Social contents in dreams: An empirical test of the Social Simulation Theory

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Abstract

Social Simulation Theory (SST) considers the function of dreaming to be the simulation of social events. The *Sociality Bias* and the *Strengthening hypotheses* of SST were tested. Social Content Scale (SCS) was developed to quantify social events. Additionally, we attempted to replicate a previous finding (McNamara et al., 2005, Psychological Science) of REM dreams as predisposed to aggressive, and NREM dreams to prosocial interactions.

Further, we investigated the frequency and quality of interactions in late vs early REM and NREM dreams. Data consisted of wake, REM and NREM home dream reports (N = 232, 116, 116, respectively) from 15 students. Dreams overrepresented social events compared to wake reports, supporting the Sociality Bias hypothesis. However, the Strengthening Hypothesis was not supported. We weren’t able to replicate the McNamara et al. finding, and no time of night effect was found. While SST gained partial support, further research on social contents in dreams is required.

Keywords: Dreaming; Social simulation theory; Continuity hypothesis; Functions of dreaming; REM sleep; NREM sleep

1 Introduction

The thoroughly social nature of our species is evident in nearly every aspect of our waking life. Research into the contents of dreams reveals our second major conscious state, dreaming, also to be preoccupied with social reality (Kahn & Hobson, 2005, McNamara, McLaren, Smith, Brown, & Stickgold, 2005; for a review, see Revonsuo, Tuominen & Valli, 2015a(2016a)). Previous research has described various aspects of social interaction (Hall & Van de Castle, 1966) and social networks present in dreams (Han, Schweickert, Xi & Viau-Quesnel, 2015). Additionally, Selterman, Apetroaia, Riela and Aron (2013) have investigated the effect of social dream contents for subsequent waking life. Regardless, a rigorous theoretical and empirical research program on the social contents in dreams has been lacking. Thus, the studies have remained descriptive, and not attempted to develop or directly test theories of social content in dreams.

1.1 Dreaming as simulation

Simulation theories rest on two assumptions on the nature of dreaming. First, dreaming is considered an offline version of the same internal phenomenon as waking consciousness. Second, the form of this phenomenon is best understood either as a “world-simulation” (Revonsuo, 2006; Tart, 1987), a credible world analogue (Foulkes, 1985), virtual reality (Revonsuo, 1995; Hobson, Hong & Friston, 201405) or an immersive spatiotemporal hallucination (Windt, 2015) (see also Nielsen, 2010).

1.1.1 Simulation theories

Specific simulation theories of dreaming can be grouped based on how they approach the evolutionarily adaptive functionality of dream content (See Fig. 1). Broadly, the *Social Simulation Theory* (SST) (Revonsuo et al., 2015a; Tuominen, Revonsuo & Valli, in press) (Changed in reference listing to Revonsuo et al. 2016a to refer to the printed version. Tuominen et al. has also now been published and should be Tuominen, Revonsuo & Valli, 2019a.)defines dreaming as a world-simulation that is likely to have, or have had, an adaptive function during human evolutionary history. This is conferred by specialized simulation of social perception, cognition, bonding and social interaction that carries benefits into the waking life (Revonsuo et al., 2015a(Similar to previous –> 2016a)). The *Threat Simulation Theory* (TST) makes a similar claim with regard to the simulation and rehearsal of dangerous or threatening events (Revonsuo, 2000; Valli and Revonsuo, 2006). The *Predictive Processing* accounts (PP) do not propose an adaptive function for dream contents per se, while they do consider consciousness itself to be adaptive (Bucci & Grasso, 2017; Hobson, Hong & Friston, 2014). Finally, a version of the *Continuity Hypothesis* (CH) considers dreaming to be a continuation of wake processing with no specific adaptive function (Schredl & Hofmann, 2003). It should be noted that the contents and hypotheses of CH are under debate; in the present article, CH is represented by the version of Schredl and Hofmann (2003). For clarity, we refer to this version of CH as *the Incorporation Continuity Hypothesis* (ICH), as its central claim is that waking events and activities are incorporated into dreams: dreaming mirrors waking experiences. This is to distinguish it from Hall and Nordby's (1972), and later Domhoff's (1996, 2003), version, which we term the *Cognitive Continuity Hypothesis* (CCH), according to which dreams are modulated by personal interests, conceptions and concerns that mirror those of waking reality. For a debate on the contents of CH, see Domhoff (2011, 2017) and Schredl (2012). We will now consider each of these theories in turn.

SST (Revonsuo et al., 2015a)(2016a) is a recent theory, based on exploratory findings (e.g. Kahn & Hobson, 2005; McNamara et al., 2005) and previous theoretical arguments (Brereton, 2000; Franklin & Zyphur, 2005~~3~~; Humphrey, 1983; McNamara, 1996). It takes our social lives as a plausible candidate for an evolutionarily beneficial target for simulation, and makes use of research into the paramount importance of social groups for our survival in the ancestral past (e.g. Sutcliffe et al., 2012). These principles combined with relevant research from social and developmental psychology allows SST to generate testable hypotheses (Revonsuo et al., 2015a)(2016a). First, *Sociality Bias* states dreaming to be specialized in the simulation and rehearsal of social perception and interaction, and therefore the contents of dreams should also be biased to overrepresent social content. Second, the *Strengthening Hypothesis* claims that to maintain in-group inclusion, the dream self engages more frequently in positive social interactions with persons of higher relationship intimacy. Several further hypotheses (such as the *Social Compensation Hypothesis*) can be derived from SST (Revonsuo et al., 2015a; Tuominen et al., in press)(2016a; 2019a), but those are beyond the scope of this study.

TST (Revonsuo, 2000) proposes another evolutionarily beneficial function of dreaming; simulation of threatening situations. Similarly to SST's Sociality Bias, TST proposes dreams to be biased to simulate threatening events. While research has indicated that threatening situations are more common in dreams than in corresponding waking life (Valli, Strandholm, Sillanmäki, & Revonsuo, 2008) and threatening environments increase dream threat simulations (Lafreniére, Lortie-Lussier, Dale, Robidoux, & de Koninck, 2018; Valli et al. 2005, 2006), TST has been criticized for failing to explain dream contents that involve no threatening elements (Bulkeley, 2004; Humphrey, 2000).

A recent conceptualization in dream research has been that of predictive processing (PP) (Clark, 2015; Hobson & Friston, 2014; Hobson, Hong & Friston, 2014). This theory treats the specific simulated dream content as a non-functional or epiphenomenal side-effect of a process related to a broader adaptive function of consciousness. While the specifics of the view vary between accounts, the crux of the argument is that prediction or Bayesian error correction is what the mind-brain does, and dreaming as our second global conscious state can be conceptualized as what happens when predictions from the generative model (i.e. priors) are not constrained by information from the senses (e.g. Windt, 2015). Similarly, dreaming can be seen as a form of streamlining the inferential world simulation from excessive noise in order to increase the model fit between internal and external reality in subsequent waking life (Hobson & Friston, 2014; Hobson, Hong & Friston, 2014(insert here a citation to Tuominen & Valli, 2019 (added to the reference list))).

Lastly, ICH shares with the simulation theories the claim that dreaming takes the form of a world simulation, yet remains skeptical on the function of the particular contents depicted in the dream. While ICH has appeared in several iterations, here the view of Schredl and Hofmann (2003) of dreams as nonfunctional continuation of wake processing is taken as the theory to be contrasted with SST, as the more elaborate conceptualizations of CCH (Domhoff 2003, 2011) can be argued to be too general in their formulation to draw definitive and risky hypotheses from. The comparisons between other simulation theories and CCH are beyond the scope of this article and will be treated elsewhere~~ (see Fig. 1)~~.

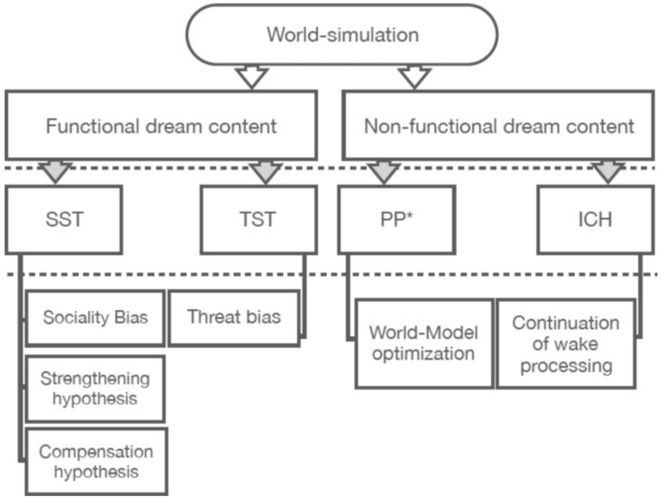

Fig. 1 Functionality assumptions and specific hypotheses of simulation theories of dreaming. Simulation theories share the core idea that dreaming is a form of world-simulation, but differ on the evolutionary functionality of the content. SST and TST claim dreams to have adaptive value, whereas PP accounts do not consider dream contents per se to be adaptive, and ICH treats them as non-adaptive re-experiences of daily events. SST = Social simulation theory, TST = Threat simulation Theory, PP = Predictive Processing accounts, ICH = Incorporation Continuit hypothesis. *Predictive processing accounts appear to place no emphasis on the functional role for dream content per se, but argue for the higher level phenomenon of consciousness to be adaptive.

1.2 Uses of dream simulation

If we are to take the claim of functional dream content made by SST or TST seriously, dream simulations should affect our waking behavior. The general idea of dreaming as a preparatory simulation has gained empirical support from dream studies. In a study devised to test the TST, Arnulf et al. (2014) investigated whether dreaming of a future stressful event – a medical school entry exam – affects subsequent performance. They found dreaming of the event on the preceding night, and the frequency of such dreams, to be correlated with higher performance in the exam. These preparatory dreams were primarily about failing the examination.

In the episodic simulation literature, several studies have looked into the effects of mental training on performance, ranging from increases in muscle strength (Yue & Cole, 1992) to better performance in sports (for a review see Kosslyn & Moulton, 2009). In the case of simple motor scripts, however, this effect appears to be found only when the simulation has been of a successful event (Woolfolk, Parrish & Murphy, 1985; Powell, 1973), possibly contradicting the explanation of benefit from negative simulations (Arnulf et al., 2014). However, in more complex perceptual motor tasks, such as pilot training and other high-risk high-cost situations – where simulation and simulators are frequently used with good results (Prather, 1973) – the effect goes beyond motor script learning to higher order processes, such as decision making, that enable versatility in responding in complex situations. Some support for such a view can be found from Driskell, Copper and Moran (1994), who meta-analyzed the episodic training simulation literature to delineate between positive and negative factors that affect the efficacy of mental simulation. They found the benefits of mental practice to be more substantial when the task has a large cognitive component.

1.3 Dream sociality

1.3.1 Social content in dreams

Dream content studies have shown that there are numerous human characters present in dreams. Comparing wake and dream diaries, McNamara et al. (2005) found dreams to be more social than waking life. On average, a single dream includes between two to four human characters (Domhoff, 1996; Hall & Van de Castle, 1966; Kahn & Hobson, 2005; Nielsen & Lara-Carrasco, 2007). Typically, half of these dream characters are familiar to the dreamer (Hall & Van de Castle, 1966; Kahn & Hobson, 2005; Kahn, Pace-Schott & Hobson, 2002) with 11–20% being family members or relatives and 31–37% friends (Hall & Van de Castle, 1966). At least one close family member – mother, father or sibling – is present in about 10–26% of dreams (Schredl, 2013), while romantic partners can be present in as much as 20% of dreams (Schredl, 2011). Hall and Van de Castle (1966) categorized social interaction in dreams as aggressive, friendly, or sexual. They reported that in nearly 50% of dream reports an aggressive interaction is described, and in about 40% there is a friendly encounter. Even as gender differences in the prevalence of aggression in dreams are small (47% in male and 44% in female dreams), men do have an increased rate of aggression per character and their aggression is more physical in nature (Domhoff, 2005). More recent studies have found 23–47% of dreams to feature at least one aggressive interaction, and 20–42% at least one friendly interaction. It should be noted that societal or cultural differences appear to influence especially the amount of experienced aggression in dreams (Domhoff, 1996, 2005). These findings may, thus, suffer from a bias due to being based on an American sample (see, for example Karagianni, Papadopoulou, Kallini, Dadatsi, Abatzoglou, & Zilikis, 2013; Schredl, Ciric, Bishop, Gölitz, & Buschtöns, 2003; Strauch & Meier, 1996; cf. McNamara et al. 2005 with lower figures for both friendly and aggressive interactions). This criticism of course applies to all western industrialized samples, when attempting to draw universal conclusions (see Henrich, Heine & Norenzayan, 2010 for a more general discussion of this problem). Furthermore, in females, 4% of dreams contain sexual interaction, whereas the corresponding figure in males is 11% (Hall & Van de Castle, 1966).

The effects of social isolation on dream contents further strengthen the general argument of the social function of dreams. In an interesting study by Wood (1962), experimentally induced social isolation was found to increase the number of social dream contents (for a possible explanation see the *Social Compensation Hypothesis* in Tuominen et al., in press)(2019a). Similar findings from the daydreaming literature suggest that loneliness increases simulation of social episodes (Mar, Mason & Litvack, 2012). They further found a predictive link between daydreaming of close others and life satisfaction, and daydreaming of strangers and perceived loneliness, and lack of social support. To conclude, there is a strong case to conceive dreams as venues for simulating social interactions, and such simulations could carry a compensatory function.

1.3.2 Social simulation in NREM and REM dreams

The physiological sleep stage might affect the respective dream experience. Normal sleep consists of two major stages: rapid eye movement sleep (REM) and non-rapid eye movement sleep (NREM). REM awakenings are more likely to result in dream reports than NREM awakenings, and REM dream reports are typically longer than NREM reports (Hobson, Pace-Schott & Stickgold, 2000; Nielsen, 2000). REM dreams have been found to be more visually vivid, emotional, and story-like in comparison with NREM dreams (McNamara, 2004). Fosse, Stickgold, and Hobson (2001) found that REM dream reports contained more hallucinations (i.e. internally generated realistic sensations) in all sensorimotor modalities than NREM dream reports. Additionally, REM reports evidenced fewer thoughts, defined as continued mental efforts that lacked images, than NREM dream reports.

Differences between NREM and REM dream contents have, however, been found to disappear after controlling for dream report length (Cavallero, Foulkes, Hollifield, & Terry, 1990). Fosse, Stickgold, and Hobson (2004) studied the effects of temporal progression on dream content and found that hallucinations increased in NREM sleep as the night progressed, thus resulting in late night NREM dreams being similar to early night REM dreams. Cicogna, Natale, Occhionero and Bosinelli (1998) reached similar conclusions, when they were unable to distinguish morning laboratory NREM and REM dream reports based on their contents. In conclusion, there is some evidence that the difference between NREM and REM dream content might not originate from the sleep stage, but from the time of night and length of the dream report.

Utilizing the concept of social simulation, McNamara et al. (2005) studied the occurrence of different types of social interactions in REM, NREM, and wake reports. They found that aggressive interactions were twice as likely to occur in REM dreams compared to NREM dreams. McNamara and colleagues thus propose that REM dreams are specialized in simulating aggressive interactions whereas NREM dreams simulate friendly interactions. However, this study raises some questions with regards to methodology and conclusions. Their sampling method based on word count matching might have resulted in overrepresentation of short REM reports and lengthy NREM reports, which indicates that their data does not reflect the typical pattern (McNamara, 2004) of longer REM and shorter NREM reports. Furthermore, this might have led to the unbalanced selection of more early than late REM dreams and more late than early NREM dreams.

1.4 Aims and hypotheses

In the present study, to follow the suggestions in Revonsuo, Tuominen and Valli (2015b) (2016b)on how to how to promote a theoretically driven, hypothesis testing approach to the study of dreaming, we set SST's Sociality Bias and Strengthening hypotheses against predictions derived from ICH, treated here as the null hypotheses. This allows us to estimate which theory is is able to predict more accurately the quantity and quality of social dream contents. Whereas ICH predicts strict continuity between waking and dreaming, and thus the amount of social contents to be equal, and to contain interactions between different types of characters in equal proportion between the two states, SST predicts that social perception and interaction are (1) more prevalent in dreams than in corresponding waking life (*Sociality Bias*), and that (2) prosocial interactions in dreams are preferentially aimed at people with whom the dreamer has close relationships (*Strengthening hypothesis*).

Further, we aimed to replicate a previous finding by McNamara et al. (2005), that (3) NREM dreams are specialized in simulating positive, and REM dreams negative social interactions, by using reports from the same larger database as the previous study, but with a more balanced sampling procedure to avoid potential sleep stage and time of night biases. We also investigated whether interactions would be more frequent or more often negative in either late night REM or NREM dreams than interactions in early night REM or NREM dreams.

2 Methods

2.1 Participants and procedure

The reports are part of a larger dream and wake report pool collected at the Department of Psychiatry at Harvard Medical School in the United States. The full dataset contains dream and wake reports from 16 undergraduate students – eight female, eight male, aged 19–26[1] (Stickgold, Malia, Fosse, Propper, & Hobson, 2001). The participants kept a dream journal at home for 14 nights. During seven of these nights, they were awoken both from early night and late night sleep, and asked to report their preceding dream experience (Stickgold, Scott, Malia, Maher, Bennett, & Hobson, 1998). The dream report data were collected utilizing the "Nightcap" sleep-monitoring system that allows for discrimination between REM and NREM sleep stages (Ajilore, Stickgold, Rittenhouse, & Hobson, 1995). The participants provided dictated dream reports either after having been woken up by the Nightcap or after spontaneous awakenings. Wake reports were collected by the experience sampling method ESM), where participants were prompted four times a day via a pager and asked to verbally report their most recent activity into a tape recorder. This dataset was selected due to its originality in containing both wake and dream reports from the same participants, with a well-controlled design.

As the reports were collected in a previous study and the sample size thus preset, we did not conduct a priori power analyses. Domhoff (1996, pp. 65–66) has concluded approximately 100 reports to be required to reach the normative estimates of dream contents. Furthermore, we wished to increase the sample size from the previous study under replication, which used 100 reports from each condition (McNamara et al., 2005). Following this rationale, a representative sample of 232 dictated dream reports were selected from the original larger sample so that the length of the report, time of awakening, sex of the participant and the NREM vs. REM dream report -ratio as well as number of reports per participant were controlled for. A corresponding number of wake reports from the same participants were selected, matched by the amount of reports per subject and report length. Further, wake reports were selected to correspond evenly to the four different prompting timespans. This resulted in data from 15 participants, eight of whom were female. The report selection was carried out in its entirety before the content analysis stage, using only descriptive information (e.g. subject, word count, time of night, sleep stage). Reports shorter than 30 words were excluded, and the reports were randomized by a person external to the content analysis process. At this stage the dream reports were provided to the independent judges. During the content analysis stage, one REM dream report had to be eliminated due to its meaningful word count being below 30 words. Altogether 232 wake, and 231 dream reports – 115 REM and 116 NREM – were thus analyzed. Wake reports were on average 107.82 (51.15, 45.5–153.91) words long, REM reports were on average 170.70 ($SD = 208.0$, 31–1719) words long, and NREM reports 104.50 ($SD = 104.10$, 30–625) words long. REM reports were longer than wake and NREM reports ($p < .0001$).

2.2 The social content scale and the rating procedure

To be able to investigate social perception and interaction in dreams more specifically, we devised the Social Content Scale (SCS). The SCS was developed based on previously created dream content scales, namely the Dream Threat Scale (DTS, Revonsuo & Valli, 2000), and the Hall and Van de Castle (HVdC, Hall & Van de Castle, 1966) coding system. While previous scales, such as the HVdC, can be used to specify social interactions and whether they are, for example, positive or negative in nature, they lack the specificity to get a fine-grained understanding of the social event in question. Using the SCS we are able to investigate, for example, the dynamics of a complex social interaction sequence, in addition to the more general information on the quality and participants of the interaction. As the SCS is developed especially for social contents, it can be argued to be easier to use. The SCS was piloted with unrelated dream reports, and developed in steps until all types of social interactions that were present in the pilot data could be accounted for, and until the raters achieved an acceptable level of agreement (>80%). The use of SCS is not limited to dream reports, but can be used for analysing the social contents of any types of written reports or narratives.

The scoring procedure proceeds as follows: First, raters identify social events (a single social episode in the report), followed by social situations (a specific social perception or interaction where the characters remain the same). One dream can include several social events, and one event can include several social situations. Characters involved are coded based on type (self; personally known familiar characters; characters known by role; strangers), with specific subcategories number (one or more) and gender. Following this, the situations are categorized into either (i) social perceptions – meaning mere noted presence of people in the report – or (ii) social interactions between, or reactions towards, characters. These categories are further subdivided based on their characteristics: Perceptions can be either passive (where a character is perceived but no action is specified) or active (where a perception causes a reaction). Interactions can be either unilateral, where the interaction is one-sided, or multilateral, where an action is performed together with other characters, either jointly (for example, sharing a task) or in an alternating fashion (for example, person A asking for assistance and person B granting it). SCS further categorizes the quality of the social event situation (positive, negative, neutral; for behaviors in case of multilateral interactions and emotional reaction for unilateral active interactions) with specific subcategories. Finally, the tense of the sequence is coded either as past, present or future. For specific categories see Table 1. The detailed SCS scoring manual is presented in Appendix A.

Table 1 The Social Content Scale (SCS).

Coding instructions				
1. A social event is first identified from a dream report and given an ascending number within that dream. One social event may include several social situations, i.e., interactions and/or perceptions				
2. Then, an individual social situation, including either interaction or perception, is identified and given an ascending number within that social event				
3. The parties, type, and quality, as well as the time of the situation are then coded with the following categories:				
Initiating character(s)	Recipient character(s)	Type of social situation	Quality social situation	Time of the event
1.0 dream self 2.0 personally known familiar characters 2.1 family members 2.2 spouse	1.0 dream self 2.0 personally known familiar characters 2.1 family members 2.2 spouse	1. unilateral social perception 2. unilateral social perception with an emotional reaction 3. unilateral social interaction 4. multilateral joint social interaction 5. multilateral social interaction	1. positive 1.1 physical affection 1.2 verbal affection 1.3 consentful sexual interaction 1.4 altruistic behavior	1. present 2. past 3. future

2.3 friends and acquaintances 3.0 characters known by role 4.0 unknown characters 5.0 not specified **b. Number of initiating characters**: 1. one 2. many 3. not specified **c. Sex of initiating characters**: 1. male 2. female 3. both 4. not specified	2.3 friends and acquaintances 3.0 characters known by role 4.0 unknown characters 5.0 not specified **b. Number of recipient characters**: 1. one 2. many 3. not specified **c. Sex of recipient characters**: 1. male 2. female 3. both 4. not specified		1.5 approach cues 1.6 request for support 1.7 mediating behavior 2. negative 2.1 physical violence 2.2 verbal aggression 2.3 forcing 2.4 unconsentful sexual interaction 2.5 avoidance behavior 2.6 abandonment 3. emotional reaction (for perceptions only) 3.1 positive 3.2 negative 4. neutral 5. no interaction, perception only	

Two raters analyzed the 231 randomized dream reports, and 232 wake reports using the SCS while being blind to the participant, vigilance state (wake or sleep), sleep stage (NREM or REM), the time of night the report originated from (early or late night), and to the sex of the participant who produced the report. The raters identified social events and situations, and classified social perceptions and interactions, independently. If both raters had assigned an item the same code, this was used as the final code. In case of a disagreement, agreement on the final code was reached by discussion. Inter-rater agreement rates were calculated after the independent coding stage, before discussion.

2.3 Statistical analyses

Interrater agreement was evaluated with Cohen's Kappa, following the classification of Landis and Koch (1977), which considers the kappa coefficients between 0.01 and 0.20 indicating slight; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 substantial; and 0.81–1.00 almost perfect agreement.

Mann-Whitney (*U*) -test was used to compare the number and length of reports, and the number of social events across sexes. Wilcoxon signed rank (*Z*) -test was used in comparing report contents across the time of night, sleep stages, and in comparing the numbers of neutral, positive, and negative interactions. Friedman's (χ^2) test was used in comparing the number of social interactions in early and late NREM and REM dreams.

The length and number of reports, and therefore also of dream contents, varied across participants. The unequal distribution of dream contents was controlled for by using the average, rather than the total, numbers of social events, perceptions, and interactions per dream. The effect of report length was controlled for by calculating the average number of events, perceptions, and interactions per 100 dream report words. In examining nominal variables, cross tabulation and Pearson's (χ^2) test were used, and effect sizes were evaluated as either Odds Ratios (OR), or, when appropriate, χ^2- and Z-scores were transformed into Cohens *d*'s (e.g. Rosenthal & DiMatteo, 2001). For Pearson's χ^2-tests where degrees of freedom exceeded 1 Cramer's V was used as effect size estimate.

We performed a generalized linear mixed model (GLMM) analysis to further evaluate the relationship between the amount of social interactions and the report condition using the *lme4* package (Bates, Maechler & Bolker, 2012) for R (R Core Team, 2012). This allowed us to control for the variance caused by the fact that the reports are nested within the data, i.e. to assess whether individual differences within reporting account for the effects. This was carried out on the level of dream and wake reports, using the binomial family. Fixed effects fitted into the model were: (a) whether or not the dream contained a social interaction, and (b) the report state (dream or wake), and random effects were (c) subject and (d) gender (see e.g. Baayen, Davidson & Bates, 2008). For additional verification, two competing models with and without subject as a fixed effect were built, and analyzed using analysis of variance (ANOVA) (Pinheiro & Bates, 2000; Bolker et al., 2009).

A new variable was created to calculate frequencies of contents for each participant, and to analyze the dependency of the quality of social interaction on the time of night and sleep stage. Dream reports were divided into four categories: early REM, early NREM, late REM, and late NREM reports. Early and late night reports were discriminated by calculating the median values for the timing of REM and NREM reports during the night. The medians for REM and NREM reports were not statistically different ($p = .53$), and therefore the median of all data was used in dividing the reports to early and late groups.

3 Results

3.1 Material

Each participant produced on average 15.4 ($SD = 8.86$, 2–34) dream and 15.5 wake ($SD = 9.03$, 2–34) reports. Female participants reported more dreams in general ($U = 10.0$, $p = .035$, $d = 1.30$ 95% CI [0.18 , 2.41]), more REM ($U = 10.5$, $p = .04$, $d = 1.15$ 95% CI [0.06, 2.25]) and more NREM reports ($U = 10.0$, $p = .035$, $d = 1.18$ 95% CI [0.08, 2.28]) than males did. On average, females reported 19.6 dreams ($SD = 9.04$, 8–34): 9.8 REM dreams ($SD = 4.53$, 4–17), and 9.9 NREM dreams (*SD* = 4.52, 4–17). Males reported on average 10.6 dreams: 5.3 REM, and 5.3 NREM dreams (both: *SD* = 3.04, 1–9). Wake reports were selected by matching the participant and word count with dream reports.

3.2 Dream versus wake comparisons

Agreements across different SCS categories ranged between 0.66 (SE = 0.14 95% CI [0.38, 0.94])[2] and 0.94 (SE = 0.03, 95% CI [0.89, 0.99] in dream and wake reports. All in all, the inter-rater percentage agreement was strong throughout the categories (86.9–99%).

In a report level comparisons at least one social situation was found in 193 dream reports (83.5%) compared to 148 wake reports (63.8%), and dreams were found to have statistically significantly more social content than corresponding waking life ($p < .05$, OR = 2.88 95% CI [1.86, 4.47]). Overall, there were 196 social situations recorded in wake reports, of which 166 (84.7%) were social interactions, compared to 410 social situations with 290 (70.7%) social interactions of dream reports. The difference between the number of social interactions from social situations between wake and dream reports was statistically significant ($p < .05$, OR = 0.44 95% CI [0.28, 0.68]). To assess whether this finding was due to individual variation, a GLMM model was built consisting of fixed effects for social interaction (yes/no) and report state (dream/wake), and random effects for subject (N = 15) and gender (male/female). This analysis was run on the level of individual reports (N = 463). Despite adding the subject as a random effect, the findings for the report state remained ($b = 0.65$, CI95% = [0.42–0.90]). Additionally, competing models were built including both with and without the subject level as a fixed effect. These findings indicate the significant effect for the report state was not due to individual reports ($\chi 2(1) = 0.294$, p = 0.588, $d = 0.05$) (see Table 2).

Table 2 Number of different types of social perceptions and interactions. Social interaction presented by subtype.

Report source	Types of social situation n/%			Interaction type n/%			
	Perception	Perc. w. emotional reaction	Perception total	Unilateral	Multilateral	Joint	Interaction total
REM	62/24.5	13/5.1	*75/29.6*	49/27.5	117/65.7	12/6.7	*178/70.4*
NREM	41/26.1	4/2.5	*45/28.2*	40/35.7	63/56.3	10/8.9	*112/71.8*
Wake	26/13.2	4/2.0	*30/15.3*	34/19.9	118/71.1	14/8.4	*166/84.7*

3.3 Quality of the social situations

Overall there were 290 dream and 166 wake report interactions. Most frequent category was neutral with 195 interactions in dream and 126 interactions in wake reports. Interaction was positive in 63 instances of dream, and 33 of wake report interactions, and negative in 32 dream, and 7 wake report interactions (see Table 3 for frequencies and percentage portions per subcategory). In dream report interactions (N = 290), the self was involved either as an initiating or recipient character in 246 interactions (84.8%), of which 173 (70.3%) were neutral, 51 (20.7%) positive, and 22 (8.9%) negative. The dream self initiated interaction in 177 cases (72% of dream self's interactions). Taking into account the dream self's positive or negative interactions only, and dividing these interactions into those that took place with personally known characters and to those with all other characters, there was no statistically significant difference in the quality of interaction depending on interaction partner (χ^2 (1, N = 73)) = 1.81, $p = .18$, $d = 0.32$). The dream self was neither selectively engaged in positive interactions with close persons – family, friends or acquaintances – nor was the dream self in particularly "negative" interaction with strangers or other not personally known characters. In wake reports, self was involved in 161 of 166 interactions (97.0%), of which 75.8% (n = 122) were neutral, 21.1% (n = 33) were positive, and 3,1% (n = 5) were negative (Table 4). A majority (71%) of wake report interactions were both neutral in tone and occurred with a known character. There was no statistically significant difference in the wake self's positive and negative interactions between familiar vs. unknown persons (χ^2 (1, N = 35) = 0.42, $p = .52$, $d = 0.22$). Comparison of dream and wake self's positive and negative interactions with familiar vs. unknown persons was nonsignificant, however with a medium effect size (χ^2 (1, N = 108) = 3.79, $p = .052$, $d = 0.38$) (Table 4).

Table 3 Subcategories of all social interactions in wake and dream reports.

Quality of interaction	Wake		Dream	
	n	%	n	%
Positive				
Physical affection	1	0.6	2	0.7
Verbal affection	2	1.2	8	2.8

Consentful sexual interaction	–	–	2	0.7
Altruistic behavior	21	12.7	35	12.0
Approach cues	3	1.8	4	1.4
Request for support	5	3.0	6	2.0
Mediating behavior	1	0.6	6	2.0
Total positive interactions	*33*	*19.9*	*63*	*21.6*
Negative				
Physical violence	1	0.6	5	1.7
Verbal aggression	2	1.2	11	3.8
Forcing	–	–	4	1.4
Unconsentful sexual interaction	–	–	1	0.3
Avoidance behavior	–	–	3	1.0
Abandonment	4	2.4	8	2.8
Total negative interactions	*7*	*4.21*	*32*	*11.0*
Neutral				
Neutral interactions	126	75.9	195	67.2

Table 4 Quality of self's interactions by interaction partner in dream and wake reports.

Quality of interaction	Familiar characters n/%		Strangers n/%	
	Dream	Wake	Dream	Wake
Positive	34/19.7	28/19.0	17/23.3	5/38.4
Negative	11/6.4	4/2.7	11/15.1	1/7.7
Neutral	128/74.0	115/78.2	45/61.6	7/53.8
Total	173/100	147/100	73/100	13/100

Across participants, and after controlling for report length by adjusting the analysis per 100 words, wake interactions were found to be more common with known than with unknown persons ($Z = -2.669$, $p = .008$, $d = 0.40$), and this interaction was often neutral in form ($Z = -2.032$, $p = .042$, $d = 0.33$). Dream reports were found to contain more negative interactions than wake reports when report length was controlled for ($Z = -2.134$, $p = .033$, $d = 0.90$) (Table 5).

Table 5 Social events, perceptions, and interactions among all characters (1) per participant in REM, NREM, and wake reports, and (2) per report in REM, NREM, and wake reports.

	REM (n = 115) *M* (*SD,* range)	NREM (n = 116) *M* (*SD,* range)	Wake (n = 232) *M* (*SD,* range)
1. Frequencies per participant			
Events/report	1.11 (0.26, 0.67–1.62)	0.74 (0.36, 0–1.35)	0.70 (0.28, 0–1.32)

Perceptions/report	0.60 (0.29, 0–0.1.25)	0.32 (0.26, 0–0.82)	0.11 (0.08, 0–0.21)
Interactions/report	1.38 (0.70, 0.25–2.92)	0.81 (0.50, 0–1.82)	0.66 (0.33, 0–1.44)
Word count/report	148.98 (75.72, 43.67–335.31)	88.10 (45.32, 32–179.94)	107.82 (51.15, 45.5–153.91)
2. Frequencies per report			
Events	1.15 (0.75, 0–6)	0.89 (0.79, 0–4)	0.79 (0.72, 0–4)
Perceptions	0.65 (0.74, 0–3)	0.39 (0.67, 0–3)	0.13 (0.34, 0–1)
Interactions	1.54 (1.89, 0–16)	0.97 (1.25, 0–8)	0.74 (0.85, 0–6)

In dream reports, there were no statistically significant differences between REM and NREM reports in positive and neutral ($p > .05$, OR = 0.71 95% CI [0.40, 1.26]), or negative and neutral interactions ($p > .05$, OR = 0.73 95% CI [0.34, 1.56]). Furthermore, there were no statistically significant differences between different types of interactions in early and late NREM and early and late REM dream reports (χ^2 (6, N = 290) = 3.14, $p = .79$, V = 0.79) (Table 6).

Table 6 Quality of social interactions between all characters in early and late REM and NREM, and wake reports.

	Time of night					
	All REM (n = 177) n/%	Early REM (n = 78) n/%	Late REM (n = 99) n/%	All NREM (n = 113) n/%	Early NREM (n = 46) n/%	Late NREM (n = 67) n/%
Positive	35/19.8	14/17.9	21/21.2	28/24.8	11/23.9	17/25.4
Negative	18/10.2	8/10.3	10/10.1	14/12.4	4/8.7	10/14.9
Neutral	125/70.1	56/71.8	68/68.7	71/62.8	31/67.4	40/59.7

4 Discussion

The current study was designed to test two of the predictions of Social Simulation Theory of dreaming (Revonsuo et al., 2015a), to replicate and extend the study by McNamara et al. (2005) and to develop a detailed analysis method for the study of social content in dreams. In the present study, we first tested the following two predictions derived from SST: That social perception and interaction are (1) more prevalent in dreams than in waking life (Sociality Bias), and that (2) prosocial interactions in dreams are preferentially aimed at people who have a close relationship with the dreamer (Strengthening hypothesis). Additionally, we attempted to replicate a previous finding by McNamara et al. (2005) that (3) NREM dreams are specialized in simulating positive, and REM dreams negative social interactions, and investigated whether interactions in late night dreams would be more frequent or more often negative than interactions in early night REM or NREM dreams.

Social situations were found to be more common in dreams than in corresponding waking life, in both per report and absolute frequency analyses. This finding was maintained when controlling for the effects of individual differences in content or reporting. This finding supports the Sociality Bias hypothesis, and fits better to the theoretical background of SST than to that of the ICH. ICH would suggest social contents to be similarly represented in both waking and dreaming (Schredl & Hofmann, 2003). Proponents of the predictive processing account could, however, argue that social situations are more complex than non-social ones, and would therefore require more complexity minimization, i.e., dream simulations (Hobson et al., 2014). One of the central hypotheses of the SST is that dreams should simulate bond-strengthening interactions with persons vital to our survival and reproductive success (Revonsuo et al., 2015a).(2016a) Dream interactions with close persons should thus selectively be more often positive than negative, and the opposite should be true of interactions with unknown persons. This Strengthening Hypothesis, however, did not gain support: The quality of dream self's interactions did not vary as a function of the emotional closeness of the interaction partner. It should be noted, however, that emotional closeness was evaluated from reported content by a third party and not separately reported or analyzed by the participants themselves.

Positive interactions represented one fifth and negative interactions one tenth of all reported interactions in which dream self was involved. In wake reports interactions were less common overall, but positive interactions similarly accounted for approximately one fifth of the reports, whereas negative interactions were less frequent than in dreams (4.2%). These results replicate the previous finding of (McNamara et al., 2005) and offer support for the SST in the form that simulating positive (as opposed to negative) interactions might be one of dreams' essential functions. Further, dreams appear to be more prone to negative social interactions than waking life, which is in line with, and occupies a shared theoretical space with TST (Revonsuo, 2000). Nonetheless, the absolute numbers of positive and negative interactions in the data were rather low, as the majority of social interactions in both report types were categorized as neutral. It should be noted that the participants represented a highly non-representative population (Harvard undergraduate students), and thus these results are not necessarily generalizable across the general population or cross-culturally. This is evident, for example, in the near total lack of sexual content in both dream and wake reports. Therefore, more research is necessitated for a closer analysis of the links between positive, negative, and neutral social interactions in dreams. It could be emphasized, however, that neutral interactions can be argued to provide support for SST as a general proclivity to simulating social content. This question along with the specific topic of sexual content and its variability due to the reporting methodology and/or individual development and circumstance should be considered in the further development of the SST.

4.1 Quality of social interactions in early and late REM and NREM dreams

Based on the previous study of McNamara et al. (2005), it was hypothesized that REM interactions are more often negative in nature than NREM interactions. These assumptions did not gain support from the data. The quality of social interactions did not vary as a function of sleep stage. The results hence do not support the proposal by McNamara et al. (2005) that REM dreams are specialized in aggressive and NREM dreams in friendly interactions. These conflicting results might stem from the sampling method between the two studies. McNamara et al. (2005) utilized a dataset derived from the same larger pool of dream and wake reports, but their sampling method may have skewed the dream report data into overrepresentation of short REM and long NREM reports, which is contrary to the characteristics of typical REM and NREM dream reports. Thus, they may have inadvertently selected early night REM reports and late night NREM reports. Additionally, McNamara et al. had not proportioned NREM and REM dreams from the same participants, or the number of coded dream elements in relation to report word counts, which may have resulted in overrepresentation of elements from those participants who produced long dream reports and thus most dream content. The data in the current study were from the same larger report pool that was utilized in the McNamara et al. study, but now sampled in a manner that takes these factors into consideration. A balanced sampling produced a representative sample of dream reports from early and late night NREM and REM sleep from the same participants. This is turn appears to have eliminated the disparity found by McNamara et al. (2005) in the nature of REM versus NREM dream social interactions. Forthcoming studies employing other data sets are needed before definite conclusions can be drawn on the potential differences between REM and NREM dream functions.

4.2 The results in relation to the social simulation theory

The current study offered some support for SST by verifying dreaming to be more social overall than corresponding waking life. Although *most* interactions were neutral, and not specifically positive or bond-strengthening, the number of positive social interactions surpassed that of negative interactions, in line with assumption of Revonsuo et al. (2015a). (2016a) A central idea of the SST is that the function of dreams is to offer selective advantage in waking life by offering numerous possibilities in practicing social encounters with close people. This would mean that there are *more* social contents in dreams than in daily lives, and that positive interaction in dreams occurs more frequently with close persons (Revonsuo et al., 2015a). (2016a) Our study found the first part of this claim to hold, especially in REM dreams. The current study does not, however, offer evidence for the latter assumption of dreams selectively choosing emotionally close persons as training partners for positive interactions.

Theoretically this finding can be interpreted in the following ways. A commonsensical argument can be made that perhaps the dreamer does not need to practice positive bonding with persons who are already close, and in these cases neutral interaction simulation would suffice. This finding therefore links to another hypothesis of SST, the *Compensation Hypothesis*, which stipulates that dreaming compensates for changes in social relationships in order to maintain or facilitate social inclusion (Tuominen et al., in press). (2019a) Could bond-strengthening interaction rather be targeted at significant individuals with whom the dreamer's connection is weak or deteriorating? Interesting findings from the daydreaming literature suggest that social daydreaming increases the sense of belonging and prosocial behavior, and thus increases social connectedness (Poerio, Totterdell, Emerson & Miles, 2015, 2016a, 2016b). Or, following the findings of Mar et al. (2012) from daydreaming, could social simulation of either close others or strangers in dreams be dependent on perceived social inclusion and life satisfaction? This line of reasoning would lead to an opposing hypothesis to the *Compensation Hypothesis*: when excluded from a group, social simulation would be an attempt to simulate interactions with strangers to re-enter any social group, independent of the previous closeness. As such it proposes an intriguing research question that can highlight the similarities and differences between these two kinds of simulations. Furthermore, testing the SST *Compensation Hypothesis* would allow for possible theoretical discrimination between SST and PP accounts. Another worthy point would be to consider the SST in relation to the Social Bonding Theory (McNamara, 1996), and to include attachment style as, at least, a control variable. This would be in line with other aspects of SST, as previous studies have linked attachment styles to both the sociometer theory (Srivastava & Beer, 2005) and need to belong (Carvallo & Gabriel, 2006), in addition to dreams (e.g. McNamara, Andresen, Clark, Zborowski, & Duffy, 2001; Mikulincer, Shaver, Sapir-Lavid, & Avihou-Kanza, 2009). Last, SST should be further expanded and clarified. Where the former would allow for more testable hypotheses, the latter would help clarify some issues raised in the recent discussions on the theory (Domhoff & Schneider, 2018), and aid in the unification of dream theories via a continuing empirical testing and theoretical discussion.

4.3 Methodological considerations

In dream content studies, the methodology by which dream contents are recorded and analysed can have large effects on the results, especially in specific contents such as dream emotions (see e.g. Sikka, Valli, Sandman, Tuominen, & Revonsuo, 2017). Schredl (2010) points out that the shortcomings of dream content analysis are on the one hand loss of information, and validity of the content scale on the other. Controlling for the loss of information has to do with crafting careful reporting instructions, data gathering and sampling methods, and a practical content analysis tool. Problems in these stages may potentially produce loss of, or bias in the data. In the current study, it was not possible to affect all these stages, but express diligence was exercised in the sampling and coding of the data.

The wake reports were collected by ESM at random intervals, where participants verbally reported their recent activity. This reporting paradigm's strength is its ecological validity, yet as a downside it is impossible to control for selective reporting. The dream data used in the current study was collected utilizing the Nightcap device.

One advantage associated with the Nightcap is that it enabled the gathering of dream reports in the homes of the participants, the monitoring of sleep stages, and awakening participants from different sleep stages. The experience of sleeping in a sleep laboratory obtrudes the dreaming consciousness and seems to result in slightly different types of dream contents compared to home-collected dream reports (Domhoff, 1996; Schredl, 2008; St-Onge, Lortie-Lussier, Mercier, Grenier, & De Koninck, 2005). Similarly, mere participation in a dream study, wearing a device on the head at night, or sleep deprivation due to frequent awakenings might affect dream contents. A few of the dream reports used in the current study did in fact portray the participant's experience of being a participant in a dream study, and some featured contents relating to the lack of sleep. Some of these dreams included social interactions. The Nightcap as a concrete device did not appear in the reports. Overall, it seems that the data gathering method did not produce any significant, visible bias in the current data.

However, the reports in this study, and the sample of reports from the same pool in the previous McNamara et al. (2005) study, appear to contain less positive or negative interactions overall than previous studies (Karagianni et al., 2013; Schredl, Ciric, Bishop, Gölitz, & Buschtöns, 2003; Strauch & Meier, 1996), and to especially underreport sexual content in both wake and dream reports (no instances in wake reports, 0.7% of interactions in dream reports) compared to previous studies (see e.g. Hall & Van de Castle, 1966). One possible issue that could affect the reporting of sexual content is selective reporting due to social desirability bias. In future studies such issues should be taken into consideration before embarking on the data collection, in order to ensure representative reporting. Further, similar analyses should be performed on different and possibly more representative datasets, before casting aside the Strengthening hypothesis.

Another source of bias in studying the contents of consciousness either during wakefulness or sleep is that it is impossible to obtain perfect reports that reflect everything experienced. Instructions that were given to the participants for reporting experiences were not available, and we do not know how participants were advised to report experiences. After having been woken up, the participants had immediately dictated their dream experiences, which were later typed by a member of the research group that collected the reports. The dictation of dream experiences resulted in the reports sometimes lacking content due to poor recording quality, or coherence due to reporting style. Another way of collecting reports would be to ask participants to write their dreams down. This would reduce the amount of lost content, and offer a chance for the participant to form a more coherent general view of the dream content, as writing forces one into processing the message more thoroughly. Yet, the writing process may lead to forgetting or distortion of the original experience when the participant has time to think about specific features of the experience and how to express the experience.

A further potential source of error affecting results has to do with the validity of the content analysis scale. There is a risk that the scale might in fact *produce* or leave out some of the elements we are interested in. In this case, using the SCS might potentially have resulted in either observing social content or certain types of social content in the data where they did not exist. The current study did, however, replicate some of the findings of other dream content studies (Domhoff, 1996; Hall & Van de Castle 1966, Karagianni et al., 2013; McNamara 2004, Schredl et al., 2003; Strauch & Meier, 1996), which supports the validity of the SCS.

As to reliability, inter-rater agreement was high on most of the SCS categories. One explanation for this is that detecting social content in a dream report is usually unambiguous, which results in the raters identifying the same interactions. A high number of congruent identifications already at this stage of analysis indicates higher agreement rates for the following stages as well. Second, the presence of the dream self in a social interaction or perception is typically self-evident. The dream self is involved in the vast majority of interactions or perceptions (89% in the current study; see also Domhoff, 1996), respectively, inter-rater agreement on characters is at the outset high.

In coding characters, SCS seemed to provide a reliable tool for analysis. However, the validity of the scale when it comes to the emotional closeness of a character is debatable, as it used a rather coarse method of categorizing all friends or relatives as close. In case of relatives, emotional closeness and biological relatedness do not always occur in the same proportions. It must be noted that an external rater's estimate of the closeness of a character is not necessarily congruent with how the person him- or herself feels about the character in question. In this study, data on biological vs emotional closeness were not available, and remain to be collected in further studies. Apart from this, the SCS might not accurately portray the continuum of emotional closeness: From the outset, the conceptualization of such an entirety for the purposes of a content analysis scale must be more or less simplified. Another approach in crafting a "closeness scale" for characters would be to apply Sutcliffe et al.'s (2012) idea of hierarchical social layers. Dream characters could then be coded as belonging to one of four groups: support clique, good friends, affinity group, or active network. Characteristic to this type of an approach is that it may emphasize emotional or social connections over biological closeness. The latter should be worked on, to combine these two levels of understanding of human relationships.

4.4 Conclusions

The aim of this study was to test predictions of the SST (Revonsuo et al., 2015a) (2016a) as well as to replicate the findings of McNamara et al. (2005) with a more carefully selected dream report sample. In this study, we tested (i) the *Sociality Bias hypothesis,* by investigating whether dreaming is more social than corresponding waking life; (ii) the S*trengthening hypothesis*, by exploring whether the emotional closeness of a dream interaction partner has an effect on the nature of social contents in dreams, and we also ascertained (iii) whether sleep stage or time of night affects the frequency or quality of social interactions. In addition, a new content analysis method, the Social Content Scale was created. Dreams were found to be more social than waking life, supporting *Social Bias hypothesis*, yet social interaction simulations did not specifically include familiar people or positive interactions with familiar characters, and the findings thus did not support the *Strengthening hypothesis*. Furthermore, the findings of McNamara et al. (2005) that REM dreams contain more negative interactions and NREM dreams more positive interactions did not replicate. We further found no time of night effect. The SCS was proven to be both a reliable and applicable tool for studies delving into social contents of dreams. Given the limited sample of this research we wish these findings to be both independently replicated and expanded in broader, more heterogenous populations.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2019.01.017.

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Footnotes

1 The data in question has been explored in several studies. In these, however, the participants' ages have been reported inconsistently: Apart from the 2001 study cited here, other studies report that the participants were 18–22 years old. The age variable was not available for the present study.

2 The 0.66 Kappa is due to the low amount of variation in the tense category: 405 of the 411 dream report interactions occurred in the present tense. Percentage agreement was 97.3%.

Appendix A. Supplementary material

The following are the Supplementary data to this article:

Multimedia Component 1

Supplementary data 1 (Reference guide in the supplement updated. If possible it would be great to have the final citation of this article in it, or at least a doi?)

Multimedia Component 2

Supplementary data 2 (There should be no Supplement 2, and the link comes up dead?)

Highlights

- Hypotheses from the Social Simulation Theory of dreaming were tested.
- A novel content analysis method,~~ the~~ the Social ~~Simulations in Dreams~~Content Scale, was developed.
- Dreams were found to contain more social interactions than corresponding waking life~~, supporting the Sociality Bias hypothesis~~.
- Prosocial social simulations were not specifically aimed at ~~close or~~ familiar persons~~, thus not providing support for the Strengthening hypothesis~~.
- REM and NREM reports did not differ ~~with regard to~~in prosocial or aggressive interactions.~~, in contrast to previous research.~~

Queries and Answers

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Answer: Thank you for spotting the Selterman reference. It is now correct. The Valli & Revonsuo 2009, however, is missing from the reference list and not misreferenced in text. The correct reference would be: Valli, K., & Revonsuo, A. (2009). The threat simulation theory in light of recent empirical evidence: A review. American Journal of Psychology, 122, 17–38. It is now changed in the reference list but no in the text. The edit mode does not allow me to add a proper dash for the page numbering. This is true for all added references. Neither can I add a line break after the ref

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Answer: Thank you for this comment. HVdC is the short name for the scale and is appropriately attributed in text (section 2.2.), and refers to the Hall & Van de Castle 1966 reference in the list.

Hobson, Hong & Friston should be 2014 (not 2005).

The missing references are added: Franklin and Zyphur (2003), should be 2005 and the reference is: Franklin, M. S., & Zyphur, M. J. (2005). The role of dreams in the evolution of the human mind. *Evolutionary Psychology*, *3*(1), 59–78.

McNamara 1996 reference is now ok, Humphrey ok, R core team ok.

Query: Please note that Fig. 1 and Table 2 were not cited in the text. Please check that the citations suggested by the copyeditor are in the appropriate place, and correct if necessary.
Answer: Fig 1 citation moved to the beginning of the chapter, as the figure refers to the chapter as a whole. Table 1 is in excellent position.

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