MEASURING METACOGNITION OF ACTION

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INTRODUCTION

Human movement can be very precisely described as the displacement of the human body parts, the distance they travel, and the velocity of them. But how well can we describe our actions ourselves? How much do we know about the way we move and the outcomes of our movements?

Introspection into one own's cognitive processes, or metacognition, can be assessed via confidence reports about some cognitive phenomenon. The vast majority of the previous studies investigation metacognition of visual perception and memory, although it is not clear if metacognition relies on the same mechanism across different domains.

AIMS

1) to develop a paradigm for measuring metacognition of voluntary movements
2) to validate such paradigm using an established task that measures metacognition
3) to investigate metacognitive ability across visual and motor domains

METHODS

PREREGISTERED

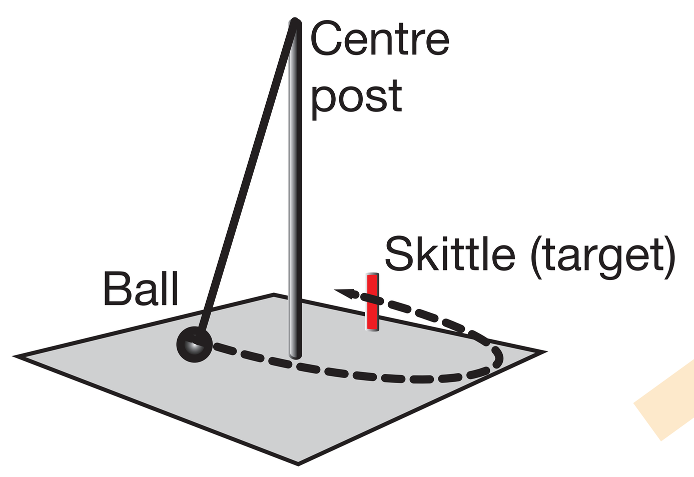
How to measure metacognition?
For the Type I, we use a 2AFC task that allows calculating *d'* - a Signal Detection Theory (SDT)-based measure. The use of a 2AFC task allows to avoid biases common in detection tasks. Each 2AFC decision is followed by a confidence rating (the Type II task). Metacognitive ability is then quantified using a metacognitive version of SDT-based measure - *meta-d'*. It reflects how well observers' confidence ratings discriminate between their own correct and incorrect decisions about the stimuli in Type I task (Maniscalco & Lau, 2012). A person with high metacognitive sensitivity is more confident when they are correct and less confident when they are incorrect. An advantage of *meta-d'* is that it's immune to metacognitive bias - an overall tendency to be more or less confident in general.

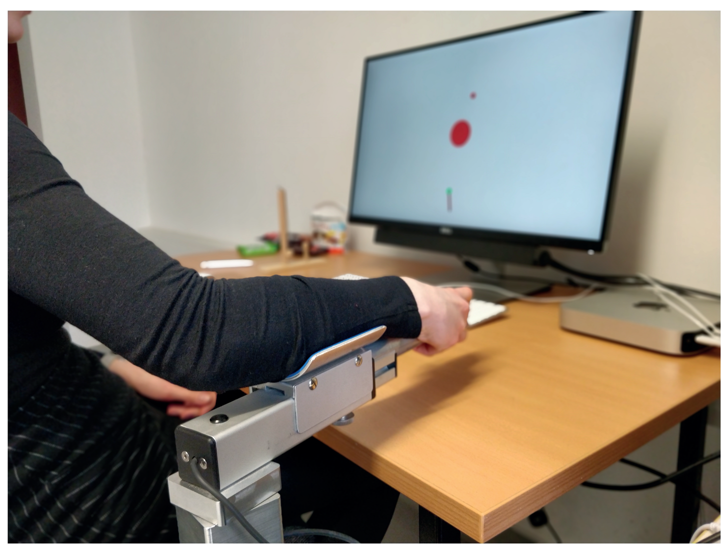
Since metacognitive sensitivity varies across different Type I performance levels, we controlled Type I performance level with staircase procedure at ~71% and used the ratio between *d'* and *meta-d'* is used as a measure of metacognitive efficiency to account for Type I performance level fluctuations.

$$M\text{-}ratio = \frac{meta\text{-}d'}{d'}$$

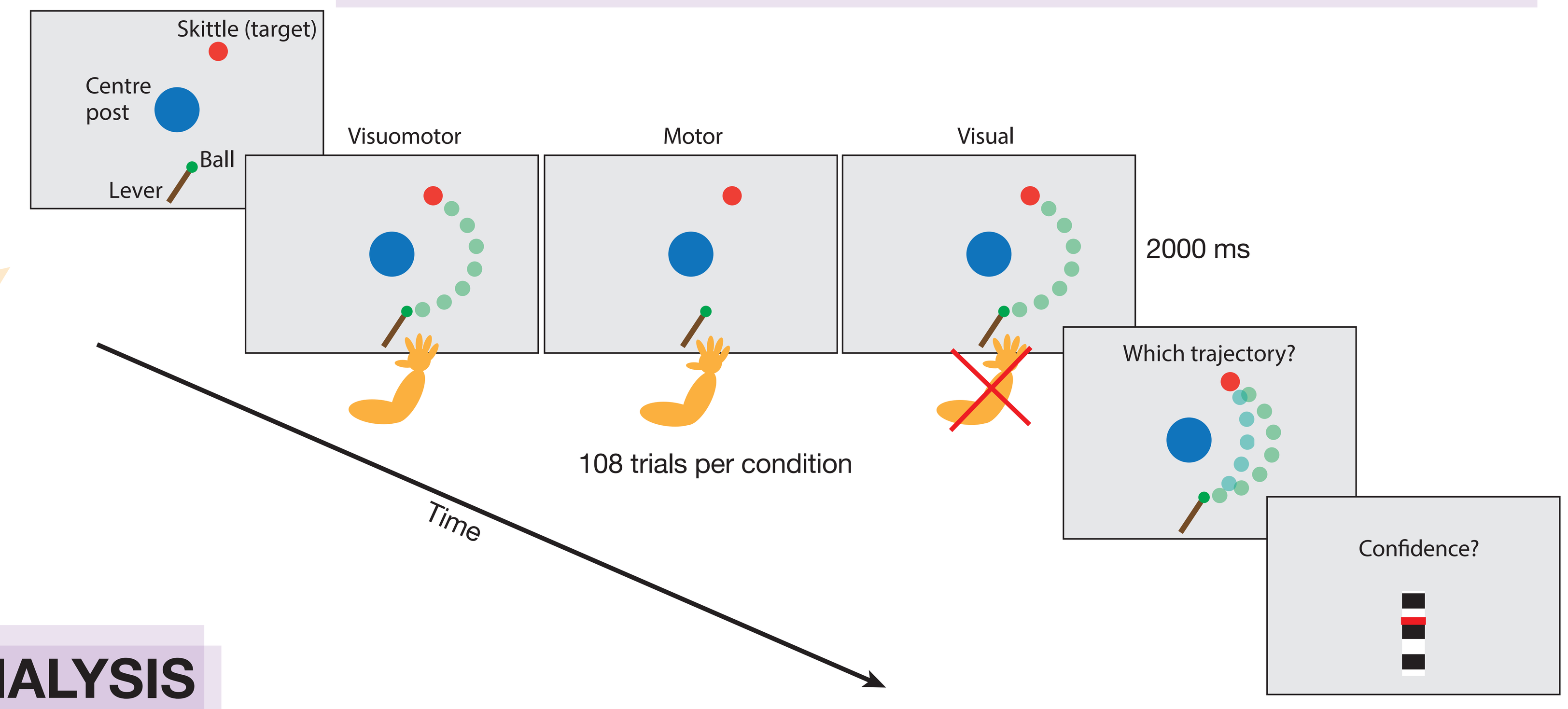
How to measure metacognition of action?
We used a virtual version of the 'Skittles' task: a ball-throwing task, where the trajectory of the ball is fully determined by 2 parameters: the speed and the angle at the point of ball release.
To control the virtual ball, participants used a custom-made manipulandum with a lever.
A passive, fully visual version of the task was used to validate the visual condition of the 'Skittles' task with a classical visual perception task: in Type I task, participants see 2 circles with dots and have to judge the numerosity of the dots.

'Skittles' game

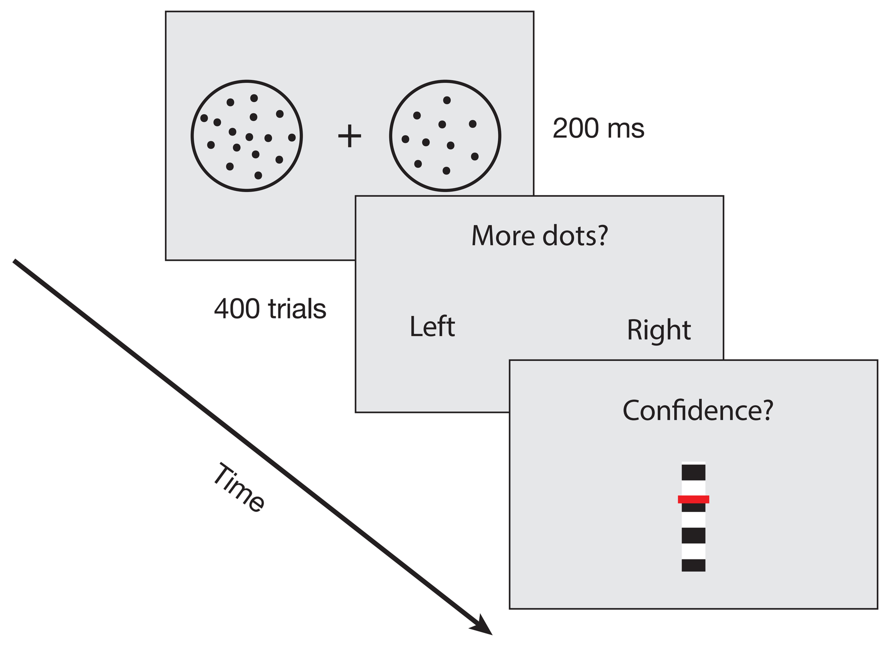




Metacognition of arm movements: 'Skittles' task



Metacognition of visual perception



ANALYSIS

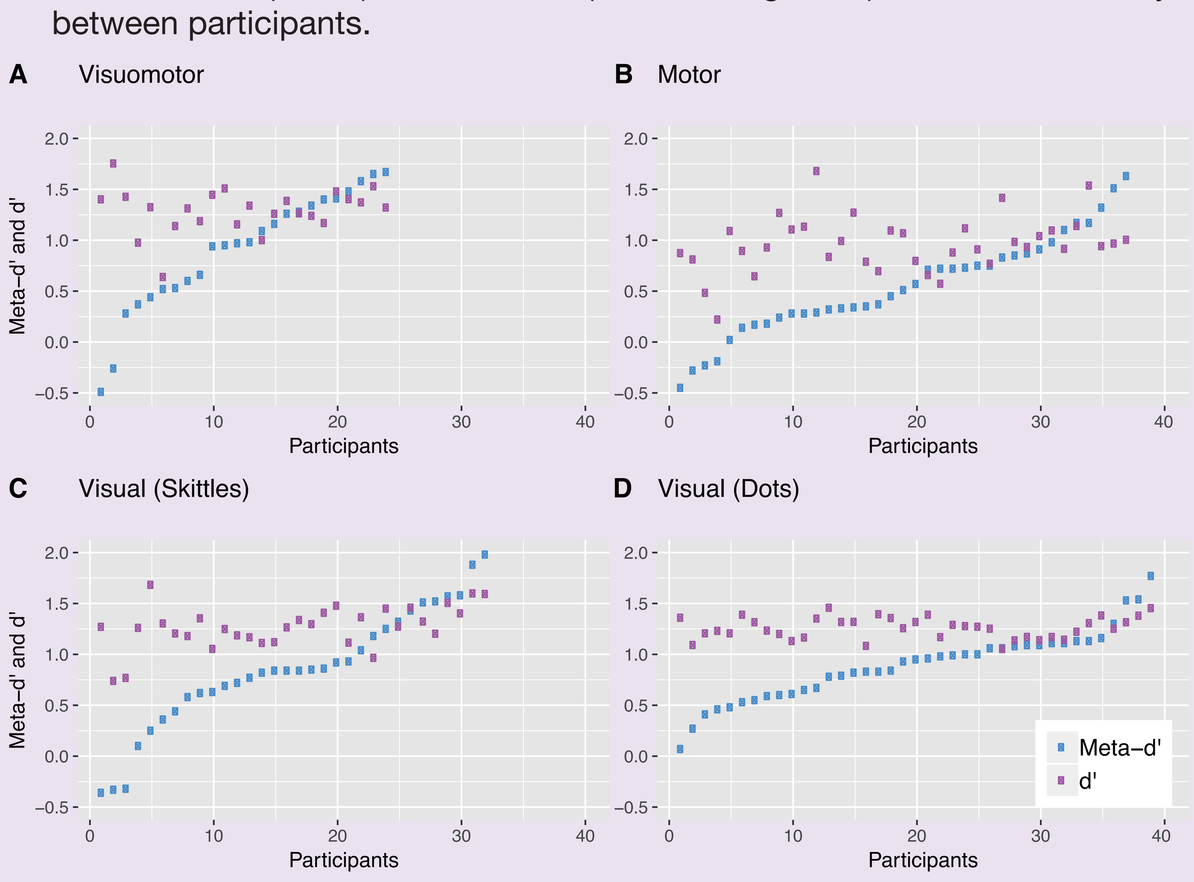
Exclusion criteria:
— Any trials with with 0.3 s > RT > 8 s. and in 'Skittles' task, trials where one trajectory hits the centre post, and the other one doesn't;
— Participants (in specific conditions) with performance level >80% or <60%, and extreme SDT values for Type I or II hit rates and false alarm rates (0 or 1) when SDT analysis is performed with 2 bins, because such values lead to inaccurate estimates (similar to Bor et al 2017).

Correlations:
For correlations analysis, we used a robust procedure: skipped correlations. They take into account the data structure and protect against bivariate outliers (Pernet et al 2013).

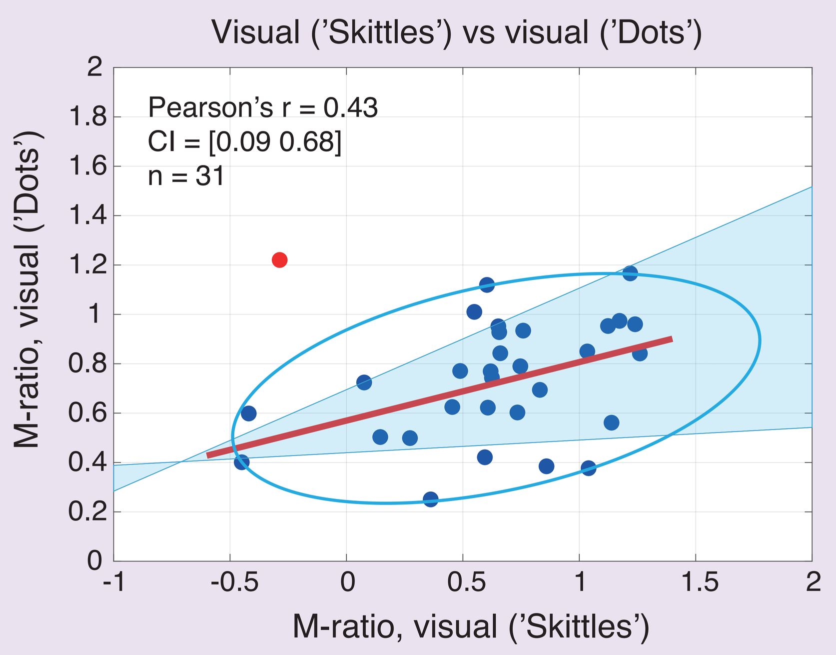
RESULTS

Despite differences in *d'* and *meta-d'*, m-ratio is similar across different conditions of the 'Skittles' task and the visual ('Dots') task.

While *d'* is relatively stable across different conditions of the 'Skittles' task and the visual ('Dots') task, *meta-d'* (in ascending order) varies considerably between participants.

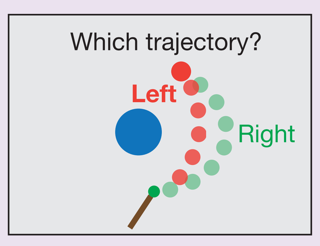


Validation of the visual 'Skittles' task



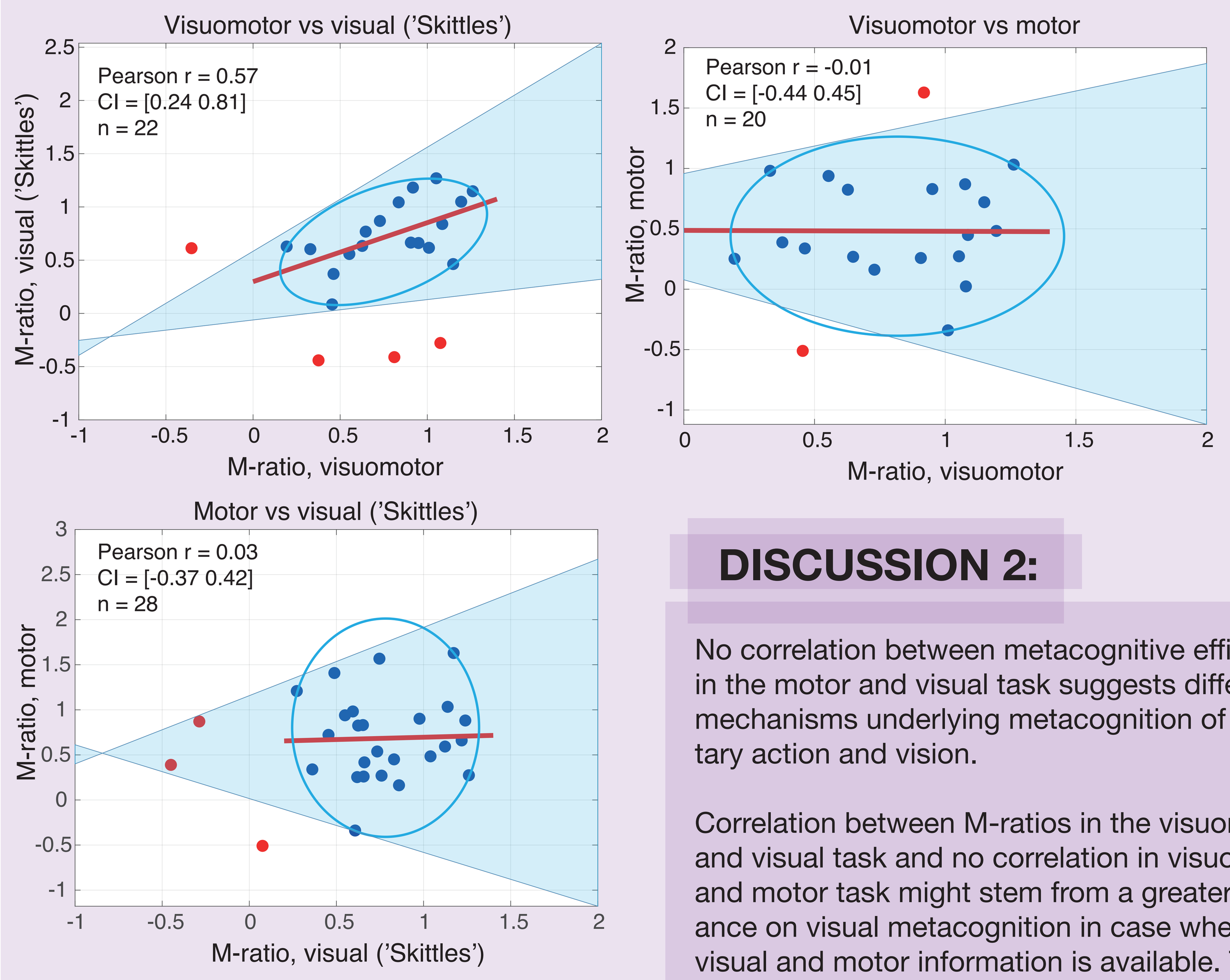
DISCUSSION 1:

Correlation between metacognitive efficiency in the visual condition of the "Skittles" task and in the visual task with dots validates the metacognitive version of the "Skittles" task.



Response bias:
In the 'Skittles' task's visuomotor (VM) and the visual (V) conditions, but not the motor one, participants were choosing the left trajectory more often than the right one (1.95 times more in VM and 1.53 times more in V), despite counterbalanced correct trajectory side.

Correlations between 'Skittles' task conditions

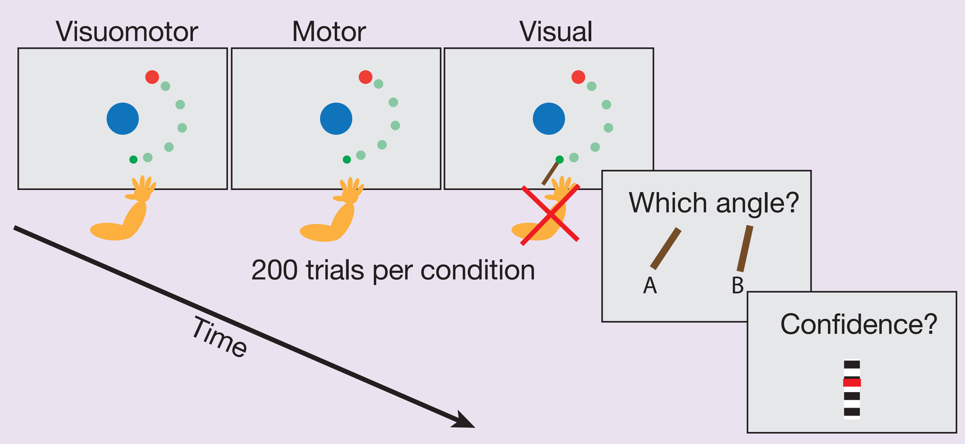


DISCUSSION 2:

No correlation between metacognitive efficiency in the motor and visual task suggests different mechanisms underlying metacognition of voluntary action and vision.

Correlation between M-ratios in the visuomotor and visual task and no correlation in visuomotor and motor task might stem from a greater reliance on visual metacognition in case when both visual and motor information is available. This might be because of the higher fidelity of the visual signal.

FOLLOW-UP STUDY IN PROGRESS



Replication of the 'Skittles' task with Type I task about the trajectory and a new version of the task: with Type I task about the angle at the point of ball release.

Aim: to see if we can replicate the pattern of correlation and if direct information about movement (angle) is more readily available for metacognitive monitoring than a secondary information (trajectory).

References:
Bor, D., Schwartzman, D. J., Barrett, A. B., & Seth, A. K. (2017). Theta-burst transcranial magnetic stimulation to the prefrontal or parietal cortex does not impair metacognitive visual awareness. *PloS one, 12*(2).
Maniscalco, B., & Lau, H. (2012). A signal detection theoretic approach for estimating metacognitive sensitivity from confidence ratings. *Consciousness and cognition, 21*(1), 422-430.
Pernet, C. R., Wilcox, R. R., & Rousselet, G. A. (2013). Robust correlation analyses: false positive and power validation using a new open source Matlab toolbox. *Frontiers in psychology, 3,* 606.