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Background

Rubber Hand Illusion (RHI) is a classical body illusion that induces in the individual the feeling that a rubber hand positioned in the expected place of the real hand is his own. The strength of the illusion can be measured by the feeling of ownership and the proprioceptive drift (PD) in the direction of the rubber hand. The illusion is believed to be a consequence of the integration of ascending signals of three main sensory modalities: proprioceptive, visual, and tactile (Botvinick & Cohen, 1998). More recently, The Bayesian Brain Hypothesis (BBH) (Tsakiris, 2017) has been suggested as a theoretical framework to account for the phenomenon of RHI. Under this view, the proprioceptive drift might be the result of a proprioceptive recalibration induced by a predictive error (Limanowski, 2022; See figure 1) It has been proposed that individuals with a lower ability to detect and interpret body signals (i.e., lower certainty in "likelihood" in the terminology of BBH) may be more affected by the illusion and will demonstrate higher proprioceptive drift (both on experimental and control conditions). The current study aimed to investigate if individual differences in anxiety, known to affect the perception of body signals, are associated with vulnerability to sense this body illusion.

Methods

Participants: Healthy individuals

Rubber Hand Illusion (Botvinick and Cohen, 1998). Synchronous (experimental) vs. Asynchronous (control) stroking. 2 outcomes:

- Subjective feeling of ownership: self-report measure
- Proprioceptive drift (PD): (Proprioception Baseline – Proprioception After Illusion)

Anxiety: State-Trait Anxiety Inventory (STAI) (Spielberger et al. 1983): measures state and trait levels of anxiety

Statistics: Spearman's correlations were used to assess associations between the illusion outcomes and the state and trait anxiety

Graph 1. The term "Location Error" refers to the discrepancy between the actual position of the participant's hand and the position indicated by the participant during the experiment, for each condition. The baseline measurement was taken before the illusion was introduced. The error bars represent the 95% confidence interval for the Location Error measurements.

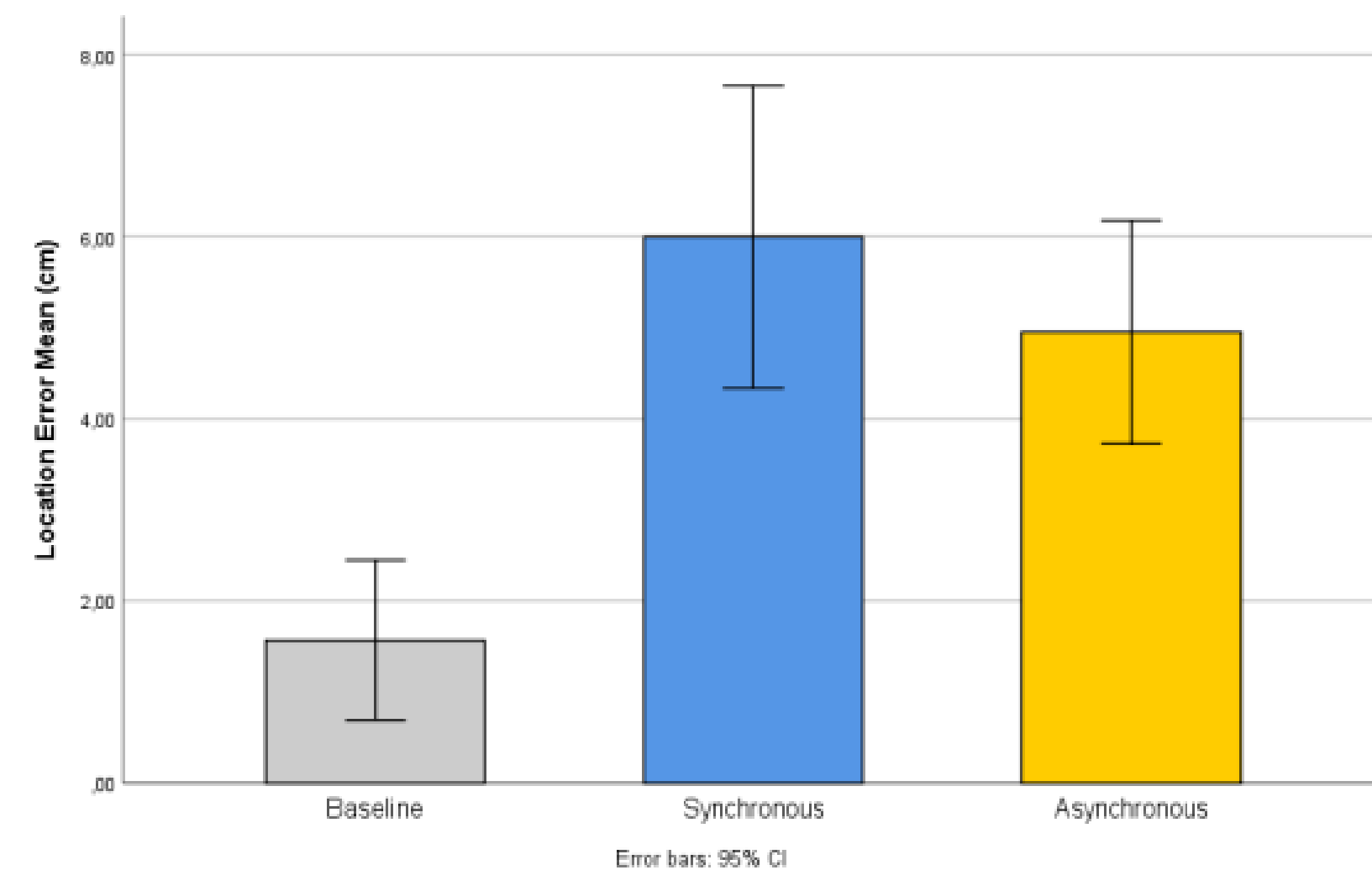


Table 1. RHI Proprioceptive Drift Outcomes for each condition.

Condition	Synchronous	Asynchronous
Mean ± DP	4.43 ± 5.46	3.39 ± 3.82
Median	3.56	3.02
Minimum	-6.04	-2.32
Maximum	27.42	12.34

Table 2. STAI Outcomes for each Sub-Scale.

Sub-Scale	State	Trait
Mean ± DP	30.29 ± 8.09	36.38 ± 8.59
Median	29.00	37.00
Minimum	20.00	20.00
Maximum	61.00	59.00

Discussion

The correlations found between anxiety and the PD in both experimental and control of the RHI suggest that individuals with higher trait anxiety may have difficulties in integrating the sensory inputs received in the two RHI conditions and be vulnerable even to the asynchronous condition, where the manipulation of the body signals (and the need of proprioceptive recalibration) would not be needed.

These results suggest that the sensitivity to the RHI is higher in individuals with higher anxiety. As measured by the changes in proprioception, the vulnerability to body illusions might be increased in individuals with high-state anxiety, thus suggesting difficulties in maintaining a stable body schema and interpreting body signals that may have clinical consequences.

References

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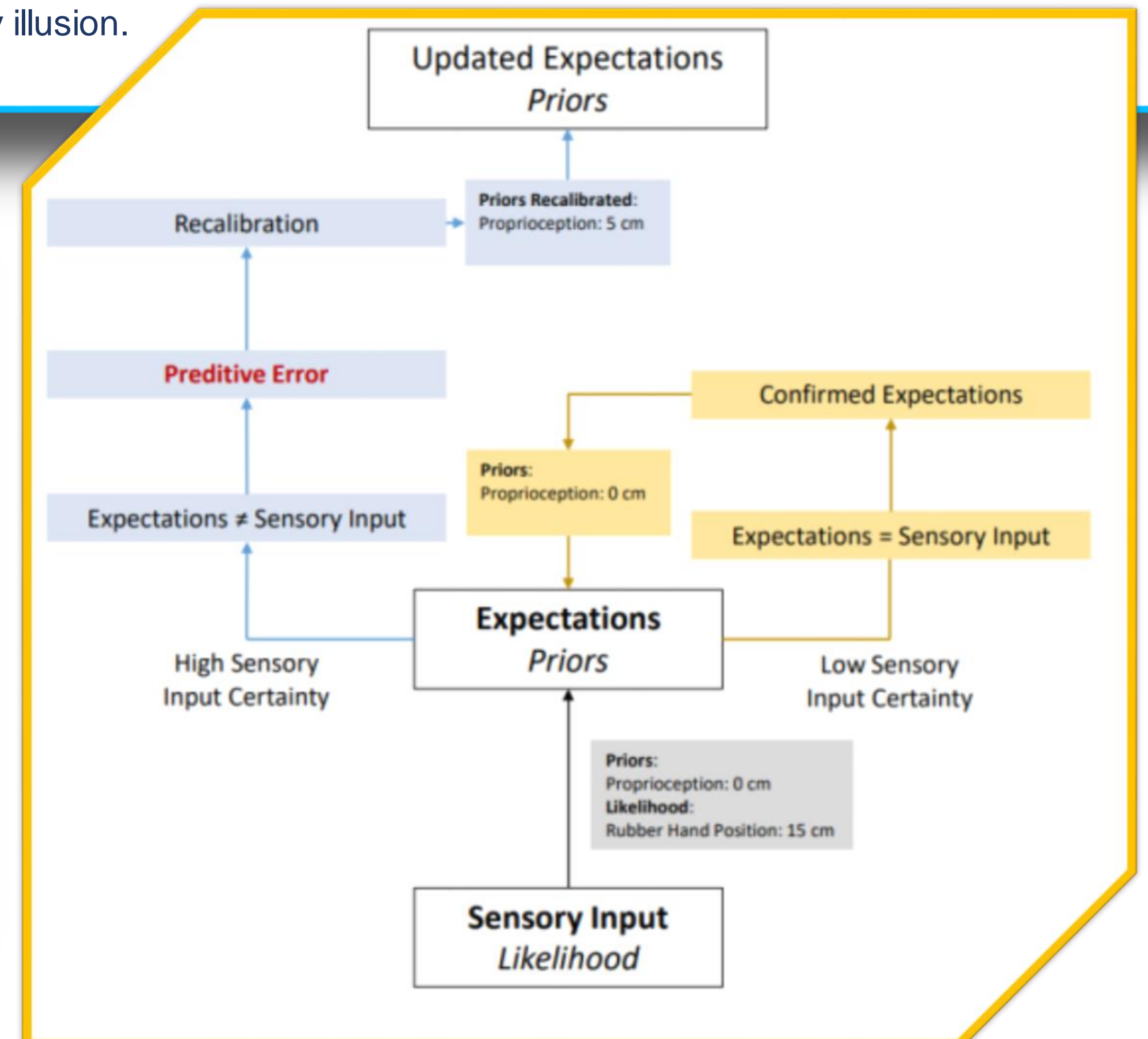


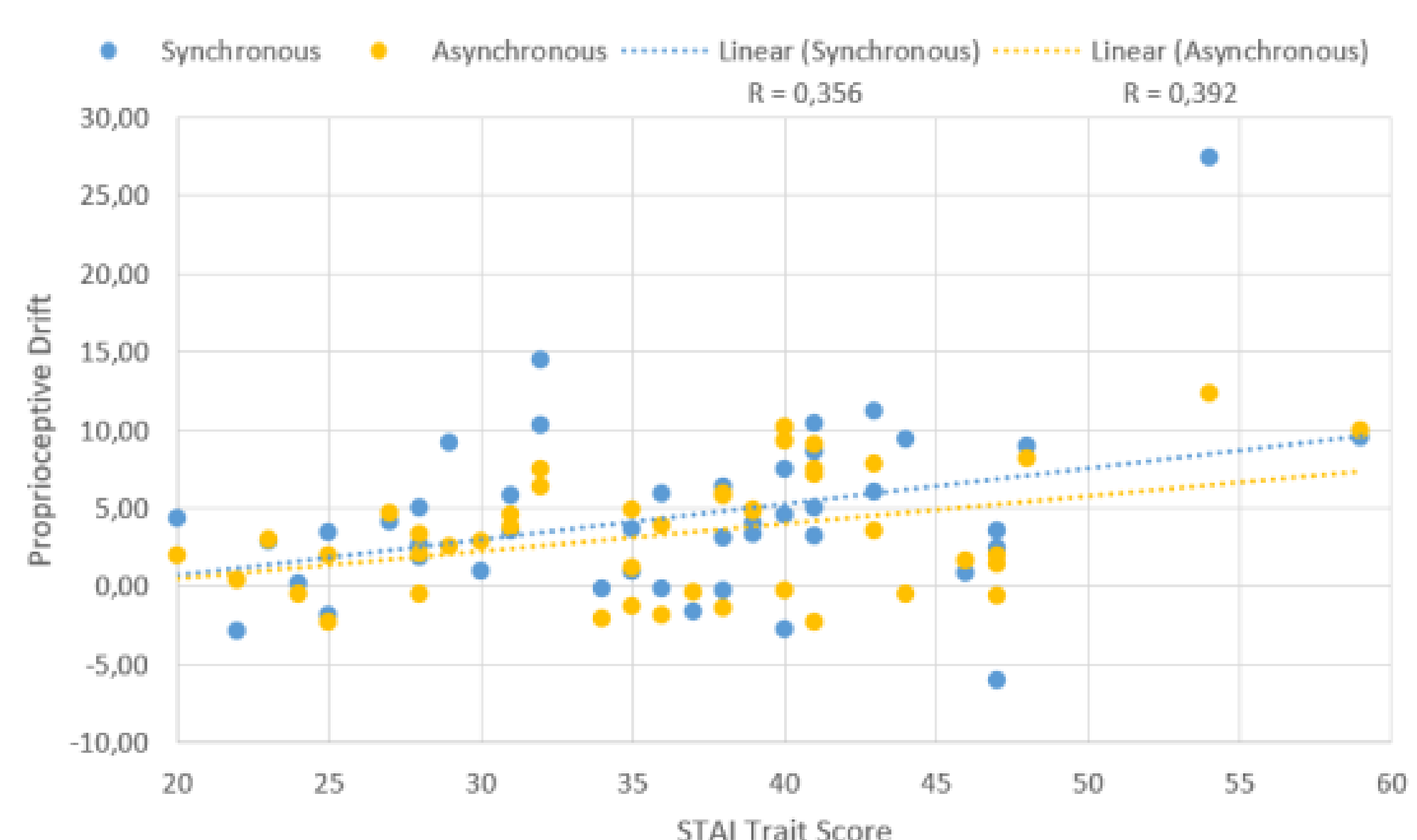
Figure 1. BBH and predictive coding account of RHI Proprioceptive Drift during synchronous Condition. Based on Katch Wiech (2016).

Results

45 participants, 9 male (20%), 36 female (80%), age $M=20.76 \pm 4.2$

State anxiety was correlated with the feeling of ownership in the asynchronous condition (Spearman's $r = 0.325$, $p = 0.029$), and **Trait anxiety correlated with all proprioceptive measures**, such as proprioceptive drift in synchronous (Spearman's $r = 0.299$, $p = 0.046$) and asynchronous condition (Spearman's $r = 0.310$, $p = 0.038$), and with the feeling of ownership in the control items in asynchronous condition (Spearman's $r = 0.335$, $p = 0.025$).

Graph 2. A scatterplot with linear regression between Proprioception Drift and STAI Trait Score. Proprioceptive drift was determined by calculating the difference in location error between the post-illusion condition (synchronous or asynchronous) and the baseline measurement.



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