The ability to self-tickle following Rapid Eye Movement sleep dreaming

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Abstract

Self-produced tactile stimulation usually feels less tickly—is perceptually attenuated—relative to the same stimulation produced externally. This is not true, however, for individuals with schizophrenia. Here, we investigate whether the lack of attenuation to self-produced stimuli seen in schizophrenia also occurs for normal participants following REM dreams. Fourteen participants were stimulated on their left palm with a tactile stimulation device which allowed the same stimulus to be generated by the participant or by the experimenter. The level of self-tickling attenuation did not differ between REM and non-REM sleep awakening conditions, where presence or absence of an accompanying dream was not controlled for. However, for the female participants, when awakening occurred from an REM sleep dream, self-stimulation ratings were higher than for external stimulation, whereas ratings after NREM sleep unaccompanied by a dream were lower for self-stimulation than for external stimulation. These results indicate deficits in self-monitoring and a confusion between self- and externally generated stimulation accompany REM dream formation.

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1. Introduction

It is well known that self-produced tactile stimulation feels less tickly than the same stimulation produced externally (Blakemore, 2003; Blakemore, Frith, & Wolpert, 1999; Weiskrantz, Elliott, & Darlington, 1971). Blakemore, Smith, Steel, Johnstone, and Frith (2000) hypothesise that this is due to self-produced stimulation being predicted by an internal forward model (Wolpert, 1997), and thus attenuated relative to external stimulation. They found that the attenuation of self-produced touch is not shown in individuals with schizophrenia who have hallucinations and/or passivity experiences, which are symptoms characterised by a misattribution of self-produced thoughts and actions to an external source.

Belief in the reality of hallucinations, and a lack of intentionality, also occur during dreams, and, in particular, during dreams in Rapid Eye Movement (REM) sleep (Fosse, Stickgold, & Hobson, 2001; Pivik & Foulkes, 1968, chap. 3). Here, we investigate whether the lack of sensory attenuation of self-produced stimuli found for hallucinating individuals with schizophrenia is also associated with REM sleep dreams in normal individuals. We hypothesised that self-produced tactile stimulation immediately following an REM sleep dream would not be attenuated relative to externally produced stimulation, but that attenuation would occur following non-REM (NREM) sleep without a dream. (For the rest of the paper, to acknowledge that the presence or absence of a dream was assessed by whether the participant remembered that a dream was occurring immediately prior to waking, these two conditions are termed ‘REM with dream recall’ and ‘NREM without dream recall.’ Participants did not, however, recall the content of any dream, they only reported on the presence or absence of a dream.) This method holds that cognitive characteristics of REM and NREM sleep can be tested while participants are waking from those sleep stages, and was first proposed by Fiss, Klein, and Bekerat (1966). They found participants gave more bizarre, complex, visual, emotional, and vivid stories on the Thematic Apperception Test immediately after REM than after NREM sleep. Similarly, Lavie (1974) found a greater spiral after effect after REM sleep than after NREM sleep. Stones (1977) had subjects learn word lists after 30 min of NREM sleep, and at the end of the first REM period of the night, and found better recall in the REM condition. However, the latter study did not control for length of preceding sleep stage, and allowed a high proportion of slow wave sleep to occur in the NREM sleep condition. Our procedure was based on that of Walker, Liston, Hobson, and Stickgold (2002), in which awakening occurred 10 min into REM sleep or 10 min into NREM sleep following REM sleep; their testing sessions lasted a maximum of 80 s, and started within 15 s of waking. In Walker et al.’s (2002) study, anagrams were presented immediately upon waking from REM and NREM sleep. Thirty-two percent more anagrams were solved after REM than NREM sleep, the REM sleep figure being similar to waking levels, but reaction times did not differ between the two sleep conditions. REM awakenings have also been found to have an advantage over NREM awakenings in accessing remote mnemonic associates (Stickgold, Scott, Rittenhouse, & Hobson, 1999). Sleep inertia, defined as transient awakening impairment of performance (Dinges, 1990), can be a function of the pre-awakening stage of sleep, and the persistence into awakening of the neurochemical differences between the sleep stages (Hobson, Pace-Schott, & Stickgold, 2003, chap. 1). However, the Walker et al. and Stickgold et al. studies show that the REM versus NREM differences are not just due to differences in reaction time and alertness on awakening from the different stages of sleep.
The above studies compared REM to NREM sleep but did not assess or control for whether the participant recalled that a dream was occurring during that sleep stage, whereas our main interest was in testing the hypothesis that stimulation attenuation after REM dreams would be less than attenuation after NREM without a dream. This was achieved by using a subset of awakenings where REM sleep was accompanied by dream recall, and using awakenings from NREM sleep without dream recall as a control. In addition, however, as there is a confound of sleep stage per se on awakening, we also compared all REM to all NREM sleep awakenings independently of whether a dream was recalled or not.

2. Method

2.1. Participants

We recruited 14 healthy normal participants (ages 18–21; 5 males) without medical or sleep problems. All participants were right handed. Local ethical approval for the study was obtained and all participants gave informed consent to take part.

2.2. Screening

Participants had to be able to assess correctly by touch alone the relative smoothness/roughness of four different grades of sandpaper. This is the screening method used by Blakemore et al. (2000).

2.3. Equipment

We used equipment based on that of Blakemore et al. (2000), see Fig. 1. A rod approximately 80 cm long pivots at its mid-point where it is attached to a vertical Perspex sheet on which the participant’s hand is placed, palm facing outwards. A thin strip of foam attached to the rod brushes against the participant’s palm. The rod (and hence the foam strip) can be moved up and down.

Fig. 1. Equipment used for tactile stimulation of participants. The left palm is stimulated by a thin piece of foam attached to the rod. Stimulation can be caused either by the participant or by the experimenter.
either by the experimenter holding and moving one end of the rod, or by the participant holding and moving the other end.

2.4. Procedure

Participants were stimulated on their left palm with the tactile stimulation device. There were six movement oscillations at 2 Hz produced by the participant, and six at the same rate produced by the experimenter. Approximately 5 min of practice was needed for each participant in the evening before the data collection to ensure a standard use of the equipment. Participants rated the self- and experimenter-stimulation in terms of how ‘Intense,’ ‘Tickly,’ ‘Pleasant,’ and ‘Irritating’ it felt on a scale from 0 (not at all) to 10 (extremely). ‘Irritating’ was a distracter variable. The measure for analysis was the sum of the Intense, Tickly, and Pleasant scores after self-stimulation minus the three scores after external-stimulation: a negative total indicates attenuation during self-produced touch. The order of self- and experimenter-stimulation was counterbalanced between participants, a single participant having the same order of self- or experimenter-stimulation for all their assessment conditions.

Stimulation occurred on waking after 10 min of REM and also after 10 min of NREM sleep (stage 2). The order of sleep stage awakenings was counterbalanced between participants following the method of Walker et al. (2002), where awakening occurred in REM period 2 and then NREM period 4, or in NREM period 3 followed by REM period 3 (see Fig. 2). On being awoken, participants were asked if they had been dreaming. Stimulation then started approximately 45 s after waking, and lasted approximately 40 s (20 s for self- and 20 s for experimenter-stimulation), the total time of stimulation thus being within the time window of 95 s from waking recommended by Walker et al. (2002). If participants did not provide an REM awakening with dream recall and a NREM awakening without dream recall, a later awakening was scheduled in order to attempt to obtain this combination, so as to test the hypothesis. Finally, tactile stimulation also occurred after breakfast the following morning, between 08.30 and 09.30, so as to provide a daytime awake measure.

Fig. 2. Awakening counterbalancing protocol. Participants are either awakened at REMa and NREMa, or at REMb and NREMb. Some participants had later additional awakenings if they did not have an REM awakening with dream recall and a NREM awakening without dream recall. Awake daytime data were collected after breakfast in the morning (adapted from Walker et al., 2002).
All data collection was conducted by the research assistant (BT). The research assistant was blind to the sleep stage awakening protocol and to the hypothesis. On interview afterwards he stated that he believed the experiment was about irritability on being woken from sleep.

3. Results

Mean sleep onset was at 00:54 (SE = 0:25) for the male participants and 00:35 (SE = 0:17) for the females. Table 1 shows the times that the counterbalanced awakenings occurred, and the time in minutes since sleep onset of these awakenings. There were no significant differences in these variables between the REM and NREM awakenings (t < 1.4 for all comparisons). The extra awakenings resulted in 7 females and 2 males having an REM awakening with dream recall and a NREM awakening without dream recall, therefore, in this comparison, only the female results were analysed. For the females, there was no significant difference between the times of the REM with dream recall and NREM without dream recall awakenings (t(6) = 1.68), and time in minutes since sleep onset also did not differ significantly between these two conditions (t(6) = 1.68).

The ratings on awakening and in the morning for experimenter- and self-stimulation are shown in Table 2. Levels of attenuation for these awakenings and for the daytime awake condition are calculated as the difference between the experimenter- and self-stimulation ratings and are presented in columns 3 and 5 of Table 3. The mean daytime self- minus experimenter-stimulation score for the females was negative, as expected. However, the stimulation ratings for the males were lower for the external condition (in which the male experimenter controlled the tactile stimulus) compared with self-tickling. Due to this difference between males and females, their results are analysed separately.

3.1. Counterbalanced REM and NREM awakenings

Table 3 shows that there was no significant difference in attenuation between REM and NREM sleep in the counterbalanced awakenings for the male (Wilcoxon test, z = 0.00) or female partic-
Participants (Wilcoxon test, \( z = 1.41 \)), where each of these sleep stages had some dream and some no dream recall. For the 9 females, 8 had NREM awakenings without dream recall and 7 had REM awakenings with dream recall. For the 5 males, 2 had NREM awakenings without dream recall and 2 had REM awakenings with dream recall.

### 3.2. REM with dream recall versus NREM without dream recall conditions

The extra awakenings resulted in 7 females and 2 males having an REM awakening with dream recall and a NREM awakening without dream recall. The hypothesis that self-produced tactile stimulation immediately following an REM sleep dream would not be attenuated relative to externally produced stimulation, but that attenuation would occur following NREM sleep without a dream, could thus only be tested for the females. Table 3 shows that after REM sleep with dream recall versus NREM without dream recall.

**Table 2**

Ratings of experimenter-stimulation (mean (SE)) (A) and self-stimulation (mean (SE)) (B)

<table>
<thead>
<tr>
<th></th>
<th>Daytime awakening</th>
<th>NREM awakening</th>
<th>REM awakening</th>
<th>NREM awakening without dream recall</th>
<th>REM awakening with dream recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Experimenter-stimulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9.20</td>
<td>1.53</td>
<td>6.60</td>
<td>2.23</td>
<td>9.60</td>
</tr>
<tr>
<td>Female</td>
<td>10.33</td>
<td>1.40</td>
<td>10.44</td>
<td>1.18</td>
<td>11.11</td>
</tr>
<tr>
<td>(B) Self-stimulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9.40</td>
<td>1.66</td>
<td>7.80</td>
<td>1.98</td>
<td>10.80</td>
</tr>
<tr>
<td>Female</td>
<td>10.00</td>
<td>1.04</td>
<td>9.33</td>
<td>4.58</td>
<td>10.89</td>
</tr>
</tbody>
</table>

Ratings are calculated as sum of how intense, tickly, and pleasant the stimulus was perceived to be. Ratings are taken during the day when fully awake, and immediately after NREM sleep (combining instances of dream and no dream recall), after REM sleep (combining instances of dream and no dream recall), after NREM sleep without dream recall, and after REM sleep with dream recall. Higher scores indicate higher level of stimulation, maximum possible rating = 30.

**Table 3**

Difference (mean (SE)) between self- and experimenter-stimulation in summed ratings of how intense, tickly, and pleasant the stimulus was perceived to be

<table>
<thead>
<tr>
<th></th>
<th>Daytime awakening</th>
<th>NREM awakening with dream recall</th>
<th>REM awakening</th>
<th>NREM awakening without dream recall</th>
<th>REM awakening with dream recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>0.20</td>
<td>1.20</td>
<td>3 (5)</td>
<td>1.20</td>
<td>1.12</td>
</tr>
<tr>
<td>Female</td>
<td>-0.33</td>
<td>-1.11</td>
<td>.54</td>
<td>-0.22</td>
<td>1.02</td>
</tr>
</tbody>
</table>

Ratings are taken during the day when fully awake, and immediately after NREM sleep (combining instances of dream and no dream recall), after REM sleep (combining instances of dream and no dream recall), after NREM sleep without dream recall, and after REM sleep with dream recall. Positive scores indicate greater self- than experimenter-stimulation. Also included are number of counterbalanced REM and NREM awakenings that were accompanied by dream recall, and (total number of counterbalanced awakenings).

\( * p < .05 \).

ipants (Wilcoxon test, \( z = 1.41 \)), where each of these sleep stages had some dream and some no dream recall. For the 9 females, 8 had NREM awakenings without dream recall and 7 had REM awakenings with dream recall. For the 5 males, 2 had NREM awakenings without dream recall and 2 had REM awakenings with dream recall.

### 3.2. REM with dream recall versus NREM without dream recall conditions

The extra awakenings resulted in 7 females and 2 males having an REM awakening with dream recall and a NREM awakening without dream recall. The hypothesis that self-produced tactile stimulation immediately following an REM sleep dream would not be attenuated relative to externally produced stimulation, but that attenuation would occur following NREM sleep without a dream, could thus only be tested for the females. Table 3 shows that after REM sleep with dream recall versus NREM without dream recall.
recall there was no attenuation for self-stimulation; indeed, self-stimulation ratings were higher than for external-stimulation. There was a significant difference between the measure of self-minus experimenter-stimulation in the REM with dream recall condition compared with the NREM without dream recall condition (Wilcoxon test, $z = 2.21, p < .05$).

3.3. Addressing the possible confound of habituation

It is possible that habituation to the stimulation occurred across the testing sessions of the night and morning, and that this may be the cause of the difference between ratings after REM with dream recall and NREM without dream recall, despite the counterbalanced design. We therefore conducted a Friedman's test on the attenuation scores for the three stimulation episodes: first awakening, second awakening, and daytime measure, which involves ranking each participants' scores as first, second or third in magnitude. We found there to be no consistent pattern for the three rankings for the males ($\chi^2(2) = 0.50, \text{n.s.}$) or females ($\chi^2(2) = 0.18, \text{n.s.}$). For the females who provided REM with dream recall and NREM without dream recall data, we conducted a Friedman's test on their three stimulation episodes: first and second awakenings that provided the REM with dream recall and NREM without dream recall data, and their daytime measure. Again, there was no systematic change in attenuation score across the three episodes ($\chi^2(2) = 1.62, \text{n.s.}$). There were also no significant changes in attenuation across any pairs of stimulation episodes (i.e., between two awakenings in the night or one night awakening episode compared to the daytime measure). Habituation to the stimulation does not therefore appear to be present.

4. Discussion

For the females in the present study, in accordance with our hypothesis, attenuation of self-stimulation was significantly less after REM sleep with dream recall than after NREM sleep without dream recall. The male participants showed a lack of attenuation of self-produced touch when awake in the day, but a far higher self- than experimenter-stimulation rating for both REM and NREM awakenings, there being a mixture of dream recall and no dream recall for each of these conditions. As no significant difference in attenuation occurred for the males or females when REM sleep in general was compared to NREM sleep in general, each sleep condition having a mixture of dream and no dream recall, it is doubtful that the difference in attenuation between REM with dream recall and NREM without dream recall was due to remnants of the muscle atonia that occurs in REM sleep.

These results indicate that a deficit in self-monitoring and a confusion between self- and external-stimulation accompany REM dream formation. Deficits in the use of an internal forward model during REM dreams would account for the rarity of expectation and deliberation in dreams (Rechtschaffen, 1978), although self-reflection is claimed by Kahan and LaBerge (1996) to be present in 53% of dreams, compared to 63% of reports of episodes from waking life. The importance to the hallucinatory experience of not knowing that one is producing the dream content is posited by Revonsuo's (2003, chap. 4) account of dreams functioning as a believable simulation of the real world.
It may be objected that the REM with dream recall results here may be due to the participants’ failure to give a proper rating, due to the distraction of remembering the preceding dream experience. One way to investigate this objection would be to see if ratings are altered when subjects are given distracting or imagery tasks immediately before, or at the same time as, the rating task. However, our participants were not allowed, nor given time, to consider or report the content of their dreams, and they were told that we were not interested in their dream content. Furthermore, the quick setting up of the stimulation equipment upon awakening, and the requirement for the participant to engage effortfully with this setting-up would count against any deliberation by them of their dream content. Indeed, distraction immediately on waking results in a lower recall of dream content (Cohen & Wolfe, 1973), so it may be that it is dream recall rather than the stimulation rating task that would be adversely affected. Along these lines, this concern was anticipated by Fiss et al. (1966), who found that their procedure of obtaining a Thematic Apperception Test story immediately on waking usually obliterated much of the recall of dream content.

Further work on this aspect of the psychophysiology of REM sleep dreams should take account of the fact that REM-like dreams do sometimes occur in NREM sleep. Studies are thus needed to compare awakenings with and without dream recall, both for REM and NREM sleep, in order to assess the importance of the condition “dreaming.” In addition, it would be useful to compare awakenings with dream recall after REM sleep with awakenings with dream recall after NREM sleep in order to assess the importance of the condition “REM sleep.” In the present study, we did not look at NREM dream recall because they are rarer than REM dreams (Nielsen, 2003), hence our choice of NREM sleep for the without dream recall condition, indeed NREM dream recall seldom occurred in our participants. Future studies should include NREM dream recall, while recognising that there is debate about differences between NREM and REM dream characteristics (e.g., Herman, Roffwarg, & Tauber, 1968; Hobson et al., 2003; Pivik & Foulkes, 1968; Takeuchi, Miyasita, Inugami, & Yamamoto, 2001), and whether such differences remain after controlling for the number of words in the dream report (e.g., Smith et al., 2004, and review by Nielsen, 2003). Also, not all dreams lack the awareness that one is dreaming, and it may be that these “lucid” dreams, which almost always occur in REM sleep, will show the normal attenuation of self-stimulation found when fully awake.

Finally, future studies on self-stimulation should take account of possible social effects of sex of the person stimulated, and of having a male versus a female stimulator, and the interaction between these two factors. Interactions of sex of participant with cognitive performance after REM and NREM sleep have been reported (Lavie, Matanya, & Yehuda, 1984), but we consider that in the present study a social effect of de-emphasising or inhibiting the stimulation from the same-sex experimenter may have been occurring for the male participants. The mechanism for this may be that, although males and females do not differ on fear of intimacy, females do score higher on intimacy motivation, which includes readiness for close and communicative interaction (McAdams, Lester, Brand, McNamara, & Lensky, 1988). Dividing intimacy into various components, Hook, Gerstein, Detterich, and Gridley (2003) found that males and females do not differ in self-disclosure or trust, but that females do score higher than males on the factor of being ‘desirous and comfortable with tenderness.’ Aside from sex differences in response to the sensations of being tickled, there is also the interaction of sex of participant with sex of experimenter, given that in this study the experimenter conducting the stimulation was male. Of relevance here is the
finding of Eshel, Sharabany, and Friedman (1998), with heterosexual young adults, that frankness and spontaneity are significantly less with same-sex than opposite-sex best friends, and the finding of Mazur and Olver (1987) that females are more comfortable than are males with same-sex intimacy. It is surprising, considering these possible effects of sex of participant and sex of experimenter on the phenomenology and disclosure of tickling, that the literature has so far not mentioned these possibilities, let alone controlled for them.

References


