Baseline- and Magnitude-Dependent Detection of Changes in Dynamic Visuomotor Mapping

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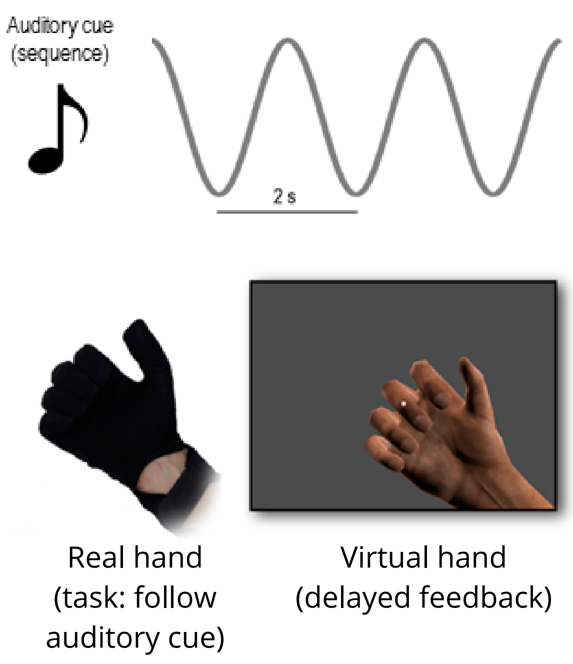
Background

The Weber-Fechner-Law states that the perception of change in many sensory modalities, like light and sound, depends not only on the magnitude of the change but also on the initial level of sensory input. It has not yet been established whether this law also holds true for multisensory stimulus mappings. Here, we asked whether the processing of changes in the mapping of visual and proprioceptive hand positions (i.e., visuomotor delays) depends not only on the magnitude of the delay change but also on the initial delay present in the system when the delay change is introduced.

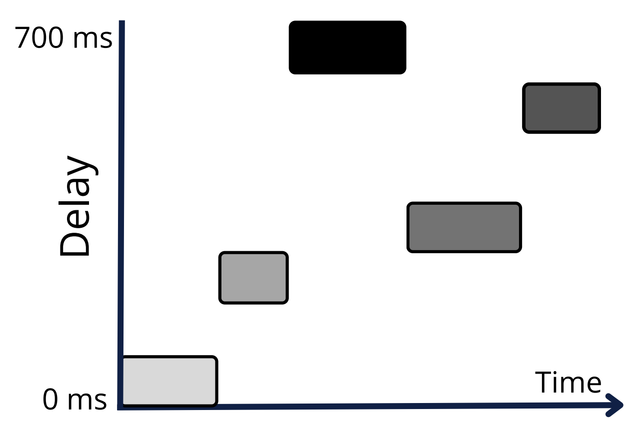
Methods

We used a data glove to measure participants' (N=30) movements in a virtual reality setting. Thus, participants were able to control a virtual hand, which showed their real hand movement – either synchronous or with some added temporal delay. Participants performed continuous, simple grasping movements, aligning the rhythm of the *real* hand grasping movements with the rhythmic oscillation of a target sound. I.e., the visuomotor delays were not task relevant and should not be adapted to.

Rhythmic grasping task



Dynamic visuo-motor delay changes



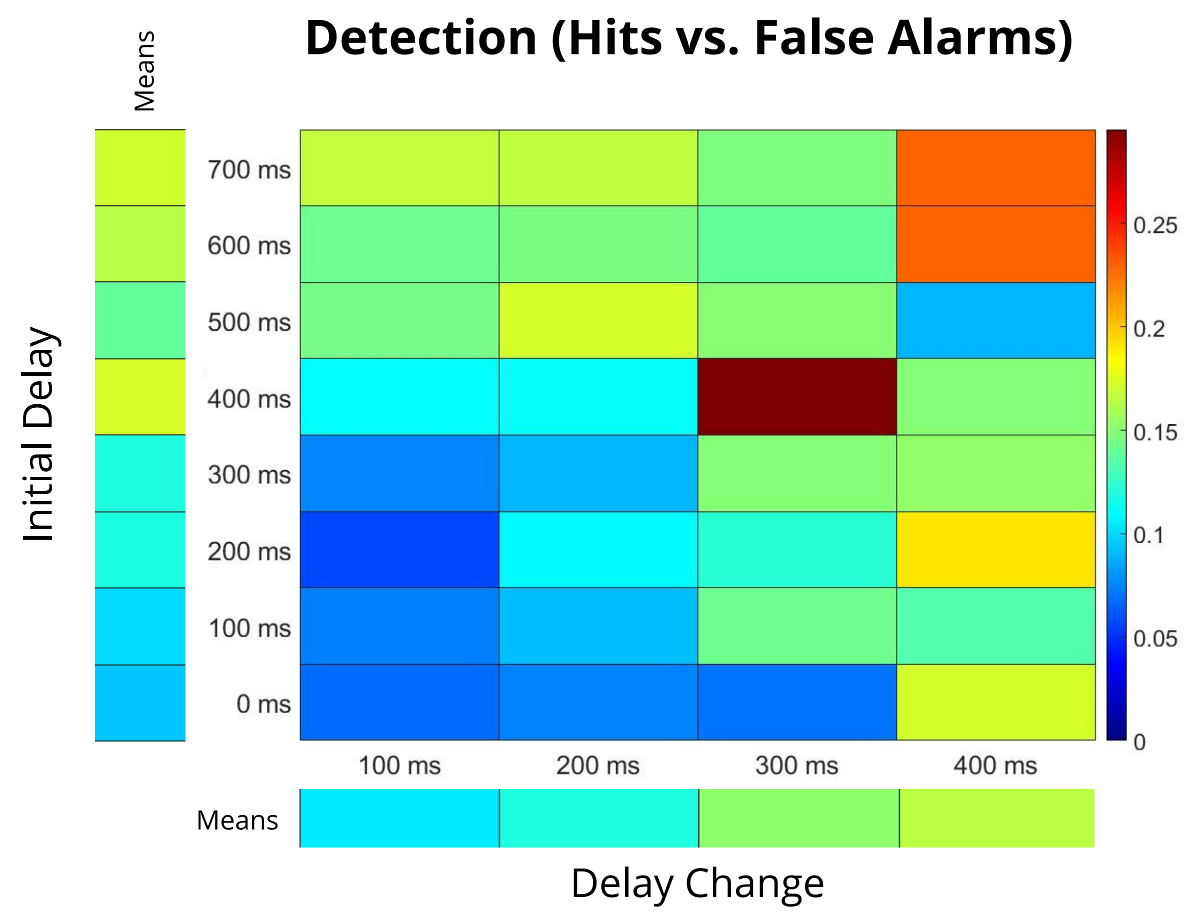
During the experiment, the visuomotor delay changed repeatedly and unpredictably in a roving oddball fashion: seven different delay levels (between 0ms and 700ms) were presented, for 6s to 12s. This means the magnitude of changes ranged from +/-100ms to +/-400ms. Crucially, participants were instructed to indicate a perceived delay change by the press of a button.

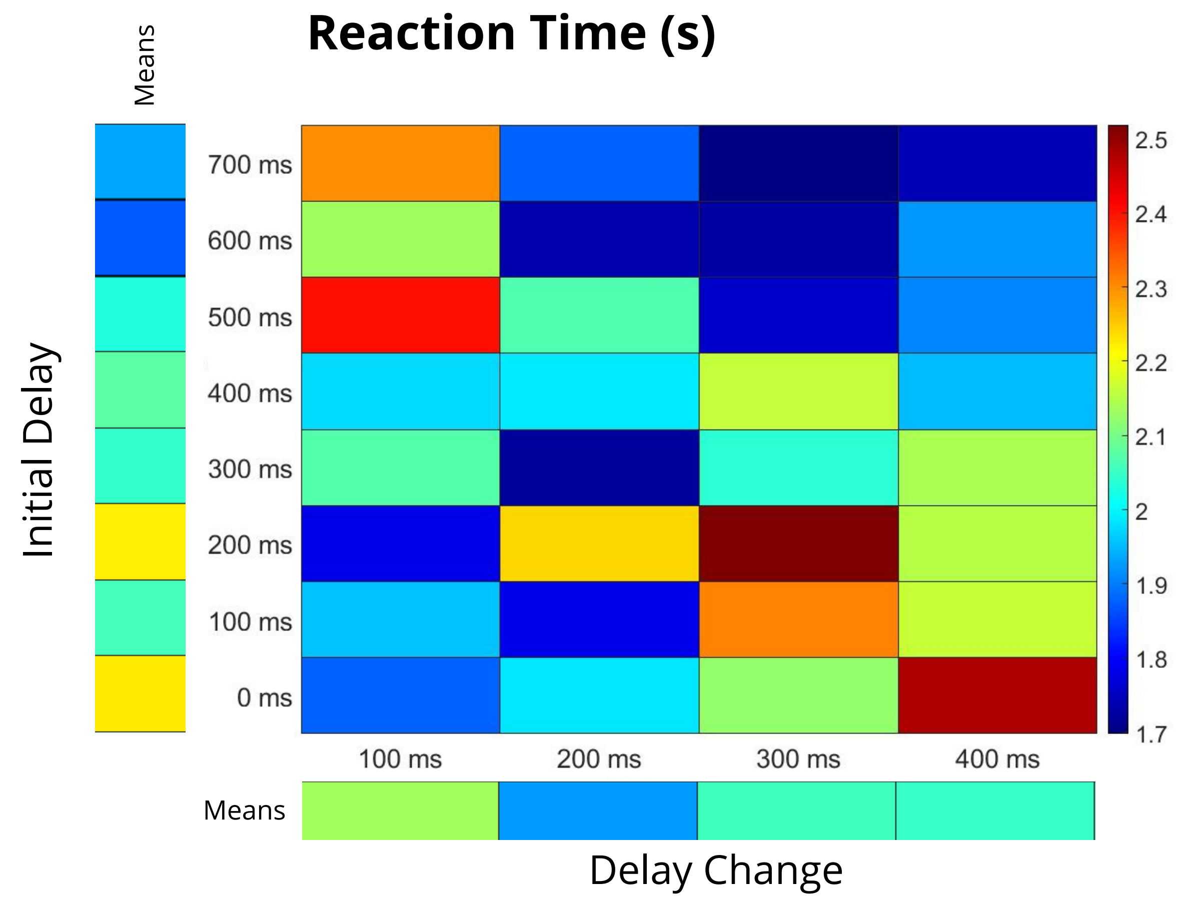
Preliminary Conclusion

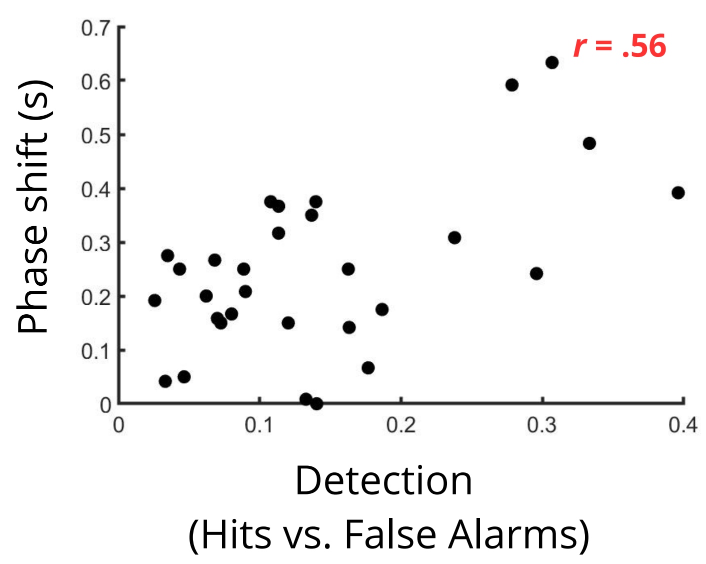
The Weber-Fechner law does not seem to universally apply to the perception of visuomotor mappings. Although larger changes in visuomotor delay were perceived better than small ones, our results suggest that changes in visuomotor delay are perceived more clearly and faster when visuomotor delay is *already high*. There are several possible explanations for this; e.g., moving under small delays could produce stronger visuomotor interference effects, thus distracting participants; or an increased embodiment of the virtual hand under small delays could increase tolerance for delay changes. This should be taken into account when designing settings where visual movement information is delayed relative to proprioception, e.g., in teleoperations or cyber-physical interactions.

Preliminary Results

ANOVA showed a main effect of Delay Change on detection performance (F(3,609)=10.17, p<.001) and reaction times (F(3,609)=5.89, p<.005): Thus, as expected, larger delay changes were overall detected better (post-hoc regression, p=.015); reaction time differences were less clear (no linear effect). There also was a main effect of Initial Delay on detection performance (F(7,609)=7.70, p<.001) and reaction times (F(7,609)=5.89, p<.001). Post-hoc regression analyses showed that these effects were linear (Detection: p<.001; Reaction times: p=.002). In other words, somewhat surprisingly, delay detection was overall better and faster, the higher the initial delay levels. Finally, an interaction effect was present on detection performance (F(21,609)=3.96, p<.001) and reaction time (F(21,609)=4.45, p<.001).







Furthermore, we found a negative correlation between delay detection and tracking performance: Participants who tracked the target rhythm overall better detected delay changes less consistently (r=.56, p=.001).