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Directional asymmetry in event schema activation

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ABSTRACT

Event schemas are important for event cognition because they support the activation of causal antecedents and causal consequences. However, an open question is whether there are biases toward the activation of antecedents versus consequences. This study investigated the activation of antecedents and consequences within event schemas. In two experiments, participants read a sentence describing an action within a schema and were then asked to judge if a second action was related to the former action. The directionality (antecedent or consequence) and temporal distance of the second action were manipulated. Experiment 1 explicitly instantiated the schema by providing a sentence describing the event but Experiment 2 did not. Both experiments revealed a robust consequence bias such that participants verified consequences faster and more accurately than antecedents. A cross-experiment analysis indicated that both antecedents and consequences were activated when the schema was instantiated relative to when it was not, albeit there was still a consequence bias. The implications of these findings for theories of event perception and text comprehension are discussed.

Event schemas are important for making sense of events we experience in the real world (e.g., Johnson & Keil, 2014; Zacks, Kumar, et al., 2009; Zacks, Speer, & Reynolds, 2009), described in language (Elman, 2009; Ferretti et al., 2007; Metusalem et al., 2012; Prystauka et al., 2024) and in narratives (e.g., Baldassano et al., 2017; Trabasso et al., 1989). They are general knowledge structures that store event information that is associated with repeated experiences (Anderson & Freebody, 1981; Bartlett, 1932; Schacter et al., 2007; van Kesteren et al., 2012). They enable us to activate situational information from semantic memory that is closely associated with the event contexts (e.g., actions, agents, locations) we experience (Abelson, 1981; Barsalou & Hale, 1993; Bower et al., 1979; Elman & McRae, 2017; Ramey et al., 2024; Schank & Abelson, 1977; Zacks et al., 2007). By activation, we mean an increase in accessibility in working memory based on the strength of the relationship between event details that are experienced (and represented in working memory) and situationally relevant content in the event schema (e.g., Barsalou & Hale, 1993). Importantly, event schemas support activation of causal antecedents that support bridging inferences (i.e., establishing how the current event is semantically and situationally related to prior events) and causal consequences that support predictive inferences (Graesser et al., 1994; Johnson & Keil, 2014; van den Broek, 1990). As an example, imagine you just entered a kitchen and see a person is whisking eggs, you may infer that the person cracked an egg a few seconds ago and will soon pour the mixed eggs in a bowl. The activation of the antecedent helps establish how the agent's current action of whisking the eggs is connected to past events, and the consequence supports a prediction of the agent's future action.

To what extent are antecedents and consequences concurrently activated when understanding an event? Answering this question is important because theories of event comprehension in the context of narratives (e.g., Trabasso et al., 1989) and everyday events (Zacks, Kumar, et al., 2009; Zacks, Speer, & Reynolds, 2009) assume that causal processing is important. However, they diverge in their emphasis on the directionality of causal processing. Theories of narrative comprehension suggest that people predominantly engage in causal bridging to prior events and generate predictions under specific conditions (Asiala et al., 2020; Graesser et al., 1994; van den Broek, 1990). Theories focusing on everyday events emphasize the importance of prediction in understanding events and how they are structured (Kurby & Zacks, 2008, 2012; Zacks et al., 2007).

To address this issue, it is necessary to understand the structure and properties of event schemas because their structure provides a constraint on knowledge activation. We are particularly interested in schemas for goal-directed events. The schema for a goal-directed event captures the structural relations between actions that comprise the event (Schank & Abelson, 1977). Fig. 1 presents a simple structure that characterizes

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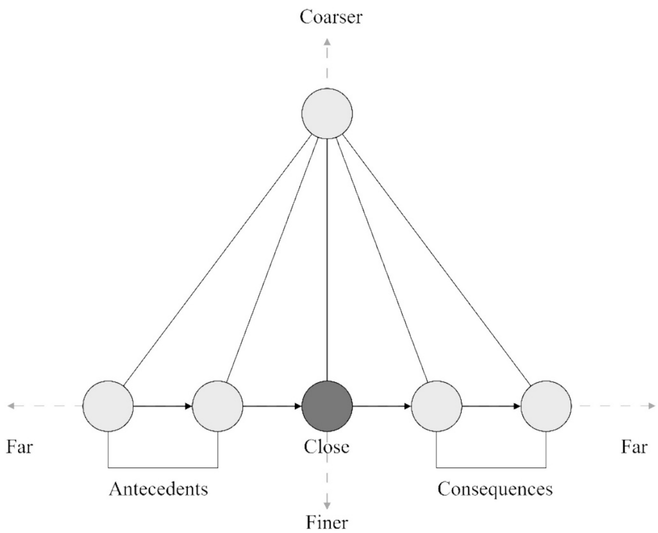

Fig. 1. Hierarchical structure of event schema with ordered subevents.
Note. The first subevent is temporally farther from the middle subevent compared to the second subevent.

common events. Each event consists of a chain of subevents or actions that follow a particular order. In the present study, we use the term 'action' because we are specifically interested in the goal-directed actions that comprise an event schema.

There are at least two properties of schemas that can potentially affect the activation of antecedents and consequences of an experienced action (e.g., seen, heard, or read) of an event schema. One property is the hierarchical relation between actions and events, because finer events build up coarser events (Johnson & Keil, 2014; Schank & Abelson, 1977). For example, the event "making scrambled eggs" can be separated into multiple actions such as "cracking eggs into a bowl," "whisking eggs," "pouring eggs into skillet," etc. At the same time, "making scrambled eggs" can be a subevent of another event, such as "making breakfast," which in turn can be a subevent of "morning routine." If one had the event schema "making scrambled eggs" activated when experiencing a person whisking eggs in a bowl, this could influence the activation of events before (cracking eggs) or after (pouring eggs in a pan) that action.

Another property of event schemas is that they store temporal information (e.g., order sequences, temporal duration of actions) between the actions they subsume (Schank & Abelson, 1977), which could also influence the activation of the antecedents and consequences of a given action (Baldassano et al., 2017; Kintsch et al., 1977; Stein & Nezworski, 1978). Antecedents and consequences temporally close to an experienced action within an event schema (e.g., cracking eggs, pouring eggs into a pan) should be more strongly activated than those that are temporally distant (e.g., getting eggs from the refrigerator, putting eggs on a plate).

These two properties of the structure of event schemas lead to three hypotheses regarding the directional bias of activation of causal antecedents and consequences. The Bidirectional Causal Hypothesis is that both antecedents and consequences are equally activated. For instance, after the action "whisking eggs" is activated, the immediately prior action "cracking eggs into bowl" and the immediately following action "pouring eggs into skillet" are expected to be activated at a similar level. This follows from the assumption that semantic knowledge is accessed through the undirected spread of activation (Anderson, 1983; Collins & Loftus, 1975). Semantic networks are generally represented by undirected graphs, where nodes represent concepts and edges represent the associations between concepts. When a concept is activated, the concepts with stronger associations are more likely to be activated. For instance, activation of "Apple" leads to stronger activation of "Red" than "Blue". Activation decays every time it passes through an edge; therefore, the more edges in the shortest path between two concepts, the less likely the distal concept would be activated after the initial concept is activated. In the case of temporal relations, the association represents the sequential relations. Therefore, the more events there are between two events, the greater the temporal distance between them, and the less likely one event is to activate the other one.

The second and third hypotheses follow from the assumption of directional activation. Evidence suggests that knowledge is not just affected by the spread of activation, and that it can be causally directed (Graesser, 1981; Graesser et al., 1980; Graesser & Clark, 1985; Graesser & Franklin, 1990). The Antecedent Biased Hypothesis assumes that causal bridging processes are relatively more important for event comprehension than prediction (Graesser et al., 1994; Kintsch, 1988). Thus, when an event is activated, there is a strong bias toward the activation of causal antecedents compared to causal consequences. For example, when readers read the event "whisking eggs", the antecedent "cracking eggs into bowl" is expected to be activated at a higher level compared to the consequence "pouring eggs in skillet". The Consequence Biased Hypothesis follows from theories of event cognition, language processing, and cognitive neuroscience that focus on prediction (DeLong et al., 2005; Elman, 1990; Elman & McRae, 2017; Kurby & Zacks, 2008, 2012; Rao & Ballard, 1999; Zacks et al., 2007). Prediction is considered essential in event cognition because it helps people detect event boundaries (Kumar et al., 2023; Reynolds et al., 2007; Zacks et al., 2011, 2007). For instance, when perceiving the action "whisking eggs", actions with high probability of following it are predicted, such as "pouring eggs into skillet". When unexpected actions occur, for instance, "phone rings", this leads to a prediction error and the detection of the event boundary (e.g., Kurby & Zacks, 2008). According to this hypothesis, the level of activation for the consequences of a perceived event should be higher compared to its antecedents, to support prediction and boundary detection.

As previously noted, the Bidirectional Causal Hypothesis assumes that activation attenuates across distance for both causal antecedents and causal consequences. In contrast, while the Antecedent Biased and Consequence Biased Hypotheses also assume that activation attenuates across distance, they assume the attenuation is asymmetric—specifically, it is stronger in the biased direction than the other. The asymmetry stems from the fact that the strength of activation in the node of the event schema will affect the decay in a semantic network (Atkinson & Shiffrin, 1968). Specifically, while the relative rate of decay might be the same over temporal distance for antecedents and consequences, the observed slope will be steeper if one is more strongly activated than the other. The difference in slope would occur because the activation in both directions shares a baseline level of activation (i.e., resting level of activation). As such, the slope is steeper for a causal direction if the initial activation is relatively stronger than the other direction.

Surprisingly, only a few studies have examined the activation of antecedents and consequences within the same event context in the same study (Fincher-Kiefer, 1995, 1996; Magliano et al., 1993; Papenmeier et al., 2019), finding mixed results. Magliano et al. (1993) studied the activation of causal antecedents and causal consequences in the context of reading narratives and provided support for the Antecedent Biased Hypothesis. The narratives were those used by Graesser and Clark (1985), who employed a question-answering methodology to identify the antecedents and consequences of the narrative events in their stories. In the original study, participants answered why and what-happens-next questions for every sentence in the stories. Answers to why questions enabled identification of causal antecedents, and answers to what-happens-next questions enabled identification of causal consequences. They created a distribution of antecedents and consequences for the sentences that reflected the proportion of participants who generated them. Magliano et al. (1993) used those distributions to identify sentences in which some antecedents and consequences were generated at high and comparable proportions. Participants read the stories one sentence at a time and engaged in a lexical decision task. At the critical sentence, the letter strings were antecedents, consequences, or control (unrelated) words. Based on lexical decision latencies, they found greater activation for antecedent target words than control words, but found no such activation for consequence target words.

Papenmeier et al. (2019) also found evidence consistent with the Antecedent Biased Hypothesis. They had participants watch videos of professional football matches and varied the presence of actions (e.g., kicking the ball) that lead to outcomes (e.g., ball in the air). Participants were explicitly asked to detect whether the critical moment of action (e.g., agent contacting the ball) was present or absent in the video clip. Participants should be less accurate in their detection performance if they generate an inference about the action in the absent condition. In the critical experiment, the video section involving the action was followed by either the outcome (e.g., ball in the air), an unrelated event, or a white frame. They made different predictions regarding the impact of the white screen for generating antecedents and consequence inferences. For antecedents, they predicted that both the non-causal and white screens would disrupt the generation of bridging inferences in the absent condition because neither shows the outcome (ball in the air) that would require inferring the missing moment (agent contacting the ball). On the other hand, they predicted that the white screen would not disrupt predictions. Specifically, if participants predicted the missing moment in the absent condition, then that prediction would still be active in working memory when the white screen was shown. Papenmeier et al. (2019) found that detection performance was lower in the absent condition than the present condition when the outcome was shown compared to the unrelated event or the white screen, which is consistent with the assumption that antecedents were activated, but not consequences.

In contrast, Fincher-Kiefer (1995, 1996) conducted a study that showed evidence consistent with the Bidirectional Causal Hypothesis. Participants read short narratives and engaged in a word recognition task after target sentences. In the experiments testing causal antecedent inferences, the target sentences occurred after a coherence gap between explicitly conveyed events, and the causal antecedent inference filled the coherence gap. In the experiments testing causal consequence inferences, the stories were written such that the causal consequences were highly likely to occur after the target sentence. The recognition items were words reflecting the antecedents and consequences inferences. Across experiments, they found participants were slower when making judgments in the experimental condition (e.g., that would lead to inference generation) compared to the controlled condition (e.g., that would not lead to inference generation). Given that the task was to judge if the words were explicitly shown in the text, they reasoned that the slower reaction times were due to interference from the inferences when making the recognition judgments. Consequently, they concluded that readers generate both causal antecedents and causal consequences during reading when the texts support those inferences. An important difference between Fincher-Kiefer (1995) from Magliano et al. (1993) and Papenmeier et al. (2019) is that the former study assessed the activation of antecedents and consequences across experiments, whereas the latter studies assessed their activation within the same experiments. We believe the latter approach is crucial to determine relative activation of antecedents and consequences.

The mixed results of these studies motivated the present study. These studies illustrate that there are two sources of the activation of causal antecedents and consequences. Specifically, the event schema and the episodic context (i.e., prior events that are likely represented in working memory or episodic memory). These studies utilize materials with episodic context, and there is likely variability in the constraints of the episodic context on the activation of causal antecedents and consequences across the materials used in the studies. This possibility motivates the need for a study that isolates the impact of event schemas on the activation of antecedents and consequences to test the three hypotheses.

The goal of the present study was to investigate how and under what conditions event schemas support the activation of causal antecedents and consequences. Two experiments were conducted to investigate the extent to which causal antecedents and causal consequences are activated when processing actions that are part of a larger event schema. In both, participants read a sentence describing an action within a schema and were then asked to judge if a second action was related to the former action. The directionality (antecedent or consequence) and temporal distance of the second action from the first were manipulated. Experiment 1 explicitly instantiated the schema by providing a sentence naming the event; Experiment 2 did not. The experiments enabled evaluation of whether instantiating a hierarchical schema affects the activation of antecedents and consequences.

The Bidirectional Causal Hypothesis predicts there will be a main effect of temporal difference such that reaction time will be longer and accuracy will be lower as temporal distance increases. This hypothesis does not lead to a prediction of a main effect of causal direction or an interaction between causal direction and temporal distance. The Antecedent Biased Hypothesis predicts there will be a main effect of causal direction such that latency will be shorter and accuracy will be higher for antecedents than consequences. It also predicts an interaction between causal direction and temporal distance such that the slope of temporal distance will be steeper for antecedents than consequences. The Consequence Biased Hypothesis predicts that there will be a main effect of causal direction such that latency will be shorter and accuracy will be higher for consequences than antecedents. With respect to the interaction between causal direction and temporal distance, it predicts that the slope of temporal distance will be steeper for consequences than antecedents.

1. Experiment 1

Experiment 1 assesses the activation of antecedents and consequences when the event schema is explicitly instantiated, thereby activating its hierarchical structure.

1.1. Methods

1.1.1. Participants

For Experiment 1, 121 adults were recruited from Prolific and compensated $6 for a 30-min task. Participants whose country of birth, nationality, and resident country were the United States, with English as their first language, were recruited. These criteria were used to minimize the impact of second language processing and differences in event schemas that may exist across cultures (Bartlett, 1932; Colby, 1966; Kintsch & Greene, 1978). The sample size was determined by a simulation-based power analysis using the R package *simr* (Green & MacLeod, 2016). For the fixed effect coefficients of the main effects and interaction effects, we set the Smallest Effect Size of Interest (SESOI) equal to Cohen's $d = 0.2$. Statistical power was estimated for different sample sizes with 1000 Monte Carlo simulations at an alpha level of 0.05. The results suggested that 110 participants were required to ensure greater than 80% power to detect the main effects and the interaction. We used 112 as the minimum sample size to ensure an equal number of participants in each counterbalancing group. After participants were removed with the exclusion criteria, we continued collection to reach the minimum sample size. Participants who failed attention checks or had an accuracy lower than 0.7 were excluded (i.e., the proportion of correct responses to the action relationship judgments described in the Procedures section), and 112 remained ($M_{age} = 37.54$ years, $SD = 11.98$; 55 males, 57 females). Self-reported ethnicity consisted of 73 Whites, 15 Blacks, 10 mixed, 9 Asians, and 5 other participants. A pilot study was conducted for materials generation in which 24 participants were recruited via Prolific and compensated $6 for a 30-min task ($M_{age} = 35.29$, $SD = 12.62$; 15 females, 9 males). Self-reported ethnicity consisted of 19 Whites, 2 Asians, 1 Black, and 2 other participants.

1.1.2. Design

Causal direction (antecedent and consequence) was manipulated as a within-participant variable. Temporal distance was treated as a continuous variable, and how it was operationalized is described below.[1] Dependent variables were the accuracy and reaction time of participants' responses to the critical items when judging whether the target and priming sentences were related.

1.1.3. Materials

The final stimuli consist of 24 events, each containing 5 actions (see Table 1). This allows each event to have an action prime sentence and four potential action target sentences corresponding to the four possible direction and distance combinations. The prime sentences were positioned in the middle of the 5 actions. A pilot study was conducted to collect the events and actions for the materials to ensure they reflect participants' semantic knowledge (Magliano & Graesser, 1991).

1.1.3.1. Pilot study. In the pilot study, a Qualtrics survey presented 36 sentences of different daily events one at a time. For example, "Making scrambled eggs". For each event, participants were asked to write 3 to 5 actions that immediately came to mind.

1.1.3.2. Matrix calculation. To assess the accessibility of each action and order relation between actions within the event schema, the proportion of participants that mentioned the action and the mean relative position of each action were calculated. The mean relative position of an action refers to the average of the positions of all individual (i.e., potentially differently worded) actions corresponding to that action (0 indicates at the very beginning, and 1 indicates at the very end). The relative position of each individual action was calculated by dividing its position index (starting from 0) by the total number of actions provided by that participant minus 1. For instance, a response to "Making scrambled eggs" might be "Grab eggs from fridge", "Crack eggs into mixing bowl", "Season eggs", "Mix eggs", and "Pour onto hot skillet and cook". These responses were clustered into standardized actions with zero-based location indices: 0) Get eggs, 1) Crack eggs, 2) Add seasonings, 3) Mix eggs, 4) Cook. Because this participant provided a total of 5 actions, the relative position for "Add seasonings" (index 2) would be calculated as $2/(5–1) = 0.5$. To calculate the mean relative position for "Add seasonings" across the sample, we average the relative positions of this clustered action across all pilot participants who generated it.

Table 1
Example of event context prime, action primes, and target actions.

Event context	Prompt type	Actions
Grocery shopping	Far antecedent	Make grocery list
	Close antecedent	Drive to grocery store
	Prime action	**Grab grocery cart**
	Close consequence	Select grocery items
	Far consequence	Check out at grocery store
Making scrambled eggs	Far antecedent	Get the eggs from fridge
	Close antecedent	Crack eggs in bowl
	Prime action	**Whisk eggs with fork**
	Close consequence	Pour eggs in skillet
	Far consequence	Cook eggs until done

1.1.3.3. Material generation. Candidate materials were created by identifying 5 actions for each event based on three criteria: 1) there was a clear temporal sequence of the actions, 2) the mean relative position specifies a middle action, and 3) maximizing the proportion of pilot participants that generated the actions. The third of the five actions was deemed the prime sentence. From the 36 events of the pilot study, 24 events were chosen for the experiment following three criteria: 1) there was a strong causal ordering of the five actions such that they had to occur in a fixed temporal order, 2) the actions could be expressed in sentences that have a common lexical item to equate the impact of lexical level semantic priming (e.g., the word "hotel" appears in all action sentences for the event "Checking into a hotel room"), and 3) maximizing the proportion of participants who mentioned the actions. To select actions, we chose the best combination of temporal order, lexical clarity, and proportion of mention. This combination made it impossible to restrict action selection based on any one factor, and as such there was a range in the proportion of participants who mentioned the actions in the pilot study ($M = 0.48$, SD = 0.20). A 2 (causal direction: antecedent, consequence) × 2 (temporal distance: close, far) design was used, yielding four conditions. Using a Latin square, four counterbalancing groups were created. Participants were randomly assigned to one of the counterbalancing groups.

Word2vec (Mikolov et al., 2013) was used to ensure that there were no differences in the semantic similarity of the sentences in the four causal direction and distance conditions to the target events. Specifically, the semantic similarity between the target event sentences and the prime sentences was computed based on semantic similarity cosines derived from a Word2Vec semantic space.

Recent research shows that Large Language Models (LLMs) can be used to judge temporal distance similarly to humans. We utilized LLMs to operationalize temporal distance as a continuous variable (Doctorarastoo et al., 2026; Li et al., 2026). Specifically, four models were used (GPT 5.4, Claude Sonnet 4.6, Gemini 3.1 Flash, and Grok 4.1 Fast) to estimate the temporal distance between the prime action and target actions in each event. For each event, the models were prompted with the event context and its action sequences (e.g., Making scrambled eggs: Get eggs from fridge, Crack eggs in bowl, Whisk eggs with fork, Pour eggs in skillet, Cook eggs until done). The LLMs were then asked to estimate the offset-to-onset temporal distance between the prime actions and the target actions in the temporal format of "HH:MM:SS" (presented in chronological order). The temporal distance for each target sentence was operationalized as the average offset-to-onset temporal distance estimated across models. Due to the inconsistency of temporal scales across events, we applied a base-10 logarithmic transformation to the estimated temporal distances.

To assess the balance of the selected stimuli across conditions (directionality and temporal distance), semantic similarity—based on cosine similarity derived from a Word2Vec semantic space—and syllable counts were analyzed using independent t-tests and a correlation analysis. For semantic similarity, the t-test showed no significant effect of causal direction ($M_{\text{antecedent}} = 0.65$; $M_{\text{consequence}} = 0.67$; $t = -0.96$, $p = .34$), while Pearson's correlation revealed a significant weak negative association with temporal distance ($r = -0.22$, $p < .05$), indicating that temporally closer actions shared higher semantic similarity compared to distant actions. Importantly, this difference in semantic similarity is not a confound for our primary findings, as item-level semantic similarity was explicitly controlled for as a fixed covariate in all analyses. For syllable counts, there was no significant effect of causal direction ($t = -0.37$, $p = .71$), nor a significant association with temporal distance ($r = 0.07$, $p = .52$). Nevertheless, syllable count was also included as a fixed covariate in subsequent analyses on reaction time. Finally, to ensure that the inclusion of covariates of semantic similarity did not introduce multicollinearity, Variance Inflation Factors (VIFs) were calculated for all final models. All VIF values were near 1.0 (highest VIF = 1.16), indicating a complete absence of multicollinearity issues.

Grammatical aspect has been shown to affect the activation of event

[1] Temporal distance was originally treated as a dichotomous variable in all analyses. The decision to create a continuous variable was based on suggestions from the reviewers. When it was treated as a dichotomous variable, it was not significant in the analyses. The original analyses are reported in the OSF page for the study.

schema such that an imperfective aspect ("X was whisking the eggs") leads to the activation of event details within the event whereas a perfective aspect ("X whisked the eggs") leads to the activation of event information at the end of an event (e.g., Ferretti et al., 2007). As such, the event context prompts were always conveyed with an imperfective aspect, whereas the target actions were conveyed with an imperative mood because it does not convey information about tense or aspect.

In the experiment, the participants' task was to judge whether the target action was causally related to the prime action. This required the creation of 24 filler items for which the correct response was clearly "no," i.e., for which the prime and target items are completely unrelated. For example, with the context "going to a party," the prime action is "dress up for the party" and the filler target action is "turn on your TV." Half of the filler items were constructed using target actions from the 12 unused events of the 36 events in the pilot study; the other 12 events were newly created.

1.1.4. Procedure

The study was implemented using Prolific. Participants logged on and completed informed consent using Qualtrics. A link for downloading the e-Prime Go program was then provided. The experiment was conducted using this platform, which enables the online administration of timed experiments. Only Windows devices were accepted to be compatible with e-Prime Go. Participants were instructed that they would be presented with an activity context (e.g., "Print an article"), followed by two actions that would be presented sequentially (e.g., "Click on print button" followed by "Turn on printer"). Their task was to decide whether the second action was related to the first. The instructions were augmented with examples. Instructions on the nature of the study were provided and can be found in the materials folder in the Open Science Framework (OSF) page for the project (see Ethics, transparency, and data availability statement*)*. After receiving instructions, participants went through 10 practice items. Fig. 2 shows the trial structure of the experiment. Each trial consisted of five screens: a self-paced get-ready screen with instructions after a 1000-ms gap, a self-paced event context screen after a 500-ms gap, a self-paced prime action screen, a reminder screen with an asterisk after a 250-ms gap, and a self-paced target-action screen after a 250-ms gap. These gap intervals were chosen to be long enough to discourage superficial lexical priming and to ensure participants were encoding the semantic meaning of the event phrase rather than individual words (Till et al., 1988). The space bar was used to advance the screen, with the F (for yes) and J (for no) keys for judgment. Participants were instructed to keep their fingers on the spacebar. Participants judged if the target action was related to the prime action as soon as possible after it was presented. The total time spent on Screen 5 was recorded to measure decision latencies with millisecond accuracy.

1.1.5. Analysis

Data were cleaned by removing responses with reaction times shorter than 500 ms, and then those with reaction times beyond 3 standard deviations of each participant's mean were also removed. This removed 2.6% of responses, with 2618 responses left. 500 ms was selected based on the average syllable silent reading speed multiplied by the minimal syllable counts in target sentences, plus 70 ms for decision-making (Brysbaert & Vantieghem, 2023).

Two analyses on accuracy and reaction time were performed on all responses to critical items. The analyses involving reaction time were conducted on all responses and on correct responses only. The former is reported in the document, and the latter is reported in the supplementary materials available on the OSF project page. Due to the cross-classified structure of the data, three two-level cross-classified random effects models (CCREM) clustered by participant and event were tested on each dependent variable, using the *glmer()* and *lmer()* functions of the R package *lme4* (Bates et al., 2015). For each analysis, we tested an unconditional model to validate the model, then tested the main effects model and interaction model. As mentioned above, causal direction was treated as a dichotomous fixed effect, and temporal distance was treated as a continuous fixed effect. The similarity score, a real number between 0 and 1, was added as a continuous fixed effect (grand mean centered) to control for semantic association between prime sentences and target sentences. The interaction between distance and direction was also tested. Logistic CCREMs were used for accuracy analysis. For the analysis of reaction time, generalized CCREMs specifying a Gamma distribution with the same structures were used. Syllable count, a positive integer, was added to the main effect model and the interaction model as a grand mean-centered continuous variable to control for reading time. Likelihood-ratio tests were used to determine the final best-fit model.[2]

1.1.6. Ethics, transparency, and data availability statement

The present study was evaluated and approved by the Institutional Review Board of the institution where the study was conducted. The present study was not preregistered, but all hypotheses and predictions were specified prior to conducting the study and data analyses. All materials and data are available on the project's OSF page (https://osf.io/km6y8).

1.2. Results

Table 2 shows the descriptive statistics of accuracy and reaction time for each directional condition, and Table 3 shows the correlation between measurements and temporal distance for each directional condition. The main finding was a main effect of causal direction, this was observed for both accuracy and reaction time. This supports the Consequence Biased Hypothesis.

For accuracy, the unconditional model suggests that the events account for 3.93% of the variance and subjects account for 49.93% of the variance. The main effects model was the final model because adding the interaction term did not significantly improve model fit ($df = 1$, $\chi^2 = 0.24$, $p = .622$). As can be seen in Table 4, there was a significant main effect of causal direction such that the expected odds of getting a correct response for a consequence were 7.58 times the odds of getting a correct response for an antecedent ($OR = 7.58$). There was a significant main effect of temporal distance, which negatively predicted accuracy (OR = 0.76), indicating that for every ten-fold increase in the temporal gap between actions, the odds of a correct response decreased by 24%.

For reaction time, the unconditional model suggests that the events account for 1.96% of the variance and subjects account for 24.51% of the variance. The main effects model was the final model, as adding the interaction term did not significantly improve model fit ($df = 1$, $\chi^2 = 0.03$, $p = .866$). As can be seen in Table 5, there was a significant main effect of causal direction such that participants respond to consequences 9% faster than antecedents. There was a significant main effect of temporal distance, which positively predicted reaction time, indicating that for every ten-fold increase in the temporal gap between actions, subjects' responses are expected to be 3% longer. There were no other main effects involving theoretically important variables.

1.3. Discussion

The results of Experiment 1 show stronger activation of the causal consequences compared to causal antecedents, which supports the Consequence Biased Hypothesis. This suggests that event schemas are biased toward activating causal consequences, which is consistent with the perspective that goal-based schemas support predicting the future actions of agents (Schank, 1999). In addition, the distance effect and the

[2] As recommended by a reviewer, we performed a supplementary analysis controlling for the processing times of the context and prime sentences using Experiments 1 and 2 data. The results remained the same. This supplementary analysis is reported on OSF.

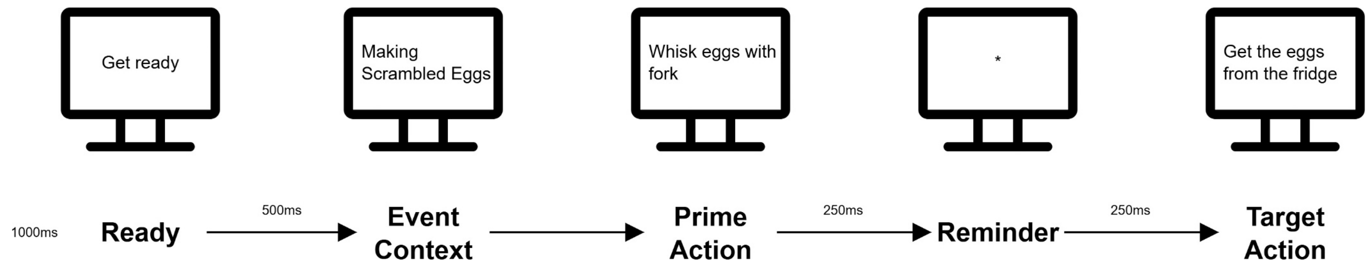

Fig. 2. Procedure for Experiment 1.
Note: The text shown in the fifth screen of each event varies depending on the counterbalance group.

Table 2
Mean and standard deviation of accuracy and reaction time for antecedent and consequence.

	Accuracy	Reaction time
Antecedent	0.87 (0.34)	1446 (892)
Consequence	0.97 (0.18)	1308 (816)

Note. Standard deviations are shown in parentheses.

Table 3
Correlation between accuracy or reaction time and temporal distance for antecedent and consequences.

	Accuracy	Reaction time
Antecedent	−0.07 (0.013)	0.03 (0.261)
Consequence	−0.08 (0.002)	0.05 (0.066)

Note. *p* values are in parentheses.

Table 4
Results of final model on accuracy.

Predictor	Log-odds	*SE*	95% CI	*p*
Fixed effects				
Intercept	4.27	0.33	[3.61, 4.94]	<0.001
Causal direction [consequence]	2.03	0.21	[1.61, 2.44]	<0.001
Distance	−0.28	0.09	[−0.45, −0.10]	0.002
Semantic similarity	1.77	1.04	[−0.28, 3.81]	0.090
Random effects				
σ^2	3.29			
τ_{00} (participant)	4.46			
τ_{00} (event)	0.26			
ICC	0.59			
N (participants)	112			
N (events)	24			
Observations	2618			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

absence of interaction effect suggest the attenuation pattern for antecedents and consequences might be the same.

2. Experiment 2

Experiment 1 tested the hypotheses when the schema was explicitly instantiated. It is therefore important to evaluate the robustness of the consequence bias in a context in which the event schema is not explicitly instantiated. We therefore also tested the three hypotheses when the context prime was not provided. If the consequence bias is robust, then the data should replicate the findings from Experiment 1. Moreover, it is possible that providing the event context led to activation of antecedents in Experiment 1. However, the design did not include a baseline for assessing the activation of both antecedent and consequence when the event context prime is not provided. A cross-experiment analysis enabled us to also assess the relative activation of antecedent and consequence when the context prime was provided and when it was not.

Table 5
Results of final model on reaction time.

Predictor	Estimates	*SE*	95% CI	*p*
Fixed effects				
Intercept	1270.45	64.42	[1150.20, 1403.27]	<0.001
Causal direction [consequence]	0.91	0.01	[0.89, 0.94]	<0.001
Distance	1.03	0.01	[1.01, 1.05]	<0.001
Semantic similarity	0.72	0.06	[0.61, 0.86]	<0.001
Syllable count	1.01	0.01	[0.99, 1.03]	0.238
Random effects				
σ^2	0.15			
τ_{00} (participant)	0.05			
τ_{00} (event)	0.00			
ICC	0.27			
N (participants)	112			
N (events)	24			
Observations	2618			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

2.1. Methods

2.1.1. Participants

124 adults were recruited via Prolific and compensated $6 for a 30-min task. Participants whose country of birth, nationality, and resident country were the United States, with English as their first language, were recruited. Participants who failed attention checks or had an accuracy lower than 0.7 were excluded. As in Experiment 1, we utilized a continual sampling procedure until 112 remained (M_{age} = 39.85 years, *SD* = 11.82; 59 males, 53 females). Self-reported ethnicity consisted of 85 Whites, 16 Blacks, 5 mixed, 2 Asians, and 4 other participants.

2.1.2. Design

Experiment 2 used the same design as Experiment 1.

2.1.3. Materials

Experiment 2 used the same materials as in Experiment 1, except the event context was removed for each event.

2.1.4. Procedure

The procedure for Experiment 2 is the same as Experiment 1 without the event context screen (see Fig. 2).

2.1.5. Analysis

The same data cleaning practices were applied, which removed 2.0% of responses, with 2634 responses left. The same CCREMs were used for analysis.

2.2. Results

Table 6 shows the descriptive statistics of accuracy and reaction time for each directional condition, and Table 7 shows the correlation between measurements and temporal distance for each directional condition. As in Experiment 1, the main finding was a main effect of causal direction, this was observed for both accuracy and reaction time. This again supports the Consequence Biased Hypothesis.

For accuracy, the unconditional model suggests that the events account for 14.17% of the variance and subjects account for 32.25% of the variance. The interaction model was the final model, as it significantly improved model fit ($df = 1, \chi^2 = 3.94, p = .047$). As can be seen in Table 8, there was a significant main effect of causal direction, suggesting participants were more likely to respond correctly for consequences than antecedents. The expected odds of getting a correct response for a consequence were 3.09 times the odds of getting a correct response for an antecedent ($OR = 3.09$). There was a significant main effect of temporal distance, which negatively predicted accuracy, indicating that for every ten-fold increase in the temporal gap, the odds of a correct response decreased by 19% (OR = 0.81). Regarding interaction, there was a significant effect between causal direction and temporal distance, indicating that the increases in the slopes over temporal distance were different (OR = 0.70). As can be seen in Fig. 3, the slope is steeper for consequences than antecedents, and the slope for antecedents was relatively flat.

For reaction time, the unconditional model suggests that the events account for 4.35% of the variance and subjects account for 21.74% of the variance. The interaction model was the final model as it significantly improved the model fit ($df = 1, \chi^2 = 5.57, p = .018$). Although the model encountered convergence warnings, we verified that estimates across multiple optimizers were highly consistent, suggesting functional convergence and reliable estimates. As can be seen in Table 9, there was a significant main effect of causal direction, such that participants responded to consequences 5% faster than antecedents. No significant main effect of temporal distance was found. Regarding interaction, there was a significant effect that suggested that the slopes of the temporal distance effect were different for antecedents and consequences. As can be seen in Fig. 4, the slope is relatively flat for antecedents, but increases as a function of distance for consequences (interaction estimate = 1.04, indicating a 4% difference in slope). The estimated reaction time for antecedents is relatively flat, showing a marginal 1% decrease (estimate = 0.99), whereas the reaction time for consequences increased by 3% (estimate = 1.03).

2.3. Discussion

Thus, the results of Experiment 2 replicated those of Experiment 1, even when the hierarchical event schema is not explicitly instantiated, lending further support to the Consequence Biased Hypothesis. The distance effect was again found in accuracy data but not reaction time data. Importantly, the interaction between direction and distance in both accuracy and reaction time suggests an asymmetric attenuation between antecedent and consequence. The expected distance effect was not observed with reaction time. The implication of the findings will be discussed further in the General Discussion.

Table 6
Mean and standard deviation of accuracy and reaction time for antecedent and consequence.

	Accuracy	Reaction time
Antecedent	0.88 (0.32)	1622 (1082)
Consequence	0.94 (0.23)	1537 (1145)

Note. Standard deviations are in parentheses.

Table 7
Correlation between accuracy or reaction time and temporal distance for antecedent and consequence.

	Accuracy	Reaction time
Antecedent	−0.03 (0.248)	0.00 (0.918)
Consequence	−0.11 (0.001)	0.04 (0.135)

Note. *p* values are in parentheses.

Table 8
Results of final model on accuracy.

Predictor	Log-odds	*SE*	95% CI	*p*
Fixed effects				
Intercept	3.56	0.28	[3.02, 4.10]	<0.001
Causal direction [consequence]	1.13	0.19	[0.76, 1.49]	<0.001
Distance	−0.22	0.11	[−0.43, −0.00]	0.048
Semantic similarity	2.73	1.04	[0.68, 4.77]	0.009
Causal direction × distance	−0.36	0.18	[−0.73, −0.00]	0.049
Random effects				
σ^2	3.29			
τ_{00} (participant)	2.19			
τ_{00} (event)	0.75			
ICC	0.47			
N (participants)	112			
N (events)	24			
Observations	2634			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

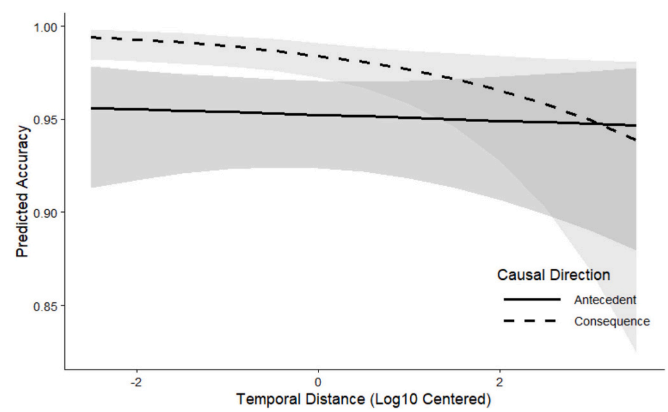

Fig. 3. The interaction between causal direction and temporal distance on accuracy.

3. Cross-experimental analysis

We conducted two cross-experiment analyses to examine how the presence (Experiment 1) versus the absence (Experiment 2) of explicit event context influenced the activation of antecedents and consequences. This analysis enabled us to assess the robustness of the consequence bias because it allowed us to assess if there was a magnitude interaction between the two experiments with respect to the activation of consequences. This analysis also enabled us to assess if the antecedents were more activated in the context of instantiating the schema relative to when it was not instantiated. The event context and causal direction variables were included in the main effects model, and their interaction was added in the interaction model. The same control variables—similarity and syllable count—were added to the models for accuracy and reaction time, and the same model-building procedure was used.

For accuracy, the unconditional model suggests that the events account for 7.90% of the variance and subjects account for 40.13% of the

Table 9
Results of final model on reaction time.

Predictor	Estimates	*SE*	95% CI	*p*
Fixed effects				
Intercept	1450.34	38.87	[1376.09, 1528.59]	<0.001
Causal direction [consequence]	0.95	0.02	[0.92, 0.98]	<0.001
Distance	1.01	0.01	[0.99, 1.03]	0.268
Semantic similarity	0.64	0.07	[0.52, 0.78]	<0.001
Syllable count	1.02	0.01	[1.00, 1.03]	0.089
Causal direction × distance	1.04	0.02	[1.00, 1.07]	0.037
Random effects				
σ^2	0.17			
τ_{00} (participant)	0.05			
τ_{00} (event)	0.00			
ICC	0.25			
N (participants)	112			
N (events)	24			
Observations	2634			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

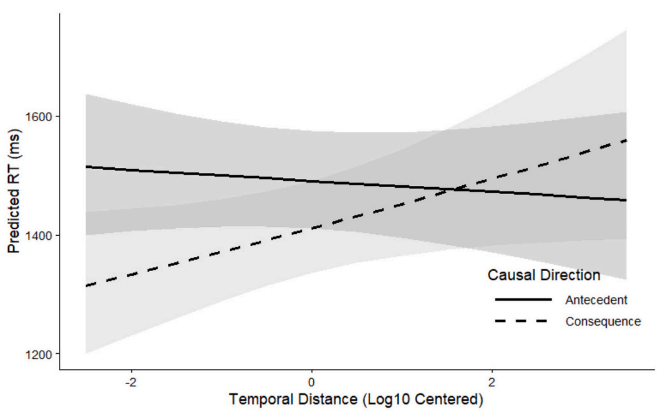

Fig. 4. The interaction between causal direction and temporal distance on RT.

Table 10
Interaction model on accuracy using cross-experiment data.

Predictor	Log-odds	*SE*	95% CI	*p*
Fixed effects				
Intercept	3.83	0.23	[3.38, 4.29]	<0.001
Event context [context]	0.64	0.30	[0.05, 1.23]	0.032
Causal direction [consequence]	1.52	0.14	[1.25, 1.79]	<0.001
Semantic similarity	2.80	0.75	[1.33, 4.26]	<0.001
Causal direction [consequence] × event context [context]	1.11	0.27	[0.59, 1.63]	<0.001
Random effects				
σ^2	3.29			
τ_{00} (participant)	3.10			
τ_{00} (event)	0.51			
ICC	0.52			
N (participants)	224			
N (events)	24			
Observations	5252			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

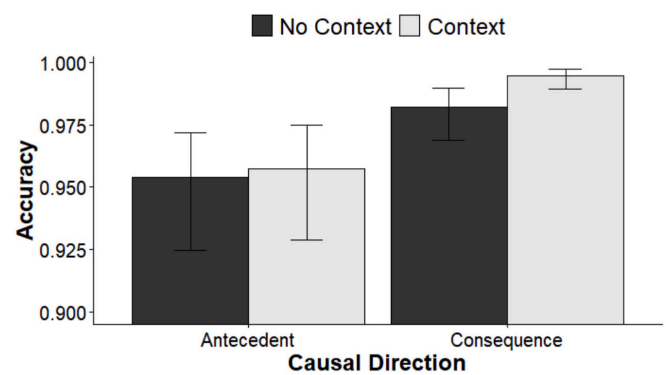

Fig. 5. Interaction between causal direction and context using cross-experiment accuracy data with 95% confidence intervals.

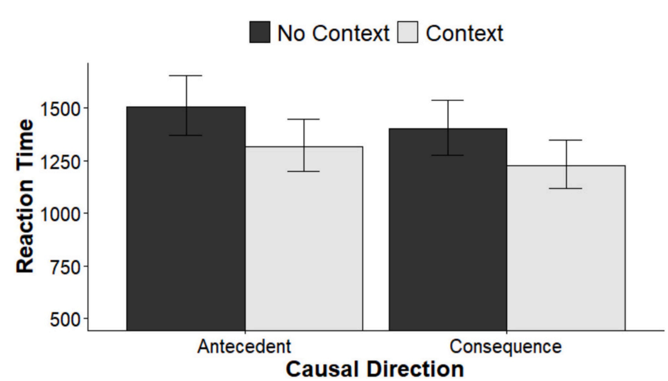

Fig. 6. Cross-experiment reaction time data with 95% confidence intervals.

variance. The interaction model was the final model as the likelihood-ratio test suggests it was the best-fit model (df = 1, χ^2 = 17.97, p < .001). As can be seen in Table 10, there was a significant main effect of event context such that participants had higher accuracy when the event context was provided. When the event context was provided, the expected odds of responding correctly were 1.90 times the odds of responding correctly when the event context was absent (OR = 1.90). There was a significant main effect of causal direction such that participants also had higher accuracy on consequences than antecedents. The expected odds of responding correctly for a consequence were 4.59 times the odds of responding correctly for an antecedent (OR = 4.59). Regarding interaction, there was a significant effect indicating the effect of causal direction is stronger when the event context was provided (OR = 3.03). Specifically, the odds ratio for the effect of causal direction was 7.98 when event context was provided and 2.63 when event context was absent, respectively. As can be seen in Fig. 5, the instantiation of the event schema had a more positive impact on accuracy for consequences compared to antecedents.

For reaction time, the unconditional model suggests that the events account for 1.38% of the variance and subjects account for 24.31% of the variance. The main effect model was the final model because adding the interaction term did not significantly improve the model fit (df = 1, χ^2 = 2.67, p = .102). As can be seen in Fig. 6 and Table 11, there was a significant main effect of event context such that participants responded 12.43% faster when the event schema was instantiated compared to when it was not. There was a significant main effect of causal direction, such that participants responded to consequences 6.96% faster than antecedents. The significant reduction in reaction time as a function of event context suggests that explicitly instantiating the event schema strengthens the activation of all actions within it, which provided higher accessibility and lower reaction time regardless of causal direction.

The cross-experiment analysis on reaction time data indicates that

Table 11
Results of main effects model on reaction time using cross-experiment data.

Predictor	Estimates	*SE*	95% CI	*p*
Fixed effects				
Intercept	1358.84	52.06	[1260.51, 1464.83]	<0.001
Event context [context]	0.88	0.05	[0.78, 0.98]	0.019
Causal direction [consequence]	0.93	0.01	[0.91, 0.95]	<0.001
Semantic similarity	0.64	0.04	[0.57, 0.73]	<0.001
Syllable count	1.01	0.01	[1.00, 1.03]	0.025
Random effects				
σ^2	0.16			
τ_{00} (participant)	0.05			
τ_{00} (event)	0.00			
ICC	0.25			
N (participants)	224			
N (events)	24			
Observations	5252			

Note. *SE* = standard error; CI = confidence interval; ICC = intraclass correlation coefficient.

both antecedents and consequences are activated when an event schema is instantiated relative to when it is not (Fig. 6). However, the accuracy data suggests that the bias toward consequences is strengthened when the event schema has been explicitly instantiated (Fig. 5). As such, event schemas likely support backward and forward causal processing, albeit more so for forward processing.

4. General discussion

It is understood that schemas support event comprehension (Schank & Abelson, 1977; Zacks, Kumar, et al., 2009; Zacks, Speer, & Reynolds, 2009). Presumably they do so by supporting causal processing (Schank, 1986), specifically the activation of causal antecedents and consequences of events. However, the relative extent to which they support the activation of causal antecedents versus consequences has not been systematically investigated. In this study, we identified two structural properties of the event knowledge that might affect the activation of knowledge: the hierarchical structure (Johnson & Keil, 2014) and temporal order (Schank & Abelson, 1977) of schemas and the actions they subsume. Three hypotheses were tested across contexts in which the event schema was instantiated (Experiment 1) or not instantiated (Experiment 2): the Bidirectional Causal Hypothesis, Antecedent Biased Hypothesis, and Consequence Biased Hypothesis. The results supported the predictions of the Consequence Biased Hypothesis. Both Experiments 1 and 2 found main effects of causal direction such that responses are more accurate and faster for causal consequences than causal antecedents. In Experiment 2, the results also showed asymmetric attenuation of activation of consequences relative to antecedents that was predicted by the Consequence-Biased Hypothesis for both accuracy and latency. In addition, the cross-experiment analysis provided evidence that both antecedents and consequences of actions were at a higher state of activation when the schema context was instantiated than when it was not. Taken together, these results show evidence that the hierarchical structure of event schemas supports the activation of causal antecedents and consequences, albeit with a bias toward the activation of consequences.

The current findings are consistent with prior research suggesting that event schemas support prediction during reading (Abelson, 1981; Bower et al., 1979). They are also consistent with studies showing that predictions occur when processing everyday events (Kumar et al., 2023; Reynolds et al., 2007; Zacks et al., 2011). Theories of event cognition postulate that people predict a continuity of events when one is within an event boundary (Zacks et al., 2007), and there is empirical evidence to support this (Wahlheim et al., 2022). While prior research demonstrates that event segmentation and prediction can rely on local, low-level motion cues, such as movement features in abstract displays (Hard et al., 2006; Zacks, 2004; Zacks, Kumar, et al., 2009; Zacks, Speer, & Reynolds, 2009), the results of the present study suggest that high-level event schemas also play a critical role in supporting predictive processes during text comprehension, particularly when processing goal-directed actions.

Notably, the present findings are inconsistent with those of Magliano et al. (1993) and Papenmeier et al. (2019). The results of both studies were consistent with the Antecedent Biased Hypothesis and were conducted in the context of reading narratives. The discrepancy between the results of these studies and those of the current study can be explained if the presence of an episodic context affects the activation of causal antecedents and consequences. During narrative comprehension, the cognitive system prioritizes coherence-building, which is supported by the activation of causal antecedents (Graesser et al., 1994). This might also be true in the context of real-world events, such as those used in Papenmeier et al. (2019). In contrast, when schemas are processed in isolation (as in the current study), the system might default to a simulative or executive mode (Klin et al., 1999).

The consequence bias is consistent with the perspective that event schemas have a planning function (i.e., supporting the achievement of outcomes related to goals) (e.g., Schank, 1994; Schank & Abelson, 1977). This bias could follow from the structural nature of event schemas. Specifically, goal-based event schemas represent sequences of temporally constrained actions. Procedural learning involves learning a forward direct sequence of actions or items (e.g., words, pictures) such that one is learning the next action that needs to be taken (e.g., Lashley, 1951), and goal-directed event schemas should reflect these learning sequences. There is evidence that there is a bias toward activating the next item in a learned sequence relative to prior items (Nissen & Bullemer, 1987), which is consistent with this interpretation of the consequence bias. The asymmetric bias toward consequence is evidenced in other aspects of human cognition, such as the perception of motion (Freyd & Finke, 1984; Hubbard, 2005), lexical access (Elman, 2009; Kutas & Federmeier, 2011), syntactic processing (Altmann & Kamide, 1999; Levy, 2008), discourse processing (Sell et al., 1994), and sequential learning (Cleeremans & McClelland, 1991; Saffran et al., 1996). These areas of cognition might not be influenced by event schema. Thus, this bias toward consequences might be pervasive, reflecting more general predictive processing in the mind and brain (Bar, 2007; Clark, 2013; Friston, 2005).

However, schemas also support explanation (e.g., Schank, 1986), and as noted above, the cross-experiment analyses found evidence that providing the schema context led to an increase in activation of antecedents relative to when it was not provided. It is possible that using antecedents and consequences to support event cognition is flexible depending on the task and context. In the context of narrative comprehension, where coherence is important (e.g., Kintsch, 1988), there may be a bias toward the activation of antecedents to support establishing coherence (Graesser et al., 1994). More research is needed to identify the mechanisms that underlie the consequence bias.

Regarding the attenuation of the antecedents and consequences over temporal distance, the results of the study were mixed. Experiment 1 showed a main effect of temporal distance but no interaction, whereas Experiment 2 showed the asymmetric pattern consistent with the Consequence Biased Hypothesis. One possible explanation might have to do with the differences in the level of activation of the antecedents and consequences across experiments. The cross-experiment analysis suggested that both antecedents and consequences were more highly activated when the event context primes were present than when they were not. In Experiment 1, it may have been the case that the level of activation of both antecedent and consequence was at a sufficiently high level that the attenuation of activation over temporal distance was at a comparable rate. In contrast, in Experiment 2, the differences in the level of activation for antecedents and consequences led to the predicted pattern reflective of asymmetric attenuation.

Although the results of accuracy and latency for the analyses for Experiments 1 and 2 were largely consistent, there was a discrepancy in the cross-experiment analysis. Specifically, causal direction interacted with event-context instantiation for accuracy, suggesting that the consequence bias was stronger when the event schema was instantiated. Such an interaction was not observed with reaction time. This discrepancy warrants further consideration and it may be understood in the context of the task. The task required participants to make deliberate decisions about the relationship between the prime and target actions. As such, performance was likely influenced by both the activation of antecedents and consequences and the controlled processes necessary to make relatedness judgments. Latency may be sensitive to the automatic processes that support the task, whereas accuracy is sensitive to deliberate, controlled aspects of the task. The cross-experiment analysis had more power than the individual experiments because it doubled the number of participants in the analyses. Future studies should replicate the present findings with tasks (e.g., naturalistic reading) and measures (e.g., eye movements, event-related potentials) that do not require an explicit decision.

We included Word2Vec cosine similarity in order to control for the impact of semantic similarity between prime actions and target actions, which was a significant predictor of accuracy (Experiment 2) and response latencies (Experiments 1 and 2). Word2Vec and other distributed semantics models (e.g., Latent Semantic Analysis) capture related units of language (e.g., words, clauses, paragraphs, text) based on overlap in lexical items (e.g., Landauer & Dumais, 1997; Mikolov et al., 2013). Given that there was variability in semantic similarities (despite having a common lexical item in prime and target sentences), the significant fixed effect of similarity is not surprising because it is well established that lexical items can prime semantic content based on word level associations (Meyer & Schvaneveldt, 1971). For the purposes of the present study, the results demonstrate that the consequence effect occurs over and above the lexical associations that are reflected in the Word2Vec semantic space.

An important issue to consider is the extent to which action primes independently activate the event schemas. In order to create the items, we selected actions from the pilot study that were based on a combination of constraints on the temporal order of actions, the affordance of a common lexical item across actions, and the proportion of participants mentioning the actions. It is inappropriate to use the proportion of mention as a proxy for the diagnosticity of a schema because this variable is also based on the uniqueness of the association of actions with the schema (e.g., Magliano et al., 2008). Moreover, the small sample for the pilot study did not afford using the proportion scores as a normative representation of their association with the schema. The fact that we found similar results across the two experiments regarding the consequence bias suggests that the event schemas were activated in Experiment 2. Future studies should systematically manipulate the diagnosticity of action primes to evaluate its contribution to schema instantiation and the subsequent activation of causal antecedents and consequences. This requires a more normative representation of the event schema than afforded by the pilot study (Brown et al., 2024).

5. Conclusion

The results of this study provide evidence that event schemas support the activation of both causal antecedents and consequences, but with a distinct bias toward consequences. These align with theories of event cognition (Zacks et al., 2007) and foundational research on event schemas (Schank & Abelson, 1977), which emphasize that event knowledge is structurally organized to support the prediction of future actions. While the present study examined schemas in isolation, the robust consequence bias we observed suggests a fundamental functional link to episodic context. Therefore, future research should move beyond studying these systems separately to understand how episodic context and event schemas interactively determine the activation of event knowledge. Moreover, we process events in the context of goals (Graesser et al., 1994), and future research should address how goals affect the activation of antecedents and consequences (Magliano et al., 1999). Understanding how event schemas support causal processing both in terms of bridging and prediction is important for understanding how coherence is achieved in event comprehension.

CRediT authorship contribution statement

Shu Hu: Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Joseph P. Magliano:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Sashank Varma:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization.

Ethics declaration

Written informed consent to take part in the study and to publish the article has been obtained from all participants or their legal representatives. The privacy rights of participants have been observed.

This study was performed in compliance with relevant laws, regulatory frameworks and guidelines where the research took place.

This study was approved by the Georgia State University Institutional Review Board (Approval No. H24058).

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Data availability

All data have been uploaded to OSF and a view-only link has been added to the manuscript.

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