Sleep Communication

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Objectives

- Limitation in experimental sleep and dream research: No conscious, bidirectional interaction between subject and experimenter possible during sleep and dreaming.
- Goal: Find a procedure ("Sleep Communication") to circumvent this limitation. Conduct a proof-on-concept study to show that this method actually works.

Methods

Basic idea: Sleep Communication

- Waking world stimuli can be incorporated into dreams (for a comparison of different stimuli see [1]).
- Dreamed eye movements largely correspond to real eye movements, which can be voluntarily controlled from within a lucid* dream and can be measured by EOG [2].
- Applying a coding scheme (e.g. Morse Code) onto the stimulus and the eye movements allows for arbitrary signs and messages to be transferred in both directions from and to sleep at the same time.

Proof-of-concept study

- Subjects: Ten healthy, very frequent lucid dreamers (at least one lucid dream per week).
- Task: Understand random math problems transmitted into sleep (e.g. "3+5", "7-2") and respond the solutions ("8", "5") whilst being asleep using eye movements.
- Subjects underwent complex training program:
    - At home (Internet-based): Learning Morse Codes (0-9, P, M). Decoding math problems in visual (blinking) and acoustic (beeping) stimuli during wakefulness.
    - In the sleep lab: Learning to produce EOG eye signals and to transmit numbers by using them.
- Two or three whole-night PSG recordings (EEG, EOG, EMG) of each subject in the sleep laboratory.
- Complex experiment protocol (see Figure 1).

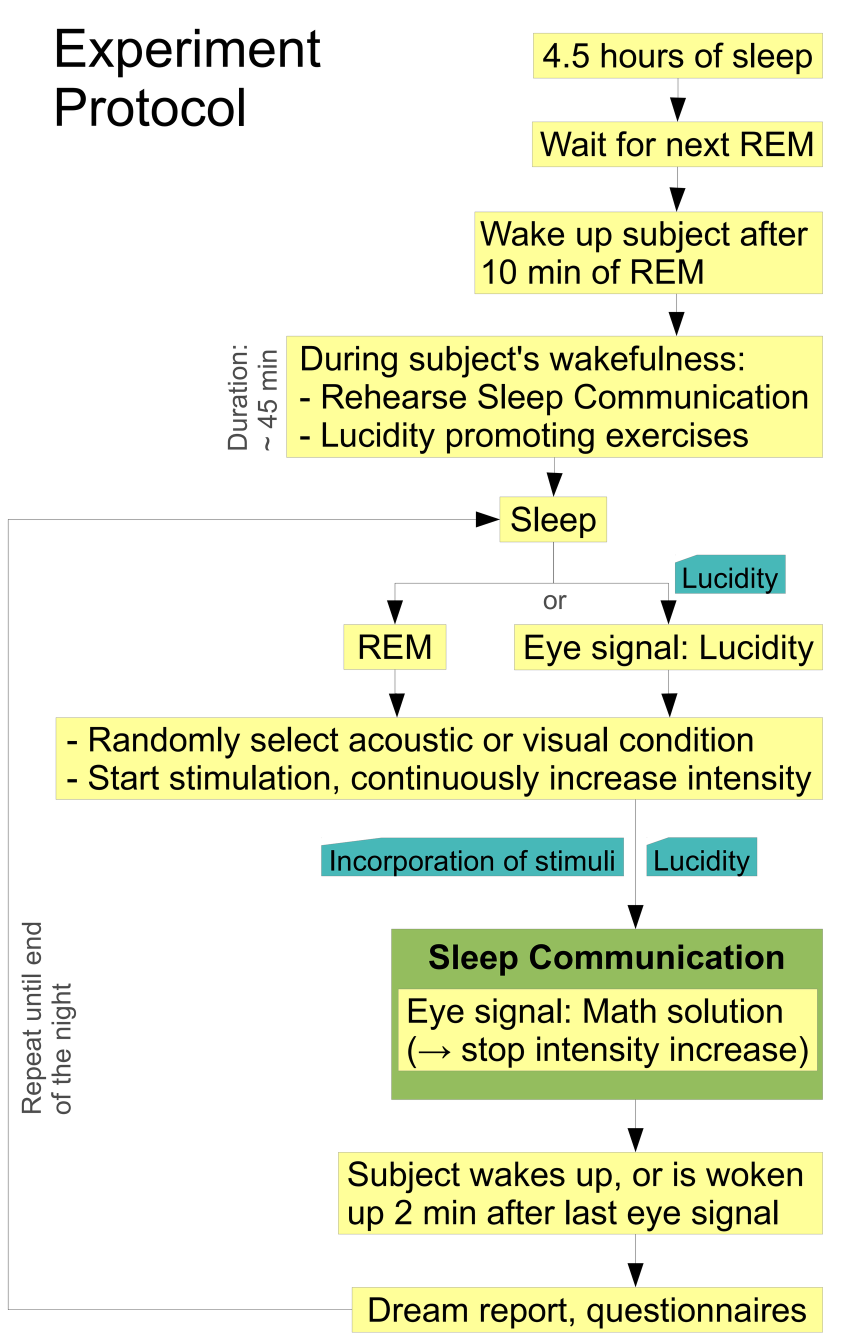

Figure 1: Experiment protocol of the proof-of-concept study.

* A lucid dream is a dream in which the dreamer realizes that he or she is dreaming whilst still being asleep.

Results

- Three subjects incorporated, decoded, solved and answered in total 15 math problems (M=5, SD=4.3) in eight dreams (M=2.7, SD=1.7) without waking up.
- Both visual and acoustic stimulation could successfully be used.
- Two additional subjects correctly decoded parts of math problems inside a dream but could not understand or answer complete problems.
- Nine subjects reported lucid dreams (total: 19), out of which 13 were marked as lucid with a predefined eye signal. Seven subjects remembered their task in 16 lucid dreams and tried to find incorporated math problems.
- 21 of 33 stimulations were clearly incorporated into a dream by seven subjects.

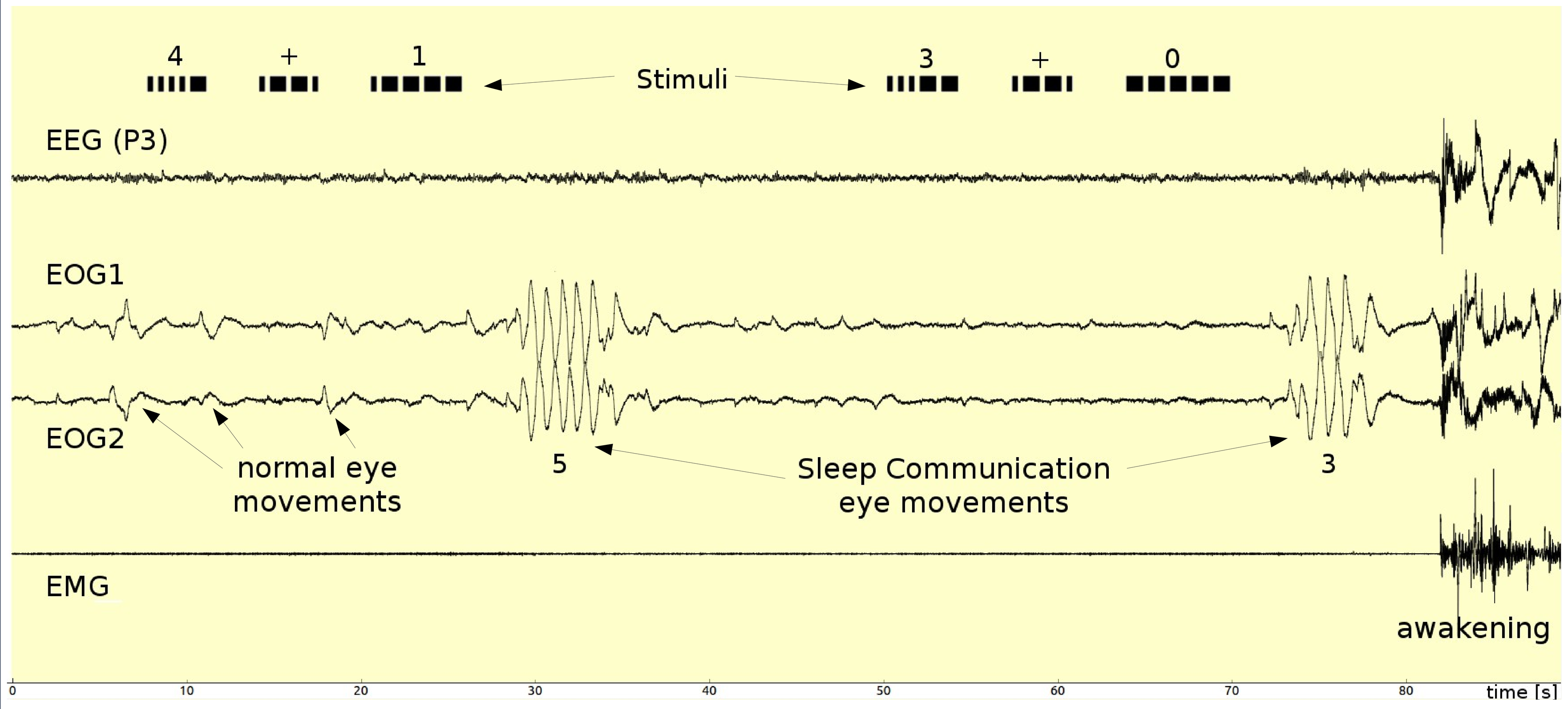

Figure 2: Exemplary Sleep Communication. Math problems "4+1" and "3+0" transmitted into sleep via Morse-coded acoustic stimuli. Correct solutions "5" and "3" answered using eye movements (here: simplified eye movement coding, not Morse-coded eye movements).

Conclusions

- Bidirectional, conscious exchange of messages with arbitrary content (e.g. math problems and their solutions) with a sleeping person is possible.
- Practical difficulties:
    - Stimuli sometimes were not intense enough (→ no incorporation) and sometimes too intense (→ arousal). Individual arousal threshold measurements could help.
    - Eye signals sometimes were unclean and thus hard to decode. More eye signal training could improve this.
    - On average less than one lucid dream per night gave most participants too few tries to succeed. More experimental nights, possibly recorded in an automated way in a home setting, could be beneficial and also make systematic comparisons of stimulus types, coding schemes, tasks etc. meaningful.
- Possible applications of a further developed Sleep Communication: Learning during sleep, new nightmare therapy approaches, creative problem solving during sleep.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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