Exploring the effects of visuomotor synchrony, touch, and human form on the embodiment of virtual hands in children

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Introduction

Embodiment is the sensation of ownership and control (agency) over one's body. This is driven by the successful integration of multisensory signals (e.g., visual, tactile, proprioceptive) and top-down knowledge about the body [1]. Embodiment typically occurs when signals are congruent (i.e., synchronous movement or a similar form (appearance). Yet, adults embody non-human body parts like a robot hand [2]. The role of multisensory processes develop across childhood [3] but little is known about the effects of such processes on children's own-body representation.

Methods

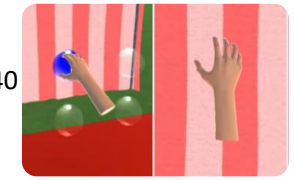
The effects of movement, touch and form on children's embodiment for virtual hands.
In two experiments, participants played a virtual reality bubble-popping game. A virtual hand moved synchronously with the participant's own movements, and asynchronously (the hand was temporally and spatially incongruent).

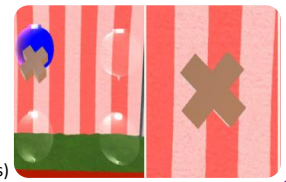
Questions
"During the game did you sometimes feel":
EXP. 1 scale 0-1 (No-Yes)
Ownership: the hand was your hand or belonged to you
Agency: you were moving the hand?
EXP. 2 scale 0-10 (Not at all-Yes lots and lots)
Ownership: the hand/block felt like my own hand
Ownership: the hand/block felt like part of my own body
Agency: I was in control of moving the hand/ block
Location: my own hand was in the same place as the hand/block
Tool: the hand/block felt more like a mouse than part of my body.

Methods

EXP. 1
N = 117 (4-14 years, $\bar{X}$ = 9)
3 haptic feedback groups:
Congruent (on bubble hit) N = 40
Delayed (1-2 secs delay) N = 37
No haptics N = 40

EXP. 2
N = 80 (5-14 years, $\bar{X}$ = 9)
2 virtual form groups:
Hand (human) N = 40
Block (non-human cross) N = 40
(Figs present data from Exp. 2,medians and IQRs)

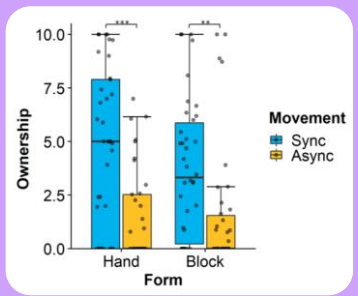


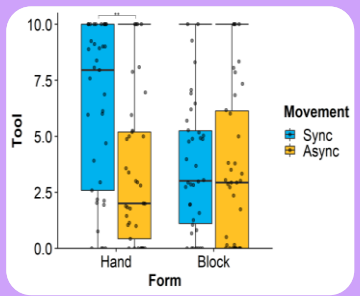


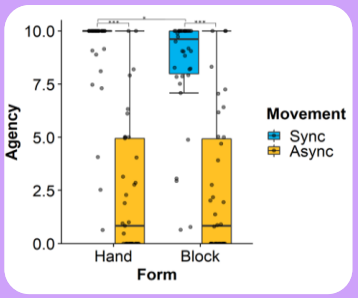
Results

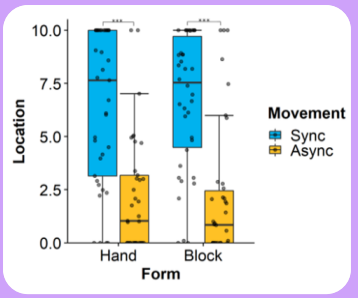
EXP. 1
- No effect of haptic touch across conditions
- Increased agency ratings after synchronous movement (but not ownership).

EXP. 2
- Higher embodiment after synchronous movement on all Qs (ownership, agency, location, tool).
- No difference between forms on ownership, agency, location.
- Tool: higher ratings for the hand vs. block. Effect of movement synchrony for the Hand only.









Take away

- Visuomotor synchrony influenced embodiment for virtual hands
- Children embodied a non-human block to some degree – provided visuomotor signals were congruent
- Yet, only the hand in the synchronous movement condition was described as feeling like part of the body, rather than like a tool (e.g., a mouse).

Discussion

- Overall dominance of visuomotor synchrony for children's embodiment.
- Children embody non-humans forms to some degree
- Embodiment is constrained by prior information about body form (i.e., tool-use).
- Both bottom-up and top-down processes are important for driving children's body representation.

References

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