Temporal and causal order effects in thinking about what might have been

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When people think counterfactually about what might have been different for a sequence of events, they are influenced by the order in which the events occurred. They tend to mentally undo the most recent event in a temporal sequence of two events. But they tend to mentally undo the first event in a causal sequence of four events. We report the results of two experiments that show that the temporal and causal order effects are not dependent on the number of events in the sequence. Our first experiment, with 300 participants, shows that the temporal order effect occurs for sequences with four events as well as for sequences with two events. Our second experiment, with 372 participants, shows that the causal order effect occurs for sequences with two events as well as for sequences with four events. We discuss the results in terms of the mental representations that people construct of temporal and causal sequences.

Thinking about what might have been requires the mental comparison of an actual situation with a simulated alternative (e.g., Kahneman & Miller, 1986; Kahneman & Tversky, 1982). Counterfactual thinking is pervasive in everyday thoughts, perhaps especially following negative outcomes (Roese, 1997). Counterfactual thoughts may play a role in many cognitive processes such as causal judgements (e.g., Roese & Olson, 1995), deductive reasoning (e.g., Johnson-Laird & Byrne, 1991, in press), and creativity (e.g., Hofstadter, 1985), and they may help people to learn and prepare for the future (e.g., Roese, 1994). They may also play a role in emotional processes such as guilt (e.g., Miller & Gunasegaram, 1990) and regret (e.g., Gilovich & Medvec, 1994; Landman, 1987).

When people think counterfactually, they tend to focus on particular sorts of events to mentally undo. For example, they tend to alter actions rather than failures to act (Kahneman &

Tversky, 1986), at least in the short-term (Byrne & McEleney, 2000; Gilovich & Medvec, 1994), exceptions rather than routines (Kahneman & Tversky, 1986), and controllable rather than uncontrollable events (Girotto, Legrenzi, & Rizzo, 1991; McCloy & Byrne, 2000). The focus of their counterfactual thoughts also tends to be influenced by the order in which the information is presented to them. People tend to undo the first event in a causal sequence of events (Wells, Taylor, & Turtle, 1987), but they undo the most recent event in a temporal sequence of events (Miller & Gunasegaram, 1990). Our aim in this paper is to examine these order effects more closely.

Order effects in counterfactual thinking

People tend to undo the most recent event in a temporal sequence of independent events. Miller and Gunasegaram (1990) constructed a scenario in which two individuals identified as Jones and Cooper were offered an attractive proposition: Each individual was asked to toss a coin, and if the two coins came up the same (both heads or both tails), each individual would win £1,000. However, if the two coins did not come up the same, neither individual would win anything. Jones went first and tossed a head; Cooper went next and tossed a tail, and thus the outcome was that neither individual won anything. Their participants judged that the outcome could most readily have been different if Cooper had tossed a head, rather than if Jones had tossed a tail. They also tended to judge that Cooper would experience more guilt, and would be blamed more by Jones.

The temporal order effect occurs in everyday situations such as when students consider an examination that they could have passed (Miller & Gunasegaram, 1990), or a baseball league (Sherman & McConnell, 1996). It depends on the order of events in the world, regardless of the order of events in the description. For example, it arises whether there are strong preconceptions about the normal descriptive order (e.g., heads and tails vs. tails and heads), or not (e.g., red and black cards vs. black and red cards). Moreover, it occurs when the scenario describes the second player's choice first—that is, it occurs not only when participants are told that Jones tossed heads, and after him Cooper tossed tails, but also when they are told that Cooper tossed tails, and before him Jones tossed heads (Byrne, Segura, Culhane, Tasso, & Berrocal, 2000).

The temporal order effect is eliminated when people are given an explicit alternative to the first event (Byrne et al., 2000). Consider a scenario in which the players are on a game-show that experienced a technical hitch: Jones picked a red card, then the technical hitch occurred; after it was resolved, the game was restarted, and this time Jones picked a black card, and Cooper picked a red card (Byrne et al., 2000). Participants' counterfactual thoughts focused as often on Jones's selection as on Cooper's. The result suggests that the temporal order effect may arise because people presuppose the first event. The result rules out the possibility that the temporal order effect arises because people tend to work backwards through the entries on a working-memory stack, encountering the most recent first, as the most recent event in the technical hitch scenario remains the second event. The result also goes against the suggestion that the temporal order effect arises because people calculate the probability of the outcome before and after each event, as the probabilities do not change in the technical hitch scenario (Spellman, 1997).

In contrast, people tend to undo the first event in a causal sequence of events. Wells et al. (1987) constructed a scenario in which a character identified as William attempted to get to a shop across town to take advantage of a sale on a limited number of stereo systems. His progress was impeded by four minor misfortunes: a speeding ticket, a flat tyre, a traffic jam, and a group of senior citizens crossing the street. William arrived at the shop 35 minutes after the sale started only to find that the last stereo system had been sold just a few minutes before. Their participants generated "if only" sentences about how the outcome could have turned out differently, and they tended to mentally undo the first event (regardless of which event occurred in first position).

Prior causes in a sequence of events are considered more important than more immediate causes (Vinokur & Ajzen, 1982), and much of the "burden of proof" in legal arguments falls on the utterer of the first statement (Bailenson & Rips, 1996). The number of events may be important for causal reasoning in general (Kuhn, Amsel, & O'Loughlin, 1988; Pozo, 1987). The first event may be more mutable because people may assume that the removal of the first cause is sufficient to undo subsequent causes and effects (Wells et al., 1987). The presupposed immutability of the first event evident in a temporal sequence may be cancelled in causal sequences (Byrne et al., 2000). The provision of a causal relation between the events in the sequence may provide an explicit alternative to the first event. The causal relation is understood by keeping in mind explicitly not only the factual situation in which the cause occurred and the outcome did too, but also the counterfactual situation in which the cause did not occur (e.g., Johnson-Laird & Byrne, 1991, pp. 71–72). Causes may be mentally represented with a readily available counterfactual alternative, and this availability may undermine the immutability of the otherwise presupposed first event in a sequence (Byrne et al., 2000).

Our aim is to examine more closely both the temporal order effect and the causal order effect. The temporal order effect has been demonstrated for sequences of two events, whereas the causal order effect has been demonstrated for sequences of four events. The number of events or elements in an argument has been shown to have an important influence on the deductive inferences that people make (Braine, Reiser, & Rumain, 1984; Byrne, 1989; Johnson-Laird, Byrne, & Schaeken, 1992), perhaps because working-memory constraints can lead people to try to represent greater amounts of information in more economical ways. It may be the case that the nature of the representations that participants construct of event sequences is such that short sequences allow for the greater mutability of the last event, regardless of whether the sequence is temporal or causal, whereas long sequences allow for the greater mutability of the first event, again whether temporal or causal. Our experiments examine whether the number of events is crucial to these effects.

EXPERIMENT 1
The temporal order effect

Our first experiment examined whether a temporal order effect occurs for sequences of four events as well as for sequences of two events. If the temporal order effect arises because people presuppose the first event and consider it immutable, then the effect should be observed in a four-event sequence just as it is in a two-event sequence. On the other hand, if the temporal order effect arises because of a particular mutability of the second event, then the second event should be undone most often even in a four-event sequence.

Method

Materials and design

We constructed two versions of the typical temporal scenario (based on the card scenario used by Byrne et al., 2000). In one version, (the *two-event* condition) the outcome was preceded by the standard two events—Juan picked a red card and Miguel picked a black card—and the condition to win was that the two must pick the same colour cards. In the second version (the *four-event* condition), the outcome was preceded by four events—for example, Juan picked a red card, Miguel picked a black card, Francisco picked a black card, and Manolo picked a black card—and the condition to win was that three of the four must pick the same colour cards. We examined all possible orders in which the two colours could be presented when the first one was fixed—that is, three different conditions (*red–black–black–red*, *red–black–red–black*, and *red–red–black–black*). An example of the four-event scenario is as follows:

> Imagine four individuals (Juan, Miguel, Francisco, and Manolo) who are offered the following very attractive proposition. Each individual is given a shuffled deck of cards, and each one picks a card from their own deck. If three of the four cards they pick are of the same colour (i.e., three from black suits or three from red suits) each individual wins 200,000 Spanish pesetas. However, if three of the cards are not the same colour, none of the individuals wins anything. Juan goes first and picks a red card from his deck. Miguel goes second and picks a black card. Francisco goes third and picks a black card. And Manolo picks a red card. So, the result is that none of the individuals win anything.

We gave the participants one of the four versions of the scenario, in a between-subjects design. Their task was to imagine how the situation could have turned out differently, and the dependent measure was which of the antecedent events was altered in their imagined alternative. Participants may mention the event by itself, "if only Juan had picked black", or they may mention it in conjunction with other events, "if only Juan had picked black or Manolo had picked red". It is important to consider both sorts of response, as order of mention provides valuable additional information (see Byrne et al., 2000, for discussion of this point).

Participants and procedure

The participants were 300 undergraduates from different departments at the University of Malaga who took part in the experiment voluntarily. None of them had participated in a similar study, the task was carried out during their regular class time, and they were tested in several groups. They were assigned at random to the two-event condition ($n = 79$) or to one of the three versions of the four-event conditions: the red–black–black–red condition ($n = 85$), the red–black–red–black ($n = 68$), and the red–red–black–black condition ($n = 68$). Participants were given a booklet with the instructions and the story, they wrote their answers in the booklet, and they were verbally debriefed afterwards.

Results and discussion

The results showed a temporal order effect for the two-event sequence and for the four-event sequences. The data were analysed by the hypothesis test for two proportions. For the two-event sequence, participants' counterfactual thoughts focused on the last (second) event (63%) more than the first (25%, $n = 79$, $z = 3.94$, $p < .01$), as Table 1 shows. For each of the three versions of the four-event sequence, participants focused on the last (fourth) event more than the first. This pattern was observed for the red–black–black–red condition (39%

TABLE 1
The percentage of counterfactual thoughts about each of the events for the temporal
scenarios of two and four events in Experiment 1

	Two events	Four events		
		Red black black red	Red black red black	Red red black black
n	79	85	68	68
First event only	19	20	9	5
First then other	6	3	3	1
First overall	25	23	12	6
Second event only	51	13	31	5
Second then other	12	2	5	0
Second overall	63	15	36	5
Third event only	–	3	11	41
Third then other	–	0	1	3
Third overall	–	3	12	44
Fourth event only	–	33	33	25
Fourth then other	–	6	0	1
Fourth overall	–	39	33	26
Total	88	80	93	81
Non-specific	3	13	3	13
Errors	9	7	4	6

Note: The remaining responses were non-specific, e.g., "if only one of them had picked a different card", or undid all players, e.g., "if only they both picked red", or were simple errors, e.g., "if only Juan picked red", when Juan did in fact pick red.

vs. 23%, $n = 85$, $z = 1.92$, $p < .01$), the *red–black–red–black* condition (33% vs. 12%, $n = 68$, $z = 2.72$, $p < .01$), and the *red–red–black–black* condition (26% vs. 6%, $n = 68$, $z = 3.12$, $p < .01$).[1] For each of the four conditions, the total classifiable responses were: 88%, 80%, 93%, and 81%, respectively (see Table 1), and so the percentage of responses that could fall into each category by chance were: 44% (for the two-cell condition), and 20%, 23%, and 20% (for the four-cell conditions, respectively). The observed responses for undoing the last event are all greater than these (63%, 39%, 33%, and 26%, respectively).

A clear focus for participants's counterfactual thoughts is the last event in the three 4–event temporal sequences (39%, 33%, and 26%, respectively, 33% overall). But in only one of the sequences is the last event the *most* focused on: In the other two sequences the last event is not the most focused on (even though it is more focused on than the first event). The pattern for

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[1] The same pattern is found if we analyse the "single-event only" responses (omitting the "one and then other" responses): For the two-event sequence, participants' counterfactual thoughts focused on the last (second) event (51%) more than the first (19%, $n = 79$, $z = 3.67$, $p < .01$). Participants focused on the last (fourth) event more than the first for the *red–black–black–red* condition (33% vs. 20%, $n = 85$, $z = 1.67$, $p < .05$), the red–black–red–black condition (33% vs. 9%, $n = 68$, $z = 3.28$, $p < .01$) and the red–red–black–black condition (25% vs. 5%, $n = 68$, $z = 3.23$, $p < .01$).

the red–black–black–red sequence is clear-cut: Participants focused on the last event more than they focused on the first event, as we have seen, and also more than they focused on either the second event (15%, $n = 85$, $z = 3.19$, $p < .01$) or the third one (3%, $n = 85$, $z = 6.16$, $p < .01$). But for the other two sequences the last event is not the *most* focused-on event of all four events. For the red–black–red–black condition, they focused more on the last event (33%) than on the first one, as we have seen, and also more than on the third event (12%, $n = 68$, $z = 0.27$, $p = .02$), but they focused *equally* on the last event and the second event (33 and 36%, $n = 68$, $z = –0.30$, $p = .38$). Likewise, for the red–red–black–black condition participants focused more on the last event (26%) than on the first event as we have seen, and also more than the second event (5%, $n = 68$, $z = 3.36$, $p < .01$), but they focused *most* on the third event, even more than on the last one (44% vs. 26%, $n = 68$, $z = –1.82$, $p = .04$).

What are people doing when they are not focusing most on the last event? One possible explanation is that people attempt to change the first events (any of the first three), and so they pick the odd one out to make it conform to the majority. Participants' next most frequent tendency (34% overall) is to focus on the odd one out of the first three events: the first event in the red–black–black sequence (23%), the second in the red–black–red sequence (36%), and the third in the red–red–black sequence (44%). An alternative explanation is that people try to make the remaining players conform to the first player's selection. The first player picks red in all three sequences, and participants tend to mentally undo those players who selected a black card and wish they had selected red, as the first player did. For the red–black–red–black condition, they mentally undid either the second or last players who selected a black card and wished they were red. Likewise, for the red–red–black–black sequence they mentally undid either the third or last players who selected a black card and wished they were red. This tendency may be particularly emphasized in sequences where participants notice a pattern—for example, a "run" of red selections, such as the red–red–black–black sequence, or the red–black–black–red sequence (where the predominant focus is on the last event).

Whichever explanation is correct, the results are consistent with the suggestion that the last event in a temporal sequence is not especially mutable—rather, it is the first event that is especially *immutable*. People may try to match subsequent events against it (Walsh & Byrne, 2001). Most importantly, with regard to the comparison of these new four-event sequences and the typical two-event sequence, participants focused *more* on the last event than on the first event.

Overall, the experiment provides some support for the suggestion that the temporal order effect occurs for sequences that consist of four events as well as sequences that consist of two events. People exhibit a tendency to mentally undo the most recent event in a temporal sequence, regardless of the number of events in the sequence. There is no general tendency to mentally undo the second event in the four-event sequences, ruling out the suggestion that there is a particular mutability of the second event. Instead, the results support the idea that the first event may be considered particularly immutable in temporal sequences.

EXPERIMENT 2
Causal order effect

Our second experiment examined whether a causal order effect occurs for sequences of two events as well as for sequences of four events. We have suggested that the causal order effect may arise because the causal relations between events cancel the presupposition that the first

event is immutable by providing an explicit alternative to it. If so, the effect should be observed in a two-event sequence just as it is in a four-event sequence.

Method

Materials and design

We constructed two versions of the typical causal scenario (based on the stereo store scenario used by Wells et al., 1987). The four-event version was based closely on the original scenario, and the two-event version contained just two of the four antecedents. The antecedents were counterbalanced in both cases, and in the two-event condition, each of the four antecedents were rotated through the two events of the scenario so that different participants were given different subsets of the four events, which were again counterbalanced. We gave the participants one of the two versions of the scenario, in a between-subjects design. Their task was to imagine how the situation could have turned out differently, and the dependent measure was which of the antecedent events was altered in their imagined alternative. Once again, participants may mention the event by itself —for example, "if only William hadn't got a speeding ticket"— or they may mention it first, in conjunction with other events—for example, "if only William hadn't got a speeding ticket or a flat tyre". Order of mention provides a valuable insight into the primacy of counterfactual thoughts (Byrne et al., 2000), and to discard these data would unjustifiably limit the informativeness of responses.

Participants and procedure

The participants were 372 undergraduates from different departments at the University of Malaga who took part in the experiment voluntarily. None of them had participated in a similar study, the task was carried out during their regular class time, and they were tested in several groups. They were assigned at random to the two-event condition ($n = 180$) or to the four-event condition ($n = 192$). Participants were given a booklet with the instructions and the story, they wrote their answers in the booklet, and they were verbally debriefed afterwards.

Results and discussion

The results showed a causal order effect for the two-event sequence and for the four-event sequence. For the two-event condition, participants' counterfactual thoughts focused on the first event (48%) more than the last (second) event (35%, $n = 180$, $z = 1.93$, $p < .01$), as Table 2 shows. Likewise, for the four-event condition, participants' 2 counterfactual thoughts focused on the first event (34%) more than the last (fourth) event (21%, $n = 192$, $z = 2.47$, $p < .01$). They also focused more on the first event than the second event (14%, $n = 192$, $z = 4.18$, $p < .01$) or the third event (18%, $n = 192$, $z = 3.15$, $p < .01$).[2] For the two conditions, the total classifiable responses were 83% and 87% (see Table 2), and so the percentage of responses that could fall into each category by chance were: 41.5% (for the two-cell condition) and 22% (for

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[2] A different pattern is found if we analyse the "single-event only" responses. For the two-event condition, participants' counterfactual thoughts focused equally on the first event (25%) and the last (second) event (30%, $n = 180$, $z = 0.90$, $p < .05$). Likewise, for the four-event condition, participants' counterfactual thoughts focused equally on the first event (17%) and the last (fourth) event (19%, $n = 192$, $z = 0.46$, $p < .05$). It is not unusual for the pattern for "single-event only" responses to be equivocal in this manner, and it highlights the importance of taking into consideration also the "first event and then other events" responses to detect subtle differences.

TABLE 2
The percentages of counterfactual thoughts
about each of the events for the causal scenarios
for two and four events in Experiment 2

	Two events	Four events
n	*180*	*192*
First event only	25	17
First then other	23	17
First overall	*48*	*34*
Second event only	30	11
Second then other	5	3
Second overall	*35*	*14*
Third event only	–	15
Third then other	–	3
Third overall	*–*	*18*
Fourth event only	–	19
Fourth then other	–	2
Fourth overall	*–*	*21*
Total	*83*	*87*
Non-specific	1	1
Outcome	16	12

Note: The remaining responses were non-specific, e.g., "if only all those delays hadn't occurred", or focused on the outcome, "if only he hadn't been late".

the four-cell condition). The observed responses for undoing the first event are greater than these (48% and 34%).

Overall, the experiment shows that the causal order effect occurs for sequences that consist of four events as well as sequences that consist of two events. People mentally undo the first event in a causal sequence, regardless of the number of events in the sequence. The result is consistent with our suggestion that the causal order effect may arise because the causal relations between events cancel the presupposition that the first event is immutable by providing an explicit alternative to it.

We can compare, at least informally, the results from the two experiments. The difference between the focus on the first and last events for the temporal two-events scenario (25% vs. 62%) is very large (37%). In contrast, the difference between the first and last events for the causal two-events scenario (48% vs. 35%), although reliable, is smaller (13%). The difference between the first and last events for the temporal four-events scenarios, averaged over the three scenarios (14% vs. 33%) is large (19%); it is of a similar size to the difference (13%) between the first and last events for the causal four events scenario (34% vs. 21%).

GENERAL DISCUSSION

The two experiments show that the temporal order effect and the causal order effect occur regardless of the number of events in the sequence, whether it is two or four events. People mentally undo the first event in a causal sequence and the last event in a temporal sequence. Of course, the causal and temporal scenarios also differ on a number of other dimensions. For example, in the causal scenario, a single individual is involved in the two (or four) events, whereas in the temporal scenario, two (or four) individuals are involved in the two (or four) events. However, the number of individuals does not seem to be crucial, as the results from a final experiment show.

In the experiment, we gave 79 students from the Department of Psychology of the University of Malaga a temporal scenario based on a single individual, as follows:

> Imagine that Juan is offered the following very attractive proposition. He is given two shuffled decks of cards, and he must pick a card from each deck. If the two cards he picks are of the same colour (i.e., both from black suits or both from red suits) he wins 200,000 pesetas. However, if the cards are not the same colour, he does not win anything. Juan picks a red card from the first deck. He picks a black card from the second deck. So, the result is that he does not win anything.

When participants were asked to imagine how the situation might have turned out differently, they tended to mentally undo the second event rather than the first (61% vs. 21%). Hence, the temporal order effect occurs even when a single individual is involved in the two events.

We have suggested that people generate counterfactuals by making alterations to their mental models of the factual situation (Byrne, 1997; Byrne & Tasso, 1999). For example, we proposed that people construct the following sort of representation of the coin-toss scenario:

jones–heads   cooper–tails

where "jones–heads" signifies that Jones tossed a head, and "cooper–tails" signifies that Cooper tossed a tail (Byrne et al., 2000). When they must think of ways in which the outcome could have been different they may flesh out the counterfactual possibilities to be fully explicit:

factual:	jones–heads	cooper–tails	*lose*
counterfactual:	jones–heads	cooper–heads	*win*
	jones–tails	cooper–tails	*win*
	jones–tails	cooper–heads	*lose*

Different possibilities are represented on different lines, and the models are tagged to keep track of their epistemic status (Johnson–Laird & Byrne, 1991). The temporal order effect indicates that people flesh-out their counterfactual models for just one of the options:

factual:	jones–heads	cooper–tails	*lose*
counterfactual:	jones–heads	cooper–heads	*win*

The earlier event is presupposed because it *contextualizes* the model, providing a cornerstone or anchor for the model's foundation. The first event is not as readily available for change in the counterfactual models because of its crucial role in integrating subsequent information into the models (Byrne et al., 2000; Segura, Fernandez-Berrocal, & Byrne, 1998).

However, the immutability of the first event can be cancelled. One way to cancel its immutability is to provide an explicit counterfactual alternative, as happens in the technical hitch scenario described earlier (Byrne et al., 2000). A second way to cancel its immutability is to describe the conditions by which the players can win in such a way that their mental representation makes only some information explicit (Walsh & Byrne, 2001). A third way to cancel its immutability is to provide a causal relation between the events in the sequence (Byrne et al., 2000). The causal relation is understood by keeping in mind explicitly the factual situation in which the cause occurred and the outcome did too, and the counterfactual situation in which the cause did not occur (Johnson-Laird & Byrne, 1991). Because causes are mentally represented with a readily available counterfactual alternative, the immutability of the otherwise presupposed first event in a sequence is cancelled. In previous experiments the cancellation of the immutability of the first event by the provision of a counterfactual alternative has led to an elimination of the temporal order effect, so that participants focused equally on the first and last events (Byrne et al., 2000), and to its reversal (Walsh & Byrne, 2001). In these experiments, the cancellation by causal content has led to a small but reliable reversal, so that participants focused significantly more often on the first event. The causal order effect is smaller in the two-event sequences than is the temporal order effect, perhaps because the causal order effect must override the temporal order effect in these short sequences.

The temporal order effect has been demonstrated previously for two-event sequences, and the causal order effect has been demonstrated previously for four-event sequences. Our results provide the first demonstration that the causal order effect is observed in sequences with two events as well as four events, and the temporal order effect is observed in sequences with four events as well as two events. Our experiments rule out the possibility that the different number of events in the sequences is the determinant of the two different effects.

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