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Your visual system provides all the information you need to make moral judgments about generic visual events

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ABSTRACT

To what extent are people's moral judgments susceptible to subtle factors of which they are unaware? Here we show that we can change people's moral judgments outside of their awareness by subtly biasing perceived causality. Specifically, we used subtle visual manipulations to create visual illusions of causality in morally relevant scenarios, and this systematically changed people's moral judgments. After demonstrating the basic effect using simple displays involving an ambiguous car collision that ends up injuring a person (E1), we show that the effect is sensitive on the millisecond timescale to manipulations of task-irrelevant factors that are known to affect perceived causality, including the duration (E2a) and asynchrony (E2b) of specific task-irrelevant contextual factors in the display. We then conceptually replicate the effect using a different paradigm (E3a), and also show that we can eliminate the effect by interfering with motion processing (E3b). Finally, we show that the effect generalizes across different kinds of moral judgments (E3c). Combined, these studies show that obligatory, abstract inferences made by the visual system influence moral judgments.

1. Introduction

We have less control of our moral judgments than we might think. Converging evidence shows that priming, highlighting, or framing one factor over another can influence moral judgments (Gu, Zhong, & Page-Gould, 2013; Haidt, Koller, & Dias, 1993; Petrinovich & O'Neill, 1996; Wheatley & Haidt, 2005). Furthermore, scientists have also exploited the dynamics of eye gaze while subjects are making a moral decision to bias subjects toward making one particular moral decision over another (Pärnamets et al., 2015).

Here we hypothesized that, in addition to being susceptible to such *behavioral* manipulations, moral judgments should also be susceptible to quirks of how the *visual system automatically interprets the world*. Specifically, we predicted and found that certain visual illusions, when present within a moral context, will distort the perception of causal relations in those moral contexts, leading people to make different moral judgments than they otherwise would. Furthermore, we used manipulations that had this effect without observers ever being aware that their moral judgments were being changed. This does not mean that moral judgments are not also influenced by non-visual factors (e.g., knowing that a person is a criminal). Yet insofar as our subtle, unrecognized visual manipulations changed moral judgments, this suggests that moral judgments about these visual scenes are based on causal information that is read out from the visual system.

In the introduction that follows, we explain why we have chosen to use visual illusions as well as what is known about visual illusions of causality per se. Next, we discuss how causal perception might be linked to cognitive processing, focusing on moral judgment as a case study.

2. Visual Illusions, and the distinction between perception and cognition

Visual illusions are perceived images or events that differ from objective reality. The best illusions exploit knowledge of how the visual system works in order to make people see features or events that are not an accurate reflection of the world, thereby illustrating the nature of the visual inferences that underlie perception.

By 'visual illusion' we will refer specifically to 'toy' displays that have been deliberately designed to demonstrate that the visual system has made an inference that goes beyond the literal features of the objects or their retinal projections (the experimenters know this, of course, because they created the stimuli). For instance, a perceiver can be tricked into seeing movement in a still image (waterfall illusion; Crane, 1988), or seeing two objects as having different brightness when they are in fact identical (shadow illusion; Adelson, 1999). Yet although these are toy displays, it is likely that the mechanisms uncovered in the illusion also operate on naturalistic stimuli. Indeed, it is likely that

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many visual illusions expose mental algorithms that capitalize on stable relationships in the statistics of the visual input present in our environments (Olshausen & Field, 1996; Purves, Monson, Sundararajan, & Wojtach, 2014; Turk-Browne, Jungé, & Scholl, 2005). It is for this reason that visual illusions are not necessarily problematic biases that fall short of how we would want a perfect observer to see the world (Felin, Koenderink, & Krueger, 2017; Rogers, 2014).

Although most famous visual illusions entail a distortion of literal, low-level features such as edges, color, and orientation, some visual illusions entail higher-level inferences about hidden variables such as identity, animacy, and causality (for a review, see Scholl & Tremoulet, 2000). These phenomena are intriguing because they suggest that the visual system also has something to say about features of the world that are typically considered to be squarely within the domain of higher-level cognition.

Here, methods from visual psychophysics, and visual illusions in particular, can be used to determine whether the given phenomenon is truly perceptual or just cognitive. This is because, unlike purely cognitive phenomena, visual illusions show a number of features that are distinctive of visual processing: (1) they are cognitively impenetrable, meaning that knowing it's an illusion doesn't alter what you see, suggesting that the process that gives rise to the percept is encapsulated from other processes, (2) the phenomena occur very fast, i.e., almost instantaneously upon viewing the displays, (3) they are largely stimulus driven, such that objectively small manipulations to the displays can lead the percepts to disappear, (4) they are categorical, i.e., there is only one specific percept, or only a limited set of qualitatively distinct percepts, e.g., bistable stimuli like the necker cube (Necker, 1832), and (5) implicit manipulations give rise to these illusions, such that observers are often unaware that they are experiencing the illusion or what manipulations gave rise to them. We do not mean to say that observers are *unaware of the stimuli at all*, only that they are unaware of how the arrangement of stimuli influences their perception. Indeed, experiencing visual illusions typically requires the observer to perceive and perhaps even attend to the items.

Thus, if a high-level inference meets these various criteria, then we can generally conclude that it is as much of a visual representation as visual inferences like brightness, color, and depth perception.

2.1. Causal perception

One such high-level visual inference is the perception of causality (Michotte, 1946, 1963). The Belgian experimental psychologist Albert Michotte was the first to notice the following: if one object moves and stops next to a second object, and then that second object moves away within a certain temporal window, people cannot help but see the first object *cause* the second to move, even though this causal information is not present in the stimuli themselves nor in their retinal projections (Michotte, 1946, 1963). He noted that this must be a causal illusion, because the events are objectively described as a sequence of objects at different locations at different times, without any need to refer to whether the interaction between them was causal or non-causal (indeed, one only needs the spatiotemporal coordinates to program such events on a computer).

For a while it was debated whether recognizing causality in Michotte's experiments might instead be computed by higher-level cognition, since observers in these experiments are free to reason about the stimuli or may feel pressure to respond in a particular way, e.g., in order to please the experimenter. Yet later work in visual psychophysics, using more subtle and indirect measures, has marshaled strong evidence that at least a subset of the phenomena originally studied by Michotte is indeed perceptual; here is a brief summary of this evidence:

Illusions of causality emerge as early as six-months, before language emerges (Leslie, 1982; Leslie & Keeble, 1987), and even in non-human primates (Matsuno & Tomonaga, 2017), showing that these effects cannot be due to response bias; causal illusions warp other perceived properties of the stimuli, including their extent of spatial overlap (Scholl & Nakayama, 2004); causal illusions are induced by hallmark perceptual manipulations such as grouping manipulations and events that occur post-dictively within a fixed temporal window (Choi & Scholl, 2004; Choi & Scholl, 2006; Scholl & Nakayama, 2002); they interact with other perceptual processes like apparent motion and the perception of space and time (Buehner & Humphreys, 2010; Cravo, Claessens, & Baldo, 2009; Kim, Feldman, & Singh, 2013); they preferentially break into awareness despite continuous flash suppression (Moors, Wagemans, & de-Wit, 2017); they correlate with activity in brain area V5, which is located high in the visual processing hierarchy (Blakemore et al., 2001); they induce retinotopic adaptation (Rolfs, Dambacher, & Cavanagh, 2013), i.e., if you show a number of causal interactions on a specific location of the retina, then subsequently presented interactions look less causal if you present them at that same location on the retina but not at other retinal locations; and factors that influence judgments of causality have no detectable effect on perceived causality (Schlottmann & Shanks, 1992).

One of the most compelling demonstrations of causal perception — both from methodological and phenomenlogical standpoints — is the 'causal capture' illusion (Scholl & Nakayama, 2002). Observers see displays wherein two objects interact in a non-causal manner, because the first object overlaps completely with the second object, before that second object then moves away. At a sufficiently fast speed, this non-causal interaction begins to look ambiguous; that is, it can be seen in one of three ways: although some observers still see (1) the true *overlap* event, others see (2) a *passing* event, in which the first object moves underneath the second object and continues right passed it (suggesting that somehow it magically morphed into the second object), or (3) a *causal launch*, wherein the first object seems to cause the other to move.

Critically, vision scientists can then employ subtle tricks in order to make such an ambiguous event *consistently look causal*, even though of course it still is not. Specifically, when a causal looking event is shown in the periphery, observers now report seeing a causal interaction in the main overlap event as well — a pure illusion of causality.[1] This illusion can also be elicited by showing just a single object that moves in time with one of the objects in the main overlap event (Choi & Scholl, 2004).

Although a number of mechanisms may be at play in these effects, a general explanation for why they occur may be that the visual system has developed a 'coincidence avoidance' heuristic, whereby stimulating a causal receptor at just the right time may lead the receptor to misattribute irrelevant information to the ambiguous event, making it appear causal even though it wasn't (Scholl & Nakayama, 2002). Although such a heuristic may perhaps seem overly sophisticated for a perceptual system to employ, we note that coincidence avoidance heuristics are embodied in various phenomena that are unequivocally visual, including amodal completion (Kanizsa, 1979; Van Lier & Wagemans, 1999), the tunnel effect (Michotte, Thinès, & Crabbé, 1964), apparent motion (Anstis, 1980; Wertheimer, 1912), illusory conjunctions (Treisman & Schmidt, 1982), auditory-induced bouncing (Sekuler, Sekuler, & Lau, 1997), and others (for a review, see Flombaum, Scholl, & Santos, 2009).

2.2. Linking causal perception to cognitive processing

It is possible that perceived causality is computed only for the purpose of interpreting visual input, and does not influence higher-level cognition. Even within the visual system, this sort of dissociation has been proposed in so-called "blind sight patients." These individuals have damage to their visual stream, leading them to report that they are completely blind, and yet they are able to accurately reach and adjust their grasp to the shape of objects (Weiskrantz, 1986) — all the while

[1] Indeed, these events are typically accompanied by the phenomenon of an "oomph", even though the objects in these displays never actually collide.

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