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# **Proceedings of the Annual Meeting of the Cognitive Science Society**

### **Title**

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### **Permalink**

<https://escholarship.org/uc/item/3vg064rv>

### **Journal**

Proceedings of the Annual Meeting of the Cognitive Science Society, 43(43)

### **ISSN**

1069-7977

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### **Publication Date**

2021

Peer reviewed

# Possibility Judgments May Depend on Assessments of Similarity to Known Events

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## Abstract

We explore whether people's judgments about the possibility of events are predicted by their knowledge of similar events. Participants read 80 events from a list including events that were ordinary, unusual, and impossible. Participants rated whether the events were possible or whether the events were similar to events they knew to have happened. The averaged ratings for each judgment were strongly correlated, and the correlation remained significant in an analysis limited to a subset of the events that were neither viewed as totally impossible, or as extremely similar to known events. These findings provide preliminary evidence that adults may judge whether events are possible by relying on a memory-based heuristic which aims to identify whether these events are similar to known events.

**Keywords:** possibility; similarity; extraordinary events; availability heuristic

## Introduction

The ability to decide what is possible and impossible is essential for both individuals and for society as a whole. Individuals prioritize planning for possibilities, such as unseen financial and medical crises, and avoid structuring their lives around impossibilities, such as planting a money tree or becoming young again. Similarly, societies allocate resources to goals that seem attainable, such as curing cancer and sending humans to Mars, while avoiding wasting time and effort by chasing seemingly impossible outcomes, such as attaining immortality or sending humans back in time. By correctly differentiating the possible from the impossible, people ensure that they do not miss out on important opportunities or work towards unattainable ends.

Many possibilities are known to us by mere familiarity; we have seen things happen, so we know that they are possible. But how do we judge the possibility of events that we have *not* encountered or heard about, or even the possibility of events that have yet to occur for the first time? Here, we explore whether people's views about the possibility of unfamiliar events are driven by knowledge of *similar* events that are known to be possible (Goulding & Friedman, 2021).

If familiarity with an event is a prerequisite for it to be considered possible, people should judge any unfamiliar event as being impossible. Indeed, children often seem to do exactly this (e.g., Cook & Sobel, 2011; Danovich & Lane, 2020; Goulding & Friedman, 2020; Lane et al., 2016; 2018; Shtulman, 2009; Shtulman & Phillips, 2018). Young children

always agree that a person could do something common and familiar, such as wearing a hat or washing a car, but are either ambivalent or dismissive towards most strange and unfamiliar events, such as a person finding an alligator under their bed or catching a fly with chopsticks. Yet adults routinely judge these same strange events—which are completely unfamiliar to them—as being perfectly possible, despite having no confirmation that these events have occurred or could occur (Shtulman, 2009; Shtulman & Carey, 2007). Further, adults often judge extraordinary events that *cannot* yet occur, such as traversing the Milky Way or performing a successful brain transplant, as being possible (Shtulman & Tong, 2013). This is especially surprising given that these events have occurred as often, and are therefore just as rare, as events people know to be truly impossible, like walking through a brick wall or growing younger (Shtulman, 2009). So these possibility judgments cannot be rooted in mere familiarity, and must be driven by other mechanisms of inference.

One potential explanation is that possibility judgments for unfamiliar events are driven by knowledge of causal circumstances. For instance, a person might feel they know *how* an event could occur, even if they have not encountered the event or heard of its occurrence. Some support for this can be found in both children and adults' justifications for their possibility judgments. Adults often use conditional explanations when justifying why an event *can* happen and principled explanations when justifying why an event *cannot* happen (Shtulman & Tong, 2013). Both conditional and principled explanations appeal to causality in some sense; conditional explanations identify circumstances that would enable an event, while principled explanations identify causal laws that would render events impossible. In contrast with adults, children typically *deny* that rare events can occur, but they too sometimes justify their decisions by appealing to causal circumstances (Nolan-Reyes et al., 2016; Shtulman, 2009). Indeed, children even provide explanations that reference mundane causal circumstances when asked to explain how events they *know* to be impossible could happen (Nancekivell & Friedman, 2017; Woolley & Cornelius, 2017). Together, these findings suggest that people hold causal considerations in mind when inferring possibility, and that greater knowledge of causal circumstances may be key to viewing more events as possible.

But there is also evidence of other, less obvious factors playing an important role in people's reasoning about

possibility. Perhaps the clearest demonstration of this can be found in the interaction between moral and modal judgment: both children and adults are hesitant to endorse events as possible when the events violate moral rules or social customs (Browne & Woolley, 2004; Cimpian & Salomon, 2014; Chernyak et al., 2013; Kalish, 1998; Komatsu & Galotti, 1986; Levy, et al., 1995; Lockhart et al., 1977; Miller et al., 2000; Phillips & Cushman, 2017; Shtulman & Phillips, 2017; Shtulman & Tong, 2013). Some work suggests that adults may even struggle to *imagine* fictional events and worlds that violate their moral intuitions (Barnes & Black, 2016; Black & Barnes, 2020).

These findings suggest that causal concerns are insufficient to explain modal intuitions. Further, it is difficult to fully reconcile a causal account with adults' affirmations that yet-impossible events are possible (e.g., travelling the Milk Way, performing a brain transplant). Put simply: the circumstances that would enable these events are not fully known to *anyone*, hence why the events have yet to be realized. So people are either relying on partial or vague circumstantial reasoning to infer possibility, or their inferences are partly guided by something else.

Here we explore an alternative mechanism for inferring the possibility of unfamiliar events, where events are more likely to be judged possible if they are *similar* to a known event (Woolley & Ghossainy, 2013). This memory-based heuristic is similar to an availability heuristic (Tversky & Kahneman, 1973), but involves recalling events that are only *similar* to the event in question rather than the event itself. This heuristic can explain why people view wholly unfamiliar events as possible, as these events may be viewed as similar to events that they know to have happened. It may also explain why people view yet-impossible events as possible, as they may view these events as superficially similar to currently possible events. For instance, people may judge a brain transplant as possible because it is "similar" to a heart transplant, and may view travelling the Milky Way as possible because it is "similar" to traveling to the moon.

Recent work suggests that children use such a strategy to infer the possibility of improbable events (Goulding & Friedman, 2021). When 4.5- to 6-year-old children are told improbable facts (e.g., a person owning a pet elephant), they often judge that similar improbable events are also possible (e.g., a person owning a pet zebra), despite usually denying the possibility of these same events. Importantly, the similarity between the facts and events is important; children do not simply affirm improbable events after hearing *any* improbable fact. These findings suggest that children's possibility judgments are directly guided by their knowledge of what has happened (Woolley & Ghossainy, 2013), and that their beliefs about possibility can change without also learning *how* events might occur. Further, this work suggests that the development of modal reasoning (i.e., coming to view improbable events as possible) at least partly hinges on greater knowledge of unlikely occurrences. Some work has also explored the relation between familiarity and modal judgment in adults, finding that adults judge alternative,

counterfactual worlds (e.g., a world in which fire freezes) as more plausible if they also see these worlds as being similar to reality (De Brigard et al., 2021). However, no work has directly explored whether adults use knowledge of similar events to infer whether strange and rare events are actually possible.

## The Current Experiment

Here, we explore whether adults' possibility judgments are predicted by their knowledge of similar events. We cannot easily manipulate adults into believing that improbable events are possible (since they usually already do), but we *can* measure whether adults' confidence that an event is possible is predicted by their confidence that something similar has already happened. To this end, we asked two separate groups of adults to rate either their confidence that events could happen or their familiarity with the events. This between-subjects design allowed us to obtain separate ratings of possibility and similarity while keeping participants ignorant to the fact that one judgment might influence the other. This study therefore looks at inter-*item* correlations rather than inter-*participant* correlations. In other words, we investigated whether the likelihood that an *event* is judged possible is predicted by its general familiarity among American adults.

In the present study, we assessed adults' judgments of possibility by asking for graded rather than binary judgments. Rather than judging events as "possible" or "impossible", we asked participants to rate each item on a 5-point Likert scale for both possibility and similarity. Most studies of possibility judgments have asked children and adults (when they have been tested) for binary judgments. For example, participants have been asked yes/no questions about whether events could happen (e.g., Goulding & Friedman, 2020; (Phillips & Cushman, 2017; Shtulman & Carey, 2007; Shtulman & Phillips, 2018; Shtulman & Tong, 2013) or would require magic to occur (e.g., Rosengren & Hickling, 1994; Subbotsky, 2004). However, a few studies have asked for more graded judgments in children (e.g., Lane et al., 2016; 2018) and adults (e.g., Phillips & Cushman, 2017; Shtulman & Morgan, 2017), and have revealed comparable patterns.

## Methods

The design and analysis plans were preregistered at [aspredicted.org](https://aspredicted.org) and can be found at [aspredicted.org/blind.php?x=m67a5d](https://aspredicted.org/blind.php?x=m67a5d). We followed this preregistration in all regards except for a design oversight in Qualtrics leading participants to gain an extra attempt at answering the first comprehension check.

## Participants

We tested 303 American adults ( $M_{\text{age}} = 36.6$  years, 198 males, 103 females, 2 other) via Amazon Mechanical Turk. After exclusions, 120 participants ( $M_{\text{age}} = 38.3$  years, 65 males, 53 females, 2 other) were included in the analyses; our exclusion criteria are described below.

## Materials and Procedure

We created a list of 80 events borrowed largely from previous work on children and adults' reasoning about possibility (Lane et al., 2016; Shtulman, 2009; Shtulman & Carey, 2007; Shtulman & Tong, 2013). To ensure that our list captured the breadth of adults' intuitions about possibility, we included items that we judged *a priori* to be ordinary (10), improbable but currently possible (28), plausible in the future (14), and patently impossible (28). The 80 events were grouped into sets of 10 and presented to participants across 8 blocks. The sets were randomly generated, and participants viewed events and blocks in a completely random order.

Participants were randomly assigned to one of two between-subjects conditions: possibility or similarity. In our final sample of 120 participants, 56 were in the possibility condition, and 64 were in the similarity condition. In the possibility condition, participants were asked if they thought the events could ever happen in real life. In the similarity condition, participants were instead asked if they had heard of the event, or a similar event, happening in real life. In both conditions, participants gave their answers on a scale from 1 (Definitely No) to 5 (Definitely Yes).

To be included in the final analyses, participants had to pass several comprehension checks. These checks were preregistered and were meant to ensure that participants' responses reflected genuine intuitions rather than lazy or inattentive responding. First, participants were asked a 4-option multiple choice question at the beginning of the study to ensure that they read the instructions correctly; participants were excluded if they did not pass this check by their third attempt. Second, participants were excluded if they failed to appropriately respond to two ordinary items ("A person wearing a baseball cap", "A person eating an apple") with ratings greater than 3, and if they failed to appropriately respond to two impossible items ("A person eating lightning for dinner", "A person living for a thousand years") with ratings less than 3. Finally, participants were excluded if they failed to respond to at least 75 events.

## Results

See Figure 1 for average scores of possibility and similarity for all 80 items. We first analyzed the correlation between each event's possibility and similarity score. This revealed a very strong positive relation between possibility and similarity,  $r(78) = .92, p < .001$ .

We then performed a second analysis with all decidedly similar items and decidedly impossible items removed. For our purposes, we considered any item with a modal similarity score of 5 to be decidedly similar, and any item with a modal possibility score of 1 to be decidedly impossible; these criteria were pre-registered. Our reasoning for removing decidedly similar items is that any fully familiar item is necessarily possible; comparably, any decidedly impossible item cannot be known to participants and is unlikely to be similar to any other possible events. This left us with 18 ambiguous items that participants judged as neither entirely possible nor entirely dissimilar from other events they know.

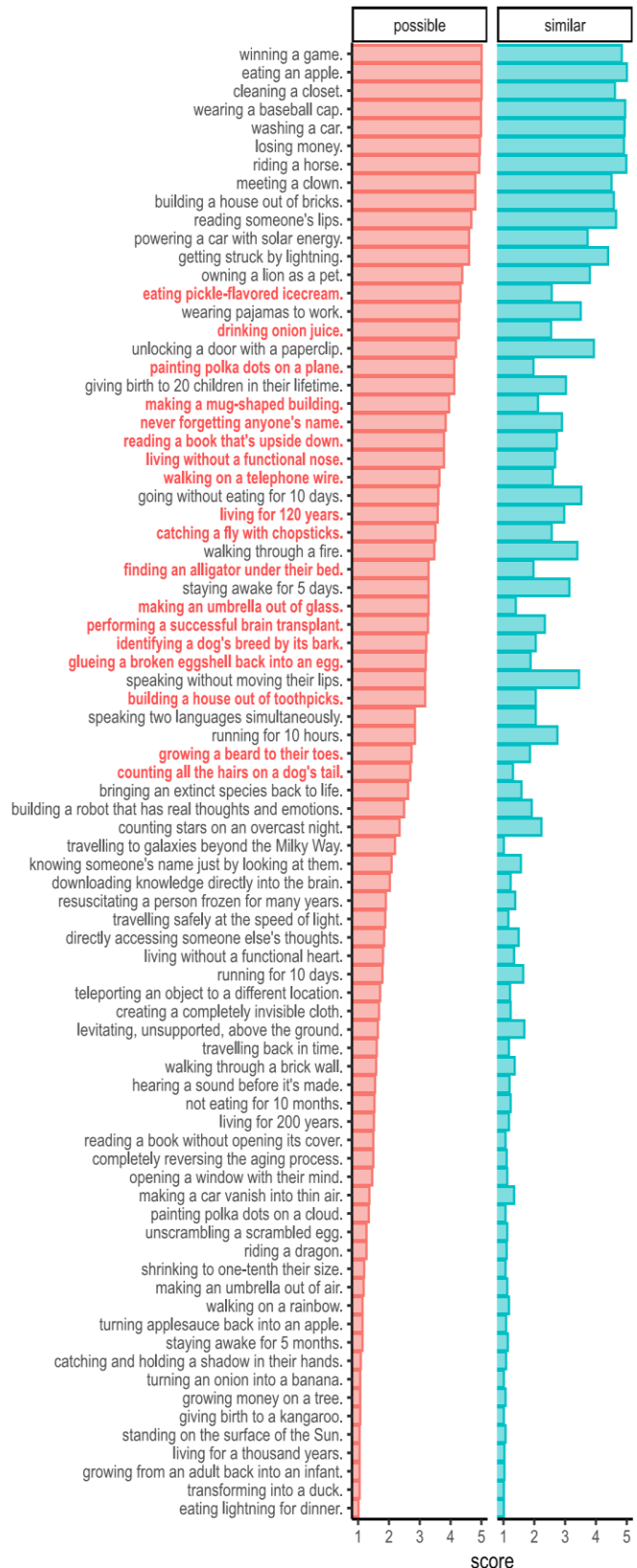


Figure 1: Participants' average judgments of possibility and similarity for all 80 events, listed in descending order of possibility. The 18 ambiguous events are red and bolded.

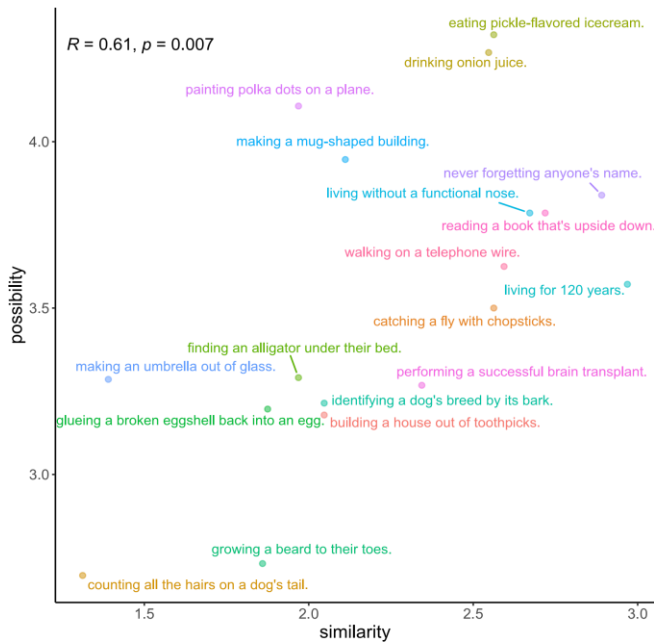


Figure 2: Scatterplot of the relation between possibility and similarity for the 18 ambiguous items. Scores could range between 1 and 5; note that these axes do not show the full range of scores and have different start and end points.

For these items, we again examined the correlation between participants' average possibility scores and their average similarity scores; see Figure 2. This analysis also revealed a moderate correlation between possibility and similarity judgments,  $r(16) = .61, p = .007$ .<sup>1</sup>

## Discussion

We found that adults' averaged ratings of whether various events are possible correlate with their averaged ratings of whether they could think of similar events. Moreover, these sets of judgments remained correlated when we excluded events that were widely regarded as impossible, and events widely regarded as similar to known events. These findings provide preliminary evidence that adults' judgments about whether events are possible may often depend on a memory-based heuristic. Adults may judge whether events are possible by consulting their memory to see if they can recall information about similar events having occurred.

The correlation between possibility and similarity ratings is most informative if we focus on the 18 ambiguous events from our set—the events that were neither viewed as outright impossible or outright similar to known events. Almost under any account of possibility judgment the correlation would be expected for the other non-ambiguous events. For example, it might seem inevitable that people would not know of events similar to outright impossible events. However, for the ambiguous events, this correlation was not inevitable and

might not be expected on alternative accounts of how people determine whether events are possible. For example, this correlation would not necessarily be expected if possibility judgments stem from a process wherein adults ask if they can identify causal principles that would prevent an event from arising (Shtulman & Carey, 2007; Shtulman & Tong, 2013), and affirm the event is possible if nothing comes to mind.

Recent work suggests that young children *may* also use this memory-based heuristic to decide whether events are possible (e.g., Bowman-Smith et al., 2018; Goulding & Friedman, 2020, 2021). *Prima facie* the suggestion that children and adults might use the same heuristic might seem very odd! After all, previous research suggests that children and adults reach very different conclusions about whether events are possible. For example, most work in this area suggests that children often deny the possibility of improbable and unusual events, whereas adults overwhelmingly affirm these events can happen (Cook & Sobel, 2011; Shtulman, 2009; Shtulman & Carey, 2007; Shtulman & Phillips, 2018).

We raise two points in response (to this potential concern). First, developmental differences are anticipated by the memory-based heuristic account. Adults have experienced more than children, and have also acquired more second-hand knowledge. So they should be able to draw on a broader array of memories and knowledge when trying to call to mind events similar to the event under consideration. It is likewise possible that we might see developmental differences in memory processes (e.g., the ability to search memory for similar events; see Levy & Anderson, 2002) or the degree of similarity required between the event under consideration and any called to mind (Chen, 1996; Chen & Klahr, 2008; see also Medin et al., 1993). Second, our findings hint that the differences between children's and adults' possibility judgments may be less stark than they might seem. Studies on children have generally found that young children view improbable events differently from impossible ones. Although they often deny that improbable events can happen, they are nonetheless more likely to deny this for events that are outright impossible. They have also been shown to clearly differentiate between improbable and impossible events (e.g., Weisberg & Sobel, 2012), despite usually denying the possibility of both. And when we asked adults about these same kinds of improbable items, their possibility scores were often *not* at ceiling. Hence, both children and adults may view improbable items as neither fully possible nor impossible.

The present findings provide a first hint that adults may use a memory-based heuristic when judging whether events are possible, but the findings are only preliminary. One shortcoming is that we looked at correlations between ratings averaged across many participants, which cannot tell us whether a person's likelihood of affirming an event is dependent on whether they can recall a similar one. Stronger evidence for relations between these two kinds of judgment

<sup>1</sup> Due to the large number of exclusions, we also performed both analyses with the full sample of participants. This revealed similar results: possibility and similarity strongly correlated,  $r(78) = .92, p$

$<.001$ , and a moderate correlation between similarity and possibility emerged for the 18 ambiguous items,  $r(16) = .57, p = .010$ .

would come from a study assessing whether individual participants show the same correlation. And stronger evidence than this might require evidence from experimental manipulations, where adults are shown to affirm new events as possible after learning about similar events. As stated earlier, this may be difficult given that adults usually affirm that even the most unlikely events are possible at baseline. However, future studies might seek to shake their confidence in truly impossible events by presenting them with superficially similar ones. For instance, presenting adults with surface-level information about quantum superposition may lead them to feel less confident in the strict impossibility of an object being in two places at once.

It is important to know whether a correlation between similarity and possibility would still emerge if participants were instead asked to make binary judgments of possibility (i.e., possible or impossible). As mentioned earlier, findings from studies using binary versus continuous ratings of possibility usually yield comparable results (e.g., Phillips & Cushman, 2017). But a continuous rating of possibility is not necessarily a true possibility judgment. Possibility *is* binary—something can happen, or it cannot. So a scalar measure of possibility might really be capturing something else, such as beliefs about the likelihood that an event has occurred or will occur. Our findings might therefore show that knowledge of similar events impacts judgments about the *likelihood* of events. Previous work with children suggests that knowledge of similar events positively impacts strict (i.e., binary) possibility judgments (Goulding & Friedman, 2021), so we might expect the same to be true for adults as well. But a further study with a binary measure is necessary to tease apart the role of similarity in driving beliefs about likelihood versus strict possibility.

Further, a single continuous rating of similarity cannot capture the source and kind of peoples' memories. We asked participants if they had heard of similar events occurring in real life, but their judgments may rely on different kinds of encounters. For instance, some participants may have recalled first-hand experiences, whereas others may have recalled facts they read in a book or on the internet. Children who learn about events from different information sources (e.g., hearsay, the internet) express varying levels of confidence in whether the events could actually occur (Danovitch & Lane, 2020; Lane et al., 2018). Future work should explore whether the same holds true for adults, and whether events learned from different sources lead to different ratings of familiarity and possibility.

It is also unclear whether adults meaningfully quarantine memories of events encountered in alternative worlds, such as fictional books and movies, from events encountered in real-life contexts, like first-hand encounters or the news, when inferring possibility. Some work has shown that children and adults integrate facts learned from fiction into their understanding of the world (Appel & Richter, 2007; Fazio & Marsh, 2008), though other findings suggest that adults are less likely to do so when facts are presented in highly fantastical contexts (Rapp et al., 2014). But it remains

possible that adults' possibility and similarity ratings for events—especially the most extraordinary ones—are partly driven by memories of fiction as well as reality.

One reason we suspect the memory-based heuristic contributes to possibility judgments is that often, there may be no other basis for determining whether events are possible. For example, consider items like *living for 120 years* and *living for 200 years*. These items received markedly different possibility ratings (Shtulman, 2009; Shtulman & Tong, 2013), but it is unlikely that most people would be aware of causal principles that might prevent (or enable) one outcome but not the other. Instead, the difference could arise because participants will be aware of individuals living to ages approaching 120 years, but not to ages approaching 200. In this sense, similar events may serve as anchors from which we adjust to infer the possibility of the unfamiliar and unknown (Tversky & Kahneman, 1974), despite knowing little about how even common events arise.

## Acknowledgments

This research was supported by grants from the Natural Sciences and Engineering Research Council of Canada awarded to BG and OF.

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