The Effects of Sleep on Neural Learning Signals

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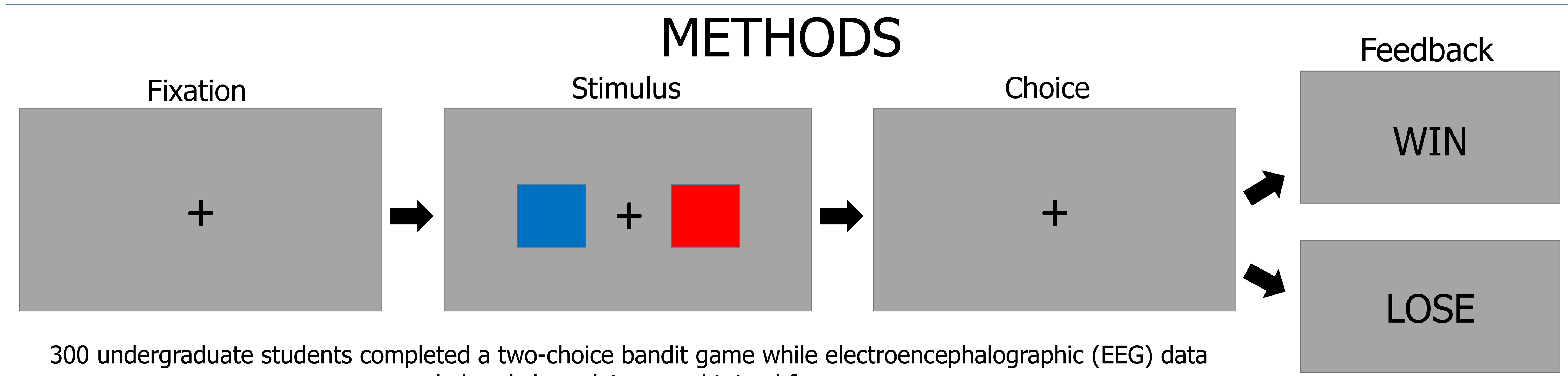
INTRODUCTION

The importance of sleep has become increasingly apparent; for example, the impact of non-REM sleep on memory consolidation. Indeed, Walker (2008) demonstrated that without adequate sleep, hippocampal function is disrupted and our ability to encode new memories is markedly decreased. But what about non-hippocampal learning systems? For instance, it has recently been posited that humans rely on a reinforcement learning system within the medial-frontal cortex for behavioural optimization. Further, there is currently a lack of research investigating sleep related effects on other learning systems such as the aforementioned one within the medial-frontal cortex. Here, we sought to address this issue. Specifically, we had participants play a simple two choice "bandit" gambling game while electroencephalographic (EEG) data was recorded after obtaining data about their previous nights sleep behaviour. Post experiment, we examined the relationship between hours slept the night before and the amplitude and latency of the reward positivity – a component of the human event-related brain potential associated with feedback evaluation. Further, we assessed the power of certain neural oscillations. Our results demonstrate a positive relationship between hours slept the night before and reward positivity amplitude. Further, we also saw sleep related effects on beta power, which has been linked to reward processing (Yaple et al., 2018). In other words, participants with more sleep had larger and faster EEG reinforcement learning signals. Given the increasing trend in society towards diminished sleep cycles our results speak to a growing need for better sleep hygiene.

METHODS



300 undergraduate students completed a two-choice bandit game while electroencephalographic (EEG) data was recorded and sleep data was obtained from surveys.

On each block, there was a winning square that produced a WIN 60% of the time, and a losing square that produced a WIN 10% of the time. As such, participants were able to learn which square was better for producing reward.

Number of Blocks: 5
Trials per block:20

RESULTS

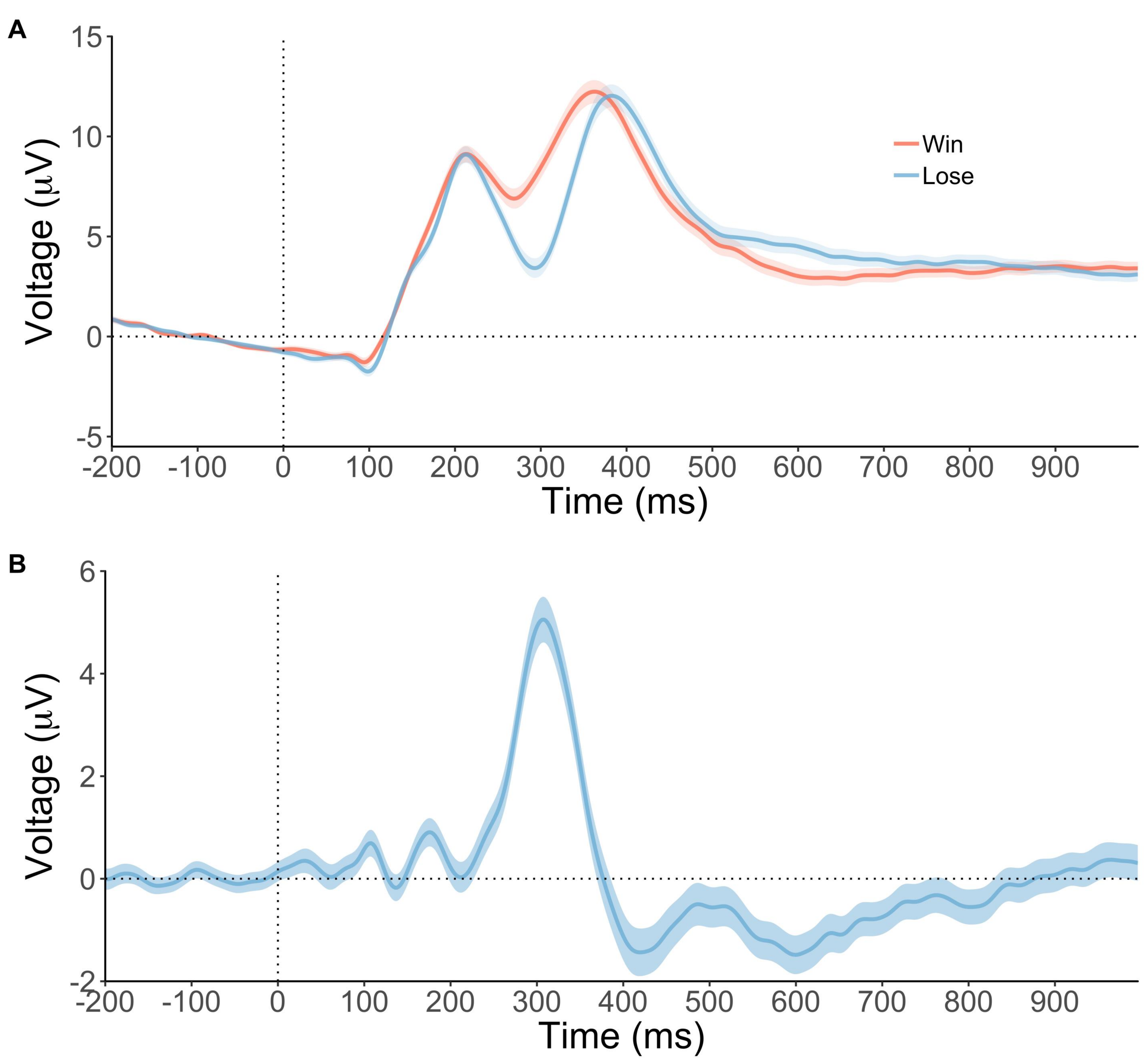


Figure 1. ERP Waveforms. A) Win and Loss waveforms B) Difference wave.

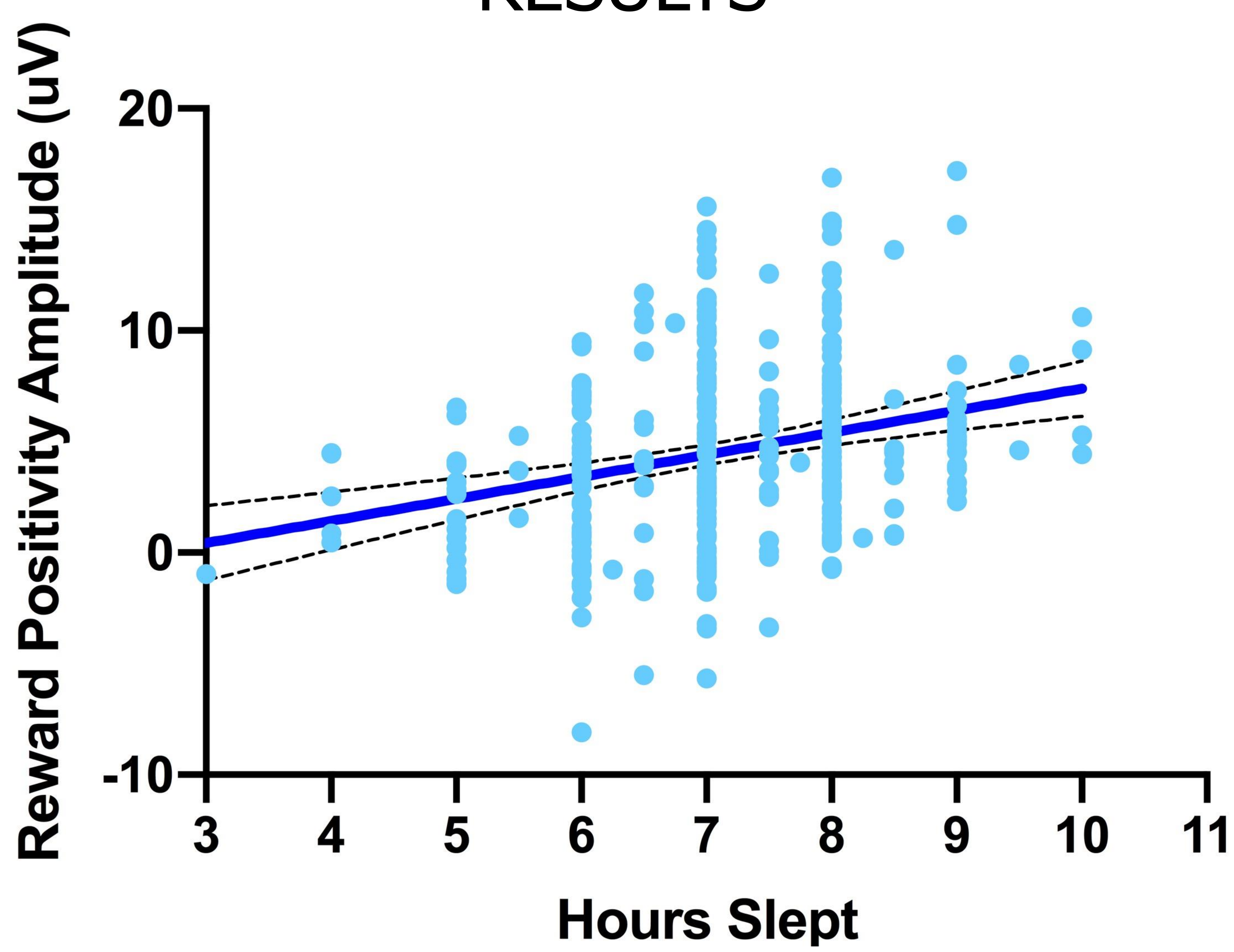


Figure 2. Amplitude of the reward positivity based on hours slept.

	Reward Positivity Amplitude	Beta Power	Alpha Power	Delta Power	Theta Power
Hours of Sleep	.275**	.155**	0.052	-0.016	0.051

Figure 3. Pearson correlation for different neural components.
** Correlation is significant at the 0.01 level. (2-tailed).

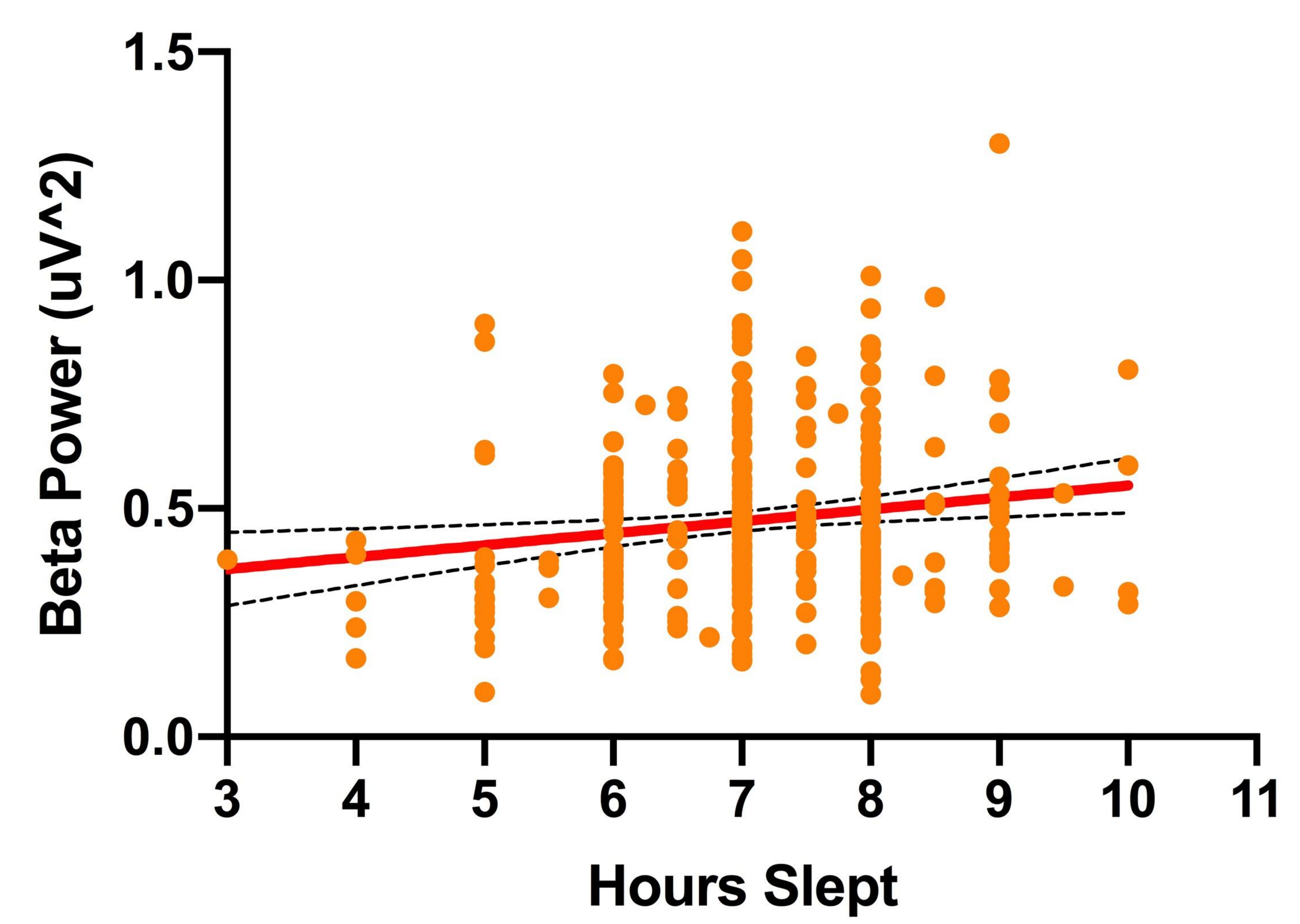


Figure 3. Beta power based on hours of sleep.

CONCLUSIONS

We conclude that sleep has an effect on reinforcement learning systems, specifically amplitude of the reward positivity (r=0.275). Further, we also found that sleep also has an affect on beta power (r=0.155), which has been previously linked to reward processing in the gambling task. Together, our results show that sleep impacts our ability to learn using feedback evaluation, and as such, emphasize the need for good sleep hygiene.