**REM SLEEP IMPROVES DEFENSIVE FLEXIBILITY**

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**Abstract**

To think flexibly in a situation of challenge or threat is an important ability. This study hypothesized that flexibility would improve after sleep, particularly for those who got into REM sleep, since REM has been found important for higher mental functions and flexibility. In a between-subjects design with random conditions Sleep and Rest, participants (*N* = 69, mean age 23.9 years) slept in the day for (a maximum of) 120 minutes (or rested 90 m.). Sum of categories in a perceptual process test of defensive strategies constituted the measure of defensive flexibility, previously found related to creativity (Carlsson, 2002). Scoring was double-blind with two raters. An ANOVA showed a significant group difference (*F* (2, 61) = 4.26, *p* = .019). T-tests showed that the REM group (*n* = 35), compared to the Rest group (*n* = 16), had significantly higher flexibility (*p* < .01), while a comparison with the No-REM group (*n* = 13) showed a tendency. The No-REM and Rest groups did not differ. The importance of the REM stage for defensive flexibility was discussed. Future studies should test the flexibility also before sleep, since flexibility might be related to more REM in the sleep architecture.

***Keywords:*** *day-time sleep, defense strategies test, defensive flexibility, perceptual process, REM sleep*

**1. Introduction**

**1.1. Aim**

 It was concluded by Pace-Schott and Hobson (2003) that the differentiation of sleep is a function of brain differentiation, which indicates functional links between sleep and other brain functions. One important cognitive function is flexibility, contributing to higher intellectual functions, and which may get restored by sleep. The present study aimed to see if flexibility would improve after sleep and especially after REM sleep, since REM sleep has been found amenable to flexibility (Walker, Liston, Hobson, & Stickgold, 2002).

**1.2. Psychological functions of sleep and REM sleep**

 Sleep in general has been shown important for human cognition, for instance memory processing and consolidation (Hobson & Pace-Schott 2002; Maquet, Peigneux, Laureys, Desseilles, Boly, & Dang-Vu, 2003). Hobson and Pace-Schott (2002) argued that the Non-REM- and REM-stages interact. New memory traces from the waking state first get stored during active “off-line” Non-REM sleep and may get reactivated during REM sleep. During this hyper associative stage they get associated with other, previously stored, memories. For a review on sleep-dependent memory consolidation, see Diekelmann, Wilhelm, and Born (2009). Diekelmann et al. (ibid.) suggested that patterns of emotional arousal that are induced during learning via amygdale circuitry may become reactivated during REM sleep, thereby strengthening memory and connectivity within hippocampo-neocortical networks. REM sleep has been found important for emotional memory consolidation, when studied in animals, as related in Nishida, Pearsall, Buckner, and Walker (2009).

 From another theoretical angle, Revonsuo (2000) earlier proposed that the REM stage evolved as a simulator to prepare for future threats, while Kramer (2007) viewed the REM stage as an emotion regulator.

 A problem in certain studies of the functional significance of different sleep stages is that people may be differently sleepy when woken up in different sleep stages during the night. To avoid such problems, researchers have used designs with naps during the day. For instance, the restorative function of naps has been investigated (Mednick, Nakayama, Cantero, Atienza, Levin, Pathak, & Stickgold, 2002). In a study on humans using a nap design, amount of REM sleep was significantly related to memory consolidation of emotional items (Nishida et al, ibid). In another study (Payne, et al 2015) that investigated how information is coded and selected in memory, it was shown that a nap in the afternoon improves the selection of useful emotional memories. Further, they claimed having preliminary evidence that a nap and a night’s sleep are equal when it comes to the ability to select between emotional memories. Further, in a nap design, Carr and Nielsen (2015) showed an advantage for REM over NREM on a word association test using positive and negative words primed before sleep, but not for non-primed words.

**1.3. Defense mechanisms**

 In modern psychodynamic theory for example Vaillant (2001) accentuates the double nature of the defense mechanisms. On one hand they occur automatically without our willing it and they distort reality as well as the relation between emotions and thoughts. But they also can contribute to creative syntheses and mature over time; thus they get adaptive rather than destructive. The defenses indicate that the mind has an adaptive response and a fully functioning brain. Defenses not only shield us from reality but enable us to adapt to it. Also Caligor and Clarkin (2010) claim that although defenses may result in a rigid personality and have effects on cognitive processes with negative results, they not always lead to strongly disruptive or pathological behavior. Benjamin (1995) even argues that defenses support the normal functioning in the individual and improve social relations. A way to understand the double nature is in degree of immaturity. Auchincloss (2015) as well as Vaillant, divide the defenses into groups according to how mature they are. According to Auchincloss, mature defenses, such as humor, sublimation or suppression, imply little cost for the ego functions. Neurotic defenses imply more distortion, such as displacement, idealisation, introjection, isolation of emotion, projection, and rationalisering. Primitive defenses are for instance denial, projective identification, splitting and somatisation.

**1.4. A perceptual process test of defense strategies**

 That the perception is the end-result of a very rapid, normally unconscious, construction process was suggested a century ago by Heinz Werner. This was point of departure for the so-called percept-genetic model (For a recent overview, see Smith & Carlsson, 2008). One of the principles in this frame-work is that when a perceptual process gets experimentally prolonged, this enables normally subconscious stages in the construction process to get visually reconstructed and verbally reported (an everyday comparison is when bushes seen vaguely in the evening at first are misperceived as something else). For recent overviews of research done within this frame-work, see Smith (2001) and Smith and Carlsson (ibid).

 When coupled with the psychoanalytic theory of anxiety and defense, this principle resulted in a perceptual process test of defense strategies, developed in the early 60-ies for clinical diagnostics (Nyman & Smith, 1961; Smith & Johnson, 1961). Test validity and reliability were studied in many investigations from various clinical and non-clinical groups. A few examples are Hagberg (1973); Lilja, Smith, and Salford (1992); and Smith and Johnsson (1997). Since groups from the age 4-5 years and upwards have been studied, defense strategies occurring in normal childhood can be discerned. Two monographs compiling studies in clinical and normal groups are Smith and Carlsson (1990) and Smith and Danielsson (1982).

 In this process test thus a person’s defense strategies get measured in experimentally controlled conditions. Defensive strategies have earlier been found related to creativity in several studies, one of them investigating defensive flexibility (Carlsson, 2002). It therefore was deemed well suited for the present study.

**1.5. Hypotheses**

 The following hypotheses based on previous research were formulated.

 ***H1****.* A group that gets into REM sleep will have more defensive flexibility than a No-REM group or a group that is resting.

 ***H2*.** A No-REM group will have more defensive flexibility than a group that is resting.

**2. Method**

 The data collection was made within a larger project about sleep, creative problem solving and creativity (preliminary reported in Carlsson et al, 2014). As a control in the present study, the group means on a state and trait anxiety questionnaire are included in the results.

**2.1. Participants and procedure**

 Participants (*N* = 69, mean age 24; 36 women) were university student at a Swedish university. Five people were excluded due to problems with the sleep recording. Information was given beforehand on overall aim, anonymity, voluntariness and written consent. The project was approved by the local ethics committee. Everyone got lunch and the equivalent of approx. 55 Euros. They were screened for relevant medicines and required not to drink any alcohol or caffeine during 24 hours before testing and having slept no less than 6 hours on average per night during the preceding week. Debriefing was made immediately after the final testing.

The participant was informed on arrival about sleep or rest condition. The testing began 10.30 with tests unrelated to this study. Then the participant got lunch, followed by sleep (maximum 120 minutes), or rest (max 90 min., in upright position, listening to instrumental music, and checked for not sleeping). The sleep participant was equipped with a portable Sleep EEG apparatus (EMBLA) by hospital sleep laboratory staff, who also analysed the sleep data (Somnologica program). After sleep / rest followed a few forms and tests. The last one was the defense strategies test.

**2.2. The defense strategies test**

 Defensive flexibility was calculated from data in the Meta-Contrast Technique, a perceptual process test of defense strategies. For all technical and laboratory specifications and full reference list, see the latest MCT manual (Smith, Johnson, Almgren, & Johanson, 2002). The computerized MCT uses two visual stimuli, a neutral picture and a threatening picture, both shown in series of rapid exposures on a TV screen.

 ***Neutral series and defense series.*** Described briefly, the test procedure starts with a neutral series that stabilizes the perception of the neutral picture (a neutral person sitting behind a table with a window beside). The testing continues into the defense series. In this series both pictures are shown, the neutral always coming a few milliseconds after the threat (which depicts a monster-like face with big teeth). The neutral picture thus acts as a back-ward mask of the threat picture, in order to prolong the perceptual process of the threat. The neutral is exposed at a fixed time level. The threat picture initially is shown a few milliseconds and its exposure time is prolonged in a standardized way. The testing stops when the participant has reported the threat picture correctly according to the manual.

 ***Scoring.*** The defense series enables the scoring of behavior and (foremost) verbally reported interpretations of the pictures. The manual lists types of interpretations scored as defense strategies. It contains 6 major defensive categories, namely repression, isolation, projection, regression, self-referential, and depression. Each major category includes sub-levels, from very immature, behavioral defense levels (one example is when a small child puts the hands on the screen trying to encircle the threat), to symbolic transformations of the threat (report of a lifeless object such as a stone, a white covering curtain, etc., is seen in the window).

 ***Defensive flexibility.*** The protocols had code numbers and were scored by two independent raters, blind to group and sleep data. For the defensive flexibility variable, it was sufficient to get one point for defensive strategy in a major category, thus a score from 0 to 6 was calculated.

**3. Results**

 ***A control for state and trait anxiety.*** Measured after sleep or rest, the state and trait anxiety questionnaire (Spielberger et al., 1983) showed that all groups were similar. The state anxiety mean range was from 34.0 in the REM group to 35.8 in the Rest group. The trait mean ranged from 37.8 in the REM group, to 39.5 in the Rest group.

**3.1. REM and No-REM descriptives**

 Total group mean for time in sleep was82 minutes (*SD* = 24.82). Thirty-five participants got into REM sleep. Their total sleep mean was 91 minutes (*SD* = 16.85) and their REM mean was 15.5 min. (*SD* = 9.67). The No-REM group contained 13 people, with a sleep time mean of59 min. (*SD* = 28.5).

**3.2. Defensive flexibility**

 The range in defensive flexibility was from 1 (11 participants) to 5 (4 participants). Total group mean was 2.6 (*SD* = 1.11).

 ***Mean defensive flexibility.*** In the REM group the mean for defensive flexibility was 2.9 (*SD* = 1.10); in the No-REM group 2.2 (*SD* = 1.19) and in the Rest group it was 2.0 (*SD* = 0.89).

 ***Analysis of group differences.*** An ANOVA showed a significant group difference (*F* (2, 61) = 4.26, *p* = .019). Subsequent t-tests showed that the REM group had higher defensive flexibility than the Rest group (*t* = 2.81, *p* = .007). The REM group tended to be higher than the No-REM group (*t* = 1.61, *p* = .115). The NREM and Rest groups did not differ (*t* = .83, *p* = .415).

**4. Discussion**

 The results partly supported hypothesis one, since the REM group had significantly more defensive flexibility than the group that did not get any sleep. However, REM group flexibility only tended to be higher than in the group that slept without REM sleep. The results did not support hypothesis two, since the No-REM and rest groups did not differ.

 To our knowledge the study is the first that investigates the sleep architecture in relation to defensive flexibility. According to Revonsuo (ibid), the REM stage functions a threat simulator, which may imply that new information gets processed and integrated in the REM sleep, resulting in a refreshed, more flexible mind after sleeping with REM. In the present study the REM group tended to be more flexible than the No REM group, thus gave inconclusive support to Revonsuo.

 Hobson and Pace-Schott proposed that REM and Non-REM sleep interact, thus the entire sleep cycle ought to be most conducive to higher mental functions. However, although the present study points in this direction, the REM group which got a whole sleep cycle was only marginally more flexible than the No-REM group. It is a limitation in the study that the No-REM group only collected thirteen participants; a larger group would have made the results more reliable.

 Sleep and naps are generally restorative. Earlier studies have shown that being woken up in the REM stage was conducive for cognitive flexibility, which is in line with REM sleep being strongly associative. Also, the value of REM for problem solving and as restoration have been shown. The present results did not support that a nap in general can improve defensive flexibility after sleep, only if it included REM sleep. However, it could be the case that the present No-REM group would have got higher on well-being than the group without sleep. A well-being test may be a more general measure, involving that the body feels restored. This may be accomplished without REM sleep, but was unfortunately not tested.

 Another limitation in this study was that the participants were not pre-tested for defensive flexibility, thus there was no flexibility baseline to control for individual differences. It is possible that individual differences in the personality are related to differences in the sleep architecture. Several studies have shown trait-like differences in the distribution of the sleep stages, including the REM stage (for example Tan, Campbell, & Feinberg, 2001). A proneness for an associative state in the waking state might entail a proneness for REM sleep too. However, the trait and state anxiety measures were similar in the present groups, indicating that trait differences were not large. Since all participants were university students, this also contributied to homogeneity.

 According to Auchincloss (2015), analysts today have broadened the manifest dream concept to include defensive modes of functioning revealed in the dream, in replacement of the Freudian concept of a dream censor “holding away” unacceptable latent dream thoughts. Empirically, Yu (2011) investigated a large cohort regarding connection between dream intensity and various defense mechanisms. The results showed that repression as a personality trait was inversely coupled to dream intensity. Thus, the more repression the less nightmares and multiple dreams during the night, and the person was moreover less aware of the dreams. Beside this, it indicated that the more repressive style, the less of splitting and immature defense.

 The results in Yu (ibid) are interesting to compare to the repressor concept (Weinberger, Schwartz, & Davidson, 1979). In a previous study repressors, high trait and low trait anxiety groups were tested with the MCT (Carlsson & Neuman, 2008). In that study the repressors showed significantly more immature MCT defenses compared to low- and high trait anxiety groups. Repressors furthermore remembered fewer dreams. It was argued by Carlsson and Neuman that a predominance of immature defense contributes to being less open to subconscious processes, possibly resulting in low flexibility, flexibility was however not analyzed in Carlsson and Neuman. In the present study we did not analyze the MCT data regarding the distinction between immature and mature defenses, which will be of interest in a future study. However, having defensive flexibility means you are not “stuck” in only one way of percieving the world. Most likely this is adaptive in the sense described by Vaillant (ibid) and others.

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