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THE PERCEPTION OF CAUSALITY: INSIGHTS FROM MICHOTTE'S LAUNCHING EFFECT, NAÏVE IMPETUS THEORY, AND REPRESENTATIONAL MOMENTUM

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Abstract

A convergence of findings regarding Michotte's launching effect (the attribution that a moving object that contacts an initially stationary target is responsible for the subsequent movement of that target), naïve impetus theory (the theory that setting a previously stationary object into motion involves imparting to that object an impetus that then dissipates), and representational momentum (a forward displacement in the remembered location of a moving target) suggests observers do not perceive causality. Studies of the representational momentum of targets in launching effect displays and in several control conditions suggest forward displacement is decreased if target motion is attributable to an impetus imparted from another stimulus. This decrease occurs because observers expect motion of a launched target to stop when impetus drops below the level needed to maintain motion, and forward displacement is decreased when observers expect a target to stop. Impetus does not correspond to a valid physical principle, and so any role for impetus in the launching effect suggests observers do not perceive causality.

The question of whether human observers perceive causality has a long history (e.g., see Scholl & Tremoulet, 2000; Sperber, Premack, & Premack, 1995). Hume's (1739/1986) view that causality is not perceived, but is inferred on the basis of spatial and temporal contiguity, has been widely accepted. However, Michotte (1946/1963) suggested the launching effect demonstrated causality could be perceived. More recently, researchers found that observers who view stimuli similar to stimuli in the launching effect do not have veridical intuitions regarding causal principles (e.g., Gilden & Proffitt, 1989), but respond in ways consistent with a belief in naïve impetus (McCloskey, 1983). The representational momentum of targets in displays based on Michotte's launching effect suggests an interpretation of the launching effect in which causality is not perceived, but instead reflects an impetus heuristic that influences spatial representation in a dynamic fashion.

Representational Momentum

If an observer views a target undergoing implied or apparent motion, that observer's memory for the final location of the target is usually displaced forward slightly in the direction of target motion (see Figure 1). This forward displacement has been referred to as *representational momentum* (e.g., see Hubbard, 1995; Thornton & Hubbard, 2002). Initial accounts of this forward displacement suggested mental representation incorporated effects of physical momentum (Finke, Freyd, & Shyi, 1986) or reflected spatiotemporal coherence

(Freyd, 1987), and more recent accounts suggest representational momentum reflects high level processes such as second-order isomorphism between properties of the physical world and properties of mental representation (Hubbard, 1999) or low level processes such as pursuit eye movements and visual persistence (Kerzel, 2000). However, displacement is influenced by high level processes (e.g., expectations of future target behavior, Verfaillie & d'Ydewalle, 1991; knowledge of target identity, Reed & Vinson, 1996) and occurs when pursuit eye movements do not occur (e.g., implied motion stimuli, Munger, Solberg, Horrocks, & Preston, 1999; frozen-action photographs, Futterweit & Beilin, 1994), and so cannot result solely from low level processes.

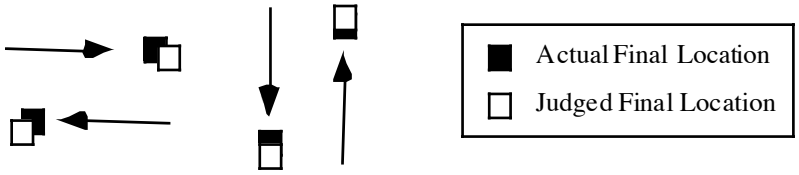

Figure 1. The relationship between actual and judged final location for horizontally or vertically moving targets. Representational momentum is shown by the forward displacement of remembered location. Arrows indicate the direction of target motion. Adapted from Hubbard (1999).

Michotte's Launching Effect and Representational Momentum

If an observer views a moving object, referred to as the *launcher*, that contacts a stationary object, referred to as the *target*, and the target begins to move immediately after being contacted by the launcher, the observer attributes motion of the target to the launcher (see Figure 2). Michotte (1946/1963) referred to this as the *launching effect*, and he noted that a launching effect only occurred if (a) the latency between when the launcher contacted the target and when the target began to move was very brief, (b) the ratio of the previous velocity of the launcher and the subsequent velocity of the target was within a narrow range, and (c) the direction of previous motion of the launcher and the direction of subsequent motion of the target were the same. As noted by Scholl and Tremoulet (2002), findings that objectively small manipulations of the latencies, velocities, and directions of stimuli in the launching effect could disrupt the reported perception of causality suggested that reports of observers were stimulus-driven and did not reflect a more general inference. Even so, given that Michotte relied exclusively on introspections of observers, it would be useful if a behavioral measure of the possible perception of causality could be developed.

Hubbard, Blessum, and Ruppel (2001) measured forward displacement in memory for the final location of targets in computer-generated displays modeled after Michotte's launching effect. Launchers and targets were square shapes 0.83 deg in width and presented on a blank background. Launcher velocity was 15 deg/sec, and target velocity was 5 deg/sec. Target motion was in the same direction as launcher motion. The target traveled a short distance before the display cleared, and observers used a computer mouse to position

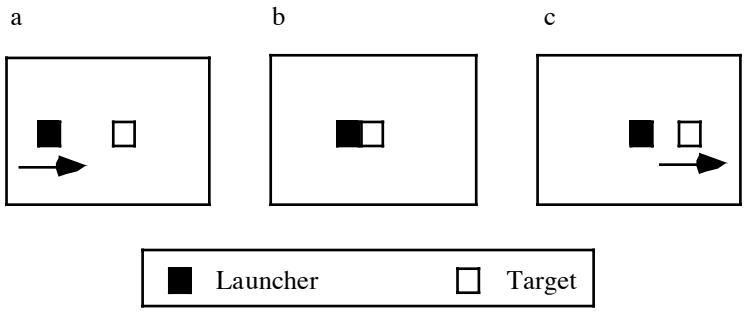

Figure 2. Michotte's Launching Effect. In Panel A, a moving launcher approaches a stationary target. In Panel B, the launcher contacts the target and then becomes stationary. In Panel C, the target moves away from the now stationary launcher. Adapted from Hubbard and Ruppel (2002).

the cursor at the coordinates of the remembered vanishing point of the target. Forward displacement in control displays (e.g., a target that in the absence of a launcher exhibited the pattern of motion of a launched target, target motion in a direction orthogonal to previous launcher motion) was also examined. Forward displacement of targets in launching effect displays was less than forward displacement of targets in control displays.

Hubbard et al. (2001) suggested decreases in forward displacement of launched targets reflected an attribution of naïve impetus. According to naïve impetus theory (McCloskey, 1983), setting a stationary object in motion involves imparting "impetus" to that object. All of the impetus is imparted at the initial moment of contact, and that impetus dissipates with subsequent target motion. Observers expect a target set into motion by the imparting of impetus to stop once that impetus has dissipated below the level needed to maintain target motion. Given that forward displacement is decreased when observers expect a target to slow down or stop (Finke et al., 1986), the decrease in forward displacement of a target in a launching effect display might reflect an expectation the target will stop once the impetus drops below the level needed to maintain target motion. Such a role of impetus in forward displacement is consistent with previous suggestions that representational momentum reflects a belief in naïve impetus (e.g., Kozhevnikov & Hegarty, 2001).

Testing an Impetus-Based Hypothesis

Hubbard and Ruppel (2002) tested an impetus-based explanation of the decrease in forward displacement of targets in launching effect displays. Stimuli and procedures were the same as Hubbard et al. (2001), except that launcher velocity and target velocity could each be 5 or 15 deg/sec, and the distance traveled by the target varied. They found that:

- Forward displacement of the target increased with increases in launcher velocity (and this effect was larger with faster target velocities), but forward displacement of the target was not influenced by target velocity.
- Forward displacement of the target decreased with increases in the distance traveled by the target.

These patterns are consistent with an impetus-based explanation because:

- If movement of the target is attributed to the launcher, then displacement of the target should reflect characteristics (e.g., velocity) of the launcher.
- Observers would have expected impetus to further dissipate with continued motion of the target, and so targets that traveled further should have dissipated more impetus and thus be closer to stopping.

Hubbard and Favretto (2003) further tested an impetus-based explanation by adapting the "tool effect" paradigm discussed by Michotte. In the tool effect, the launcher does not directly contact the target, but the causal power of the launcher is conveyed to the target by an intermediary or "tool" (see Figure 3). Hubbard and Favretto (2003) hypothesized an intermediary might convey impetus from the launcher to the target, and by varying whether the intermediary was contacted by the launcher or contacted the target, they controlled whether impetus was potentially conveyed from the launcher to the target. Stimuli and procedures were the same as Hubbard et al. (2001), except the final location of the launcher and the initial location of the target were separated by 30, 60, 90, or 120 pixels. The intermediary was (a) a square adjacent to the final location of the launcher that began moving immediately after the contact from the launcher and stopped immediately after contacting the target, or (b) an extended stationary rectangle with one side adjacent to the final location of the launcher and the opposite side adjacent to the initial location of the target. They found that:

- Forward displacement of the target decreased when the intermediary was a moving stimulus that traveled from the final location of the launcher to the initial location of the target or was a larger stationary stimulus bridging the gap between the final location of the launcher and the initial location of the target.
- Forward displacement of the target was not different from that of control targets when the intermediary was not presented or did not bridge the gap between the final location of the launcher and the initial location of the target.

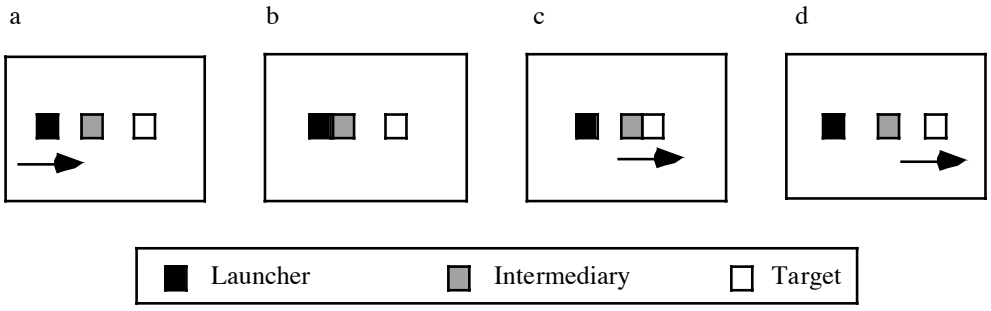

Figure 3. Michotte's Tool Effect. In Panel A, a moving launcher approaches a stationary intermediary and a stationary target. In Panel B, the launcher contacts the intermediary and then becomes stationary. In Panel C, the intermediary moves toward the stationary target, contacts the target, and then becomes stationary. In Panel D, the target moves away from the intermediary. Adapted from Hubbard and Favretto (2003).

In general, displacement decreased only when the intermediary provided a visible conduit for impetus from the launcher to the target, and these patterns are consistent with an impetus-based explanation.

If belief in impetus is responsible for the decrease in forward displacement of launched targets, then a decrease in forward displacement of a target should occur when observers believe impetus has been imparted from a launcher even if the launcher does not actually move. Such an attribution of impetus might arise from illusory gamma movement of a stationary launcher that appeared adjacent to a target. Hubbard, Ruppel, and Courtney (in press) presented a stationary launcher that appeared or vanished adjacent to a target, and the target moved away from the (previous location of the) launcher after the launcher appeared (or vanished). They found that:

- Forward displacement of the target was smaller when the launcher appeared than when the launcher vanished.
- Forward displacement of the target was smaller when target motion was in the direction of potential impetus than when target motion was in the direction orthogonal to potential impetus.

In general, displacement decreased only when impetus attributable to gamma movement of the launcher was in the direction consistent with target motion, and these patterns are consistent with an impetus-based explanation.

Perception of Causality or an Impetus Heuristic?

Findings from several experiments converge on an impetus-based explanation of the decrease in forward displacement in memory for the location of a target in the launching effect. However, impetus does not correspond to a valid physical principle, and observers do not accurately perceive causality if their responses are influenced by a belief in impetus. Rather, observers might rely on an impetus heuristic to predict the outcomes of physical interactions such as those in the launching effect. Why might observers develop or use an impetus heuristic? There may be at least two reasons:

- Although physically incorrect, an impetus heuristic allows useful predictions regarding behavior of pushed or launched objects (e.g., if a stationary object such as a chair is given an initial push, it will move a small distance and stop).
- An impetus heuristic is simpler and requires less effort than a physically correct account because an impetus heuristic involves one parameter (i.e., impetus that dissipates), whereas a physically correct account involves multiple parameters (i.e., kinetic energy of the target, friction from the surface the target moves across or from the medium the target moves through, etc.).

Summary and Conclusions

A consideration of representational momentum in memory for targets in the launching effect suggests observers do not perceive causality. Instead, observers' responses appear to reflect a belief in impetus. Impetus does not correspond to a valid physical principle, and

so any apparent influence of a belief in impetus on observers' responses suggests causal principles are not perceived. Changes in displacement magnitude tracked attributions of Michotte's observers (i.e., forward displacement of the target was decreased in displays similar to those in which Michotte's observers reported motion of the target was attributed to a launcher), and so displacement can provide a useful behavioral measure for the study of causal cognition. Also, a role of impetus in displacement is consistent with claims that representational momentum results from cognitive rather than perceptual processes.

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