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Does the “Why” Tell Us the “When”?

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Abstract

Traditional approaches to human causal reasoning assume that the perception of temporal order informs judgments of causal structure. In this article, we present two experiments in which people followed the opposite inferential route: Perceptual judgments of temporal order were instead influenced by causal beliefs. By letting participants freely interact with a software-based “physics world,” we induced stable causal beliefs that subsequently determined participants’ reported temporal order of events, even when this led to a reversal of the objective temporal order. We argue that for short timescales, even when temporal-resolution capabilities suffice, the perception of temporal order is distorted to fit existing causal beliefs.

Keywords

causality, perception, time, temporal order, causal judgment

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Does the ball bounce before touching the ground? Is the shadow cast before the light is switched on? No one would think this; but, if it did happen, would anyone see it? Laypeople and causal theorists alike regularly assume that the order of events is directly and objectively perceived. From at least Hume (1748) onward, most metaphysical and psychological theories of causation maintain that this perceived temporal order functions as one of the principal cues in causal learning and judgment.

Apart from the intuitive plausibility of this thesis, it has received strong experimental support: Children as young as 4 years old consistently choose the temporally prior event as the potent cause (Bullock & Gelman, 1979; Rankin & McCormack, 2012), whereas at the age of 6 to 7 years, temporal-order information suffices to discriminate between common-cause and chain structures (Burns & McCormack, 2009). Adults also find it challenging to infer the causal structure of complex systems from covariation information alone and improve significantly when given temporal cues (White, 2006). Covariational data can, even erroneously, be overridden in favor of temporal-order information, whereas interventions carry implicit temporal cues that partly explain their superiority over pure observations (Lagnado & Sloman, 2004, 2006).

Temporal-order judgments fall into two distinct categories, depending on timescale. For longer durations, the task is achieved by comparing perceptual inputs with memory contents. If you can remember an event, you can be fairly certain that it occurred before the event you currently perceive. At shorter timescales, however, the judgment of temporal order is not as straightforward. This becomes apparent if one considers the ability to perceive motion rather than a succession of still images. Seeing an object in motion requires the simultaneous perception of more than one “frame,” and this observation has led philosophers to posit the *specious-present* doctrine (James, 1890): the idea that the subjective present is not instantaneous but includes an extended period of “objective” time. Thus, if to perceive motion, multiple events must be perceived at once, how does the brain order them?

According to Grush (2007), “what is experienced within [an] interval is not a mere passive reflection of the world’s temporality, but is the result of active interpretation” (p. 2). We present experimental evidence in support of Grush’s thesis and furthermore propose that it is causal beliefs that guide the interpretation of temporal order.

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Several experiments have shown influences of causal beliefs on perception. Scholl and Nakayama (2004) demonstrated spatial illusions resulting from different causal interpretations, whereas Buehner and colleagues (Buehner, 2012; Buehner & Humphreys, 2009) showed that the temporal-binding effect (Haggard, Clark, & Kalogeras, 2002; Stetson, Cui, Montague, & Eagleman, 2006) is attributable to causal beliefs, over and above intentionality or sensorimotor adaptation. When events A and B are considered to be causally related, they appear closer together in time; that is, they become *causally bound* (Buehner, 2012).

In the two experiments reported here, we extended these findings to show that causal beliefs not only influence the perception of temporal distance between events but also can lead to the reordering of these events, so that the perceived temporal order matches the expected causal order.

The Abstract Physics World

We developed a software-based "physics world" consisting of various abstract objects, each with its own properties (Fig. 1; the physics world used in both experiments can be seen at http://www.ucl.ac.uk/lagnado-lab/experiments/christos/causeAndTime/). The objects are stationary at the start of each trial, but some of them can be moved by the participant (a yellow hand appears over movable objects). When the "play" icon is clicked, the objects are activated and display a variety of predefined behaviors. Some objects move in a predefined direction as if affected by gravitational pull, whereas others remain static unless disturbed by another object. Objects can also interact through collisions and repulsions (at a distance), and some of these interactions lead to transformations of the objects themselves (e.g., changes in shape). Participants must learn the rules of the physics world through trial and error. The way the objects behave is governed by a physics engine, which makes the environment rich but predictable.

The main part of the experiment is presented as a puzzle game, in which the goal is to place a red rectangle inside a purple square by transforming it into a star. To achieve this, participants move objects around while the world is paused (Fig. 1b) and then click the "play" button to activate it. If unsuccessful, participants have to reset the stage to its initial configuration (Fig. 1a) and try again; if successful, participants see a congratulations message (Fig. 1c), and they progress to the next stage.

The various stages differ in terms of the objects present, their initial positions, and which objects participants are allowed to move. Crucially, objects retain their properties from stage to stage (e.g., blue circles always repel other objects). This stability allows participants to learn the properties of the objects and the relationships among them. Given that participants lacked any specific prior knowledge, we were able to assess and manipulate people's acquired causal beliefs and study the influence of these beliefs on the perception of temporal order.

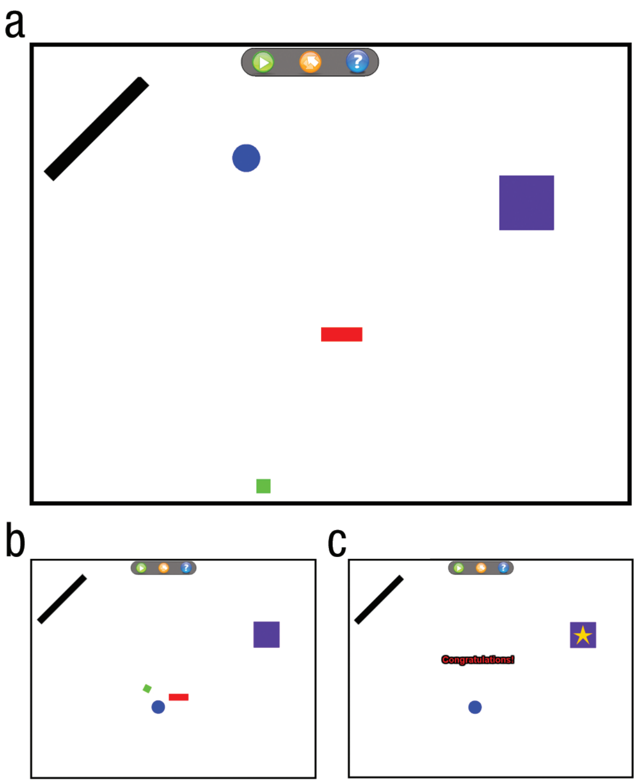

Fig. 1. Sample frames from a stage in the physics world. The objects initially appear in a stationary configuration (a), but when the "play" icon (right-facing triangle inside the green circle) is clicked, the objects are activated: The red rectangle will move left, the blue circle will repel nearby small objects, and the red rectangle will transform into a star when the green square contacts the black platform. The goal is to position the objects such that the red rectangle will transform into a star and enter the purple square. To successfully solve this puzzle (b), participants must move the blue circle and the green square so that when "play" is clicked, the blue circle will repel the red rectangle toward the purple square and the green square toward the black platform. When the green square collides with the black platform, the red rectangle will become a star and thus be "admitted" into the purple box, prompting a "Congratulations!" message (c).

Experiment 1

In the first experiment, we used the physics world in a between-groups design. The experimental group played seven stages of the puzzle game (Fig. 1). The aim was to position the objects in a configuration such that when "play" was clicked, the red rectangle drifted into the purple square. However, the purple square only "admitted" stars, with other objects bouncing off its exterior. To transform the red rectangle into a star, a separate object, the green square, had to collide with the black platform.

The collision between the green square and the black platform effectively acted as a switch, transforming the red rectangle into a star and thus enabling it to enter the purple square. By completing all seven stages, participants gradually learned the two critical causal relations (Fig. 2, top row): First, the green square colliding with the black platform causes the red rectangle to transform into a star, and, second, this transformation causes (or enables) the star to enter the purple box.

The seven stages of the training phase were followed by the test phase, in which participants were asked to watch a video clip. The clip featured the familiar objects in motion, but, crucially, it violated the expected causal order of events: The star entered the purple box before the red rectangle transformed into the star, and this transformation occurred before the green square collided with the black platform (Fig. 2, bottom row).

The control group saw exactly the same clip without receiving any training. After they viewed the clip, participants in both groups were asked the same set of questions regarding the temporal order of events and their causal beliefs. The control group's responses served as a baseline and also verified that the presented temporal order of events was discriminable. Our prediction was that the responses of the control group would tend toward the objective temporal order, whereas those of the experimental group would tend toward the causal order of events.

Method

Participants and materials. The experiment was programmed in Adobe Flex 4.5 and Box2DFlashAS3 (Boris the Brave, 2010) and conducted over the Internet through Amazon Mechanical Turk. Sixty-six participants (42 male, 24 female) aged 18 to 48 years (M = 26.59, SD = 7.5) were recruited. Participants in the experimental group were paid $1, and those in the control group were paid $0.30; the difference in compensation was due to the short time taken to complete the latter condition.

Design and procedure. Each participant was randomly assigned to one of the two conditions, resulting in 35 participants in the control group and 31 in the experimental group. Participants in the control group were simply asked to click the "play" icon and carefully observe the events that took place.

The clip lasted for approximately 2.5 s and was presented only once. As shown in Figure 3, a red rectangle moved horizontally from right to left toward a purple box while a green square moved diagonally toward a black platform adjacent to the purple box. The red rectangle entered the purple box, and approximately[1] 160 ms later (M = 162.76 ms, SD = 8.014), it transformed into a star. Approximately 200 ms (M = 204.47 ms, SD = 8.567) after that, the green square collided with the black platform. Finally, a "Congratulations!" message was shown.

Participants in the experimental group completed seven stages of training before watching exactly the same clip. In each training stage, they had to position the various objects so that when "play" was pressed, the green square had to collide with the black platform in order for the red rectangle to transform into a star and be allowed to enter the purple box. However, to guard against the possible confounding factor of the visual system being habituated to a certain sequence, the transformation of the red rectangle always took place 100 ms before the collision of the green square with the black platform.[2] We return to this important experimental detail in the Discussion section.

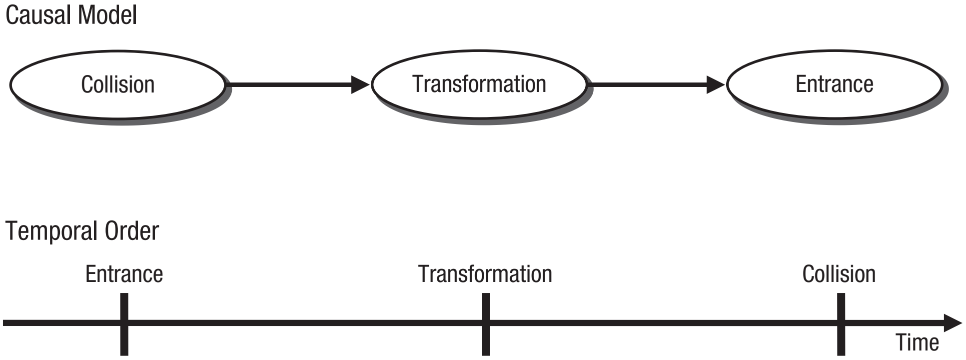

Fig. 2. Design of the training and test phases of Experiment 1. In the causal model underlying the training phase (top row), the green square colliding with the black platform causes the red rectangle to transform into a star, and this transformation causes (or enables) the star to enter the purple box. The temporal order of events during the test phase (bottom row) contradicted the causal model: The entrance of the star into the purple box preceded the red rectangle's transformation into a star, and the green square collided with the black platform at the end of the sequence.

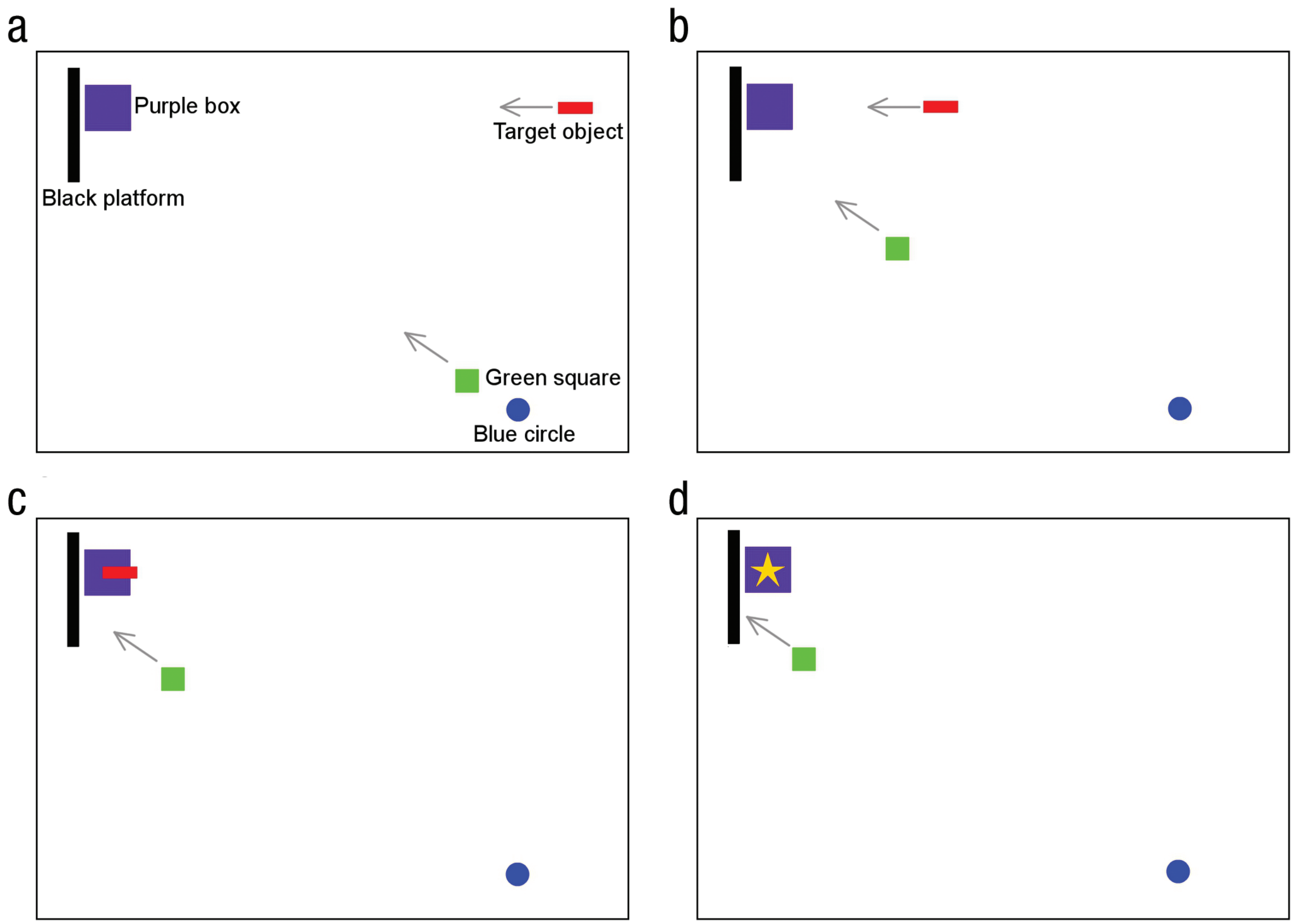

Fig. 3. Sample panels from the test video clip shown to participants in both conditions in Experiment 1. Panel (a) shows the initial configuration of the objects (the labels were only visible after the clip was finished, when participants were asked to recall the temporal order of the events). When the clip began, the red target rectangle and the green square both moved toward the purple box; the midpoint of movement is shown in (b). The target entered the purple box (c) and then transformed into a star 160 ms later (d). The transformation occurred 200 ms before the green square collided with the black platform. The arrows show the direction of movement and were not present during the experiment.

After watching the test clip, both groups were shown the clip's starting configuration with labels next to each object (as shown in Fig. 3a); they were given four prompts and asked to place the prompts in the same temporal order in which the various events had occurred. The prompts in the temporally correct order were as follows: "The target object entered the purple box," "The target object became a star," "The green square collided with the black platform," "A 'Congratulations' message appeared." Next, participants were asked to explain their answer by selecting one or more of the following: "That's what I saw," "That's what makes sense," "That's what I remember from previous rounds" (available only for the experimental group), and "Other." Finally, a question directly assessed participants' causal beliefs by asking what made the red rectangle become a star in the test clip; the response options were as follows: "The green square collided with the black platform," "The target object entered the purple box," and "Other."

Results

There was a significant difference in the selected order of events between the two groups, $\chi^2(7, N = 66) = 23.48$, $p = .001$. Most striking, 38.7% of the participants in the experimental group provided the exact causal order of events, and only 19.3% gave the objective temporal order. For the control group, these percentages were 2.9% and 42.9%, respectively. (The chance level for each separate ordering was 4%.)

Figure 4 shows that 67.7% of the trained participants perceived the green square colliding with the black platform before the red rectangle transformed into a star. So, as predicted, the event that was recognized as the cause

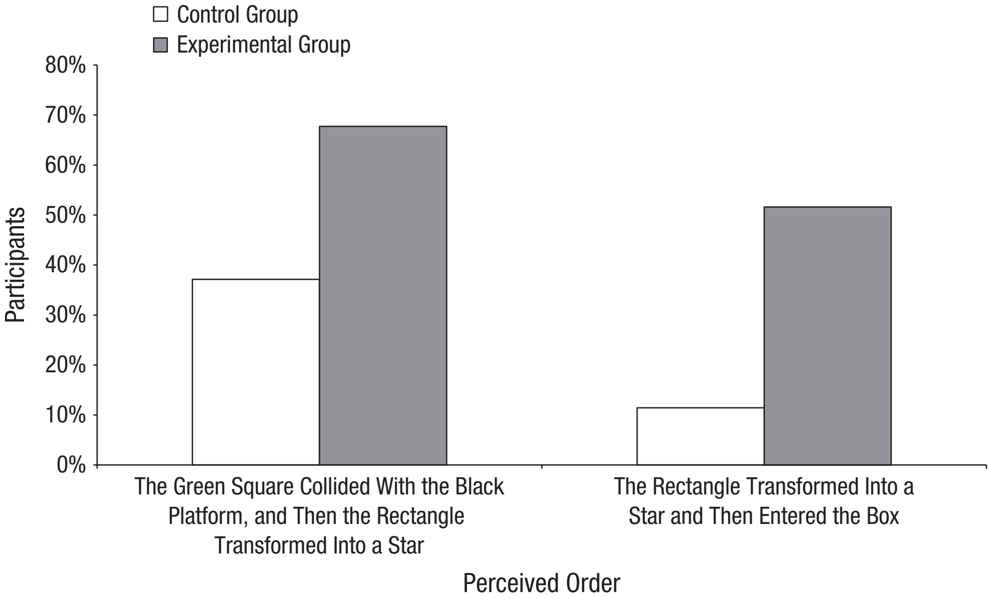

Fig. 4. Results of Experiment 1: percentage of participants in each group who reported the causal as opposed to the objective temporal order for the two critical sets of events.

was seen to temporally precede its associated effect, even though it actually followed it by 200 ms. The percentage of participants from the control group that gave this answer was significantly lower (37.1%), $\chi^2(1, N = 66) = 6.16, p = .016$.

Similarly, 51.6% of participants in the experimental group saw the red rectangle transform into a star prior to entering the purple square, an order that was explicable in terms of the learned causal relationships but was objectively wrong. This contrasts with only 4 participants (11.4%) in the control group who reported this ordering, $\chi^2(1, N = 66) = 12.60, p < .001$.

The causal basis of the explanation for the observed reordering effect is also apparent in that 48.4% of the participants in the experimental group, when asked directly, pointed to the collision of the green square with the black platform as the cause of the transformation of the red rectangle, and that number correlated significantly with those participants who placed the collision prior to the transformation, $r(64) = .470, p < .01$. Finally, there was no difference between the groups when asked to explain their answer: 85.7% from the experimental condition and 80.6% from the control condition responded that the order they provided was the one they saw.

Discussion

Experiment 1 showed that participants had a definite bias toward the causal order of events: The majority of participants in the experimental group (80.6%) perceived at least one of the critical events in the wrong temporal order, congruent with the causal beliefs that were induced during the training rounds.

One potential concern stems from the fact that, by the end of the experiment, the two groups differed not only in their causal beliefs but also in the number of times they experienced the temporal order of events. It might be argued, therefore, that habituation to the repeated temporal order led participants to reorder the events in the test phase. However, as mentioned in the Design and Procedure section, for one of the manipulated relationships (collision of the green square and the black platform → transformation of the red rectangle into a star), the order of events was inverted not only in the test clip but also throughout the training phase. Participants never witnessed the causally potent event (collision) occurring before its presumed effect (transformation). Thus, at least in respect to this relationship, the 67.7% of participants who responded with the causal order of events were not driven by habituation to a repeated temporal order but by causal beliefs that were established through a combination of direct instructions and the strong causal impression generated by the Michotte-like collisions.

One problematic issue with this experiment is that the responses of the control group also showed higher-than-expected levels of reordering (though significantly lower levels than in the experimental group). Nevertheless, it can be argued that although we intended that this group hold no causal beliefs about the sequence of events, this was pragmatically unavoidable. Evidence supporting this suggestion comes from this group's answers to the direct causal question, with 82.8% providing a direct cause, the entrance of the rectangle into the box. Thus, even these untrained participants probably imposed some causal interpretation onto the sequence, which then affected their perception.

Experiment 2

In the second experiment, we replicated and extended the findings of Experiment 1 by more carefully controlling participants' causal beliefs. We used the same environment but introduced two separate training phases, each featuring different causal relations. Training Phase A consisted of seven stages suggesting, as before, that the collision of the green square causes the transformation of the red rectangle into a star. Training Phase B consisted of seven different stages suggesting that the entrance of the red rectangle into the purple square causes the transformation, similar to what participants in the control group of Experiment 1 seemed to infer.

Regardless of condition, all participants completed a training phase and then a test phase with a single clip. In the test clip, the temporal order of events was either congruent or incongruent with the causal relations presented in the training phase. We hypothesized that the perceived order in the test clip would be strongly influenced by the causal beliefs developed in the training phase.

Method

Participants and materials. The experiment was conducted over the Internet, using Amazon Mechanical Turk: 163 participants (68 male, 95 female) aged 18 to 67 years (M = 31.33, SD = 10.6) were paid $0.50 for participating.

Design and procedure. This experiment used a 2 × 2 factorial design, with type of training (A or B) and congruency of test clip (either consistent or inconsistent with training type) as factors. In both types of training, participants completed seven stages. Training Phase A was very similar in design to Experiment 1, as presented in Figure 1. The only exception was that the black platform was removed, and the green square had to collide with the purple square to transform the red rectangle into a star. The stages in Training Phase B were similar, but, as shown in Figure 5, there were two key differences. First, the red rectangle became a star after entering the purple square, thus implying that it is the entrance that causes the transformation (Fig. 5c), and second, the green square was seen as competing with the red rectangle to enter the purple square: If the purple square was already occupied by one of the shapes, the other shape would be rejected and bounce off the purple square's exterior (Fig. 5c). Thus, in Training Phase B, the collision of the green square with the purple square was seen as a side effect, a result of the purple square being occupied by the star.

Following the training session, participants viewed the test clip and were asked to carefully observe the events that took place. The test sequence was presented once and was very similar to the test sequence in Experiment 1, as shown in Figure 3a (except for the absence of the black platform). This time, however, we reordered a single event, the transformation of the rectangle into a star. Figure 6 summarizes the conditions in Experiment 2. In all conditions, the key event is the transformation of the rectangle into a star, which in Training Phase A was the result of the collision of the green square with the purple square and in Training Phase B was the result of the rectangle entering the purple square.

Two points are important to note. The first two conditions received identical training (A), but, in the test clip, for the congruent group, the transformation of the red rectangle into a star occurred immediately after the collision of the green square with the purple box, whereas for the incongruent group, the transformation occurred approximately 165 ms before the collision (M = 166.15

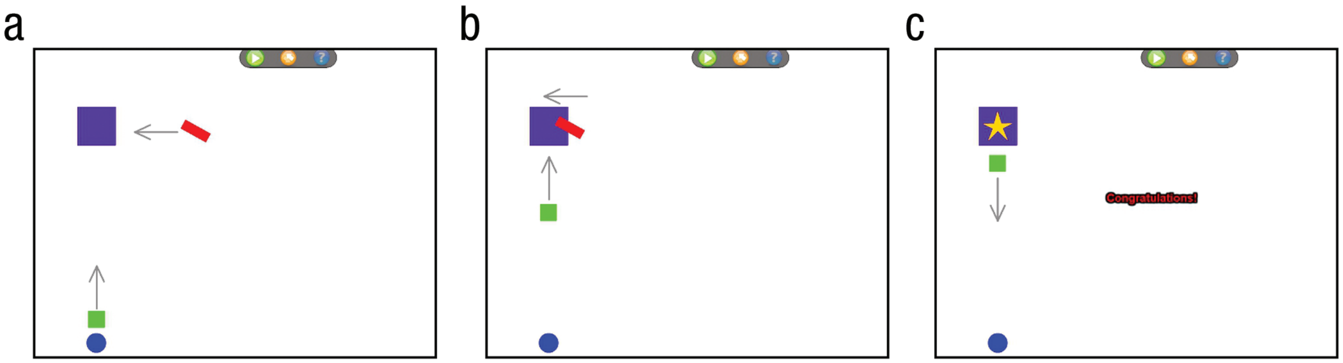

Fig. 5. Sample panels from a stage in Training Phase B of Experiment 2. Panel (a) shows the initial configuration of the objects. The red rectangle entered the purple box without becoming a star (b). The red rectangle became a star and the green square bounced off the purple box's exterior (c). This led participants to believe that the green square was "rejected" because the box was already occupied by the star. The arrows show the direction of movement and were not present during the experiment.

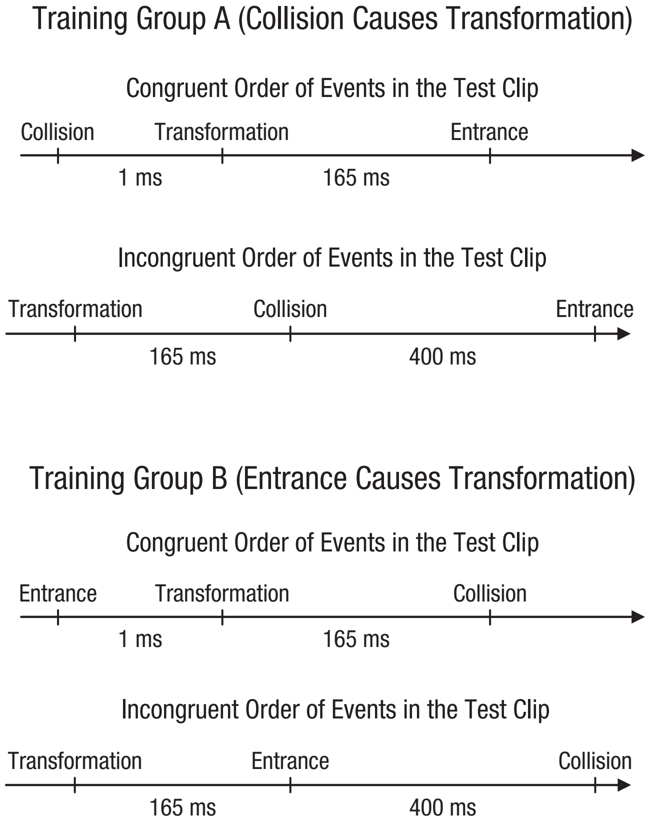

Fig. 6. Timeline of events for the four conditions in Experiment 2. Each participant was placed into one of two training groups (A or B) and shown one of two test clips (either congruent or incongruent with the type of training he or she received). "Collision" refers to the collision of the green square with the purple square, "transformation" refers to the transformation of the red rectangle into a star, and "entrance" refers to the entrance of the rectangle or star into the purple square.

ms, *SD* = 10.05). Similarly, for the congruent group in Training Phase B, the transformation occurred after the red rectangle entered the purple square, whereas for the incongruent group, it occurred 165 ms before the entrance (*M* = 167.32 ms, *SD* = 4.56).

The second way to compare the conditions is to observe that, as shown in Figure 6, the transformation of the red rectangle occurred 165 ms before the collision of the green square in the incongruent condition of Training Phase A and the congruent condition of Training Phase B but only in the former was this order incongruent with the causal beliefs implied during training. The same comparison can be made between the congruent and incongruent conditions of Phases A and B, respectively, in which the transformation happened 165 ms before the entrance, but only the former group received training consistent with this order.

Immediately after watching the test clip, participants were given the same questions as in Experiment 1, namely, to order the events in time, to state whether they saw the ordering or remembered it from previous rounds, and, finally, to state the cause of the transformation of the red rectangle.

Results

In the incongruent conditions, almost none of the participants gave the correct temporal order of events (0% for Training Phase A and 4.9% for Training Phase B). The vast majority of participants in Training Phase A (95.0%) responded with the causal order of events. This percentage was lower for participants in Training Phase B (51.2%), but even then it was much higher than for those preferring the objective temporal order.

These results are even more striking when focusing on the specific events that were reordered in the incongruent conditions. As a reminder, in both the incongruent condition of Training Phase A and the congruent condition of Training Phase B, the transformation of the red rectangle took place 165 ms before the collision of the green square with the purple box. However, as shown in Figure 7a, none of the participants who were trained that a collision transformed the rectangle (Training Phase A) reported this order, compared with 46.3% of the participants whose training was indifferent relative to the order of these events, $\chi^2(1, N = 62) = 24.22, p < .001$. Additionally, the number of participants in the incongruent condition of Training Phase A who placed the collision before the transformation was almost the same as the number of participants in the congruent condition of Training Phase A for whom the collision indeed occurred before the transformation.

There was an even stronger effect of prior training when participants responded whether the transformation of the rectangle into a star occurred before or after the star's entrance into the purple square (Fig. 7b). When the training suggested that the entrance into the square caused the transformation (incongruent condition of Training Phase B), only 7.3% of participants reported the objective order of events in the test sequence, namely, that the entrance happened after the transformation. This percentage rose to 92.7% when the training was congruent with the order of the presentation in the test sequence (congruent condition of Training Phase A) and is comparable to the percentage of participants in the congruent condition of Training Phase B for whom the transformation indeed happened after the entrance. In this case, participants' responses were highly determined by their causal beliefs and, for the incongruent condition of Training Phase B, the objective order was ignored.

As in Experiment 1, participants' reported order was guided by their causal beliefs: Those in Training Phase A responded that it was the collision of the green square that caused the transformation of the red rectangle in the

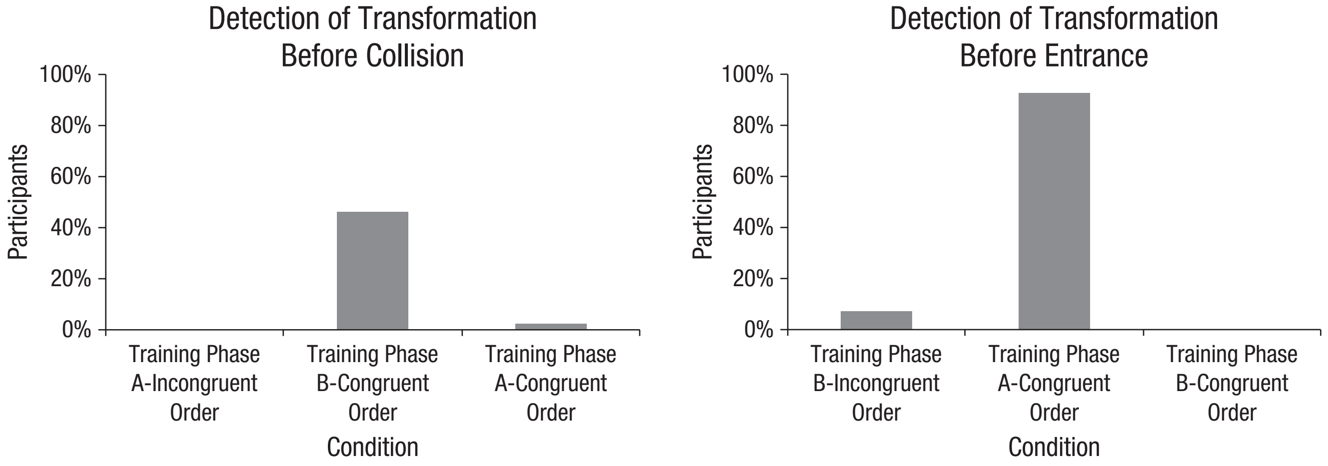

Fig. 7. Percentage of participants in the four conditions in Experiment 2 who detected the transformation of the red rectangle before the collision of the green square with the purple square (a) or before the entrance of the red rectangle into the purple square (b). For the conditions in the first two columns in each graph, the transformation actually happened about 165 ms earlier than the causally potent event, and, for the last column in each graph, it happened later than the causally potent event.

test clip (82.9% for the congruent condition and 97.5% for the incongruent condition), whereas participants in Training Phase B responded that it was the entrance of the red rectangle into the purple square that caused its transformation (92.7% for the congruent condition and 95.1% for the incongruent condition).

Finally, 79.7% of participants across conditions showed confidence in their response by claiming that they saw that specific order of events: 52.8% also said that they remembered the order from previous rounds, 43.6% said that it was the order that made sense, and 3.7% gave other explanations.

Discussion

Experiment 2 replicated and significantly extended the findings from Experiment 1. The majority of participants perceived the key events in the order that matched their causal beliefs irrespective of the temporal order of the presentation.

General Discussion

In two experiments, we demonstrated that the perception of temporal order can be strongly biased toward causally plausible orderings of events. In line with other studies (Buehner, 2012; Fernbach, Linson-Gentry, & Sloman, 2007), our results highlight the role of causal beliefs in perception and show that the temporal content of perception is the result of active interpretation using causal information.

These experiments do not show that perceptual input is ignored altogether. We believe that the features of the presented sequences in some cases assisted and in others hindered the conjectures that participants made. For example, a relatively high proportion of the untrained participants in Experiment 1 (i.e., those in the control group) wrongly perceived the green square colliding with the black platform before the red rectangle transformed into the star. This may have been due to either spontaneously formed causal judgments, as argued earlier, or features such as the color and size of the objects or the direction of movement that attracted participants' attention, thus influencing the perceived order of events (Stelmach & Herdman, 1991).

Despite these possible attentional issues, the temporal-reordering effect persisted under a number of manipulations. We used several different sequences and varied the implied causal relations while keeping constant the spatial proximity of the crucial events (within 2–7 cm of each other) and the long temporal intervals (150–200 ms), which were at least twice the length of detectable intervals in visual order-judgment tasks (Hirsh & Sherrick, 1961; Kanabus, Szelag, Rojek, & Pöppel, 2002). Additionally, we presented identical sequences of events to groups of participants with diverging causal beliefs and observed that those beliefs significantly influenced the reported order of the events.

We hypothesize that, in judging temporal order, perceptual input is integrated with high-level causal knowledge, with the saliency of the perceptual input and the strength of the causal knowledge determining the resulting judgment. People's causal expectations about the way events unfold not only direct their attention prospectively but are also used retrospectively in the interpretation of the temporal order that the perceptual system delivers.

What remains relatively unclear is the precise mechanism that operates during the demonstrated effects. Although, as mentioned in the Discussion section of Experiment 1, habituation alone does not suffice as an explanation, we have not ruled out the possibility that causal beliefs induce temporal-order beliefs that subsequently lead to the reordering of the perceived events. It remains to be seen whether the perceptual distortion is a direct result of causal beliefs or, alternatively, if it is driven by an expectation of temporal order induced by causal beliefs.

At first sight, these findings appear to contradict recent studies that focused on sensorimotor adaptation (Heron, Hanson, & Whitaker, 2009; Stetson et al., 2006). In these experiments, participants adapted to a delay (e.g., 100 ms) between an action (e.g., mouse click) and an effect (e.g., visual flash) and then perceived the effect as preceding the action when the delay was reduced (e.g., to 50 ms). One difference between these studies and our findings is that the test-clip section in our experiments was observation only, without a cross-modal element. Thus, there was no need for participants to synchronize input from different modalities. However, the critical difference is that whereas our experiments were designed to induce strong causal beliefs, in both Heron et al. (2009) and Stetson et al. (2006), the relationship between the action and the effect was left open. Thus, even if participants initially established a loose causal belief during the adaptation phase, the repeated request to temporally order the two events should have increased the uncertainty, which should have sufficed to dissolve any causal assumptions. In contrast, it has been shown (Buehner & McGregor, 2006) that established causal beliefs can change even default expectations, such as the short delay between the cause and the effect (Shanks & Dickinson, 1987). Similarly, the demonstrated distortion of the perceived temporal order was driven by and thus required the presence of stable causal beliefs.

Following from Hume's (1748) original analysis, temporal priority is commonly taken as a critical cue for causal learning and inference (Holyoak & Cheng, 2011; Lagnado & Sloman, 2004, 2006; White, 2006). However, our findings paint a more complex picture of the relation between temporal-order perception and causality. The judgment of temporal order between events, usually regarded as a fundamental percept, was in our experiments actually determined by prior causal beliefs. Temporal-order perception was both a cause and an effect of causal judgment.

Author Contributions

C. Bechlivanidis and D. A. Lagnado developed the study concept. Study design, data collection, and analysis were performed by C. Bechlivanidis. C. Bechlivanidis drafted the manuscript, and D. A. Lagnado provided critical revisions. All authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. Because of the online nature of the experiment, there were slight deviations among participants regarding the temporal distances between the various events, but these were not significant. Events were logged with millisecond accuracy immediately after they occurred. Thus, the logged time corresponded to the event onset time plus the time required for the generation of a time stamp. The time-stamp generation was tested on a variety of computer systems and did not exceed 0.065 ms.

2. To ensure that the red rectangle transformed 100 ms before the green square collided with the black platform, we surrounded the black platform by an invisible object. The collision with that invisible object actually caused the transformation of the rectangle into a star.

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