Individual differences in shift work tolerance
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“The whole of science is nothing more than a refinement of everyday thinking”

Albert Einstein
Chapter 7

General discussion
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This thesis adds knowledge on the topic of individual differences in shift work tolerance by using different study designs (cross-sectional, longitudinal) and assessments (subjective: questionnaires; objective: cortisol). This final chapter discusses the main issues that have been raised in previous chapters. We start with the main findings, followed by a discussion of the results, the strengths and limitations, and recommendations for future research including practical implications.

Main findings

The central aim of this thesis is to investigate shift work tolerance, focused on inter-individual variability in response to shift work, and to examine potential baseline predictors thereof.

The results of the survey, presented in chapter 2, revealed that shift workers’ judgement of their own shift work tolerance was primarily determined by their values of sleep quality and subsequently by need for recovery, fatigue and work-life balance. In the cross-sectional study on croupiers (chapter 3), the person-specific factors flexibility of sleeping habits and vigorousness appeared to be the main factors related to subjective health, emotional stability and sleep (as indicators of shift work tolerance).

In our longitudinal study, described in chapters 4 and 6, systematic inter-individual differences were observed in the sleep response in the first two years of shift work exposure. Even more, clearly different individual time trends of the cortisol awakening response were found, indicative for inter-individual variability in the development of shift work tolerance (chapter 5).

As for examination of potential baseline predictors, flexibility of sleeping habits, gender and subjective quality of nighttime sleep were found to be significant for sleep responses (chapter 4 and 6).

Discussion of the results

This thesis highlighted the central role of sleep in shift work tolerance (see chapter 2, 4 and 6), as described in recent reviews (Puttonen et al., 2010; Rajaratnam et al., 2013). We focused primarily on the diurnal sleep after night shifts, which differs substantially from
nocturnal sleep (Jay et al., 2006; Kerkhof & Lancel, 1991; Pilcher & Coplen, 2000). Our result of a significant decline in the amount of daytime sleep after night shifts compared to nocturnal sleep at baseline is important. Research has shown chronic sleep restriction to be associated with degraded performance, reduced safety, and long-term adverse health effects (Cappuccio et al., 2011; Hoevenaar-Blom et al., 2011; Raslear et al., 2011).

The systematic inter-individual differences in sleep response were found to be predictable by flexibility of sleeping habits, gender and subjective sleep quality of nighttime sleep prior to shift work. Similar to our results, Kaliterna and colleagues (1995), in a 3-years follow-up study, recorded that low scores on flexibility of sleeping habits (‘rigidity’) were consistently related with poor health (Kaliterna et al., 1995). However, the authors noted that the correlations were small. Also, the study of West et al. (2007) found flexibility of sleeping habits to be associated with sleep disturbances after 6 months of shift work exposure, yet this association disappeared after 12 months (West et al., 2007). This last finding of West and colleagues could be attributed to the fact that for some shift workers this relation disappeared whereas for others it remained. Hence, this approach was statistically not optimal. An individualized approach, as used in our thesis, is more desired (Van Dongen et al., 2004).

The subjective sleep quality at baseline as predictor was also consistent with results of a previous longitudinal study (Radošević-Vidaček et al., 1995).

Our finding that females showed more total daytime sleep time after night shifts than males seems to be contradictory to the typical finding that female gender predisposes to shift work intolerance (Saksvik et al., 2011). However, in our sample the females as a group were younger and may not have had domestic duties and/or children at home yet, which is believed to be a significant contributor to shift work intolerance in general (Costa, 2003; Monk, 1988).

In chapter 4, 5 and 6, we found dissociations between changes in objective sleep duration and in subjective sleep quality, as well as the objective stress response (cortisol) and subjective fatigue.

We also investigated whether the inter-individual differences in objective sleep response were related to the differences in the cortisol trends. Analyses revealed no relation between sleep and cortisol responses in this sample.
Strengths, limitations and recommendations for future research

Several strengths can be pointed out in this thesis. Research on the development of interindividual differences in responses to shift work is in short supply. Just three studies have measured sleep, subjectively, within the first years of shift work (Radošević-Vidaček et al., 1995; Vidaček et al., 1993; West et al., 2007). This thesis contributes with new results of objective sleep assessments as well as cortisol responses.

To our knowledge this thesis is the first to present data of the effects of shift work exposure both subjectively as well as objectively in novice shift workers. As discussed in the first chapter, one of the difficulties in identifying predictors of shift work tolerance is that there is no single, all-encompassing definition of shift work tolerance (Saksvik-Lehouillier et al., 2015). Conceptually, we believe cortisol, as an end product of the HPA-axis, to become nearest to a comprehensive definition of shift work tolerance.

Even though most shift work field studies consist of a large amount of noise in the data (Knutsson, 2004) and our relative small sample size, we were still able to find interindividual variability in the intensity of shift work tolerance and to identify potential predictors.

Besides strengths, some limitations hold for the cross-sectional and longitudinal studies. First, the surveys lack inclusion of objective assessments to complement the results. The survey on police officers had a response rate of 43%, which can be regarded as acceptable (Baruch & Holtom, 2008). Yet, the healthy-worker effect may have confounded the results and no causal conclusions could be made. Nevertheless, investigating sleep deficiencies and well-being of croupiers in relation to working hours is unique.

The second sample, i.e. the novice police officers, were well suited for our research purpose. Police officers work in a high-stress environment and they frequently experience irregular and extended shifts (Vila, 2006; Zimmerman, 2012). Caution should be made before generalizing the results from police officers to shift workers in other occupations, which might differ in levels of workload and worktime schedules.

In considering the results of our longitudinal studies we do not claim that a period of twenty months suffices to assess short-term as well as long-term effects of commencing shift work. On the contrary, long-term adaptation most likely is a continuous and dynamic process,
impacted by effects of changing conditions at work and at home, aging and health alterations.

For the short term, however, our results add to the existing evidence for inter-individual differences in shift work tolerance. For future studies it is a challenge to identify intolerant shift workers, before or during the adaptation phase, and to investigate whether additional support may enforce their adaptation.

**Practical implications**

This thesis provides a better understanding of shift work tolerance and rudiments for identifying ‘vulnerable’ shift workers. Sleep was expressed as a significant predictor of shift work tolerance and as a major outcome variable to identify inter-individual variability in the responses to shift work. Occupational medicine should pay more attention to the prominent role of sleep in shift work tolerance.

Early detection of maladaptation to shift work is an essential first step in the targeting of person-directed interventions in order to decrease risks of sleepiness-related accidents and help prevent long-term adverse health outcomes (Herbst et al., 2013). Participation of the individual shift worker in scheduling working times, for instance through self-rostering, offers one potential strategy for mitigating sleep problems and improving shift work tolerance (Albertsen et al., 2014; Ingre et al., 2012).

Improving self-awareness and autonomy of shift workers is another potential strategy, which can be done by educational programs on sleep and lifestyle issues. This may include education on sleep hygiene, best napping techniques, physical fitness and stress management (Pallesen et al., 2010; Ruggiero & Redeker, 2013). Such strategies are to be recommended for the improvement of shift work tolerance in the individual shift worker.