Introduction

- Sense of agency (SoA) = the feeling of controlling external events through one’s actions [4]
- Intentional binding is a widely used implicit measure of SoA [5]
- SoA in human-computer interaction (HCI) [2] - user’s experience of control is of primary importance in HCI design [6]
- Touchless technology allows users to interact with systems without physically touching them [3]
- Touchless interaction may impact the user’s SoA in two ways:
  - Absence of tactile (haptic) feedback
  - Temporal delay between actual movement and visual representation

In the present study we address these concerns by exploring SoA during a virtual button press task by manipulating:
- a) mid-air haptic feedback and
- b) the latency of the virtual hand’s movement

Method

- Participants
  - Recruited via email, screened for handedness [7] and no reported visual impairments
- Tasks and measures
  - Binding was measured using the direct interval estimation method [1] in a virtual button pressing task
  - Explicit agency was measured via Likert scales of felt control and causation respectively
- Apparatus
  - The programme was set up, coded and run via Unity engine (v. 2019.3.0)

Results

- Interval estimation error = Estimate - Actual
  - Lower scores = Greater binding.

<table>
<thead>
<tr>
<th>Actual interval</th>
<th>Latency</th>
<th>No Haptic</th>
<th>Haptic</th>
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<tbody>
<tr>
<td>shorter</td>
<td>longer</td>
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<td>150ms latency</td>
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<td>700ms latency</td>
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<td>1500ms latency</td>
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- Significant haptic vs actual interval interaction (p = 0.043)
  - Significant mean difference (p=0.039) between haptic and no haptic conditions at the 700ms interval length

- Significant decrease of control with latency in the no haptic feedback condition, (p = 0.027). Non-significant in the haptic feedback condition, (p = 0.283)
  - Significant mean difference (p=0.038) at 150ms latency

Discussion

- Greater implicit SoA with haptic feedback at the 700ms action-outcome intervals
  - Visual cues may be sufficient for SoA with shorter action-outcome intervals, but longer action-outcome intervals may depend on additional haptic cues to preserve SoA
- Self-reported control of the virtual hand representation decreased as latency increased from 0ms–150ms but this effect of latency on explicit SoA was attenuated with the presence of mid-air haptic feedback
  - Latency has a deleterious effect on explicit SoA but this may be mitigated by mid-air haptic feedback

In conclusion, our results showed that mid-air haptic feedback has two effects on SoA:
- a) promoting implicit SoA at longer action-outcome intervals, and
- b) protecting against latency-induced reductions in the explicit SoA

References


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