Sensory uncertainty shapes the perception of causality

Susan Kang[1,3], Martin Rolfs[1,2] and Sven Ohl[1]
[1]*Department of Psychology, Humboldt University of Berlin, Germany*
[2]*Bernstein Center for Computational Neuroscience, Berlin, Germany*
[3]*Department of Education and Psychology, Free University of Berlin, Germany*
susan.kang@fu-berlin.de

Abstract

Imagine seeing a disk on a screen moving straight towards a second, stationary disk. Upon contact, the first disk stops, whereas the second continues the former's motion in the same direction and speed. In most people, such simplistic stimuli lead to the percept of a launch, the vivid impression that the first disk physically caused the movement of the second disc. In the present study, we investigated the role of sensory uncertainty for perceiving causality and tested how a Bayesian model in comparison to several heuristics – all based on position estimates of the two disks – can account for the behavioral reports in the psychophysical task.

In a trial, we presented two moving disks and manipulated the overlap of the two stimuli (when the first disk stopped and second disk started to move) by nine different amounts ranging from full overlap (resulting in the percept of a non-causal pass) to no overlap (resulting in the percept of a causal launch). Moreover, we manipulated sensory uncertainty by increasing the eccentricity (either 0, 4, 8, or 12 degrees of visual angle) at which the disks were presented. Both increasing overlap and eccentricity reliably decreased the proportion of perceived launching events. Further analysis confirmed that both observer's individual threshold of differentiating between a launch and a pass, as well as their discriminatory ability was affected by increasing eccentricity – implying that we successfully manipulated sensory uncertainty.

A heuristic model that postulated a linear relationship between eccentricity and threshold accounted best for the observed reports. This heuristic linear model also showed a considerable advantage over a model in which the threshold was kept constant across eccentricities. A third model, applying Bayes' theorem in order to classify the stimuli into launches and passes came close to achieving comparable results but ultimately didn't surpass the linear one.

In summary, the influence of sensory uncertainty on the perception of causality is twofold – increasing sensory uncertainty decreases the precision of position estimates at the time of contact, and in addition, observers accepted fewer overlap with increasing uncertainty when reporting a launch. This heuristic outperformed a Bayesian model, suggesting the use of sub-optimal decision strategies in the perception of causality.

Keywords
Perception of causality, heuristics, Bayesian modeling