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Causality

One is tempted to believe that perception is limited to the reconstruction of meaningful objects such as rocks or chairs on the basis of raw sensory information. The topic of perceptual causality shows that one should resist that temptation and be open to widen the scope of perception. Subjective causality is by no means a mere reflection of physical causality, but is our interpretation of whether one event is causing another event. It often approximates reality and sometimes deviates substantially from it. The function of this subjective and immediate sense of causality is to make sense of the world and to guide our actions. Albert Michotte has in many ways become the father of perceptual causality by arguing that the phenomenal impression of causation is a fundamental building block of perception and that causality is perceived in a direct manner that is not qualitatively different from that of perceiving rocks or chairs. Before describing the work of Michotte and his followers, this entry looks more closely at causality and its context of event perception.

Efficient Versus Final Causes

Causality can be conceived in two different manners, one relating to internal events, such as goals, opinions, and cultural settings. The other relates to the observation of external events that happen in the world. Aristotle proposed this distinction between causation from within and external causation. He called the former *final causation* and the latter *efficient causation*. Take, for instance, the event of a player's leg making contact with a ball, upon which the ball proceeds to move into the direction of a box. In terms of efficient causation, one could say that the leg has caused the ball to move. The leg moved first and somehow imparted its motion or impetus to the ball. We observed one motion as the cause of another subsequent motion.

David Hume has extensively discussed this type of causality. Besides temporal succession, one has to assume additional mechanisms that distinguish a true cause from coincidental succession. For instance, in the case of a collision of two billiard balls, the ricochet motion of the target ball has been caused by the cue ball via such intermediate mechanisms as friction and energy transfer. A soccer fan would not agree to this description. She would describe the same event as a forward player intending to score a goal. The intention causes the player to aim for the goal, and this intention causes the ball to move. Unlike the efficient cause, the final cause relates to an involved observer, for whom the simple chain of events (1) intention (2) leg movement (3) ball movement is no longer a chain. The intention does not end when the leg starts to move, nor does it disappear when the leg has stopped moving.

Cause and effect cannot easily be narrowed down in temporal or spatial terms. Although the conditions that must be met to perceive an efficient cause can be described with comparative ease, the conditions for perceiving a final cause are more intricate because they do not fit into straightforward descriptive categories. Not surprisingly, psychologists have put their primary focus on the efficient cause although the final cause is in many ways more important for us as acting individuals. In the world of a human actor, actions are caused by the intended environmental effects. The final cause for our fingers flipping the light switch is our intention to turn on the lamp. This intention stretches to the point in time where the lamp is on, and thus the succession of cause and effect is no longer valid. To make things even more difficult, the technological advances of our time require us to perceive causal relations between goals and events that appear to be dissimilar. Where our ancestors pulled a mechanical lever to set a switch, we achieve the same effect by means of a mouse click on the computer or even a verbal input.

Phenomenal Reality of Efficient Causes

Since the days of Hume, our understanding of an efficient cause has been shaped by the idea of associationism. We see A as the cause of B because

A precedes B with regularity. Turning the switch is perceived to cause the light to go on because the switch action has become associated with the light. In contrast to this associative concept of causality, Michotte put forth a fundamentally different concept of visual causality, claiming that we have direct phenomenal access to causality. It requires neither learning nor conscious or unconscious inferences. He was able to demonstrate that observers perceive the motion of two simple objects as causally related as long as surprisingly few boundary conditions are met. Take, for instance, the case of an actual billiard shot. The cue ball moves toward the stationary target ball and abruptly stops at the moment of collision, instantly setting the target ball into motion. Michotte discovered that impoverished renditions of such an event suffice to convey the impression of causality. The motion of a painted dot toward another painted dot on a screen and the subsequent motion of the second dot are readily and immediately perceived as causally connected.

Michotte did most of his experiments using a turntable. Two lines were drawn on a rotating disk, which was covered by a mask except for a small slit that served as a viewing port. Changing the distance between the circular lines at different stages would produce different dot motions. Whenever the first dot moved toward the second dot, followed by motion of the second dot, the stimulus was perceived as "dot 1" launching "dot 2." Despite the artificial nature of the stimuli generated with this method, a stable impression of causality was readily produced. Depending whether the first dot stopped after contact with the second, Michotte distinguished among a launching effect proper, entrainment, launching across a spatial or a temporal gap, and others. Some of these effects are illustrated in Figure 1.

Infants readily perceive launching and entraining, which suggests the innate nature of phenomenal causality. Michotte's insights remain valid, albeit with considerable elaborations. Efficient causality has turned out to be more complex than thought by Michotte. In some cases, observers are reluctant to make causal attributions where they should according to Michotte, and in other cases, observers perceive causality even outside the conditions he put forth for launching and entrainment. For instance, judgments of causality change depending on the perceptual attitude and experience of the observer. Observers who adopt an analytic attitude tend to

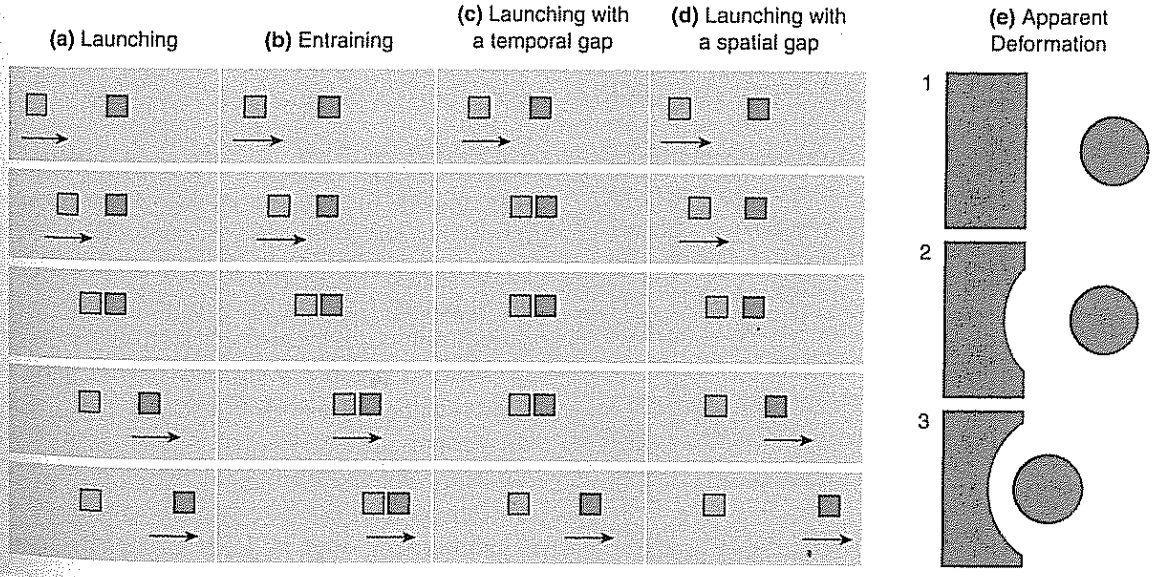

Figure 1 Schematic Illustration of Michotte's Stimuli

Notes: (a) Launching, (b) entraining, (c) launching with a temporal gap, (d) launching with a spatial gap. In (e), the observer has the impression that the motion of the circle causes the deformation of the rectangle although neither launching nor entrainment is the case.

describe the standard launching stimulus as a sequence of independent movements, rather than cause and effect. Conversely, the sequence of events shown in column (e) of Figure 1 is readily seen by most observers as the gray circle putting a dent into the grey rectangle although the two never touch. This suggests that the boundary conditions for perceptual causality may be even wider than originally thought.

Intuitive Physics

From an evolutionary point of view, one could argue that true causal relations have only been discovered by the perceptual system inasmuch as they have been internalized to secure the survival of the species. Whenever erroneously perceived causal relations did not have any adverse consequences, errors were not corrected. Thus, our direct access to efficient causes should be limited by the needs of the hunter and gatherer who moved around in a world determined by the laws of classical mechanics. According to the field of intuitive physics, the approximation of perceptual causality to physical causality has not progressed any further than what was known about physics in ancient Greece. For instance, when asked to indicate the trajectory of an object dropped from a moving carrier, many observers believe that it will fall straight down. Accordingly, when being moved on a conveyor belt, many adults and most children will release a ball directly above the stationary target on the ground when intending to hit it. They overshoot the target because they act as if they were stationary and the ball moved straight down. Instead, it moves down and in the direction of self-motion. After a few trials, the behavior adjusts quickly, but the causal relations that are expressed by Newton's laws remain opaque. The understanding of classical mechanics seems indeed limited to pre-Newtonian theory. The direct access to causation has clear limitations that are well described by intuitive physics. In other words, human observers have internalized causal relations that hold in the environment, but only to a rough approximation. This approximate internalization would also explain the inclination to perceive causal structure in mere graphic illustrations.

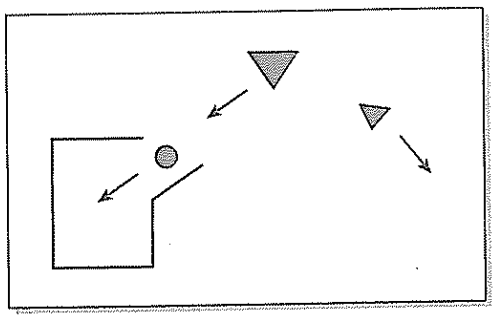

Figure 2 Geometric Figures Used by Fritz Heider and Georg Simmel in a Cartoon

Notes: The arrows indicate the direction of motion and were not present in the experimental stimuli. Movements of the figures are seen as actions and the figures take on particular traits.

Overestimation of Action Goals

When it comes to final causes, a new domain of perception opens up, one that is sometimes dramatically removed from physical causality. The laws of physics and mechanical causality are being bent dramatically when it comes to the perception of causes for willed events. For example, in the case of ballistic movements, a large number of observers believe that a cannon ball accelerates after it has left the cannon. Similarly, observers judge a thrown ball that increases its speed after leaving the pitcher's hand to look more natural than a ball that decelerates in accord with physical law. This surprising but stable finding can be explained by the projection of an intention into the object itself. Rather than limiting the effect of the intentional cause to the movement of the effector—the arm that throws the ball—the effect migrates to the ball. In Aristotle's terms, a person's goal to throw the ball to a particular target causes the ball to move, not just while it is being held in his or her hand but also beyond this point on its way to the target.

Final causality also leaves the domain of perception proper and enters the realm of emotion and cognition. We spontaneously "see" intentions, emotions, and social relationships in simple movements of geometrical objects as Fritz Heider and Georg Simmel have demonstrated. When the geometric drawings in Figure 2 are animated, as indicated by the arrows, observers spontaneously describe the actions in social terms. They may readily see the large triangle as a villain chasing the circle while

the small triangle is the friend of the circle (apparently a female), and the large rectangle is a house. We cannot help but experience inanimate motion within a framework of social meaning.

Interestingly, even stationary objects tend to be interpreted in a causal manner that considers the history of the object's deformations, as Michael Leyton has pointed out. A crumpled piece of paper readily reveals that its prior state was uncrumpled and that it has been put into its crumpled state by an actor.

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See also Event Perception; Intentionality and Perception; Phenomenology (Philosophy); Social Perception

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Cell Phones and Driver Distraction

Operating a motor vehicle is an activity engaged in by more than one billion people on an annual basis. Given that each year there are more than one million fatalities worldwide associated with motor vehicle accidents, driving represents one of the more risky activities undertaken on a regular basis by adults between the ages of 25 and 65. Estimates suggest that as many as 80% of accidents on the roadway are the result of some type of driver distraction, and it has been noted that one of the basic road errors is a failure to see and react to another road user in time. Driver distraction associated with visual processing can be divided into two general categories: Situations where drivers fail to look at roadway hazards in the driving environment (i.e., failures to look or fixate upon an object) and situations where drivers look at objects in the driving scene, but show degraded processing of the driving environment because attention is directed elsewhere (i.e., failures to see or attend to the object). This entry describes the relationship between cell phones and driver distraction.

Driver distraction associated with a failure of visual processing can be attributed to situations where drivers fail to direct their eyes to hazards in the roadway. This source of impairment can be the result of distractions from outside the vehicle (e.g., an electronic billboard with sudden onsets or movement that results in a reflexive orientating of the eyes to the billboard) or to distractions within the vehicle (e.g., dialing or text messaging on a cellular phone). In both situations, driving is impaired because the eyes are diverted from the roadway and the information necessary for the safe operation of the vehicle is not fixated on for a sufficient duration to allow for its processing. This results in a source of driver distraction wherein the driver fails to look at critical information in the driving environment. Research indicates that the concurrent performance of ancillary visual tasks often compromises driver safety; however, some drivers are more impaired than others. Compared with more experienced drivers, novice drivers are less able to interleave the performance of a concurrent visual task with driving. For example, novices tend to allocate longer epochs of visual processing to a secondary task than do more experienced drivers who exhibit frequent and short glances between the two tasks. In sum, the first source of distraction occurs if the driver does not look at an object, and thus, he or she cannot see and react in a timely fashion.

Driver distraction can also be caused by attention being diverted from driving to some other