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Probabilistic trend detection in different levels of consciousness

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Aim and hypotheses

- We aim to explore how alertness modulates the management of probabilistic information in order to accurately detect changing patterns in a stream of conflicting evidence.
- We hypothesize that a decreased level of alertness might disrupt the strategy deployed to approach a probabilistic reversal learning task by impairment of working memory, of integration and value-updating of each piece of evidence, and decreased cognitive control.

Experimental setting

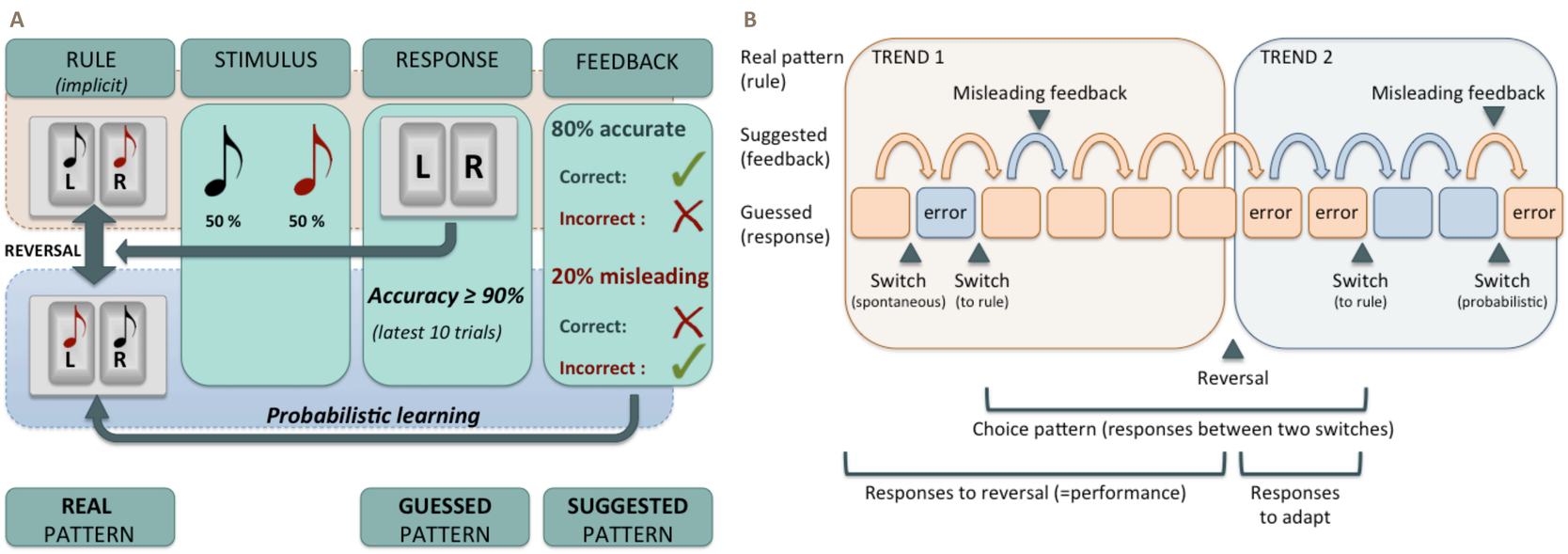

Fig. 1: The task is adapted from the probabilistic reversal learning paradigm, employing auditory stimuli and an abstract rule. Participants are instructed to infer the rule from the feedback received, knowing that sometimes it might be misleading and that the rule might change after a certain time. Since a reversal is triggered when a high level of accuracy is reached, the number of responses needed to attain a reversal is used as the main measure of performance.

Assessment of alertness

- Participants remained with their eyes closed and in the dark, on a confortable chair with reclined backrest, and were instructed to relax and not to fight drowsiness.
- EEG recording was performed during the whole 2-hour experiment.
- Alertness was measured by calculating the EEG theta-alpha ratio for the 2 seconds leading up to each stimulus. Within-subject ratios were then categorized into tertiles, thus defining awake trials (lower tertile), mild drowsiness (medium) and heavy drowsiness (upper tertile).
- Subjects with a low range of theta-alpha ratio values were excluded, coincidental with absence of other signs of drowsiness during the study.

Performance depends on maintaining a stable choice pattern

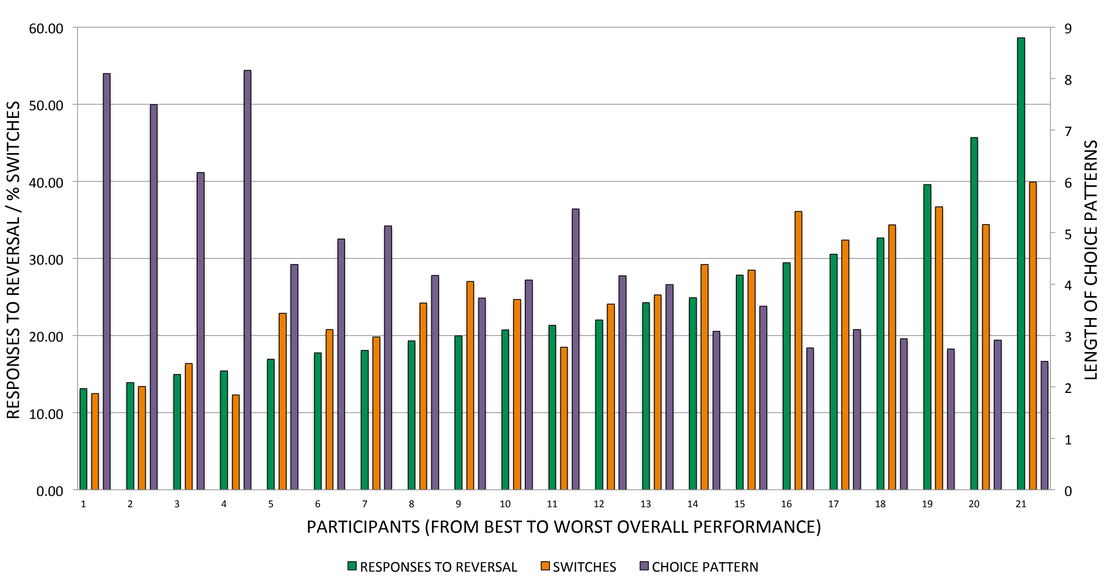

Fig 2: Individual behavioural measures. All subjects are arranged by performance, i.e. responses to reversal, from best to worst. This variable is strongly correlated to the frequency of switches between patterns (r=0.863, P<0.001) and inversely to the length of choice patterns (number of responses between two switches, r=-0.714, <0.001).

Performance-related measures are altered in drowsiness

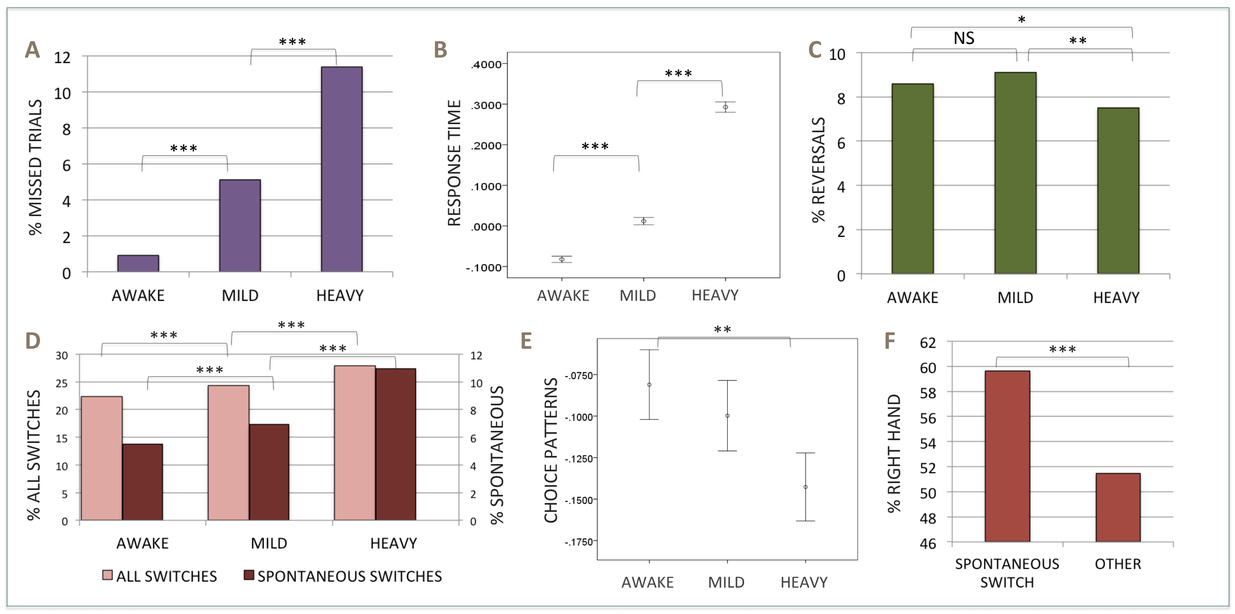

Fig 3: **A-E:** Several behavioural measures by categories of alertness**: A.** Missed trials (P<0.001). **B.** RT (P<0.001). **C.** Reversals (P=0.003). **D.** All switches and spontaneous switches (both P<0.001). **E.** Choice patterns (P=0.030). **F:** Hand (button) choice for spontaneous switches versus other responses (P<0.001). There is no interaction between alertness and right-hand choice in spontaneous switches (B=-0.231, P=0.533). *: P<0.05. **:P<0.01. ***: P<0.001.

Drowsiness impairs adaptation to a new rule

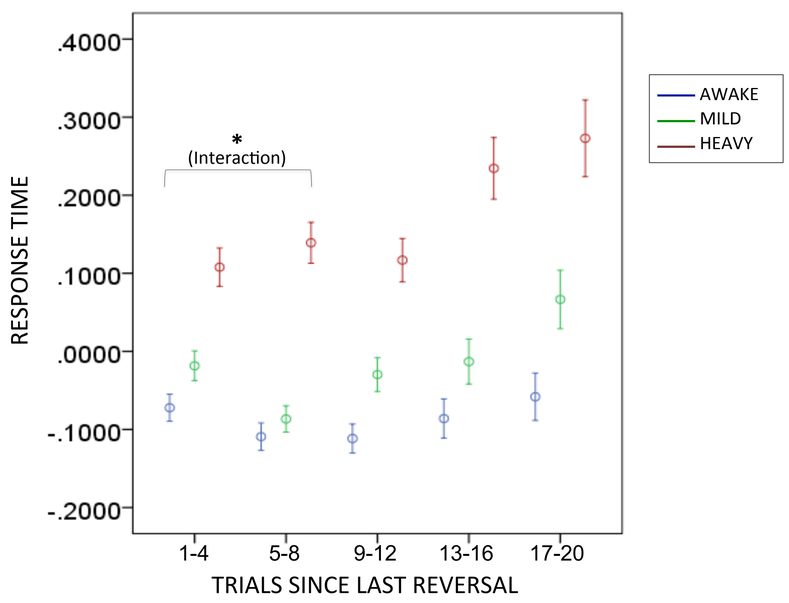

Fig 4: Response times by categories of alertness and position within trend. GLM: alertness, position and interaction alertness*position, all three P<0.001. When considering only trials 1-4 versus 5-8, the association remains for alertness (P<0.001) and the interaction (P=0.048).

Evidence-driven behaviour is impaired (but present) in drowsiness

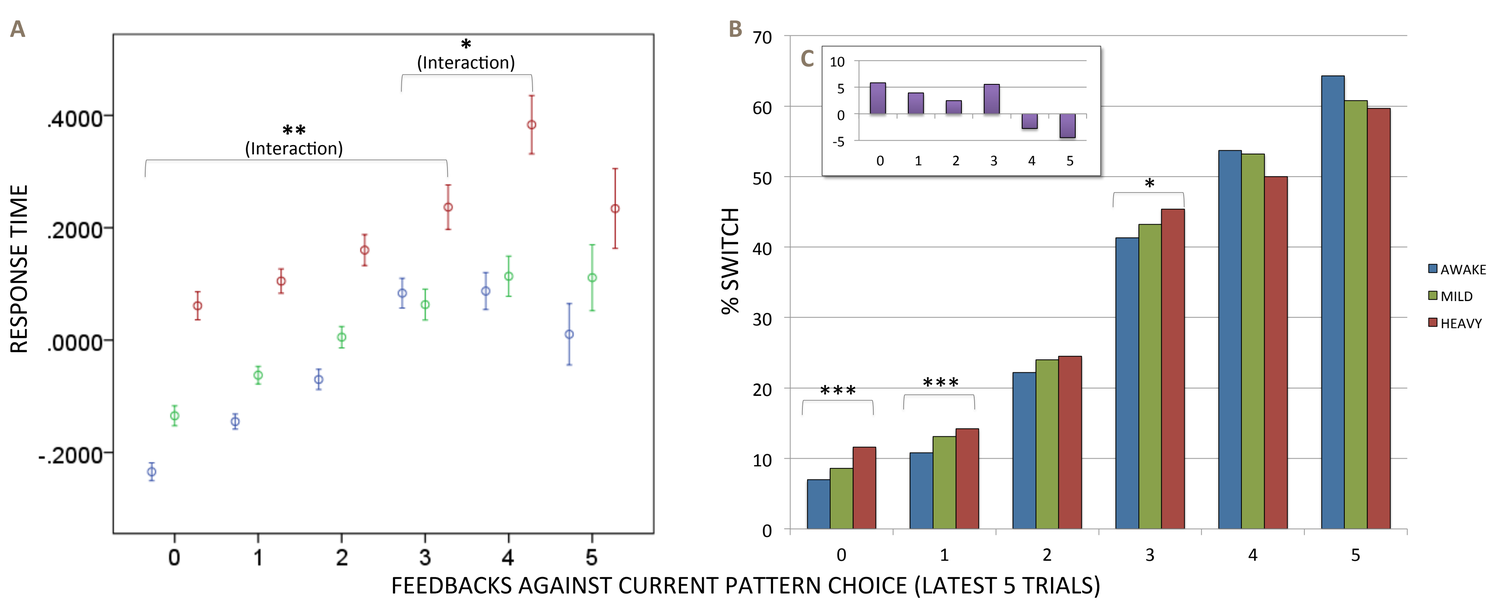

Fig 5: Alertness and processing of probabilistic evidence, namely number of feedbacks against current pattern choice in the latest 5 trials. **A.** Response times. GLM: alertness and evidence, both P<0.001. Interaction alertness*evidence: P=0.032. **B.** Switch to the opposite pattern. Binary logistic regression: alertness, evidence and interaction alertness*evidence, all three P<0.001. *: P<0.05. **:P<0.01. ***: P<0.001. **C.** Difference between individual frequencies of switch in awake versus heavily drowsy trials, per amount of evidence.

Discussion

- Performance in probabilistic reversal learning is altered in decreased alertness , in relation to a higher frequency of spontaneous switching between patterns.
- Response time and type suggest an impaired ability to generate a stable evidence-based strategy, although evidence-driven responses are present even in heavy drowsiness.

References: *[1] Paulus MP et al, Neuroimage (2002). [2] Waltz JA et al, Schizophr Res. (2007). [3] Patzelt EH et al, Drug Alcohol Depend. (2014).*