A Causal Feeling: How Kinesthetic Haptics Affects Causal Perception

Elyse D. Z. Chase[1], Phillip Wolff[2], Tobias Gerstenberg[3], and Sean Follmer[1]

***Abstract*— While haptic feedback is vital to how we gather information in the world, most research on causal perception has focused on visual information. To assess how haptics affects people's perception of causal events, we ran a psychophysical study modeled after Michotte's launching paradigm. Participants watched trains move on the screen and judged whether one train caused the other to move, with half the trials providing 1-DoF kinesthetic haptic feedback synchronized to the motion of the second train. We manipulated the temporal offsets between when the first train stopped and the second train started. The results show that adding haptic feedback increases causal perception for events with positive offsets.**

I. Introduction

Humans often use causal relationships to learn about the world – and touch plays a large role in exploring these causal structures. However, while prior research has explored multimodal perception and sensory integration, less is known about how haptic information shapes causal perception (interpretation of how action relates to outcome) in concert with information from other sensory modalities [1]. Most research on causal perception has focused exclusively on the visual domain, leaving a knowledge gap on the effects of touch.

To study causal perception, researchers often use the classic Michottean launching paradigm [2], in which a moving *launcher* contacts a stationary object, then the *launcher* stops moving and the object begins to move. The temporal delay between when the *launcher* arrives at the object and when the object moves is manipulated. We use this experimental paradigm to better understand how haptic feedback affects people's perception of potentially causal events.

II. Study Design

The study is a within-subjects, repeated measures design with 2 factors: temporal offset and sensory modality (vision vs. vision & haptics). We treat sensory modality as a blocking factor, and then randomize offsets within each block. Each offset is repeated 12 times per block. Block order is counterbalanced between participants. We blocked the experiment in order to group each portion of the psychometric study, during which a method of constant stimuli is used to estimate the temporal offset threshold at which the events are perceived to be causally connected. At the end of every trial, participants are asked what occurred, selecting either the causal or noncausal statement.

[1]Department of Mechanical Engineering, Stanford University, Stanford, CA 94305 USA. e-mail: elysec@stanford.edu

[2]Department of Psychology, Emory University, Atlanta, GA 30322 USA.

[3]Department of Psychology, Stanford University, Stanford, CA 94305 USA.

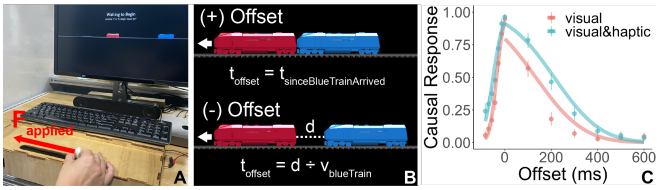

Fig. 1. (A) The study setup with user's hand on the haptic device, (B) illustration of offsets, and (C) grouped experimental results.

Haptic feedback, when present, is delivered to the right hand via a 1-DoF device that provided a constant force (3 N) synchronized with the motion of the second train (Fig. 1A). Temporal offsets create both a visual delay (+ offset) and a visual gap (- offset) (Fig. 1B). A total of 13 temporal offsets were used (6 positive, 6 negative, and zero), with equal separation between each group of offsets.

III. Experimental Results

A total of 18 right-handed participants (8 ♀, 10 ♂; age $\mu = 25$) were recruited and compensated for participating.

Four psychometric curves were generated for the positive and negative offsets in both the "visual" and "visual & haptic" conditions as seen in Fig. 1C. There was no significant difference between the vision and vision with haptics condition for negative offsets. However, the addition of haptics affected participants' judgments for positive offsets. The probability with which participants view an event as causal for positive offsets was significantly greater in the vision and haptic condition compared to vision alone (one-tailed paired t-test of detection thresholds at a probability of 0.5; $t(17) = 5.61, p < 0.001, d = 1.32$).

IV. Discussion & Future Work

Our results indicate that kinesthetic haptic feedback can alter people's perception of causal events in cases with temporal delay. To understand what salient haptic information is used to form these judgments, we plan to explore other types of haptic feedback. In order to discover the specific role haptics may play, future work should include comparisons to other sensory modalities such as sound [3]. Overall, this research will uncover whether the effect haptics has on causal perception is unique to touch, and how people use haptic information to make higher level judgements about events that occur around them.

References

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