THE MEASUREMENT OF CAUSAL PERCEPTION THROUGH MEMORY DISPLACEMENT: IS ALL PASSING A NON-CAUSAL EVENT?

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Abstract

Forward memory displacement of the position of a moving object (RM) has been suggested to capture relevant properties of causal perception. However, the ability of RM to specifically index causality was called into question by Choi & Scholl (2006), who found equivalent patterns of RM reduction in causal "launching" and non-causal "passing". This work takes issue with the idea that "passing" is an a priori non-causal event, by noting its similarities with the "braking effect" studied by Michotte's collaborators. Two localisation response modalities (mouse and pointer) were used in displays where a square travelled across a screen with either a textured stripe of background or a steady rectangle (same height as the square). Target velocity, passing surface (stripe vs. rectangle-object), extent of passing, trajectory layer (in front vs. behind) and target's travelled distance were crossed in a full factorial design. Overall results suggest the presence of subjective causal properties in these displays, meaningfully captured by RM.

Representational Momentum (RM), the forward bias in localising the vanishing point of a moving object (Freyd & Finke, 1984), has been argued to capture properties of causal perception. At the centre of this claim is the finding by Hubbard (Hubbard et al., 2001; Hubbard & Ruppel, 2002; Hubbard & Favretto, 2003) of significant RM reduction in launched objects, observed in schematic collision settings like those studied by Michotte (1954; 1963). In a recent paper, Choi & Scholl (2006) offered a rebuttal of that claim by concluding that RM-attenuation confounds causal and non-causal events. Their conclusion rested on the comparison of classical launching events with allegedly "non-causal" passing events, which produced equivalent amounts of RM attenuation.

This study takes issue with Choi and Scholl's argument on the basis of an analogy to the "braking effect" studied by Michotte's collaborator Levelt (1962). In Levelt's typical displays a rectangle (A) moved across a background presenting either two sections of distinct colours or a steady rectangle (B) of same size but different colour as A, and suddenly slowed down at some point of its course. While only a small number of subjects reported a causal "braking" impression (due to some counteracting force) in the first condition, that number raised significantly in the second condition, especially if the slowing down was limited to the superposition period of A and B. Levelt's "braking effect" thus features a passing situation where causal properties (associated in subject's explanations to friction or viscosity) nevertheless arise.

The proposed analogy is less than perfect, since no physical slow down is part of Choi and Scholl's displays. However, by revealing the potential for causal impressions in passing events, it calls inquiry upon any *a priori* claim that a passing event is devoid of causal properties. Michotte interpreted "braking" impressions as a modality of "phenomenal

dependence" (engaging inferential elements), as distinct from proper "causal perception" - while acknowledging that subjects do give causal responses in both situations. This raises the question, concerning Choi and Scholl's results, that equivalent RM-attenuation for "passing" and "launching" might signal the ability of RM (just as of phenomenological report) to reflect two sorts of "causal bonding", rather than a confounding of causal and non-causal properties.
The following experiment was conceived as an empirical check on that possibility. Holding to the braking analogy, a number of hypotheses were put forward: **(1)** if a "braking" property is associated with schematic passing, increases in *passing extent* should produce greater RM reduction; **(2)** RM reduction should be augmented when the *passing surface* possesses an "object-like" character (grey stationary rectangle), as compared to a mere "background sector" (grey vertical stripe, with no defining contour at the top and bottom); **(3)** RM reduction should in principle be larger when the passing occurs "*in front*" rather then *"behind"*, especially in the "object" condition (this prediction is complicated by reported properties of the "tunnel effect", leading to the expectation of some reduction of RM associated with passing behind – cf. Michotte et al., 1964, 28-29; actually, most passing was done "behind" in Choi and Scholl studies). Some additional variables typically considered in RM studies, such as target's speed and travelled distance, and a response modality variable (mouse *vs.* pointer) were added to the previous set of factors, and jointly manipulated in a full factorial design.

Method

Subjects

40 under-graduate students at the University of Coimbra, naïve regarding the investigator's purposes, took part in the experiment in return for course credits. All subjects had normal or corrected to normal vision.

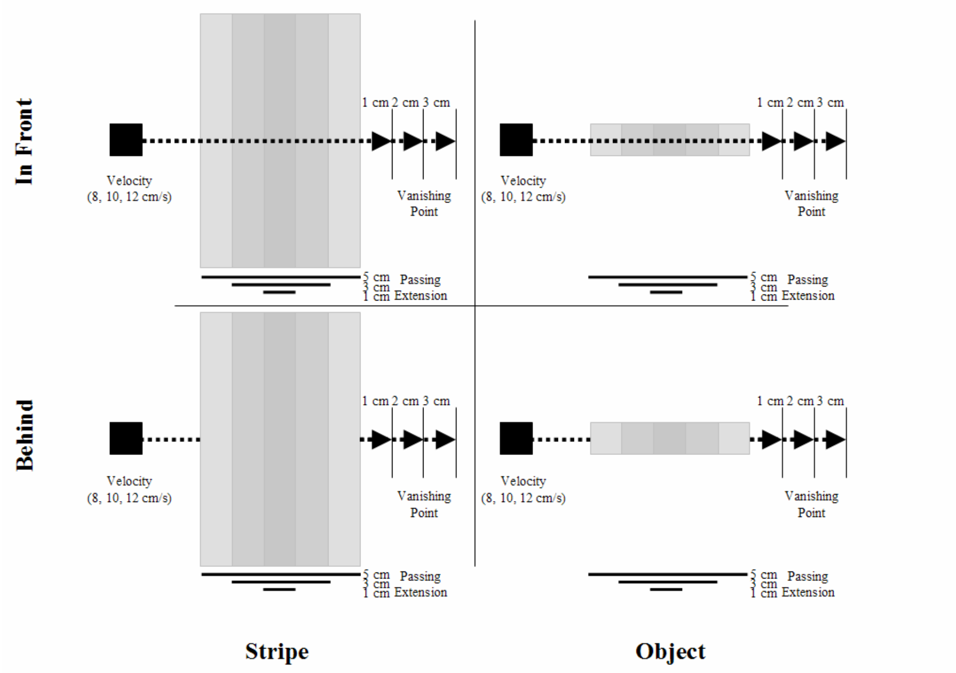

Figure 1 – Schematic representation of the main "passing" conditions included in the experiment.

Stimuli

Stimulus consisted of avi-type animations (compressed with TechSmith Screen Capture algorithm; rate of 40 frames per second) displaying a 1 cm^2 black square (target) which moved horizontally across a screen, at the centre of the vertical axis and at constant speed. Target's velocity could be of 8 cm/s, 10 cm/s or 12 cm/s. In some conditions, a vertical grey stripe of background with widths of 1 cm (the same as the target), 3 cm, and 5 cm, or alternatively a static rectangular-object, of same height as the target and same range of widths as the stripe (see schema in Figure 1), were also presented together with the moving target, which passed either behind or in front of them during its course. Displays suddenly vanished when the target reached a distance of either 1, 2, or 3 cm ahead of the closest edge of the stripe/rectangle – or, in those conditions featuring the translating target alone, after equivalent distances have been travelled. Rightward (LF) and leftward (RL) direction of motion were equally represented across trials. All animations were created with the program *Interactive Physics 2000*.

Apparatus

The experiment was built in and run with Super Lab 4.0. Stimuli were presented on a dual-core PC equipped with a flat touchscreen LSD monitor. Depending on which group they were assigned to, subjects gave their responses either by controlling a cross-shaped cursor (appearing at the centre of the screen when the animation was ended) with an optical wireless mouse, or by directly touching a point in the screen with a Softpoint Pen.

Design, Analysis and Procedure

The experiment obeyed a full factorial 3 (*target velocity*) × 2 (*passing surface*: textured stripe vs rectangle) × 3 (*passing extent*) × 2 (*trajectory layer*: behind vs. in front) × 3 (*travelled distance*) × 2 (*direction of motion*) repeated-measures design, with two replications. Subjects were randomly split by half (resulting in 2 groups of n = 20), and given different instructions as to the modality of response, "mouse" for one group and "pointer" for the other. The main design was supplemented with a three-way subdesign (*velocity* × *distance* × *direction of motion*) corresponding to the conditions where the moving target was portrayed alone. This subdesign offered a basis for the proper calculation of RM reduction in all "passing" conditions. Data analysis was mainly performed through mixed ANOVAs with "response modality" as a between-subjects factor and all remaining variables as within-subjects factors.

Subjects were asked to carefully look at the randomly presented animations and, as soon as they vanished, to locate the geometric centre of the target at its last seen position. They sat at 60 cm from the screen with no restrictions to head or eye movements, but were urged to keep an overall steady posture. The "mouse" response consisted in displacing a "plus-sign" cursor, which became visible at the centre of the screen, to the sough position. The "pointer" response consisted in touching the screen at the intended location (subjects were instructed to only raise their hand from the table after the animation was over). The experiment proceeded at a personal pace, with subjects moving to the next trial by clicking a mouse's button or by touching the screen. A number of practice trials were given beforehand to ensure good understanding of the instructions and familiarity with the task.

Results

Magnitude of RM was calculated as the difference in pixels between the *x*-coordinate of the target's centre on the last frame of the animation, and the *x*-coordinate of the position indicated by the subject. *Magnitude of RM reduction* (rRM) was obtained from the difference between RM in "passing" conditions and RM in equivalent conditions (matched for velocity, travelled distance and motion direction) where the moving target was presented alone. Both measures were analysed through mixed ANOVAs with response modality as a between-subjects factor. Because of the considerable number of comparisons involved, the significance criterion was set at $\alpha \leq 0.01$.

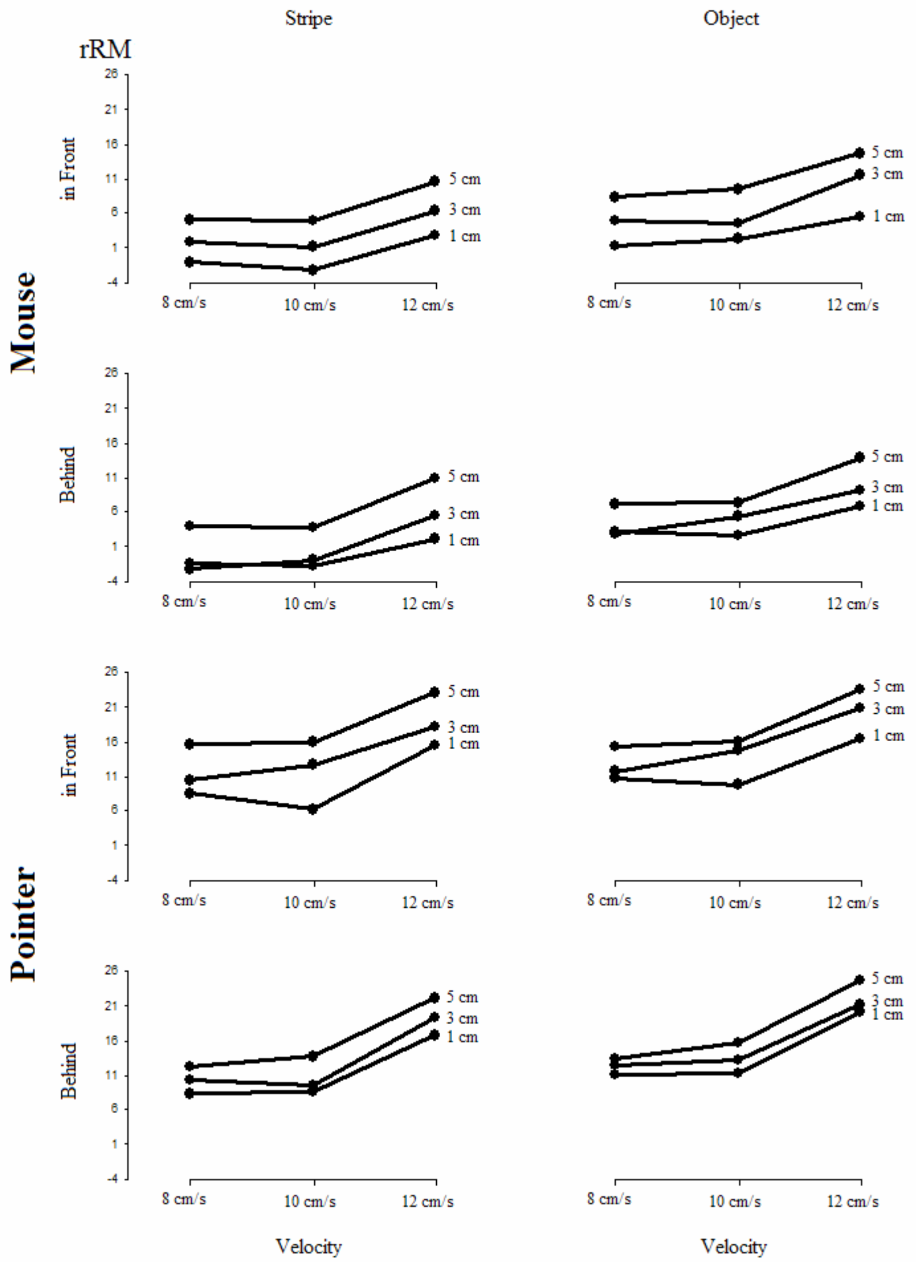

Figure 2 – Factorial plots of "target's velocity" (abscissa) x "passing extent" (curve parameter), with mean rRM magnitude on the ordinate. Results are illustrated across "response modality" (panel blocks) "passing surface" (columns) and "trajectory layer" (individual rows).

Graphics in **Figure 2** concern *RM reduction* (rRM). Factorial plots of *target's velocity* × *passing extent* are illustrated across "response modality" (mouse: four top panels; pointer: four bottom panels), "passing surface" (stripe: left column; object: right column) and "trajectory layer" (in front: first and third rows; behind: second and fourth rows). In every case, the vertical separation of lines and their upward trend suggest that both factors contribute to rRM. Moreover, overall parallelism in the plots signals that factors combine additively. As anticipated under the "braking" hypothesis, increases in "passing extent" thus contribute (in an additive manner) to increased RM reduction. A general trend for higher RM reduction on "pointer" panels and on the "object" column (within-rows comparisons) can also be observed. This last trend is again convergent with the "braking" hypothesis. **Figure 3** summarizes the patterns of results more directly relevant to the "braking" hypothesis. In line with predictions, "passing extent" and "object-character" both contribute to augmented rRM (again additively, given near-parallelism of the lines). *Trajectory layer* displays a trend for larger rRM in the "passing in front" condition, as generally expectable from the "braking" assumption, which nevertheless cancels out at the lower level of passing extent (1 cm, the same as target's width)

Outcomes of visual inspection were closely supported by statistical analysis. Both *velocity* (F(2; 76) = 21.618, p=0.000) and *passing extent* (F(1.689; 64.194) = 110.36, p=0.000) showed significant main effects and a non-significant interaction term. *Passing surface* also displayed a significant main effect (F(1; 38) = 53.592, p=0.000), with larger rRM for "object" than for "stripe". *Trajectory layer* had no significant main effect, but revealed a highly significant interaction with *passing extent* (F(2; 76) = 10.035, p=0.000) - larger effect of "passing extension" when passing was "in front". A similar interactive pattern was found with *travelled distance* (F(2; 76) = 11.885, p=0.000) - larger effect of "passing behind" for the shortest distance, and of "passing in front" for the other distances. *Response modality* presented a significant main effect (F(1; 38) = 34.523, p=0.001), with greater rRM for "pointer" than for "mouse". No other statistically significant results were found.

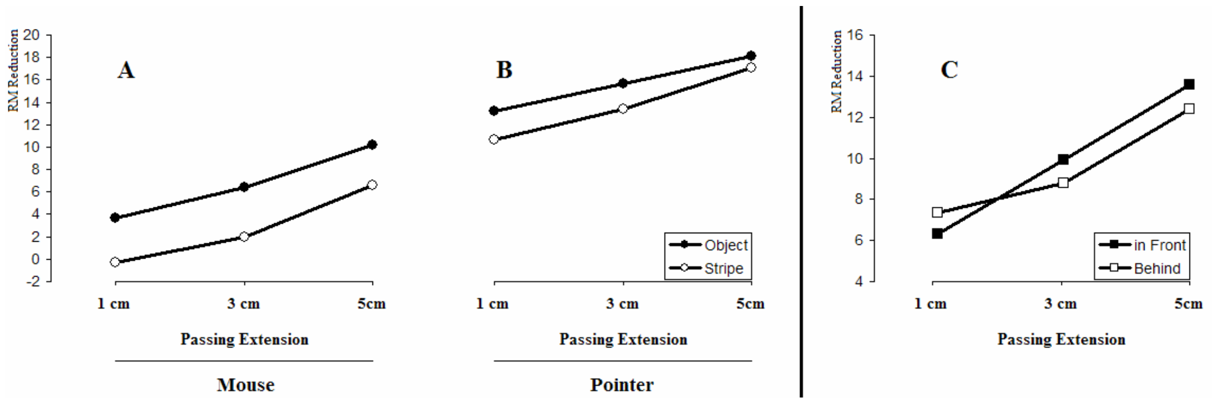

Figure 3 – A & B: Factorial plots of "passing extent" × "passing surface" with mean rRM on the ordinate. C: Factorial diagram featuring the interaction passing surface × trajectory layer.

Discussion

On the whole, findings are consistent with the suggested presence of causal properties in schematic 2-D scenarios depicting "passing" events. The observed effects of "extension of passing" and of "object-character" can be reasonably linked back to the framework of early studies of the "braking effect" by Levelt (1962). The main trend of differences between "passing in front" and "passing behind" also partially argues in that direction, but it remains unclear why an augmented reduction of RM in the "in front" condition ceases to be observed at the shortest passing extension (which exactly matches target's width). While "landmark attraction" and "memory averaging" effects could be generally invoked, given the presence of stationary non-targets in the displays (see Hubbard & Ruppel, 2000), they don't appear capable of providing a coherent explanation to the overall pattern of results.

These causal properties need not be the ones at stake in "proper" causal perception in Michotte's sense, involving "ampliation of movement", but simply those referred by Michotte and collaborators as "phenomenal dependency", of which the *braking effect* studied by Levelt is actually an historical example (just as "action at a distance" is, according to Michotte). The forced-choice procedure employed by Choi & Scholl to depart between causal and non-causal displays, by imposing on subjects to choose among "launching" and "passing", could not but make these causal dependency properties go unnoticed. In light of these arguments and of the collected evidence, Choi & Scholl's results might in fact be showing that, just as phenomenal causal reports, RM-attenuation is capable of gauging causal properties of the two sorts already acknowledged by Michotte. Rather than a confounding of causal and non-causal phenomena, that would eventually offer a valuable feature to address perceptual causality where it has been suggested to lie, at the interface of perception and cognition (Schlottmann, 2000).

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