

A Motor Recalibration Influence on Color-Motion Asynchrony Effect Size in a Visuo-Motor Paradigm



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INTRODUCTION

Color-Motion Asynchrony (CMA)

• CMA is the perceptual difficulty of pairing the correct phases of color and motion direction of an oscillating pattern alternating between two colors and directions (i.e. green upwards and red downwards) simultaneously at the same rate.

Processing Latency Account¹

• The apparent asynchrony was suggested to be caused by the neural processing latencies differing for different visual features (i.e. colour and motion direction), each processed separately in segregated cortical areas.

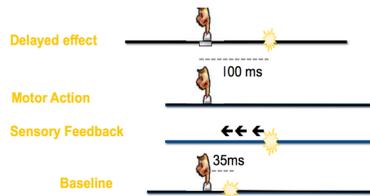
Processing Latency Account in Question

• CMA is apparent in the feature correspondence task (i.e. which direction dominant for target color) but disappears in the temporal ordering task (i.e. direction change before or after color change), suggesting that it is not caused by the shifts in the apparent temporal positions of transitions between the phases of a feature².

Delay in Forming a New Surface Representation Account³

• The asynchrony in CMA occurs due to the directional inhibition in the area MT+ that leads to a delay in the formation of a new steady-state surface representation with an opposite direction of motion and a different color.

Can this delay be overcome by a predictive signal / a readiness potential to reduce the CMA?



Motor-Sensory Recalibration⁴

• Dynamic adaptation to a fixed delay between an action and a subsequent sensory stimulus creates an illusory reversal of cause – effect order when the sensory feedback is then presented at the time of action.

RESEARCH QUESTIONS

• Can a motor-sensory recalibration, previously shown between an action and a first-order sensory change (i.e. colour change), be also established between an action and a second-order sensory change (i.e. change in motion direction)?

• If so, does motor-sensory recalibration act as shifting the temporal position of the second-order sensory change or as a different mechanism?

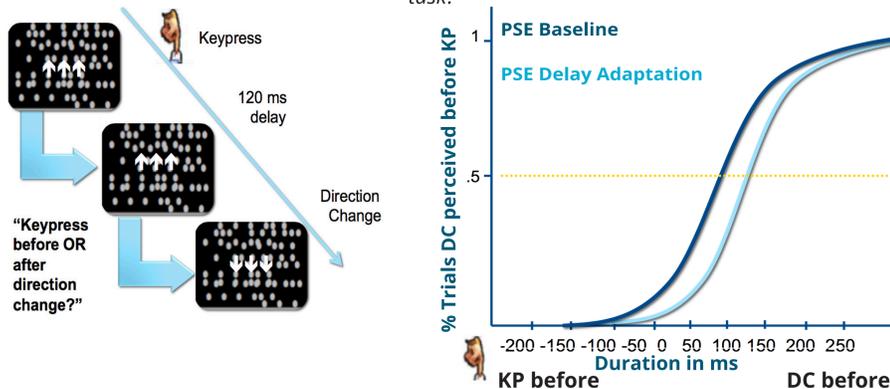
• If CMA is caused by a delay in forming a new surface representation at the area MT+, then, could potentially establishing an action-outcome prediction by a motor-sensory recalibration overcome this delay and reduce the size of the asynchrony?

• Would this reduction -in such case- be attributable to a predictive signal generated on the basis of an intentional action, or a pure visual association established between two temporal events?

STUDY 1

Visuo-Motor Temporal Ordering Task (TOT)

Does the visuo-motor adaptation to a constant delay between a key press (KP) and a achromatic motion direction change (DC) shift the point of subjective simultaneity (PSS) in a visuo-motor temporal ordering task?



Adaptation Trials

- Baseline Condition: instant DC in response to the KP of subjects. No judgment required.
- Experimental Delayed Feedback Condition: 100 msec delayed DC in response to KP.

Test Trials

- DC occurred somewhere before or after KP according to the average response time of subjects in the previous trials.

A motor-sensory recalibration can be established between an action and a second-order sensory change (i.e. change in motion direction), as indicated by the rightward shift of the psychometric function.

STUDY 2A

Visuo-Motor Feature Correspondence Task (FCT)

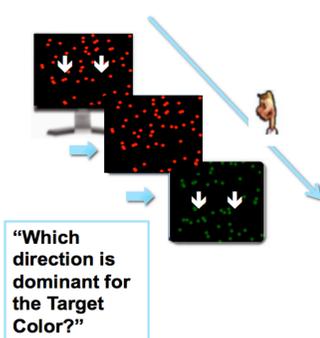
Does adaptation to a delayed sensory feedback of self-caused action reduce the asynchrony between colour and motion in a visuo-motor test paradigm?

Minimum Motion Task⁵

• In order to obtain isoluminant cyan-magenta in the DKL space for each participant.

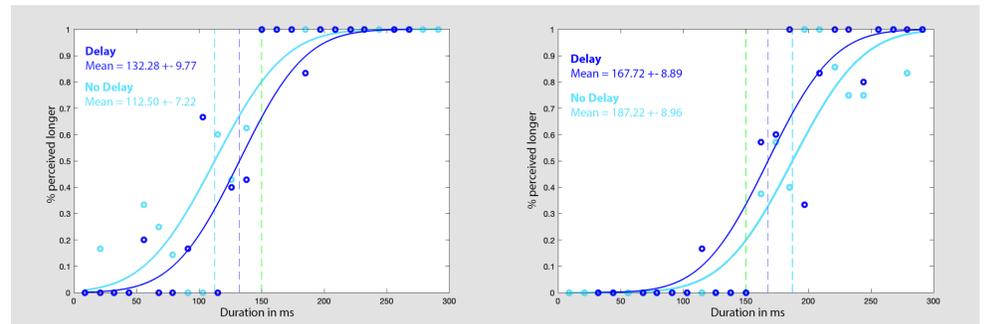
• After an adaptation period, where direction of achromatic drifting dots changed after a delay for 5-8 trials, in the test trials subjects were required to judge the dominant direction of the target colour.

• We manipulated the duration of green and red intervals and asked participants to press a key somewhere during red or green period.



a period of 300 ms before the keypress

a period of 300 ms after the keypress



• Compression of the interval following the change in the direction of motion is reduced when the change is caused by a self-caused action following motor-sensory adaptation (MSA).

CMA is significantly reduced following a delayed sensory feedback adaptation in response to self-caused action.

• MSA formed between a keypress and the motion direction change of an achromatic array of dots is transferred to a chromatic dot array composed of multiple features (i.e. chromatic motion).

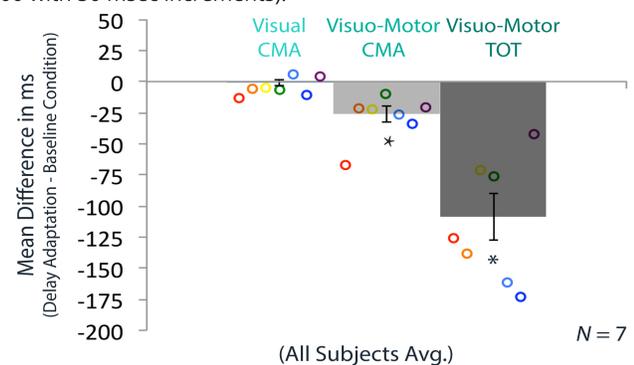
STUDY 2B

Visual Feature Correspondence Task

Does adaptation to a delayed sensory feedback reduce the asynchrony between colour and motion in a passive visual test paradigm?

• Passive visual feature correspondence task preceded by MSA.

• Direction change occurs as determined by the 7 levels in a method of constant stimuli paradigm (range: -100 to 200 with 50 msec increments).



The reduction in CMA following the MSA observed in Study 2A is attributable to the voluntary action – action outcome pairing rather than a passive visual adaptation.

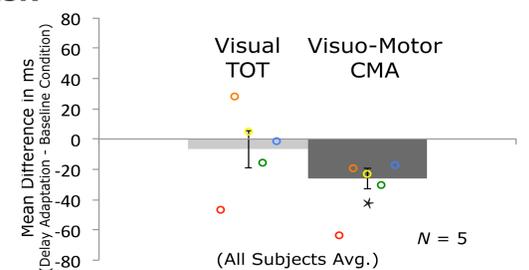
STUDY 3

Visual Temporal Ordering Task

Does adaptation to a delayed sensory feedback shift the PSS in a visual temporal ordering paradigm?

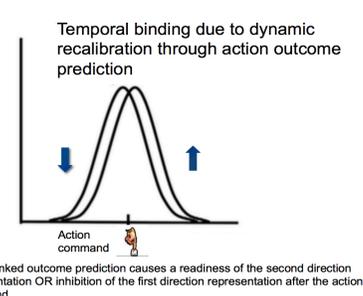
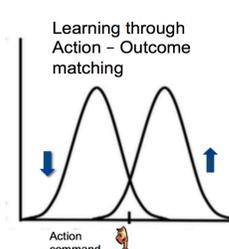
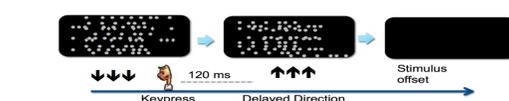
• Direction of motion changes before or after the color?

Motor-sensory recalibration does not act by shifting the temporal position of the direction change.



DISCUSSION

• Since the reduction in CMA effect size following MSA is not a result of a shift in the onset of DC relative to that of color (Study 3), **we argue that** the presentation of the sensory change (DC) at the same time as KP following a delayed motor-sensory feedback adaptation counteracts the opponent direction inhibition and reduces the delay it takes to form a new surface-level representation in a high-level motion area (i.e. MT+) (following the proposed mechanism for CMA by Clifford³).



Action-linked prediction is dynamically readjusted throughout the recalibration adaptation phase

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