Explore the Current Causal Perception Hypothesis

Jinfan He
Peking University
2200012979@stu.pku.edu.cn

Abstract

Causality is a crucial means by which people perceive and understand the world. The deduction and mechanism of causality is a significant area of research in psychology and artificial intelligence. Causal perception, as a domain of causality, is important in understanding the mechanisms of causality. This article explores two major hypotheses in the field of causal perception: the causal detector hypothesis and the causal schema hypothesis. I analyze the relevant supporting evidence and combine the effects of temporal and spatial cues on causal perception to propose hypotheses for future directions of exploration.

1 Introduction

Causality is everywhere in our lives. Causality is not only employed in abstract concepts and high-level logical causal inference but is also frequently applied in various real-life scenarios. For instance, when an object A in motion comes close to another stationary object B, and upon contact with B, B starts moving in the same direction, we intuitively infer that object A causes the movement of object B. Such simple causal inference requires no conscious thought and may sometimes conflict with the results of higher-order causal logical analysis. This phenomenon, known as causal perception, exhibits the characteristics of a typical perceptual process – rapid, automatic, irresistible, and highly stimulus-driven. However, it differs from common visual perceptual processes (e.g., color or object classification) as it perceives information latent in the stimulus, not explicitly present in the actual events.

Currently, [6]causal perception is guided by two main hypotheses: Michotte's causal detector hypothesis and the causal schema hypothesis. Michotte's hypothesis posits the existence of a specialized perception module for the recognition of simple causal relations. When this perception module generates a representation, it indicates the presence of a causal interaction in the observer's field of view. This perception module for causal detection is believed to be innate, encapsulated, and impervious to empirical learning. The causal schema hypothesis proposes that causal schemata are derived by recognizing causal sequences from representations in long-term memory. Due to the quick and automatic execution of these schemata, we can immediately identify simple causal relationships, sometimes erroneously attributing this immediacy to perceptual processing. In the following sections, we will explore supporting evidence for both hypotheses and present potential avenues for further investigation.

2 Causal Detector Hypothesis

Supporting evidence for this hypothesis comes from neuropsychological research, such as the study conducted by Roser[3]. In his study, he tested two split-brain patients by presenting them with sequences in their right or left hemispheres, including launching, gapped, or delayed sequences, and asking them to judge whether a causal event had occurred. Roser found that patients could distinguish between launching sequences only when their right hemisphere processed the event. Moreover, only the left hemisphere could engage in causal reasoning, for example, figuring out which of two switches controlled a light. This suggests that the right hemisphere may be responsible for perceiving causal

relationships, while the left hemisphere is involved in higher-level causal reasoning. This evidence strongly indicates the existence of a distinction between causal perception and higher-order causal reasoning.

However, functional magnetic resonance imaging experiments[5] indicate the involvement of the right hemisphere in integrating information and causal reasoning during text processing. This suggests that the right hemisphere can handle certain aspects of causal reasoning. Thus, by distinguishing between different types of causal reasoning, the causal schema hypothesis can still explain Roser's findings.

3 Causal Schema Hypothesis

To demonstrate the innate nature of the causal perception ability, investigating the presence of causal detectors in infants is a promising approach. However, experimental findings largely challenge the existence of these causal detectors. Studies[1] of infants aged 4 to 6 months have shown that responses to launching sequences change throughout infancy. Laura[4] suggests that infants can perceive hidden causal events. In addition, Spelke[2] has revealed different responses of infants to causal displays involving inanimate objects and humans, suggesting that infant causal perception is influenced by top-down expectations. Meanwhile, studies[7] show variations in causal perception among individuals, with some participants being more concerned with the relative velocities of the two objects when assessing the naturalness of launching events. Therefore, the causal detector hypothesis needs to be modified, suggesting that causal detectors may be affected by more parameters. However, this complexity may degrade the accuracy of causal detectors.

4 Some Discussion

In fact, both the causal detector hypothesis and the causal schema hypothesis emphasize the significant role of temporal and spatial cues in causal perception. While there are individual differences in causal perception among different people, with varying sensitivities to temporal and spatial cues, increasing the distance or time interval between events consistently decreases the likelihood of inferring a causal relationship through causal perception. And, even in the absence of causality, proximity in time and space can lead to miscaculations. For example, if a distant house is on fire and you happen to light a cigarette at that moment, you might mistakenly believe that lighting the cigarette is causally related to the house catching fire. This kind of perception is intuitive and not based on logical reasoning. Your erroneous perception may arise simply because the events occurred close together in time and space. Such a perception can conflict with rational expectations, creating strong stimuli, but after a period of continuous observation, you adapt to these stimuli, reducing the perceptual response. This phenomenon is known as visual adaptation[8].

We propose the hypothesis that there might exist more fundamental causal detectors than perceptual launch sequences that specialize in recognizing spatial-temporal cues in a narrower and more precise manner while generating perceptual responses that are inversely correlated with the degree of temporal and spatial interval. This may explain the effects of individual differences and top-down expectations on causal perception and the phenomenon of perceiving causality between unknown events.

5 Conclusion

This article has explored the two main hypotheses of causal perception, the causal detector hypothesis and the causal schema hypothesis, analyzing the evidence in support of these hypotheses and the existing challenges. It highlights the critical role of spatio-temporal cues in causal perception and proposes a hypothesis to focus the functional module on perceiving these cues. By combining this with the causal schema hypothesis, we provide a possible explanation for the problem raised by both hypotheses in experimental phenomena and provide directions for future exploration.

References

[1] Leslie B Cohen and Geoffrey Amsel. Precursors to infants' perception of the causality of a simple event. *Infant behavior and development*, 21(4):713–731, 1998. 2

[2] Ann Phillips Elizabeth S Spelke and Amanda L Woodward. Infants' knowledge of object motion and human action. 1995. 2

[3] Roser M.E. Corballis P.M. Gazzaniga M.S. Dunbar K.N Fugelsang, J.A. Brain mechanisms underlying perceptual causality. *Cognitive Brain Research*, 24:41–47, 2005. 1

[4] Laura Kotovsky and Renée Baillargeon. Reasoning about collisions involving inert objects in 7.5-month-old infants. *Developmental science*, 3(3):344–359, 2000. 2

[5] Just M.A. Mason, R.A. How the brain processes causal inferences in text. *Psychological Science*, 15:1–7, 2004. 2

[6] Lance J Rips. Causation from perception. *Perspectives on Psychological Science*, 6(1):77–97, 2011. 1

[7] Anne Schlottmann and Norman H Anderson. An information integration approach to phenomenal causality. *Memory Cognition*, 21(6):785–801, 1993. 2

[8] Yixin Zhu, Tao Gao, Lifeng Fan, Siyuan Huang, Mark Edmonds, Hangxin Liu, Feng Gao, Chi Zhang, Siyuan Qi, Ying Nian Wu, et al. Dark, beyond deep: A paradigm shift to cognitive ai with humanlike common sense. *Engineering*, 6(3):310–345, 2020. 2