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# Perceived Momentum Influences Responsibility Judgments

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## Abstract

This work examines the extent to which people hold independent sequential events (e.g., players making correct/incorrect guesses) responsible for overall outcomes (e.g., the team winning/losing the game). Two types of events are found to garner the majority of responsibility for overall outcomes: (1) final events and (2) events that are perceived to disrupt momentum (e.g., an incorrect guess after a sequence of correct guesses). While previous research has shown that final events tend to be perceived as more responsible for overall outcomes, the current experiments are the first to document the role of perceived momentum on responsibility judgments. Specifically, we demonstrate that the effect is mediated by perceived momentum changes after the time of the event and moderated when exogenous factors (e.g., a delay between events) disrupt perceived momentum. We discuss how these findings relate to *pivotality*, the *counterfactual simulation model*, and the role of *unexpectedness* in responsibility judgments.

**Keywords:** perceived momentum; responsibility judgments; perceived causality

## Introduction

Many *outcomes* are the result of a collection of sequential *events*: Sports championships are determined by the results of games played during the regular and playoff seasons, the success or failure of parlay bets depends on the results of multiple independent events (games, races, or the like), final grades are a function of the student's performance on multiple assignments and exams, and the winners of games such as chess are determined by the set of moves each player has made during the match.

We examine how people assign responsibility for a given outcome to the events (which occurred sequentially) that resulted in that outcome. Of particular interest is how people assign responsibility to *aligned events*. Aligned events are those events whose valence corresponds with that of the outcome. For instance, imagine a group of people playing a guessing game in which each player must guess which of two options is the "correct" option. The players make their guesses in secret and sequentially (one

after the other). If a certain percentage of the group guesses correctly (incorrectly) then the group will win (lose) the game. Consequently, if the game outcome is a win (loss), the aligned events would be the correct (incorrect) guesses. Taking the loss outcome as an example, our research is interested in the amount of responsibility for the group's loss that is assigned to each incorrect guess (or, equally, to each player who gave an incorrect guess).

Responsibility judgments are at least partially derived from causal inferences (Chockler & Halpern, 2004): It is unlikely that one will be held responsible for an outcome if one's actions did not make some difference to that outcome (Gerstenberg, Halpern, & Tenenbaum, 2015). Further, the closer a given individual's actions are to being *pivotal* to the outcome, the more responsible the individual will be held for the outcome (Bartling, Fischbacher, & Schudy, 2015; Chockler & Halpern, 2004; Lagnado, Gerstenberg, & Zultan 2013). However, both causal and responsibility judgments are highly nuanced, drawing on many inputs, as exemplified by the *counterfactual simulation model* (CSM; Gerstenberg, Goodman, Lagnado, & Tenenbaum, 2015).

Using the current context of events and outcomes, the CSM distinguishes between four different counterfactual contrasts. *Whether-causation* refers to the perceived probability that the outcome would have been different had a specific event been altered or removed. In contrast, *how-causation* pertains to the perceived probability that the outcome would have occurred in exactly the same manner—not whether it would have occurred or not—had a specific event been altered or removed. *Sufficiency* is the perceived probability that the same outcome would have been reached if all candidate causes other than the target event were removed. Finally, *robustness* is the perceived probability that a causal relationship between a specific event and the outcome would remain unchanged were the circumstances (i.e., the nature of the alternative candidate causes) altered in some small way.

The current research examines contexts like the guessing game described above in which the outcome would change if any one of the aligned events had a different result.

Consequently, the aligned events are all equally pivotal to the outcome and are all whether-causes. Moreover, all of the aligned events are necessarily how-causes as each influences the manner by which the outcome is reached. Lastly, none of the aligned events is a sufficient or robust cause of the outcome as changing any other aligned event would change the outcome.

Importantly, the equivalence of the aligned events in terms of pivotality and the CSM's counterfactual contrasts does not depend on the timing of the events in the sequence leading to the outcome. More concretely, a given event's pivotality, whether-causation, how-causation, sufficiency, and robustness will be the same whether that event was the first or last event in the sequence. Yet, as is argued and demonstrated below, responsibility judgments are impacted by the sequence in which events occur.

### The Sequence of Events

Taking the loss outcome in the guessing game described above as an example once more, we contrast two specific sequences of events for a game in which the team is allowed no more than three incorrect guesses. The aligned events (guesses) for this example are bolded in each sequence ("I" = incorrect, "C" = correct).

1. **All-Late:** C<sub>1</sub>-C<sub>2</sub>-C<sub>3</sub>-C<sub>4</sub>-C<sub>5</sub>-C<sub>6</sub>-**I<sub>1</sub>**-**I<sub>2</sub>**-**I<sub>3</sub>**-**I<sub>4</sub>**
2. **One-Late:** **I<sub>1</sub>**-**I<sub>2</sub>**-**I<sub>3</sub>**-C<sub>1</sub>-C<sub>2</sub>-C<sub>3</sub>-C<sub>4</sub>-C<sub>5</sub>-C<sub>6</sub>-**I<sub>4</sub>**

There are three things to note about the above sequences. First, four events (incorrect guesses) align with the overall outcome of the game (loss) in both sequences: Had there only been three incorrect guesses, the team would have won in either case. Second, the players made their guesses in secrecy and, therefore, could not know the other players' guesses or how the group was performing until the conclusion of the game (i.e., the guesses were explicitly independent). Third, since the players' guesses were collected sequentially, the outcome (loss) was not determined until the tenth player made his guess.

Given this context, prior research would suggest that the final aligned event (I<sub>4</sub>) will tend to be judged more responsible for the outcome of the game (Miller & Gunasegaram, 1990) in both sequences. Yet, no research to date would predict that responsibility judgments for the aligned events will differ between the all-late and one-late sequences. In fact, since changing the result of any aligned event would change the game's outcome, models of responsibility judgments relying on pure pivotality (Chockler & Halpern, 2004), counterfactual pivotality (Zultan, Gerstenberg, & Lagnado, 2012), or the CSM would predict no differences in responsibility judgments across the two sequences of events. However, we contend that differences in the timing of the aligned events between the two sequences can meaningfully impact causal responsibility judgments via perceptions of momentum.

### Perceived Momentum

Although rooted in physics, the concept of *momentum* also holds a place in social cognition and refers to the tendency of, or expectation for, a person or group to repeat recent success or failure. In other words, repeated success (or failure) is expected to beget a higher likelihood of subsequent success (failure).

When sequential events are not independent (e.g., the same sports team playing repeated games) perceptions of momentum may be grounded in rational reasoning. Indeed, in such contexts, it is reasonable to predict that earlier success will increase the likelihood of subsequent success via the boosted confidence or increased learning and ability of the individual or group. Empirical support for actual momentum in such contexts is still a matter of debate (Gilovich, Vallone, and Tversky, 1985; Green and Zweibel, 2013; Miller and Sanjurjo, 2015), but perceptions of momentum persist nonetheless.

We contend that people overgeneralize their beliefs and perceptions of momentum from contexts where it could reasonably exist (i.e., when events are not independent) to contexts where it cannot (i.e., when events are objectively and explicitly independent). We return to our guessing game example in which players make guesses sequentially and in secret. A series of repeated correct guesses in this game may be the result of many factors (e.g., obvious answers or talented players), but it cannot be the result of the players or the team gaining momentum via confidence or increasing ability since each player's guess is objectively independent of those of the other players. Yet, this series of repeated correct guesses can easily be mapped onto contexts in which people normally (and, perhaps, normatively) perceive momentum. Hence, observing repeated successes (or failures) may result in perceptions that the team of players, despite making objectively independent guesses, does have momentum.

Perceiving momentum, even when events are objectively independent, would in turn lead to the inference that succeeding events are more likely to stay the course (e.g., success following repeated successes) than to deviate from it (e.g., failure following repeated successes). Thus, deviations from the direction of perceived momentum should be considered more unexpected. Since aligned events that are more unexpected tend to be held more responsible for outcomes (Gerstenberg, Halpern, & Tenenbaum, 2015), aligned events that deviate from perceived momentum should be considered more responsible for the outcome.

This reasoning suggests that the degree of responsibility assigned to aligned events may differ between the *all-late* and *one-late* sequences described above. Previous research suggests that the last aligned event (I<sub>4</sub>) is disproportionately likely to be assigned blame in both conditions. However, if people's responsibility judgments are influenced by the perception of momentum, and consequent relative unexpectedness of the aligned events, the tendency to assign blame to the last event should be

stronger in the one-late sequence than in the all-late sequence. In the one-late sequence, the result of the final event terminates a series of six favorable results that preceded it. Conversely, perceived momentum should lead to a higher likelihood of assigning responsibility to the first aligned event ( $I_1$ ) in the all-late sequence (in which its result deviates from the results of the previous six events) than in the one-late sequence (in which it is not preceded by any events). The interim aligned events ( $I_2$  and  $I_3$ ) should be relatively uninfluenced by the sequence as they are always preceded by at least one other aligned event.

## Summary

We examined whether people perceive momentum in a series of events where the results were sequential and objectively independent. We predicted an event aligned with the overall outcome (e.g., an incorrect guess in a game whose outcome was a loss) would be assigned greater responsibility if that aligned event directly followed a series of unaligned events (e.g., an incorrect guess after a series of repeated correct guesses).

The experiments that follow support this prediction. Experiments 1 and 2 show that aligned events were assigned significantly greater responsibility when directly preceded by a series of unaligned events. Experiment 3 finds that judgments of perceived momentum mediate this effect. Experiment 4 finds the effect can be moderated by disrupting perceived momentum. Finally, Experiment 5 finds that the expectation of success for a given event is higher, all else being equal, when that event is preceded by successes versus failures.

## Experiments

Experiments 1 and 2 tested the proposition that

- (1) the tendency to hold the *final aligned event* responsible for the overall outcome would be higher in the one-late (vs. all-late) sequence (both described above) and
- (2) the opposite would hold for the *first aligned event*.

### Experiment 1: The Influence of Event Sequence on Responsibility Judgments (Losses)

**Method.** One hundred eighty-eight paid Amazon Mechanical Turk (AMT) participants were told of a hypothetical team of 10 players playing a guessing game in which each player guessed which of two colors a computer had randomly chosen before the game began. The players were indicated to have made their guesses sequentially and in secret, such that no player knew what previous players had guessed or how the team was doing at the time they made their guess. If the team had three or fewer incorrect guesses it would win. Otherwise, it would lose. All participants were told that four players had made incorrect guesses and that the team had lost the game.

Participants were randomly assigned to either the one-

late or all-late sequence described above. To reiterate, (1) the first three guesses and the final guess were incorrect (i.e., were aligned with the outcome) in the one-late sequence, while (2) the final four guesses were incorrect (aligned with the outcome) in the all-late sequence.

Participants were shown the complete set of results (correct/incorrect guesses) in a table ostensibly organized in the order in which players had made their guesses. They were then asked which of the four players who had guessed incorrectly was the most to blame (i.e., was most responsible) for the team's loss. Participants could indicate that either all four players were equally to blame or that no player was to blame if they desired. (In all experiments, the percent of participants indicating equal/no blame did not significantly differ between the one-late and all-late sequences. Thus, although these equal/no-blame responses are retained and included in the data analyzed in each experiment, they are not discussed further.)

**Results.** As expected, the percentage of participants indicating that the player making the final incorrect guess (i.e., the final aligned event) was the most to blame for the team's outcome was significantly lower in the all-late (44%) versus the one-late (66%) sequence ( $\chi^2(1) = 7.97, p < .005$ ). Conversely, a larger proportion of participants felt the player making the first incorrect guess (i.e., the first aligned event) was the most to blame in the all-late (25%) versus the one-late (1%) sequence ( $\chi^2(1) = 26.10, p < .001$ ). These results are consistent with our contention that people (1) perceive momentum in contexts where sequential events are objectively independent and (2) use this perceived momentum in forming responsibility judgments for the overall outcome.

### Experiment 2: The Influence of Event Sequence on Responsibility Judgments (Wins)

**Method.** One hundred ninety-nine paid AMT participants participated in Experiment 2, which was identical to Experiment 1 except the following: (1) the team needed at least four correct answers to win, (2) the team's outcome was a win, and (3) the correct and incorrect responses were switched in the two sequences (e.g., the all-late sequence featured six incorrect guesses before concluding with four correct guesses). Thus, the aligned events in Experiment 2 were the four players that had guessed correctly. After viewing the results table, participants were asked which of the four players that had guessed correctly deserved the most credit (i.e., was most responsible) for the team's win.

**Results.** Replicating Experiment 1 in the domain of wins, the percentage of participants indicating that the player making the final correct guess (i.e., the final aligned event) deserved the most credit for the team's outcome was significantly lower in the all-late (68%) versus the one-late (84%) sequence ( $\chi^2(1) = 6.82, p < .02$ ). Conversely, a larger proportion of participants felt the player making the first

correct guess (i.e., the first aligned event) was the most to credit in the all-late (16%) versus the one-late (0%) sequence ( $\chi^2(1) = 17.23, p < .001$ ). Again, it seems that participants perceived momentum in the described game and used this in forming their responsibility judgments. Experiment 2 also demonstrated that this result is not limited to contexts with negative outcomes.

### Experiment 3: Testing the Role of Perceived Momentum via Mediation

While the results of the first two experiments are consistent with our contention that people perceive momentum in contexts where sequential events are objectively independent and use this perceived momentum in forming responsibility judgments, they do not provide any direct evidence of this process. Accordingly, Experiment 3 was designed to explicitly measure perceptions of momentum in the sequences examined in Experiment 1.

**Method.** Two hundred ninety-four paid AMT participants participated in Experiment 3, which used the same sequences (one-late vs. all-late), team outcome (loss), and dependent variable (most to blame) as Experiment 1. However, prior to indicating which aligned event (incorrect guess) was the most to blame for the outcome, participants first indicated how much momentum they felt the team had *after* each player's guess (-5 = strongly negative momentum, 0 = no momentum, +5 = strongly positive momentum). This measure of perceived momentum was collected to test whether changes in perceived momentum mediated the influence of sequence (one-late vs. all-late) on responsibility judgments.

**Results.** As in Experiments 1 and 2, a smaller proportion of participants felt the player making the final incorrect guess (i.e., the final aligned event) was the most blame in the all-late (37%) versus the one-late (60%) sequence ( $\chi^2(1) = 14.93, p < .001$ ). Conversely, a larger proportion of participants felt the player making the first incorrect guess (i.e., the first aligned event) was the most to blame in the all-late (38%) versus the one-late (12%) sequence ( $\chi^2(1) = 27.22, p < .001$ ).

We further explored the role of perceived momentum in forming responsibility judgments. For both sequences, perceived momentum peaked after the sixth consecutive success (see Figure 1). Examining the individual responses of the 83% of participants who indicated that a specific event (i.e., player) was most to blame, 60% assigned blame to the event that corresponded with the biggest drop in perceived momentum. Of the 17% of participants indicating equal/no blame, 39% also reported no changes in perceived momentum over the course of the events, further suggesting a link between perceived momentum and assigned blame. Notably, only 7% of the total number of participants indicated no changes in perceived momentum across the sequences of events.

We conducted a series of regressions to examine the mediating role of perceived momentum on the likelihood of assigning blame to the fourth aligned event (which was the tenth event in both sequences). First, a logistic regression with sequence (one-late vs. all-late; effect coded 1 and -1 respectively) as the sole predictor showed a significant effect on assigned blame ( $\beta_{\text{sequence}} = .46, z = 3.83, p < .001$ ; this mirrors the results from the previously described chi-square test). Second, a regression with sequence (effect coded as before) as the sole predictor showed a significant effect on the *change* in perceived momentum associated with the final aligned event ( $\beta_{\text{sequence}} = -1.84, t = -13.57, p < .001$ ). Finally, when both sequence (effect coded as before) and change-in-momentum were used as predictors in a logistic regression, change-in-momentum was a significant predictor of blame ( $\beta_{\text{change-in-momentum}} = -.18, z = -3.41, p < .001$ ) while sequence no longer held significant predictive power ( $\beta_{\text{sequence}} = .14, z = .91, p = .36$ ). This suggests perceived momentum may play a mediating role in the formation of responsibility judgments.

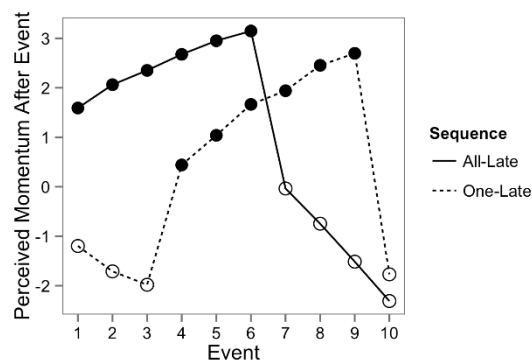


Figure 1. Perceived momentum in Experiment 3. Non-solid circles indicate incorrect guesses (aligned events).

### Experiment 4: Testing the Role of Perceived Momentum via Moderation

If responsibility judgments are partially derived from perceptions of momentum, then disrupting the momentum perceived to exist in a series of events should mitigate its impact on responsibility judgments. Experiment 4 tested this prediction.

**Method.** One hundred ninety-five paid AMT participants participated in Experiment 4, which used the same sequences (one-late vs. all-late), team outcome (loss), and dependent variable (most to blame) as Experiment 1. However, Experiment 4 added a second factor that was crossed with the sequence factor: whether or not participants were told the game was unexpectedly delayed immediately prior to the 10<sup>th</sup> player's guess (i.e., the final aligned outcome in both sequences). It was expected that an unexpected delay in the game would disrupt the perceived momentum occurring in the game at that

point. Accordingly, the sequence of events should be less informative for responsibility judgments for the final aligned event when it is known that this event was preceded by an unexpected delay in the game.

To summarize, Experiment 4 used a 2 (sequence: one-late vs. all-late) x 2 (game delay: yes vs. no) between-subjects design. We predicted a significant effect of sequence on blame assigned to the final player when there was no game delay (as in previous studies), but not when there was a game delay.

**Results.** As expected, there was a significant interaction between the sequence (dummy-coded; 1 = one-late, 0 = all-late) and game-delay factors (dummy-coded; 1 = no delay, 0 = delay;  $\beta = 1.85, p < .002$ ). When there was no game delay, a smaller proportion of participants felt the player making the final incorrect guess (i.e., the final aligned event) was the most blame in the all-late (47%) versus the one-late (76%) sequence ( $\chi^2(1) = 9.16, p < .002$ ). However, when there was a game delay, the influence of sequence on responsibility judgments for the final player was muted and even slightly reversed (all-late = 60% vs. one-late = 48%;  $\chi^2(1) = 1.44, p < .08$ ). We contend that the unexpected game delay disrupted perceived momentum and, necessarily, mitigated the influence of event sequence on responsibility judgments.

### Experiment 5: Evidence of Perceived Momentum via Expectations of Success versus Failure

We have argued that perceiving momentum in a sequence of events leads to the inference that success is more likely after a series of repeated successes and vice versa. Consequently a failure after multiple successes is more unexpected and assigned greater responsibility for the outcome (Gerstenberg, Halpern, & Tenenbaum, 2015). While the results of the preceding experiments have supported this contention indirectly, Experiment 5 explicitly tested whether people are biased towards expecting a success (failure) to follow a series of successes (failures).

**Method.** One hundred sixty-nine paid AMT participants participated in Experiment 5, which used the same sequences (one-late vs. all-late) and team outcome (loss) as Experiment 1. However, although participants were told of the team's loss, they were not given all of the events' results. Instead, participants (randomly assigned to either the one-late or all-late sequence) were shown the results of eight events, while the results of the other two events were hidden. See Table 1 ("I" = incorrect, "C" = correct; bolded events = aligned events).

After seeing the table of event results, participants were told that the team had lost by exactly one incorrect guess. Thus, one of the hidden results was necessarily an incorrect guess and the other a correct guess. The primary dependent

variable in this experiment asked participants which of the two hidden results they believed was the incorrect guess (participants had to choose one or the other).

**Results.** We analyzed the percentage of participants choosing event 10 as the incorrect response across sequences (one-late vs. all-late). Since perceived momentum would lead one to believe a correct guess is more likely after a series of correct answers, we expected and found that a smaller proportion of participants chose event 10 as being the incorrect response in the one-late (40%) versus the all-late (57%) sequence ( $\chi^2(1) = 4.93, p < .03$ ). Thus, it would appear that people perceive momentum in contexts where sequential events are objectively independent.

Table 1: Sequence Stimuli for Experiment 5

Event (Guess)	Event Results	
	One-Late	All-Late
1	<b>I</b> <sub>1</sub>	C <sub>1</sub>
2	<b>I</b> <sub>2</sub>	C <sub>2</sub>
3	<b>I</b> <sub>3</sub>	C <sub>3</sub>
4	?	?
5	C <sub>1</sub>	C <sub>4</sub>
6	C <sub>2</sub>	C <sub>5</sub>
7	C <sub>3</sub>	<b>I</b> <sub>1</sub>
8	C <sub>4</sub>	<b>I</b> <sub>2</sub>
9	C <sub>5</sub>	<b>I</b> <sub>3</sub>
10	?	?

### General Discussion

Responsibility and causality judgments have received a lot of attention within the cognitive science field (e.g., Halpern & Pearl, 2005; Miller & Gunasegaram, 1990). The results presented here add to that literature. Two main findings expand the current understanding of causal responsibility judgments. First, people often perceive momentum where it cannot exist. We show this in a context where sequential events are explicitly and objectively independent. Second, since perceived momentum implies that it should be more likely for an event to stay the course (i.e., have the same result as a preceding series of repeated results), aligned events whose results deviate from the previous course are more unexpected and, therefore, tend to be attributed more responsibility for the overall outcome.

The role of perceived momentum in responsibility judgments was empirically supported in three ways: (1) via mediation analysis (Experiment 3), (2) via moderation of perceived momentum (Experiment 4), and (3) via measured expectations of success/failure as a function of the results of the series of events preceding the target event (Experiment 5).

These results add an important level of nuance to responsibility judgments not captured by the counterfactual

simulation model (Gerstenberg, Goodman, Lagnado, & Tenenbaum, 2015) or models relying on perceived pivotality (Chockler and Halpern 2004). The aligned events in the sequences examined in these studies were equally pivotal to the outcome and were all whether- and how-causes that were equally (in)sufficient and (not) robust causes. Yet, the degree of responsibility each was assigned varied as a function of where it appeared in the overall sequence of events.

This work also extends that of Gerstenberg, Halpern, & Tenenbaum (2015) by demonstrating that the unexpectedness of a given event can be influenced by an implicit, inference-based cue: perceived momentum.

In future work, we will more explicitly examine counterfactual reasoning in the contexts examined here. Specifically, while most factors associated with counterfactual reasoning (e.g., pivotality) were held constant in the above studies, it is possible that an unexpected result is one that is associated with more plausible counterfactuals, which should increase the perceived responsibility of that event (consistent with our findings). Additionally, sequences other than those used in the current set of studies will be examined to further understand the role of perceived momentum in responsibility judgments.

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