditions in everyday life, while setting up the baseline is a very demanding task. Depending on variable circumstances, location and surroundings change (at school, at home; guests come, tasks are need to be completed). To prevent possible noise distortion–as a main source influencing one’s cognition–it is necessary to provide a place with relatively stable sound conditions since it is impossible to guarantee absolute silence or to maintain it repeatedly. The source of the sound produces different sound (fix prevention) without lyrics (apart exceptions, circa 5 %), which can draw attention; it is available on-line and active throughout whole test battery, with non-disturbing (chaotic or unpleasant music) and non-stimulating (favourite or known music) sounds of course. Online radio *Sleepbot Environmental*
Broadcast\textsuperscript{8} suits these conditions because it plays very calming and relaxing ambient genre. This music also emphasises states of fatigue, whose influence is sought in the tests. Volume is set ad hoc according to the activity of the environment, to be loud enough to eliminate as much disturbances as possible. For listening, I use headphones with soundproof-effect earmuffs (K\textsc{oss} UR20) to decrease usually required volume. For the test B and E, a wireless laser mouse is required.

4.3 Constructs

Areas observed can be divided into three categories: cognitive abilities, time termination of sleep, and sleep environment conditions. This thesis focuses on following cognitive abilities: short-term memory, alertness, and working memory. Time termination of sleep and sleep environment conditions are being monitored: SED (includes falling asleep time, waking-up time, breaks and disruptions) and other sleep conditions (sleep place, not/falling asleep). Diary with daily records could serve as a secondary source of date concerning experiencing the adaptation and polyphasic sleep. Particular records can present another view on the whole experiment.

4.4 Hypothesis

$H_1$: The polyphasic sleep pattern E3 allows better performance in short-term memory compared to one on monophasic sleep pattern.

$H_2$: The polyphasic sleep pattern E3 allows better performance in attention compared to one on monophasic sleep pattern.

$H_3$: The polyphasic sleep pattern E3 allows better performance in working/operating memory compared to one on monophasic sleep pattern.

$H_4$: The polyphasic sleep pattern E3 allows overall better performance compared to one on monophasic sleep pattern.

$H_5$: While performing polyphasic sleep, there exists an ‘adaptation phase’ when cognitive abilities are weakened, compared to monophasic sleep pattern, following by performance improvement.

\textsuperscript{8} Can be found on http://sleepbot.com/seb/
4.5 Materials

4.5.1 Short-Term Memory (A)

Memory tests can be sub-tests of intelligence tests (i.e., Wechsler, Amthauer intelligence structure test), or a direct method to test short-term and long-term memory—Luria-Nebraska Neuropsychological Battery or Miele’s method. These tests may have a standardized procedure but none of those allow a repeated use in range shorter than 6 months. Due to this disadvantage, a special test suitable for this experiment had to be developed. Common rules for a short-term memory test described by Svoboda (1992) were used to create the test. Subjects are usually exposed to a set of visual or auditory stimuli and after a certain period of time—either short or long—a list of items that could be recalled is noted down. Although Miele method mentions a 10 s break (Svoboda), in this case it is 1–2 s due to writing down and faster entrainment to stabilize the baseline. The reliability of a memory test is not very high because an attention oscillation interferes with the performance (Svoboda). However, the attention oscillation can be examined closer by a subsequent alertness test.

To build a bank of words to remember, I chose English as non-native, yet still well known language to lower the risk of possible associations, imaginativeness, personal preferences, fewer occurrences in the same day, and less structured mind maps for words. I looked up\(^9\) a random list of English words to avoid personal selection, which could bring a distortion. I used words of different syllable count to cover different scales of difficulty. Used results: mono-syllabic words (Coltheart, 1993) with equal amount of phonologically dissimilar and similar (96 in total), 2-syllabic (OnTrack Reading, 2012a): (201), 3-syllabic (OnTrack Reading, 2012b): (142) and 4-syllabic (OnTrack Reading, 2012c): (100); this gives 539 words in total. There were 4 mono-syllabic and 12 2/3/4-syllabic words in each particular test run. The number of mono-syllables is lower to prevent strategy picking up mainly easier words and to force the focus on multi-syllables as well. All capital letters (approx. 10 words) were converted to lowercase to prevent abnormalities in the test run. Finally, no words were excluded or preferred so that my influence would be minimized. At the beginning, site with matrix of 4 * 10 words (see Figure 5) is chosen from 539 English words, with syllable distribution of 1 syllable of 96, 2: 201, 3: 142 and 4: 100. Every test sample contains 4 one-syllabic and 12 of 2/3/4-syllabic words selected randomly. I had 2 minutes to remember as many words as possible; time limit was counted down on the top

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\(^9\) Using Google.com and combination of keywords ‘English, word, list, syllable, 2-syllable, 3-syllable, 4-syllable, monosyllable’
of the screen and after the deadline, page was automatically redirected to a response page. I wrote down all words I was able to recall, separated by a comma. Although there was a countdown on the top of this page as well, this time it was only to give a general overview; no strict time limit was set, a maximal concentration was recommended. Taking this test in Opera or Chrome browser is connected with default language correction, thus typo mistakes are prevented, for example, the word ‘proffesor’ is underlined because of the correct form ‘professor’; therefore this word (if found on the list of tested words) would be approved as correct and typo mistakes would not distort the final result.

4.5.2 Alertness (B)

The test measures sustained or vigilant attention by recording response time to visual stimuli that occurs at random inter-stimulus intervals. The test used is based on an online version of *Psychomotor vigilance test (PVT)*\(^{10}\). This test is among the most widely used measurements of behavioural alertness and it has a high sensitivity to sleep deprivation (Basner & Dinges, 2011). It is based on the standardized 10-min version, but test duration usually differs among studies (Basner & Dinges), for thesis’ purposes of repeated testing I set 2 minutes duration. Low entrainment level is obviously expected due to testing speed of nervous system. The task is to click into the square as fast as possible after red number appears in the box (see Figure 7). False start with time under 100 ms are excluded and recorder, if clicked after its start. Stimuli appear each 2–6 seconds for the duration of approximately 2 minutes. The goal is to click as fast as possible to make minimal average time with minimum false starts.

4.5.3 Group Bourdon Test (GBT, C)

The d2 Test of Attention is test measuring success and speed of crossing out instructed symbols. D2 is standardized one-run only test, therefore I had to find another, flexible and random generator. I used freeware program *Group-Bourdon Tool 2.0*\(^{11}\), which is fully configurable, generates random plots and dispose of two modes *GBT* and *S Fooat*. Main task is to select all 4-dot images as fast and as much possible. Test duration is set to 2 sheets 1 minute each. Test result includes targets omitted, marked incorrect, total cells, mean cell time, median cell time, completed rows, mean row time, median row time and row fluency, overall and for each sheet and also chart of cell time development during the test (see Figure 8).

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\(^{10}\) Sleep Disorders Center Florida, [http://www.sleepdisordersflorida.com/pvt1.html](http://www.sleepdisordersflorida.com/pvt1.html)

\(^{11}\) Downloaded from [http://www.digital-reality.org.uk/download.html](http://www.digital-reality.org.uk/download.html), on 2012-03-03. This is used by aspiring train drivers to prepare for an entrance exam.
Figure 5. Tester App.

Take a test!
A. Short-term memory
- Words: You have 1 minute to remember 30 words. Then answer 20 words to recall all you’ve remembered.

B. Alertness
- Reaction time test (1 min).

C. Bourdon’s test
- Insert data from software and press ‘Test’ to start.

D. Trail making test
- Go through 3 test tests (~1 minute).

Figure 6. Test A - Short-Term Memory

Words to remember
Time left: 10.9

<table>
<thead>
<tr>
<th>invitation</th>
<th>rob</th>
<th>organic</th>
<th>capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>passenger</td>
<td>attack</td>
<td>divisible</td>
<td>library</td>
</tr>
<tr>
<td>harmonica</td>
<td>accept</td>
<td>political</td>
<td>december</td>
</tr>
<tr>
<td>ped</td>
<td>today</td>
<td>extinct</td>
<td>personal</td>
</tr>
<tr>
<td>community</td>
<td>gal</td>
<td>gasoline</td>
<td>operate</td>
</tr>
<tr>
<td>retreat</td>
<td>direct</td>
<td>purple</td>
<td>overdue</td>
</tr>
<tr>
<td>yesterday</td>
<td>escape</td>
<td>lag</td>
<td>reproduction</td>
</tr>
<tr>
<td>although</td>
<td>capacity</td>
<td>proving</td>
<td>semicircle</td>
</tr>
<tr>
<td>february</td>
<td>highest</td>
<td>support</td>
<td>circulation</td>
</tr>
<tr>
<td>vacation</td>
<td>wilderness</td>
<td>professor</td>
<td>perimeter</td>
</tr>
</tbody>
</table>

Figure 7. Test B - Alertness (PVT)

Psychomotor vigilance test

Instructions: Press start button. Single click on the box as soon as possible after red numbers appear in the box. Test will continue for 5 minutes or until you press the stop button.

Taking the test for the entire 2 minutes allows a more accurate assessment. False starts (response times less than 100 ms) are excluded from final analysis.
Figure 8. Test C - GBT

Figure 9. Test D - SCAAT

Figure 10. Test E - TMT
4.5.4 SCAAT (D)

SCAAT standing for Safe Concentration And Attention Test is test similar to GBT. Quoting the test author: ‘SCAAT ... some Train Operating Companies favour over the dot test. Some also use this test as a pre-filter to remove those individuals likely to fail a full assessment’ (Gresham, n.d., para. 2). Therefore SCAAT is more complicated and gives more diverse results than GBT. It takes 6 minutes in total, 3 sheets 2 minutes each. Instructions are more difficult each round: 1st round cross 1 required symbol, 2nd round cross 2 required symbols and 3rd round cross 1 required symbol and first symbol in each particular line (see Figure 9). Test results are the same as in case of GBT test–chart and raw data.

4.5.5 Trail Making Test (TMT, E)

Trail making test is standardized test, standard component of most neurocognitive, neuropsychologic, and neuropsychiatric assessments. Originates from the Army Individual Test Battery (1944). I created application with random positioning generator similar to online version of Trail Making Test 3.0a. Test has 3 rounds: connect letters, connect numbers and its combination, all in logical order, to be specific connect 10 letters in round A, 10 numbers in round B, 24 numbers and letters on a rota bias starting with numbers in round C (1–A–B–2 etc., see Figure 10). Between particular rounds there is single click step to next round. First two rounds (A, B) are considered warming-up, their purpose is to create specific setting and remove possible previous distortions. Token’s position is generated by random to matrix 10 * 10 for round A and B, and 24 * 24 for round C under condition to fill in every row and every column to ensure random area distribution simulation (e.g. for 3 * 3: [1,3], [2,1], [3,2]). Clicking last token finishes the test and closes result, but only under condition of previous correct completion (e.g., 1, 3, 2, is not acceptable to follow by 4, but fix is required to do so: 1, 3, 2, 3). There is no warning displayed on incorrect click, to prevent indolence and random free clicks. In opposite, I have to pay attention to relevant miss clicks.

4.6 Procedure

4.6.1 Test Timing

Test timing is related to circadian rhythm (see Circadian Rhythm and Performance), specific period is determined by body temperature, on polyphasic sleep also in context of previous sleep experience (see Subject).

4.6.2 Test Battery

Raw test and testing procedure description is in the same order as in test battery. 3 of those tests (A, B and E) were programmed to form of online web application (Tester app) specifically for this project. All of them are outgoing from standardized test and were base upon theoretical principles. Whole battery of test is running on laptop with diagonal 15.6" in not disturbing environment in Opera or Chrome browsers in full screen mode.

4.6.3 Short-Term Memory Test

I open my web browser and go to http://tester.schmutzka.eu/, where Tester app is located. Internet connection is required. I click to run test A, try to remember as much as possible in 2 minutes I have, then after page is redirected to form, I write down all words I can retain I submit the form when I think I do not remember anything more. End of test A.

4.6.4 Alertness Test

After finishing memory test I switch to PVT also in Tester app. Next 2 minutes I click as fast as possible when the red numbers appear. At the end of the test average reaction time, stimuli count and number of false reactions are preset so save. Clicking ‘save’ is the end of test B.

4.6.5 GBT

I run application Group-Bourdon Tool 2.0 from my computer, select 2 sheets by 1 minute, click run, select by up arrow all 4-dot figures. In the end I save graph and stats to the tester application.

4.6.6 SCAAT

After finishing GBT test, I switch type of test in Group-Bourdon Tool 2.0 to SCAAT, select 2 sheets by 1 min. In the end I save graph and stats to the tester application. Close the application.

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13 For marginal cases without internet connection, I have possibility to use offline mirror of Tester app and after complete results into the online version.
4.6.7 TMT

After finish SCAA test, I run TMT in Tester app, complete 1st round with letters, click next, complete 2nd round with numbers, click next, complete 3rd round with both numbers and letter, click finish. Test battery is over.

4.7 Subject

I am 22 years old, male, with 4 years of undergraduate studies, and profession of freelance PHP programmer.

4.7.1 My Sleep Experience

I am natural biphasic sleeper with average 2.24 sleep episodes a day for year 2011\(^{14}\), although I did not keep any strict schedule for a longer period. This annual average covers experience with monophasic sleep, biphasic sleep, Everyman 2/3 schedules most often in combination with SPAMAYL or free-running sleep (see *Polyphasic Sleep Schedules*). Therefore, I have to establish monophasic sleep pattern to be able provide comparison to polyphasic sleep and adaptation phase, including learning new habits absent on monophasic sleep. Since December 20, 2011, 3 months before start of phase B kept monophasic schedule. Before this my schedule was uncontrolled and chaotic, with nap and core count it could be labelled as Everyman 2 (2.94\(^{15}\) in December till 20).

<table>
<thead>
<tr>
<th>Period</th>
<th>Mean SED</th>
<th>Mean SE</th>
<th>SE Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1–19</td>
<td>5:17</td>
<td>05:45–12:17</td>
<td>2.94</td>
</tr>
<tr>
<td>December 20–31</td>
<td>6:05</td>
<td>02:14–08:30</td>
<td>1.50</td>
</tr>
<tr>
<td>January 2012</td>
<td>5:53</td>
<td>06:12–11:46</td>
<td>1.48</td>
</tr>
<tr>
<td>February</td>
<td>5:35</td>
<td>03:26–09:56</td>
<td>1.17</td>
</tr>
<tr>
<td>March 1–8</td>
<td>6:19</td>
<td>03:40–09:59</td>
<td>1.13</td>
</tr>
</tbody>
</table>

\(^{14}\) Number of records per year 2011 divided by 365 from personal daily records on http://www.sleeper.cz, application I use for SE recording.

\(^{15}\) Average number of sleep episodes a day, with no matter of it’s duration or position in the day.

Figure 11. My E3 Schedule in May 2011.

Note: Columns in order: date, total amount of sleep, SEDs during the day (0:00–23:59). Sleep (black), awake period (blue), dream record (white mark).

Figure 12: My SPAMAYL/Monophasic Sleep in August 2011. Structure is the same as in Figure 11.
4.7.2 My Motivation Influence

Since the polyphasic sleep pattern is a deep change in my life’s stereotype, negative changes can be a-priory expected, for example a sleep deprivation, or an unstable circadian rhythm. My motivation is rather pro-polyphasic both on explicit and implicit level. Explicit motivation is under my direct influence, so I can decide to avoid such action, against implicit motivation. Therefore, I attempt to overcome obstacles brought by polyphasic sleep, such as the sleep deprivation, and the disturbance of the circadian rhythm, rather than to sabotage the experiment by resigning myself to the fatigue. Regarding the self-fulfilling prophecy effect, there is a peril that I put myself at disadvantage to get worse results because I know, though unconsciously, those a-priory stereotypes. This motivation to perform better in phase B brings less distortion than would motivation to perform worse in base B, in combination with possible obstacles mentioned above.

4.7.3 My Lifestyle

Apart rational and pure functional reasons, there is polyphasic way of life connected with one's claimed benefits. It is better to have complex reasons and motives, to be really convinced about attempt a polyphasic sleep, poor reasons like ‘I need more time per day’, ‘I got sleep problems. If free running sleep might help, I will try it first’, ‘science does not have all the answers yet’ (Wozniack, 2010) are mostly predictors of failure of the attempt. Based on my previous
experience (see Subject), I want to accept polyphasic sleep as life approach with all his benefits and handicaps as part of my identity. Difficulty of success adaptation to polyphasic sleep can be compared to difficulty of one’s resolution to stop smoking or drinking alcohol in such quantity. In those cases complex motivators are required as well, otherwise failure is most certainly expected. Family, friends and all circumstances must support ones goal, unless one’s is a very dedicated person with one strong stimulus. Therefore I have created a narrative approach to my life, which goes through my identity and aims to maximal use time and mental sources I was given. In raw point of view, my lifestyle proclaims to use as maximum source of human energy for as long as possible with maximal consistency and low variations.

This means to joy power of body moving, ability of getting educated fast, ability to build complex memory structure connected with early adulthood etc. Many studies (Donald & Malekeh, 1983, Hasher & Zacks, 1988, Salthouse, 1994, Naveh-Benjamin, 2000, Howard & Howard, 2001, Naveh-Benjamin et al., 2009) compared different age groups (around 20, 40 and 68 years old), which results showed prevalence 20 year group as the best performing in memory tests, implicit learning, memory retention, information retrieving and associative tasks. In conclusion, broad range of abilities usually decreases with age. For its full use in lifetime performance peak (or at least very close to it) I prefer sleep less now and use my development potential than in older age. Moreover, during studies I have more free time and less responsibility than is hold by parent, in matter of finance, knowledge and lifetime experience in field of law, taxes, work contracts, children and family, therefore I am have no burden and should effectively use this short period (till age of 26) to develop myself. This would be much more complicated in age of 40 with wife, 2 children and dead parents.

Next reasons is connected with self-development and perception of life freedom, ego the time one’s given to do things he or she desires to. Many people depend on enjoying their life before productive age or after, when going to pension, while productive age is dedicated to work, family and children mostly. The same example as above: it is more effective (not just by time, and body, but also to gain experience for further live) to travel round a world for year at the age 20–25, than in the pension. ‘Travel round the world’ you can substitute by anything people postpone to older age due to time limitations of young life, e.g. at age 20–25 people need to build career, finish university, get a job—if they succeed, they can travel in the pension. Those two examples should illustrate the importance of youth, mainly fully working mind and body. 20/25 years old person ‘works’ better than 65 years old.
By following this philosophical approach I should be able and willing to trade my ‘youth time’ for my ‘pension time’, because youth time has bigger value to me, because not all life periods are have the same value from narrative point of view, e.g. I would like to skip 6 months of divorce with my wife due to her infidelity, but I would like to maximize those 6 months while travelling round Asia and Indonesia where I met her. I would prefer to die earlier at pension but to live more time, than people dying later than me. Example with raw data: I would prefer die in 60 years of age and I am able to live 45 years of time (= being awake, sleeping 6 hours a day on average) to die in 65 years of age and living (43,3 year, sleeping 8 hours a day on average). Even if the vigil time would be the same, and it's only think that counts in this case. Reaching maximum age and different life period time indiscrimination are social constructs my lifestyle tries avoid to.

This approach also reflects in cognition, in particular with worse long-term memory I can focus on working/short-them memory, which allows me to shorten perceived presence. This means a notion ‘now’ is shorter interval compared to monophasic approach with less vigil time to perceive. By moving skills from long-term memory to working/short-term memory (probably not in equally amount in behalf of long-term memory), I get feeling my life is far more extended than before.
5. Results

Data are divided into baseline and *polyphasic* group, which has subgroups phase 3 and phase 4 (both in the same day), where phase 4 is mainly as control group. Results are ordered by hypothesis and analysis complexity, which is slightly different from the test order.

5.1 Temperature Peaks

Data about my body temperature development (see *Figure 14*) through the day, collected to determine optimal time during the day to perform testing (see *Circadian Rhythm and Temperature*) show 2 temperature peaks. Peak 1 during 16:00–19:30 and peak 2 during 21:00–22:30.

*Figure 14. My Daily Temperature Development*

![Temperature Graph]

Based on this result, I can exclude rest of the daytime to perform testing. Peak 1 contains slightly higher values thus the best performance can be expected during this time of the day. Due to personal schedule limitation caused by school lectures, Peak 2 is more suitable on few days a week. I prefer this flexible model to Peak-2-only model, because it does not include the highest temperature during the day, and performance would not be as good as it could be. Also, if I would feel tired during Peak 1 due to any circumstances (i.e., exhaustion from work, emotional instability), I could shift testing to other Peak 2. This test schedule fits for phase A.

5.2 Data Sample

Number of records on baseline differs due to gradual test implementation and test battery. Some from all possible 34 measurement on polyphasic records are missing, (a) because of an
absence of testing device (day 10), (b) unfitting sleep schedule/oversleeping and illness conditions (days 15, 22, 25, 31 on phase 4). Sometimes, data only from a particular test are missing, because of (c) technical issues—they were not recorded although the test was filled properly (day 2 – test C, D and E - phase 4). Data missing for reason (b) are not missing at random.

5.3 Short-Term Memory

5.3.1 Data Sample

On baseline was recorded 18 samples (100 %), 30 samples on phase 3 (88.2 %) and 28 samples on phase 4 (82.4 %). Result presents number of correctly answered items from total amount of displayed words (40). 3 values with standardized score distance >2 influenced one group each (2 positively, 1 negatively), which would handicap one group to others, therefore were considered outliers and were also eliminated from analyses. Used data contains 17 samples on baseline (94.4 %), 29 samples on phase 3 (85.3 %) and 27 samples on phase 4 (79.4 %).

5.3.2 Time Independence

Data in each phase were tested for presence time independence by autocorrelation analysis. To full record independence is expected correlation lag 1–3 not to be significant ($p < .05$), or if so having small correlation $r < .3$. Meeting time independence is required to comparison in a form of mean and Cohen’s $d$.

All groups have time independent trend, none of lags were significant.

5.3.3 Linear Regression

On baseline and phase 3 was found linear regression as significant. For baseline with $B = .24$ ($p < .05$), for phase 3 $B = .13$ ($p < .05$). This shows there exists time trend for number of correctly retained words. Positive regression on baseline could be sign of practice effect. On the other hand, polyphasic sleep, in particular its refreshing effect (see Nap Effect) could influence positively influence cognitive structures and enabled achievement of deeper practice effect on phase 3.
Figure 15. Linear Regression Line of Correct Items. Groups: Baseline (blue), Phase 3 (red), Phase 4 (green).

5.3.4 Mean and Effect Size

Table 3. Mean of Correct Items and Cohen’s d Comparison

<table>
<thead>
<tr>
<th>Phase</th>
<th>M</th>
<th>SD</th>
<th>Cohen’s d to baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>12.82</td>
<td>2.35</td>
<td>—</td>
</tr>
<tr>
<td>Phase 3</td>
<td>20.66</td>
<td>3.59</td>
<td>2.51</td>
</tr>
<tr>
<td>Phase 4</td>
<td>16.96</td>
<td>3.93</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Comparing phase 3 to baseline by Cohen’s $d = 2.51$ hypothesis $H_1$ is confirmed. Even if sample size differs almost twice (baseline $N = 17$, phase 3 $N = 29$) and there exist linear relation in phase 3 with $B = .13$ ($p < .05$), so phase 3 has advantage of higher mean of 12 records, effect size is much larger than Cohen’s criterion for large effect $d = .8$ (Cohen, 1988).

Similar effect size is between phase 4 ($N = 27$) and baseline ($N = 17$) in favour of phase 4, and phase 3 ($N = 29$) and phase 4 ($N = 27$) in favour of phase 3 with Cohen’s $d = 1$. 
5.4 Alertness

5.4.1 Data Sample

On baseline was recorded 18 samples (100 %), 30 samples on phase 3 (88.2 %) and 28 samples on phase 4 (82.4 %). 4 values with standardized score distance >2 influenced group in favour of phase 3, which would handicap other two groups, therefore were considered outliers and were also eliminated from analyses. Used data contains 17 samples on baseline (94.4 %), 29 samples on phase 3 (85.3 %) and 26 samples on phase 4 (76.5 %).

Results are formed by average response speeds. False start count is excluded due to its 2 only records. Because there was found no relation to average speed in correlation test, number of attempts has no relevance to the result, and were excluded from further analysis.

5.4.2 Time Independence

All groups have time independent trend, none of lags were significant.

5.4.3 Linear Regression

No significant relation was found, thus data have no linear trend.

*Figure 16. Average Speed in Relation to Time*
5.4.4 Mean and Effect Size

As data are time independent, compare by mean and effect size can be performed.

*Table 4. Mean Speed [ms] and Cohen’s d Comparison*

<table>
<thead>
<tr>
<th>Phase</th>
<th>M</th>
<th>SD</th>
<th>Cohen’s d to baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>307.06</td>
<td>10.90</td>
<td>—</td>
</tr>
<tr>
<td>Phase 3</td>
<td>295.03</td>
<td>13.12</td>
<td>-1.00</td>
</tr>
<tr>
<td>Phase 4</td>
<td>314.85</td>
<td>10.56</td>
<td>.75</td>
</tr>
</tbody>
</table>

Comparing phase 3 to baseline by Cohen’s $d = -1.00$ hypothesis $H_2$ is confirmed with large effect size ($d > .8$). Sample size is irrelevant, because no linear relation was found in any phase. On the other hand, downgrade in phase 4 to baseline was found Cohen’s $d = .75$. This could be caused by larger fatigue influence on alertness as instant ability contrary to short-term memory, which could be trained and develops through the time. Also, despite of large effect size, difference of 12.03 ms is debatable in practice use.

There is also large effect size Cohen’s $d = -1.83$ of phase 3 to phase 4.

5.5 Trail-Making Test

5.5.1 Data Sample

On baseline was recorded 13 samples (92.9 %), 29 samples on phase 3 (85.3 %) and 26 samples on phase 4 (76.5 %). 4 values from of test time and error count with standardized score distance $>2$, for practice effect in the first case and environment distortion in the second case, were considered outliers and were also eliminated from analyses. Used data contains 12 samples on baseline (85.7 %), 28 samples on phase 3 (82.4 %) and 24 samples on phase 4 (70.6 %).

Result is formed by time in seconds test C with combination of letters and numbers is filled in. Correlation of number of errors and test time is significant for phase 4 ($r = .71$, $p < .001$), showing relationship: the higher test time (slower performance), the greater number of mistakes. For speed and number of errors distribution in each group, see Figure 17. This behaviour would be contra-productive, because the aim in this test is finish it as soon as possible (low speed, fast performance) with minimum of mistakes (low mistakes), also this relation is obvious: if I make a mistake, I have to correct it, which will take some time. It shows, that the higher number of mistakes is already included in the higher time (both values rise together), it would be useless to
perform separate analysis for both values and because this relation exists in phase 4 only, it was excluded from further analysis.

Figure 17. Distribution of Speed and Number of Errors across Groups.

5.5.2 Time Independence

All groups have time independent trend, none of lags were significant.

5.5.3 Linear Regression

On baseline and phase 4 was found linear regression as significant, $B = -.72$ ($p < .05$) on baseline, $B = -.25$ ($p < .01$) on phase 4. From this I conclude, there exist time trend for test time on baseline and phase 4. Regression on baseline could be sign of practice effect. On the other hand, polyphasic sleep, in particular its refreshing effect (see Nap Effect) could influence positively influence cognitive structures and enabled achievement of deeper practice effect on phase 3.
5.5.4 Mean and Effect Size

*Table 5. Mean Speed [ms] and Cohen’s d Comparison*

<table>
<thead>
<tr>
<th>Phase</th>
<th>$M$</th>
<th>$SD$</th>
<th>Cohen’s $d$ to baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>32.58</td>
<td>4.40</td>
<td>—</td>
</tr>
<tr>
<td>Phase 3</td>
<td>25.07</td>
<td>2.78</td>
<td>−2.31</td>
</tr>
<tr>
<td>Phase 4</td>
<td>27.73</td>
<td>3.77</td>
<td>−1.25</td>
</tr>
</tbody>
</table>

Comparing phase 3 to baseline by Cohen’s $d = −2.31$ hypothesis $H_3$ is supported with large effect size ($d > .8$). Even if sample size differs more than twice (baseline $N = 13$, phase 3 $N = 29$), there is no linear trend in phase 3. Moreover, effect size is much larger than Cohen’s criterion for large effect $d = .8$ (Cohen, 1988).

There is also large effect size Cohen’s $d = −.82$ of phase 3 ($N = 29$) to phase 4 ($N = 26$).
5.6 GBT

Although GBT provides detailed subtest information for each sheet, only summary values are used, because performance development in 2 minutes this subtest provide is not aim of this thesis. Number of mistakes needs to be taken into account with omitted chars with major weight. One mistake equals to two omits, as it is minimal possible way to distinguish. Higher value would be debatable, ergo error score (ES) = omitted + 2 * mistakes.

5.6.1 Data Sample

On baseline was recorded 15 samples (100 %), 31 samples on phase 3 (91.2 %) and 28 samples on phase 4 (82.4 %). ES and cell mean time (CMT) samples with standardized score distance >2, for practice effect in the case of baseline (standardized values $D_{-14} = 4.6$ (first day), $D_{-13} = 2.3$, $D_{-12} = 2.5$, $D_{-10} = 2.1$ and $D_{-8} = 2.2$), were considered outliers and were also eliminated from analyses, 8 samples in total. Used data contains 10 samples on baseline (67 %), 28 samples on phase 3 (79.4 %) and 28 samples on phase 4 (no change).

5.6.2 Relation between CMT and ES

During testing, I always had to choose and find balance between right speed to get both minimum CMT and ES, which could be described as optimal test strategy. For this reason, their relation needed to be inspected by correlation and linear regression. No results were significant. Correlation between day, ES and CMT were tested to examine possible strategy development in time. Only significant correlation was between day and CMT $r = -0.82$ ($p < .005$) on baseline. This could be sign of practice effect, because this test is very atypical to common daily tasks. Managing such test to get a stable baseline level would take longer than in other test, i.e., short-term memory and alertness. Practice effect is also evident by great standardized values in the beginning of baseline ($day_{-14} = 4.55$, $day_{-13} = 2.30$, $day_{-12} = 2.53$, $day_{-10} = 2.07$ and $day_{-8} = 2.18$). From this I conclude there is no practice effect and relation between CMT and ES, thus they will be tested separately.

5.6.3 Time Independence

For ES all data are time independent. For CMT only phase 3 is not time independent with $lag_1 = -0.48$ ($p < .01$) and $lag_2 = 0.31$ ($p < .01$). This could not be caused by strategy changing, because the same relationship is not present in ES. Possible explanation is inner motivation from the last day’s performance, e.g. I know I did well last day, so I do not have to try so hard now.
Figure 19. Linear Regression of ES. Groups: Baseline (blue), Phase 3 (red), Phase 4 (green).

Figure 20. Linear Regression of CMT. Groups: Baseline (blue), Phase 3 (red), Phase 4 (green).
But this would have to be sort of intuition, because I did not know last day’s result, moreover in application only number of omitted target was displayed. Also, as displayed in Figure 20, changes between particular days are around 25 ms, which on small scale could be random distribution. Positive factor of this is absence of practice effect, which would be optimal in all phase 3 and phase 4 measures.

5.6.4 Linear Regression

For ES no significant relation was found, data have no linear trend. For CMT was found linear regression as significant on baseline, \( B = -2.27 \) \( (p < .005) \), which again is practice effect.

5.6.5 Mean and Effect Size

Table 6. Mean ES, CMT [ms] and Cohen’s d Comparison

<table>
<thead>
<tr>
<th>Phase</th>
<th>ES</th>
<th>CMT</th>
<th>Cohen’s d to baseline</th>
<th>ES</th>
<th>CMT</th>
<th>Cohen’s d to baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>4.80</td>
<td>2.34</td>
<td>—</td>
<td>219.20</td>
<td>11.51</td>
<td>—</td>
</tr>
<tr>
<td>Phase 3</td>
<td>3.43</td>
<td>1.67</td>
<td>-0.76</td>
<td>195.18</td>
<td>8.59</td>
<td>-2.62</td>
</tr>
<tr>
<td>Phase 4</td>
<td>4.04</td>
<td>2.52</td>
<td>-0.32</td>
<td>205.45</td>
<td>14.49</td>
<td>-1.02</td>
</tr>
</tbody>
</table>

Comparing CMT phase 3 to baseline by Cohen’s \( d = -2.62 \) hypothesis \( H_3 \) is supported with large effect size \( (d > .8) \). Even if sample size differs more twice (baseline \( N = 15 \), phase 3 \( N = 31 \)), there is no linear trend in phase 3. Comparing ES between same groups has moderate effect Cohen’s \( d = -0.76 \), but considering different sample size it does not have such an impact. It is also support for hypothesis though.

5.7 SCAAT

This test provides 3 subtest information (2 sheets each), from which only last subtest with most complicated procedure will be used, i.e., info from last 2 sheets in summary. Same ES as in GBT is used.

5.7.1 Data Sample

On baseline was recorded 13 samples (92.9 %), 30 samples on phase 3 (88.2 %), and 28 samples on phase 4 (82.4 %). ES and CMT with standardized score distance >2 were considered outlier and were also eliminated from analyses, 8 samples in total. Used data contains
11 samples on baseline (78.6 %), 26 results on phase 3 (76.5 %) and 26 samples on phase 4 (76.5 %).

5.7.2 Relation between CMT & ES

Relation between CMT and ES on phase 4 showed as significant, $r = .4 \ (p < .05)$, which shows close positive relation the slower performance, the more mistakes possibly reflecting fatigue.

5.7.3 Time Independence

For ES all data are time independent. For CMT only phase 3 is not time independent with lag$_1 = .49 \ (p < .01)$ and phase 4 with lag$_3 = -.44 \ (p < .05)$. Phase 3 shows increasing performance between days, which could be explained as strategy improvement as part of practise effect, or adaptation of cognitive abilities on more complex tasks due to refreshing effect of habitual nap (see *Nap Effect*). On phase 4 there is only very light and negative relation, possibly because cognitive incapability to create strategy on such a complex problem.

5.7.4 Linear Regression

For ES no significant relation was found, data have no linear trend, neither for CMT.

5.7.5 Mean and Effect Size

As data are time independent, compare by mean and effect size can be performed.

Comparing ES phase 3 to phase 4 Cohen’s $d = -.95$, for CMT phase 3 to phase 4 Cohen’s $d = -1.59$, both support for $H_3$ with great effect size. Sample size is irrelevant, because no linear relation was found in any phase.

From data for groups baseline and phase 3 is obvious negative relation ES to CMT in time. Correlation between ES and CMT with all data showed $r = .25 \ (p = .051)$, which is slightly over accepted limit, but regarding 8 removed samples and with sufficient amount of data significance could be on acceptable level. This concludes the slower performance, the more mistakes. Also correlation between day and ES was found $r = .31 \ (p < .05)$, thus number of errors rises in time. This could be caused inner drive to perform faster unintentionally create more and more mistakes.
Figure 21. ES in Relation to Time

Figure 22. CMT [ms] in Relation to Time
### Table 7. Mean ES, CMT [ms] and Cohen’s d Comparison

<table>
<thead>
<tr>
<th>Phase</th>
<th>ES</th>
<th>CMT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline</td>
<td>4.54</td>
<td>2.07</td>
</tr>
<tr>
<td>Phase 3</td>
<td>6.07</td>
<td>2.20</td>
</tr>
<tr>
<td>Phase 4</td>
<td>8.58</td>
<td>3.11</td>
</tr>
</tbody>
</table>

As hypothesis H₁ and H₂ were confirmed, and there are many arguments in favour of H₃, I consider hypothesis H₄, which concerns overall better performance on polyphasic compared to monophasic, as confirmed as well.

### 5.8 Adaption

For insufficient time dependent data development it is not possible to examine curve of data development and test hypothesis, thus H₅ is declined. Data from performed tests does not clearly reflect any dip at the beginning of adaptation phase and it would be unethical trying to find break points by hand.

### 5.9 Sleep Data

Sleep records only serve as E3 documentation, because this thesis aims on complex effect of polyphasic sleep on cognitive abilities. Monophasic schedule on phase A was successful apart 2 days on biphasic. Phase B schedule data are described with help of personal diary, divided into weeks to more transparent overview. Data description in following level of detail is sufficient for this thesis’ purpose. For particular daily sleep records see Figure 23 and Figure 24.
Figure 23. Sleep Records of Phase A (March 4–22) and Phase B (March 23–31).

Note. Structure is the same as in Figure 11.

Figure 24. Sleep Records of Phase B (April 1–24).

Note. Structure is the same as in Figure 11.
5.9.1 Week Distribution

On week 1 (days 1–7, March 22–28), I overslept on day 3 (24), morning were very tough to get through, usually I lied an hour more unable to perform any intellectual activity. On week 2 (days 8–14, March 29–April 4), I overslept on day 9 (March 30). On day 10 (April 1), I went to concert abroad unable to test myself or take core sleep (apart short naps bus). I took semi-core and felt functional. On day 13 I got ill and on week 3 (15–21, April 5–11) I was still ill. I suppose the main reason was broken air-condition in my workplace I have not notice for a long time, while side reason could be exhaustion from abroad concert and immunity fade during adaptation period. I had to extend my core to 4.5 hours minimum, to get healthy. On week 4 (22–28, April 12–18) I was still ill, oversleeping was pretty much on purpose. I got better on day 27. On week 5 (29–34, April 19–24) went everything according plan.

Table 8. Average SEC and SED during Phase B.

<table>
<thead>
<tr>
<th></th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC</td>
<td>4</td>
<td>4:54</td>
<td>3:6</td>
<td>4:35</td>
<td>3:9</td>
</tr>
<tr>
<td>SED</td>
<td>4:54</td>
<td>3,6</td>
<td></td>
<td>5:00</td>
<td>3:6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4:35</td>
<td></td>
<td>5:21</td>
<td>3:8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3:9</td>
<td></td>
<td>4:41</td>
<td></td>
</tr>
</tbody>
</table>

Note. SEC - sleep episode count. SED - sleep episode duration.

On phase A an average sleep episode count was 1.14 a day and total sleep duration 6:07 hours, plus 3 transition days before phase B on biphasic with SED 5:22 hours. On phase B an average sleep episode count was 3.78 SE a day and total sleep duration 4:48 hours.
6. Discussion

The findings of this thesis are consistent with my hypothesis suggesting that polyphasic sleep allows better performance to one on monophasic sleep pattern. As there is no similar study on E3, results can relate only to Stampi’s U 19 days experiment (2002), which concluded that performance was not significantly reduced below baseline levels during the experiments. This E3 experiment showed that performance improved significantly (based on Cohen’s $d > .8$), but it would be a very superficial comparison as they are completely different sleep schedules and 19 days is very short time to adapt on U. In another U experiment Stampi describes improvement after 36 days (2002). This at least confirms my previous expectation that adaptation phase differs among sleep schedules. It is important to mention that some cases could be influenced by time trend of practice effect, although Cohen’s $d$ were often much higher than great effect ($d > .8$), e.g. short-term memory phase 3 to baseline Cohen’s $d = 2.51$. Adaptation phase was not found and is considered as more complex topic, but also less important in polyphasic sleep research than expected in the begging of this study.

As this thesis failed on adaption hypothesis about performance dip in the beginning of polyphasic sleep attempt, I offer some explanation. First, having rich experience with polyphasic sleep (see Sample), my adaptation period has not the same level as in those, who attempt polyphasic sleep for the first time, i.e. Sbragia (Stampi, 1992) who described successful adaption to U after 2-3 weeks. Probably, the more experience with adaptation I have the easier it is to undergo another adaption. This could be also connected with a trained sleep-deprivation resistance.

Second, a better time to examine the presence of adaption would be morning phase 1 of E3 sleep schedule because first week I felt really tired in the morning. Choosing test timing in temperature peaks, which are not influenced by sleep pattern but by fixed circadian rhythm (Zulley & Campbell, 1985), results are expected to remain the same. Thus, testing cognitive abilities to compare with monophasic and testing adaption should have separated timing. Also testing in the middle of the phase (on its expected performance peak) is less sensitive than timing around 20 min after and before sleep. Similar testing pattern was even suggested by Stampi (1992) in his researches.
Third, this study of E3 attempt was not as successful as desired. Illness and oversleeping are factors influencing progressive and fluent adaption. Moreover, as test results show, different cognitive abilities show different evolution of performance in that particular ability, thus adaption period in context of cognitive abilities cannot be generalized as ‘3 days’ or ‘7 days’. This finding denies my previous expectation about existence of a strict adaptation period, regardless of ability, which differed only among individuals.

Next, methodological issues also included insufficient data sample size. To get the desired significance in linear regression, bigger data sample is required. This could be secured by testing on phase 1 and phase 4, 20 min after and before sleep giving 4 samples a day. Unfortunately, the adaptation is by definition a very short period of time (at least in some cases) not long enough to get result of significant linear regression.

Finally, finding adaption differs not only among individual, but also abilities, its research needs to be very complex and still it would have really small external validity, thus inapplicable in practice. For scientific conclusion about 5-10 days evolution does not bring much contribution, so I suggest leaving this topic to further experiment, and aim on evolution rate of particular abilities preferably.

Moving to internal validity issues, the first is that test setting was not always in sufficient level. In phase A, it was not a problem to arrange proper settings but in phase B I faced a problem of disturbance and distraction (caused by similar issues as those mentioned above), mainly due double measuring—one in phase 3 and other in phase 4—it was highly demanding to ensure stable conditions. Because of the illness, I also had to stay at my flat, which can sometimes be a noisy environment (thin walls, 7 people, guests etc.), compared to phase A, where almost all test were performed in my workplace, where is stable environment with none of those issues. Both of these conditions could have influenced results in favour of phase A. Moreover, not all the people in my surroundings were familiar with my test processing, especially with my daytime schedule, and interrupted me unintentionally. Thanks to a relatively loud background music I was usually able to get the setting I needed, apart from 5 test cases which required I retook alertness test B after an interruption.

Test timing and test battery order was properly set. 3 hours in the middle of each phase gave me enough time to fit into my day program. Although phase 4 did not bring much more to
the hypothesis verification, it points out differences in cognitive abilities during the day, even on polyphasic. Before the beginning of the experiment, I considered both phase 3 and phase 4 quite similar but a great effect size in improvement to baseline, in case of short-term memory Cohen’s $d = 1.24$, but also downgrade, in case of alertness Cohen’s $d = .75$, can occur. This shows that phases not only differ from each other, but also abilities change diversely in each particular phase. This finding is significant especially because this experiment is the first one on longitudinal effects of E3. It would be of a great contribution to examine if there are any patterns among individual declaring which ability changes to what level. It would be also interesting to find out in what time of what phase what ability is on its peak, which could help to organize day performance in a way that would make specific abilities’ peaks most effective. However, such a research would be really demanding and there may be more attractive topics to explore in the field of longitudinal polyphasic sleep research.

As far as the short-term memory test is concerned, it included with proper word list, although after reconsideration I would exclude all word with capital letters rather than changing it to lowercase as I did. Such words appeared strange to me, for example words ‘january’ or ‘america’, thus were easier to remember. Apart from this, I consider test proper. For psychomotor vigilance test on alertness, it would be interesting to exclude standardized values over distance >2 because if I took an item and missed reaction getting 500 ms response time, it clearly distort results with average speed of 300 ms. Same for other case of a ‘lucky’ reaction and getting 150 ms. Results of trail making test were sufficient. To improve the test, it would be useful to perform multiple measuring, e.g. shorten test C from 24 chars to 12 and repeat it 3 times. This would reduce specific distortion if I got lost on one letter and thus lost 5 s, although overall I was fast. In other words, the aim would be less luck or bad luck test attempts. Also first two tests (10 letters and 10 numbers) could be completely skipped. With GBT I am completely satisfied since it includes repeated measuring, and precise and clear procedure. In SCAAT test I often thought of different symbol distortion, i.e., it is easier to cross out all signs ‘N’ or ‘Z’ than ‘>’ or ‘∠’. Thanks to great test sample this causes no serious problem but it would be preferable to use more signs which would consist of the same amount of lines and curves. Also descending subtraction test, which was used by Stampi in his U experiments (2002), in modified form could be included. This test is easy to implement, it is resistant to practise effect as usual activity (subtraction), and it takes short time to complete.
What influenced all tests and is a great theme arising in this thesis, is the practise effect. This effect could distort data by starting polyphasic sleep without finishing practise effect on baseline, thus improvement on polyphasic sleep could be caused not by the sleep schedule, but by continuing of practice effect, as probably happened in case of short-term memory test and trail-making test. To prevent this effect on polyphasic sleep phase, multiple measuring on baseline would be applied, e.g., to take short-term memory test five times a day to get into it faster, and also test baseline data for by autocorrelation and linear regression before transferring to phase B.

External validity is closely connected with natural conditions. Data sample is incomplete for illness, few cases of oversleeping, and social occasion (social or music event in time of testing), which could influence nap timing and its quality. Oversleeping and social occasions were expected as marginal, thus not influencing data as complex. Unfortunately, illness a longitudinal intervening influence occurred during experiment for almost two weeks of time. This intervention not only negatively influenced performance during the test but also disabled time development and polyphasic sleep adaptation connected (discussed further). However, this thesis aims on performing of polyphasic sleep in practice; everyday life with all positive and negative influences which relate to that. In laboratory or very successfully controlled conditions, it would be possible to gain 100% complete data sample: perfect nap and core timing, high quality sleep with no distortions by environment, during the testing. Those data would give us proper insight into changes of cognitive structures (meaning improvement of cognitive abilities) caused by polyphasic sleep, but from point of external validity, data would be applicable again only in laboratory (or very similar) conditions. That would be undesirable because to achieve successful adaptation of polyphasic sleep is very difficult, comparable with getting rid of alcohol addiction, mainly—and I from my experience I would say ‘only’—because of external influences, i.e., due to distortion during nap or core sleep, mainly during the day, it is very difficult to find a quiet place to take a nap (in context of city; in the village it may be possible) 4 times a day. Moreover for the whole polyphasic sleep attempt, sudden problems or tasks require nap shifting, outer influences cause emotional problem that make it harder to fall asleep while taking a nap, people trying to contacting you (for example, via a cell phone, or in your home) or trying to talk to you (for example, waking you up, or entering the room to find out you are sleeping and by that waking you up). Almost all of this is the result incompatibility with monophasic lifestyle. For monophasic people is very difficult to imagine anyone could perform different sleep pattern and to respect that completely. Not only because it is strange and impractical for their day time schedule, but also because it is difficult to remember when the person is sleeping and learn all the
new habits connected with—also scheduled—communication with such a person, i.e., for a person sleeping according to a monophasic pattern it may be unusual to hear for the first time during a social event or a good conversation: ‘Excuse me for 30 minutes, I have to take a nap’. Evidence mentioned above should explain those ‘intervening values’ and highlight them as a part of polyphasic schedule, to remind the external validity and applicability to normal life conditions. I consider the presence of illness positive because it was possible to show that despite certain immunity fade, it is still possible get well and continue performing polyphasic sleep without cognitive abilities being affected by illness. Back to incomplete sample data, these were the reasons for which I decided not to collect data because those data would not be obtained in sufficient amount to provide any conclusion, and more importantly, I could have tended to fail my sleep schedule to get more data sample for this case. I felt this tendency immediately after the first illness symptoms occurred, so I tried to avoid being biased immediately.

All findings from this study can be generalized only on people of similar lifestyle and sleep experience (see Sample), mainly people working freelance, with higher sleep deprivation resistance, and with at least month experience of successful E3 schedule before. The effect on people who do not fit to this group would probably be inferior or even negative. No other generalization can be done. Proponents of single-case studies use the process of logical (non-statistical) generalization (Edgington, 1980) by repeating the same study several times with similar subjects. More on single-case study replication was written by Long & Hollin (1995).

Main target of this thesis is to establish single-case design that could be easily replicated by people interested in polyphasic sleep, meeting and discovering main issues of such an experiment. The description of this procedure has not been done before by any research into amateur polyphasic sleep so that this thesis may inspire potential researchers, either professionals or amateurs, to replicate and publish their results in more professional form. According to recommendations of Long & Hollin (1995), to enable and support generalization, next research could be similar removing mention deficiencies, removing topic of adaptation phase, and with longer and more stable baseline. It would be also interesting to replicate the study on a person who has not performed polyphasic sleep yet and carry on the same process again on the same person 6 months later. This could show—apart this thesis hypothesis examination—if and how important previous experience with polyphasic sleep experience is. However, it is not recommended, because personal experience of mine suggest that transition from monophasic sleep to E3 schedule without any previous polyphasic sleep experience might be too great shock.
to the body of the subject which might be too difficult to deal with. In that case, a biphasic schedule would be a better choice. However, some new issues might arise and interesting findings could dispel possible myths concerning polyphasic sleep.

Hopefully this thesis will contribute to applicable sleep research and will provide possibility of better sleep, life enjoyment and equanimity to many people, whose life is stressful and in rush
7. References


