Balancing in dreams: Effects of playing games on the *Wii* balance board on dream content

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Summary. Based on the continuity hypothesis of dreams, elements of waking life should be incorporated into nocturnal dreams. The purpose of the current research is to build upon previous studies and investigate the effect of a gross motor balancing task on dream content. Thirteen (13) university students played balancing games on the *Wii* balance board for two hours. They were then monitored in the laboratory during their sleep using polysomnography. Dream reports were collected from the participants' second REM-phase onwards. A total of 36 dreams were collected. Of those, seven dreams (19.4%) were subjectively reported to contain elements of balance, but only two of them (5.6%) were confirmed by external judges. In contrast, 17 dreams (47.2%) contained laboratory references. Additionally, as an exploratory analysis, task performance before sleep and task performance after sleep were compared. The seven participants who reported dreams containing elements of balancing did not perform better than the other participants. Thus, the results obtained imply that the motor task had some influence on participants' dreams, and in total, consolidation effects were limited.

Keywords: continuity hypothesis; dream content; REM sleep; first night effect; memory consolidation

1. Introduction

The *continuity hypothesis* of dreams suggests that content of waking life is reflected in dreams in one way or another (Schredl, 2003). For example, in their diary study, Erlacher and Schredl (2004) found that sport students dream more often about sports in comparison to psychology students. Some studies investigating the continuity hypothesis applied experimental manipulation by having the participants watch a movie; engage with a story; or perform activities before going to sleep. Participants were then awakened during their rapid eye movement (REM) sleep in order to collect their dreams. These studies showed that dream content can be influenced to a limited extent (Cartwright, Bernick, Borowitz, & Kling, 1969; Foulkes & Rechtschaffen, 1964). Physical activities were also used for experimental manipulations, but mainly in the context of memory consolidation (e.g., Buchegger, Fritsch, Meier-Koll & Riehle, 1991). Further studies investigated whether consolidation processes are reflected in dream content. For example, in a recent study Wamsley, Tucker, Payne, Benavides, and Stickgold (2010) showed that there is an association between dreaming of a learning task during NREM sleep, and enhanced sleep-dependent memory consolidation. In the pilot study of De Koninck, Prevost and Lortie-Lussier (1996), participants who dreamt of the experimental task during REM sleep performed better afterwards. Schredl and Erlacher (2010) could not replicate these results with mirror drawing. Participants had noticeably low incorporation rates of the motoric task in the dream content. This may suggest that the mirror tracing may not have been as intensive as in other studies.

The purpose of this study is to examine the effect of a two-hour gross motor task training on dream content. The exploratory goal was to determine the consolidation effects of the dream content by comparing the performance of participants who dreamt of the experimental task to the performance of the participants who did not have task-related dreams.

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2. Method

2.1. Balancing Task

For the motor skill task, a Nintendo Wii, a Wii balance board, and the complementary game Wii Fit were acquired. The board registers shifts in weight and simultaneously and wirelessly transmits them to the Wii console to be integrated in the game. The games require the player to shift the bodyweight and balance to achieve effects, thus qualifying as a coordination and balance motor task. Five games were used:

- The Soccer Heading game involved the player heading 80 virtual balls, where each successful header was awarded with points, and if the player hit distractors, such as shoes, points were subtracted. Combo points were added for each successive hit.
- The Ski Slalom performance was measured by the time the player required to complete the course. An additional 7 seconds of penalty time was added when any of the 20 gates were missed.

- In the Table Tilt game, depending on the level, one ball or more had to be guided around a surface into a hole, thus scoring 10 points for completing the level.
- Tightrope Walk was a game in which the player had to move and balance the game character across a rope, having to reach the end as quickly as possible without falling. The maximum time limit was 2 minutes.
- Ski Jumping required the player to crouch on the board, hold the position, and to straighten his/her legs in a quick manner at the right time, thus making timing crucial. If timing was missed, then the character would fall and the jump was not counted. Scores for each round were made up from the addition of the achieved distances of two successive jumps.

2.2. Sleep Recording

Electroencephalography, Electrooculography and Electromyography were recorded using Xltek's Inspirex Sleep System, and viewed using Sleep Works 5.0. Sleep stages were scored by the Rechtschaffen and Kales (1968) standard.

2.3. Participants

Thirteen sports students (4 women, 9 men) aged 23 to 33 years (M = 26.8, SD = 3.5) participated in the study. Participation was voluntary and part of a seminar at the University of Heidelberg.

2.4. Procedure

2.4.1 Balancing task

Each participant came to the sleep laboratory and performed a balancing task prior to sleeping. At 8 p.m., participants, all of whom had no previous experience with the Nintendo Wii-Fit-Balance Board, went through a 10-minute calibration and practice process. Following the calibration, a selection of balanced-based games, including Soccer Heading, Ski Slalom, Ski Jump, Table Tilt, and the Tightrope Walk were played at the beginner level. Each game was played five successive times, except Table Tilt, which was played only three times. The first round of each game was counted as the pretest. After the first learning phase, participants rested for a short time and at 9:15p.m. proceeded with the second learning phase. They played the same games, the same number of times, but at the intermediate level. At 10:15 p.m., the post-test was performed at the beginner level. Following the motor skill training, participants were prepared for a polysomnographic recording. At 11 p.m., they were ready to sleep and the lights were turned off.

2.4.2 REM-waking

Throughout the whole night, participants and their sleep were monitored so that they could be awakened from their second REM-phase forward. These awakenings were based on a standardized protocol which required the waking during the second REM-phase to be at least 5 minutes after the onset. The waking in the third REM-phase was specified to occur 10 minutes after the onset. The waking was 15 minutes after onset for the next REM-phases. This is because REM-phases get longer in the later stages of sleep. If the REM-phase was interrupted by participants' movements or short awakenings, the waking procedure had to be delayed by an extra 2 minutes of REM sleep. If the required length of REM sleep was not achieved, then that REM-phase would be skipped and a waking procedure was to be initiated in the next REM-phase.

After the participants were awakened, via an intercom they were asked: "What was the last thing that went through your head before waking up?" The question could be repeated up to three times, to reduce the chance of the participant falling asleep again. The answer was recorded with a recording device. After the dream was recorded, participants answered questions about the valence of the dream content and whether or not the balancing-theme was salient in their dreams, and if so, in which form. Dream reports were later written up and then scored by two external raters using a dream manual that included existing scales, as well as new nominal scales relevant to the study (Schredl, 2010).

2.4.3 Retention test

Between 7 a.m. and 7:30 a.m., lights were turned on and participants were asked to get up. After the electrodes were removed and to reduce sleep inertia, participants were awake for over 30 minutes. Then, they performed the retention test, where they played each game again at the beginner level.

2.5. Statistical Analysis

Change of performance over time is analyzed using t tests. Dream-content-dependent change in performance is studied in an exploratory manner using a two-way repeated-measures ANOVA. The factors are defined by participants' subjective reports of whether or not they dreamt of balance-related themes. The retention test is compared with the post-test. Results for the Ski Jumping game were excluded from the ANOVA analysis. Good performance was measured more by timing and less by active balancing as in the other games.

3. Results

Average time spent in bed (M = 477.4, SD = 27.2), time spent sleeping (M = 352.1, SD = 49.7) and the duration of the different sleep stages are summarized in Table 1 below. Participants were awakened 2 to 4 times per night, making up a total of 40 REM-phase awakenings (see Table 2). Thirty-six dream reports were collected, which represents a dream recall of 90%.

Table 1. Mean and Standard Deviation (in Parentheses) and Percentage Distribution of the Sleep Stages (n=13)

Sleep parameter	Minutes	Percentage
Time in bed	477.4 (27.2)	-
Sleep time	352.1 (49.7)	100
Stage 1	67.7 (26.5)	19.25
Stage 2	150.1 (38.9)	42.6
Stage 3	44.9 (23.2)	12.75
Stage 4	47.5 (16.5)	13.5
REM	41.9 (15.9)	11.9

Table 2. Number of Awakenings and Number of Dream Reports for each Participant

Participant	Number of awakenings	Number of dream reports
1	2	2
2	2	2
3	4	4
4	3	3
5	4	4
6	3	3
7	2	0
8	4	4
9	4	4
10	4	3
11	3	2
12	2	2
13	3	3
Total	40	36

3.1. Performance Data

When comparing pre and posttests, participants significantly improved in all games, with the exception of the Ski Jump game (see Table 3). However, there were no significant differences between post and retention tests.

3.2. Dream Content

Table 4 shows that balancing elements were subjectively reported by seven participants in one of their dreams, when asked if the balance-theme was salient in their dream. Below are their responses:

- Yes, while jumping over the waves and while skiing.
- No, except when Britney Spears climbed over the fence.
- Yes, maybe when greeting once, taking someone into my arms and spinning around.

Table 4. Frequency of Dream Elements Relating to Previous Evening

	Subjective ratings			External ratings		
Category	Yes	No	n	Yes	No	n
Laboratory references	-	-	-	17	19	11
Game/balance-related activities	7	29	7	2	34	2
Computer/ device (Wii)	2	34	1	1	35	1

- Yes, I said somehow, that we would get to the institute quicker if we did not take the path, but walked cross-country, like through the field (…), which was rough and annoying to march through, and then there was a bridge.
- Yes, maybe the submarines in the water.
- Yes, the balancing girl on the tree.
- Yes, maybe because of the biker.

However, when external raters read the complete dream reports, only two dreams were rated as containing balance-related elements. In comparison, a total of 17 dreams were rated as containing references to the laboratory.

3.3. Effect of Dream Incorporation

Both before and after sleep, the exploratory two-way repeated-measures ANOVA analysis compared the performance of the Balance Dream group who subjectively reported to have dreamt about balance-related elements with the performance of the No Balance Dream group who did not report such dream content. The analysis resulted in no significant differences: Soccer Heading $F(1,11) = 0.43$, $p = .52$; Ski Slalom $F(1,11) = 0.21$, $p = .65$; Table Tilt $F(1,11) = 0.71$, $p = .41$; and Tightrope Walk $F(1,11) = 1.45$, $p = .25$.

Table 3. Mean, standard deviation and t-test comparisons of Pre-Post-tests and Post-Retention-tests

	Pretest		Posttest		Retention		Pre-Post			Post-Retention		
	Mean	SD	Mean	SD	Mean	SD	t	p	d	t	p	d
Soccer Heading[a]	59.4	68.6	211.5	128.0	181.9	104.9	-5.2	<.001*	1.4	1.4	.26	0.4
Ski Slalom[b]	90.7	19.3	49.9	10.7	49.6	14.6	7.2	<.001*	2.1	0.1	.92	<0.1
Table Tilt[a]	42.3	9.3	68.2	31.5	69.1	26.7	-3.1	.01*	0.8	-0.1	.92	<0.1
Tightrope Walk[b]	112.1	16.7	74.2	28.2	71.0	30.3	3.8	.002*	0.5	0.4	.70	0.1
Ski Jump[c]	175.9	69.0	201.4	80.2	225.5	57.8	-1.3	.24	0.4	-1.1	.30	0.4

Note. *Significant p-value; [a]Higher scores signify better performance; [b]Lower times signify better performance; [c]Higher sums of two distances signify better performance.

4. Discussion

The results of this study support in part the continuity hypothesis of dreams. Half of the participants reported to have dreamt about elements from the experimental task. However, when considering the number of dreams externally rated to contain balance, the incorporation rate is as low as 5.6%, which is similar to the study done by Schredl and Erlacher (2010), in which only 1.4% of the 72 dreams were externally rated to contain references to the motor task. This low percentage, however, may underestimate the incorporation rate, as external raters only score what is explicitly stated in the dream report. The ratings' validity depends on the details of the dream report which still may not completely reflect the dream experience (Schredl, 2010).

The participants dreamt more about their new sleeping environment, as 11 of the total of 13 participants dreamt at least once about the laboratory. This is most likely the result of the so called first-night effect that, as the name suggests, most commonly occurs on the first night when participants must adapt to the new environment, the electrodes, and being monitored during sleep (Schredl, 2008). It often leads to decreased sleep efficiency, shorter REM sleep, and supporting the continuity hypothesis, increased dreaming of the sleep laboratory.

In contrast to the stress and worry that is associated with undergoing a polysomnographic recording, the Wii games might have been less intensive, thus producing lower incorporation in the dream content. To potentially increase the incorporation rate, the task would have to be introduced after an adaption night, and also made more enticing to the participant by an incentive.

The exploratory analysis showed no significant interactions between dreaming of balancing elements and an improved performance in the Wii balancing games. In fact, the mean scores in the retention test after sleep were not significantly different from the scores in the posttest. This suggests that the participants did not benefit from sleep in terms of consolidation. However, this may not necessarily be true as participants' quality of sleep differed in the new environment from sleep in their usual home setting. Because the focus of the study was to investigate the effect of the gross-motor task on dream content, participants were awakened from their REM sleep. Although the waking protocol allowed sufficient REM sleep, the procedure nevertheless shortened the total amount of REM sleep, possibly interfering with consolidation processes. Additionally, there was no warm-up before the retention test, which might have led to underestimation of the performance after sleep. Furthermore, the Wii games used are commercial games which lend themselves well to study incorporation into dream content. They are less useful to our exploratory analysis of consolidation effects. For example, in the Ski Jumping game, timing was crucial. In the Soccer Heading game, participants who successfully hit the virtual balls 20 times in a row achieved much greater scores due to the combo points, than did participants who hit 20 virtual balls in total, but not in a row. Future studies could use tasks on a stabilometer to reliably examine consolidation effects on balancing.

In light of the studies linking procedural memory to not only REM but also to other stages of sleep, such as stage 2 sleep, and further differentiating between learning new skills and building upon them (Smith, Aubrey, and Peters, 2004), future studies will need to clearly categorize a studied motoric task and associate it with a single one or both mentioned sleep stages. Following the example of the study of Wamsley et al. (2010), the link between dream content in NREM sleep and improving task performance could be further expanded upon and extended to include motoric tasks.

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