

Correlates of Confidence in Metamemory Beliefs

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Statement of Contribution

This work was supported by funding from the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Canada Research Chairs program to Dr. Evan Risko.

This research was conducted at the University of Waterloo by Isabelle Simionescu under the supervision of Dr. Evan Risko. Dr. Evan Risko and Isabelle Simionescu contributed to study design and participant recruitment. Isabelle Simionescu conducted the primary coding of the data analyses. Evan Risko reviewed coding and analysis. Isabelle Simionescu wrote the draft manuscripts, which Dr. Evan Risko reviewed, edited and contributed intellectual input on. Dr. Samuel Johnson and Neil Hester also reviewed and contributed intellectual input on the final manuscript.

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Abstract

How we think about our thinking (metacognition) plays a critical role in how we perform day-to-day activities. An important part of our metacognitive lives are the beliefs we have about how our minds work. Among these are metamemory beliefs, which refer to people's beliefs about how memory works. In the present investigation, I examine a novel potential correlate of individuals' confidence in such beliefs: the presence of causal reasoning. Across two experiments, participants read descriptions of a cognitive task that featured a manipulation and were asked to provide a prediction about its outcome. I used this prediction as an index of their belief about how the manipulation influences our thinking. Participants were then asked to provide a confidence judgement about that belief, followed by a justification for their prediction, and finally another confidence judgement. Justifications were then coded for the presence of causal reasoning, defined as attributing the predicted memory outcome to an underlying cause beyond the manipulation itself. In Experiment 2, which had sufficient power to detect the small association between causal reasoning on confidence, I found that the presence of causal explanations in participants' justifications was significantly associated with higher confidence in their prediction. Nonetheless, only about one-quarter of participants provided such causal explanations for their prediction. Additionally, I observed that participants' confidence increased after they generated a justification for their prediction, indicating that explaining one's beliefs may reinforce, rather than undermine, confidence in them.

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General Introduction

Beliefs play a central role in human cognition, fundamentally shaping how we interpret our experiences and interact with the world around us. An important class of beliefs are metacognitive beliefs which are beliefs about how our minds work. These beliefs contribute to both our monitoring of our thinking, as well as the strategies used to control it (Dunlosky & Thiede, 2013). In my Master's thesis, I examine one potential correlate of the confidence we have in our metacognitive beliefs, focusing specifically on our beliefs about memory (i.e., metamemory beliefs).

Metamemory beliefs are the set of beliefs people hold about how their own memory functions (Dunlosky & Thiede, 2013). These beliefs shape how people interpret memory experiences and guide their choices about remembering (i.e., the control of memory processes). For example, many students believe that re-reading notes or textbook passages enhances retention (e.g., Carrier, 2003; Karpicke et al., 2008), leading them to prepare for exams by re-reading the study material. Much of the existing research on metamemory beliefs has focused on their content, particularly on what individuals believe about how memory functions. To examine these beliefs, researchers often use vignette-based methods, presenting participants with descriptions of previous memory experiments and asking them to predict past participants' recall performance under different conditions. This approach allows researchers to separate people's beliefs from immediate processing experiences, such as fluency or effort, and instead evaluate the underlying theories individuals hold about memory (Koriat, 2004). For example, Mueller et al. (2014) had participants read a vignette that described a past memory experiment in which participants had to memorize a list of words, half of which were a large font-size and half of which were a small-font size. Participants then estimated the number of words the past

participants had remembered from each condition (e.g., number of words remembered in small versus large-font size). Overall, they found that participants predicted better memory performance for large-font size words compared to small-font size words without performing the experiment themselves. From these findings, Mueller et al., (2014) concluded that people have an a-priori theory about how memory operates in that larger words are easier to remember than smaller words. This kind of approach has been used to study and identify a variety of different metamemory beliefs. For example, through this approach researchers have found that people generally believe concrete words are more memorable than abstract ones (Witherby & Tauber, 2017), high-frequency words are easier to remember than low-frequency words (Jia et al., 2016), semantically related pairs are more memorable than unrelated pairs (Mueller et al., 2013), loud words are better remembered than quiet ones (Frank & Kuhlmann, 2017), and identical word pairs are better recalled than related ones (Mueller et al., 2016).

As noted above, research investigating metamemory beliefs has focused on the content of people's beliefs. Here, I focus on a different characteristic of belief. Beliefs can be defined as a type of propositional attitude, which consists of two key components: a proposition (for example, "it is raining") and the mental stance or attitude one takes toward the truth of that proposition (for example: "I believe it is raining"). Belief is just one type of attitude a person can hold toward a proposition; other attitudes include hoping ("I hope it is raining"), desiring ("I wish it were raining"), or fearing ("I'm afraid that it is raining") that the proposition is true. While beliefs can clearly vary in their content (i.e., the proposition), some have suggested that beliefs can also differ in strength, that is, individuals may hold them with varying levels of confidence (Ramsey, 1926). For example, a person might be 70% confident that a bone they have broken will heal without surgery. Jackson (2020) argued that beliefs involve one of three distinct stances one can

take towards a proposition: believing a proposition to be true, disbelieving it, or withholding judgment on the nature of its truth. In contrast, credence, the degree of confidence a person has in the truth of a proposition, can, in principle, range across infinitely many values. Credences are more fine-grained than beliefs in that they are typically expressed as values between 0 and 1, where 1 signifies complete confidence that the proposition is true, and 0 signifies complete confidence that it is false (Jackson, 2020). Related to the notion of confidence in one's belief is the construct of attitude certainty. Attitude certainty refers to the subjective sense of conviction one has about an attitude (Tormala & Rucker, 2007). It can be measured by asking participants to rate how certain they are about their attitude toward a given item or by asking how likely they believe it is that their attitude might change in the future. Although no research has directly examined confidence in metamemory beliefs, the factors identified in the attitude certainty literature may offer a useful starting point for understanding how confidence is shaped in this domain.

Previous research has identified multiple factors that influence attitude certainty. One such factor is accessibility: attitudes that have been repeatedly expressed are more easily retrieved from memory, which leads to greater certainty (e.g., Holland et al., 2003). Another factor is ease of retrieval. For example, when individuals were asked to list only three arguments in favor of doctor-assisted suicide instead of seven, the task was easier for them, which led them to feel more confident in their beliefs after generating their arguments (Haddock et al., 1999). A third factor is the type of experience through which the attitude was formed in that attitudes based on firsthand experiences typically inspire greater certainty than those formed through second-hand sources, such as reading or observation (e.g., Fazio & Zanna, 1978; Wu & Shaffer, 1987). Together, these findings suggest that multiple cognitive and experiential factors can shape

the confidence people place in their attitudes. In the present investigation, I extend the examination of confidence in one's beliefs or attitude certainty to the metamemorial domain and test of novel correlate of that confidence based on Conviction Narrative Theory (CNT; Johnson et al., 2023).

Conviction Narrative Theory (CNT; Johnson et al., 2023) provides a framework for understanding how people generate a sense of conviction in their decisions when faced with uncertainty. According to CNT, sense-making and decision-making are guided by narratives, which are structured representations of causal, temporal, analogical, and emotional (valence) relationships. In the context of metamemory beliefs, individuals may form their beliefs based on internally constructed narratives about how memory works. For example, someone might hold a belief that a particular study strategy, such as self-testing, enhances memory retention. This belief may be embedded within a broader narrative that causally explains why the strategy works, draws on past experiences or analogies, and evokes a positive emotional response. These elements together may increase the perceived coherence and credibility of the belief, thereby enhancing the individual's confidence in it. According to CNT, the presence of a causal structure in a narrative (i.e., the presence of a clear cause-and-effect relationship) plays a critical role in strengthening conviction. The present study examined whether the inclusion of causal reasoning in participants' explanations of their metamemory beliefs is associated with their confidence in those beliefs.

Present Investigation

In the present investigation, I examined whether confidence in metamemory beliefs is associated with the causal structure underlying individuals' narratives. Specifically, I tested whether people express greater confidence in their memory beliefs when their explanations for

having these beliefs describe a clear cause-and-effect relationship. To examine this idea, I presented participants with a vignette about a memory experiment that manipulated repetition and had them predict its outcome. Specifically, the vignette described a memory experiment in which participants were asked to memorize a list of words and recall them later. Half of the words were described as being shown twice (i.e., repeated-presentation condition), while the other half were described as being shown once (i.e., single-presentation condition). I selected this specific vignette because I anticipated a strong consensus in participants' predictions, which allowed me to set aside variation in the specific belief. As noted above, this vignette-based method is a popular method to elicit beliefs about memory (e.g., Koriat, 2004; Kornell, 2011; Mueller, 2014). Novel to the present investigation, we also asked individuals to rate how confident they were in this belief. To attempt to uncover the narrative underlying this belief participants were asked to provide justifications for their prediction. As noted above, Mueller and colleagues' (2014) examined participants' beliefs about font size and memory using the vignette approach. After providing their predictions, participants were asked to justify their predictions. The researchers found that participants often explained their prediction that large-font words would be remembered better than small font words by referencing underlying psychological mechanisms. For example, many believed that larger words were more distinct or attracted more attention, which would lead to better recall, reflecting an effort to draw on causal narratives to support their judgments. In my experiments, participants justifications were used to determine whether participants' underlying narrative included a causal element. Specifically, justifications were coded for whether participants attributed the predicted memory outcomes to an underlying cause beyond the experimental manipulation. For example, a participant might predict better memory performance in the memory task for words shown twice (i.e., the repeated-presentation

condition) compared to words shown once (i.e., the single-presentation condition). To explain their prediction, participants might cite a specific cause, such as having more time to study the repeated words, which may reflect an underlying causal narrative about how memory works. Such narratives may increase the perceived coherence and credibility of the beliefs informing participants' prediction, which may in turn boost their confidence in that prediction.

The process of articulating a justification for a memory prediction may itself influence the confidence individuals have in their metamemory beliefs. Research examining the illusion of explanatory depth (IOED) has demonstrated that providing an explanation can reduce confidence in one's understanding of mechanical phenomena (Rozenblit & Keil, 2002). This effect occurs primarily because people often overestimate their knowledge and the act of generating explanations forces them to confront gaps in their understanding (Rozenblit & Keil, 2002). The tendency for people to overestimate their knowledge is particularly evident in assessments of causal knowledge, where individuals often overestimate their understanding of matters such as how a zipper works, how an earthquake occurs, how symptoms of mental health disorders develop, and even their ability to justify their position on political issues (e.g., Fisher & Keil, 2014; Mills & Keil, 2004; Rozenblit & Keil, 2002; Vitriol & Marsh, 2018; Zeveney & Marsh, 2016). Given that metamemory beliefs also involve causal assumptions about how memory functions, asking participants to justify their memory prediction may reveal similar overconfidence, potentially altering their confidence in these beliefs as they confront gaps in their understanding. To test this idea, participants rated their confidence both before and after generating explanations, allowing us to compare the two and determine whether explanation generation influenced their confidence in their prediction.

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Data, pre-registrations, and analysis code for the reported analyzes are available at [E1 pre-registration: <https://osf.io/g4kbr/>E2 pre-registration: <https://osf.io/xryjq/>Data and analysis code: <https://osf.io/xryjq/files/>]. Data was analyzed using R, version 4.5.1. (R Core Team, 2025). This study's design and its analysis were pre-registered on Open Science Framework.

Experiment 1

Participants

A total of 201 participants were recruited through Prolific to take part in this online study. Prior to data collection, an a-priori power analysis was conducted using G*Power to determine the necessary sample size to detect a small effect ($d = .30$) with 80% power ($\alpha = .05$) using an independent samples t-test, assuming equal group sizes. Participants were pre-screened to have completed between 100–1000 previous submissions on Prolific and have a 98–100% approval rating. Participants ranged in age from 18 to 76 ($M = 37$, $SD = 14$).

Table 1

Demographic Data for Experiment 1 Sample

Demographic Variable	Chosen Option	Percentage
Gender	Man or Transman	54%
	Woman or Transwoman	43%
	Another option	2%
Ethnicity	White	72%
	Black	6%
	Asian	21%
	Another provided option	13%
Education	No formal education	2%
	High school diploma	23%
	College diploma	17%
	Bachelor's degree	37%
	Master's degree	14%
	Doctoral degree	5%

Stimuli, Measures and Procedures

After providing informed consent, participants completed a demographic questionnaire including age, gender, ethnicity, highest level of education, and English proficiency. They then read a vignette describing a memory experiment:

Imagine an experiment is conducted wherein participants are presented with a list of 36 different words one after the other. Each of the words is presented for 5s. The participants' task is to study these words so that they can remember as many words as possible on a later memory test.

Half of the words on the list (i.e., 18) are presented twice and the other half of the words on the list (i.e., 18) are presented once.

The memory test takes place 10 minutes after studying the words and participants are asked to recall as many words as they can.

After reading the vignette, participants were asked to make a prediction regarding how memory performance was affected by the described task manipulation (i.e., repetition).

Specifically, I asked participants to select which of the following outcomes they thought was most likely: that participants would recall more words presented twice, they would recall more words presented once, or that there would be no difference in the number of words recalled between the two conditions. After making their prediction, participants were then asked to rate their confidence that their prediction was true, specifically, how confident they were that their predicted outcome was correct. They were then asked to generate an explanation for their memory prediction. Specifically, they were asked: "You selected an outcome for the experiment described that you thought was most likely to occur. Please provide a detailed explanation for your selected outcome in the box below. That is, what made you think that the outcome you

selected was the mostly likely to occur.” After generating an explanation, I asked participants to re-rate their confidence in their prediction. Participants were then debriefed and compensated for their participation.

Results

A total of 201 participants completed the study. The study employed a quasi-experimental design, as participants were not randomly assigned to conditions but were instead categorized based on whether they provided a causal explanation for their memory prediction. Specifically, I compared the confidence of those who provided a causal explanation for their memory prediction versus those who did not. I initially conducted an independent samples t-test to compare the confidence levels of participants who provided a causal explanation versus those who did not. However, due to violations of the normality assumption in confidence scores, I also performed a Wilcoxon Rank Sum Test, which yielded qualitatively similar results. The open responses provided by participants were coded by two independent raters who were blind to all conditions. Raters were instructed to code whether participants’ explanations attributed the outcome they predicted to causes beyond the experimental manipulation. All raters completed two rounds of training, during which they coded explanations from a separate experiment and received feedback from the researcher. They were allowed to begin coding participants’ explanations in this study only after achieving at least 80% agreement with the researcher’s coding. The raters agreed on the classification of 83% of responses, with a moderate level of agreement according to Cohen’s $\kappa = .54$. Researchers met with the coders to resolve any coding disagreements. Of the total sample, 52 (26%) participants provided causal explanations for their prediction, whereas 149 (74%) did not. All analyses were conducted using both the full sample and a subset that excluded participants who predicted no difference in memory performance

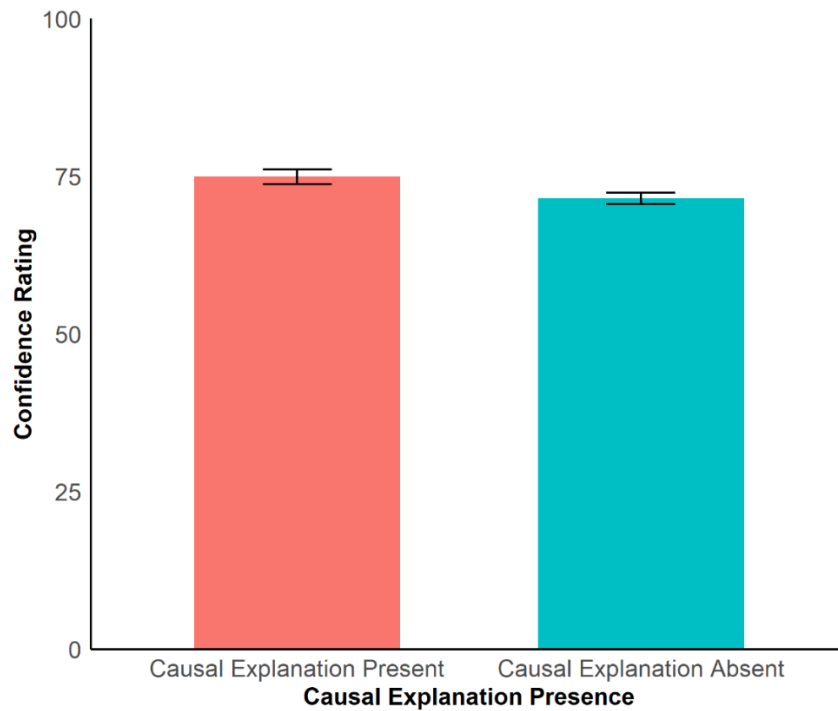
across word conditions (i.e., no expected benefit or cost of repetition). This subset included 187 participants who predicted either a benefit or a cost of word repetition, excluding the 14 participants who predicted no difference. I conducted these separate analyses because I hypothesized that it may be easier to attribute a cause to an effect (i.e., the memory benefit or cost of repetition), than the absence of the effect. Additionally, I conducted all analyses using participants' confidence ratings collected both before and after they generated their explanations and found no differences in the overall pattern of results. Therefore, to simplify reporting, I present the main analyses using the confidence ratings collected before participants wrote their explanations. This study's design and its analyses were all pre-registered on Open Science Framework.

Relation between the presence of a causal explanation and confidence

To examine whether participants' confidence in their memory prediction was associated with the presence or absence of a causal explanation, I conducted an independent samples t-test. This test compared confidence between participants who provided a causal explanation and those who did not. In the full sample, the presence of a causal explanation in participants' justifications had no significant effect on confidence in their memory prediction, $t(199) = .43, p = .664, d = .07$, [causal explanation: $M = 71.5, SD = 18.5$; non-causal $M = 70.3, SD = 17.5$]. In the subset of participants who predicted a difference across word conditions, there was also no effect, $t(185) = 1.58, p = .116, d = 0.26$ [causal explanation: $M = 75.0, SD = 14.6$; non-causal explanation: $M = 70.5, SD = 17.3$].

Figure 1

Confidence by Presence of Causal Explanations (E1: Whole Sample)



Note. Error bars are 95% intervals.

Word count variation in causal and non-causal explanations

In order to explore whether causal explanations tend to exhibit specific features, such as being longer, I also examined whether the word count of participants' explanations varied based on whether their explanations were classified as causal. To test this, I conducted an independent samples t-test comparing the word counts of explanations classified as causal versus non-causal. Across both the full sample and the subset of participants who predicted a cost or benefit of repetition, the presence of a causal explanation in participants' justifications was associated with significantly higher word counts. [full sample: $t(199) = 2.79, p = .005, d = .45$; subset: $t(185) = 2.68, p = .008, d = .46$]. On average, causal explanations had a greater number of words [full: M

= 39.4, $SD = 16.5$; subset: $M = 37.1$, $SD = 18.7$] compared to non-causal explanations [full: $M = 30.7$, $SD = 20.2$; subset: $M = 26.8$, $SD = 14.5$].

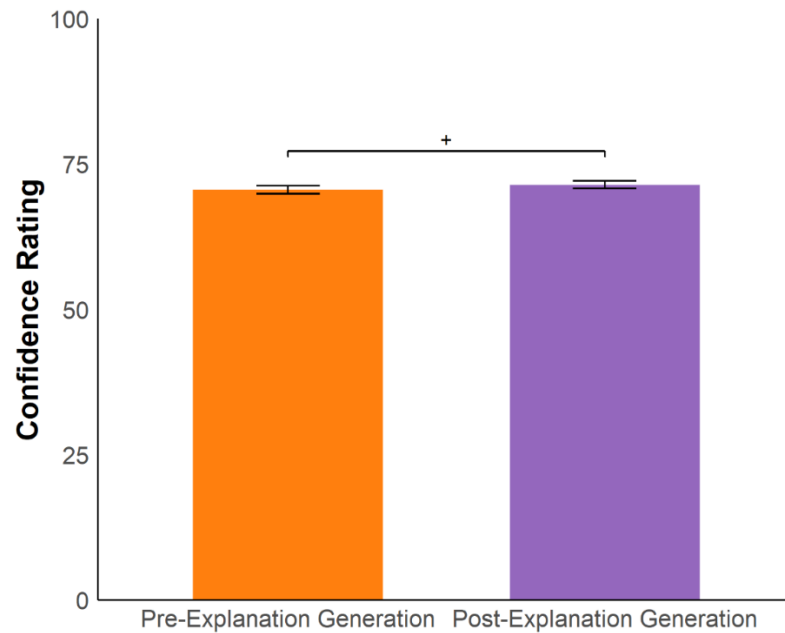
The word count of the explanations did not significantly correlate with confidence [full sample: $r(199) = .01$, $p = .845$; subset: $r(185) = 0.03$, $p = .669$]

Effect of explanation generation on confidence

To examine whether participants' confidence in their memory prediction was influenced by the act of generating an explanation, I conducted a dependent samples t-test comparing participants' confidence before and after generating an explanation. There was a marginally significant effect of explanation generation on confidence, $t(200) = 1.86$, $p = .064$, $dz = .13$, such that participants were more confident after generating an explanation ($M = 71.5$, $SD = 17.7$) compared to before ($M = 70.6$, $SD = 17.8$). This same pattern was present in the subset that predicted an effect of the experimental manipulation, $t(186) = 1.39$, $p = .167$, $dz = 0.10$ with confidence scores increasing from before ($M = 71.6$, $SD = 16.8$) to after ($M = 72.2$, $SD = 16.9$).

Figure 2

Confidence Before vs. After Explanation Generation (E1: Whole Sample)



Note. Error bars are 95% intervals.

Effect of type of memory prediction

In an exploratory analysis, I examined whether the nature of participant's prediction—specifically, whether they expected a memory effect from word repetition—was associated with their reported confidence. To test this, I conducted a one-way between-subjects ANOVA comparing confidence ratings across three groups of participants: those who predicted a positive effect of the task manipulation (i.e., improved memory performance for repeated-presentation words), those who predicted a negative effect (i.e., reduced memory performance for repeated-presentation words), and those who predicted no effect (i.e., similar memory performance for single and repeated word presentations). As predicted, the majority of participants (89%) predicted a positive effect, while 3% predicted a negative effect and 7% predicted no effect. Pairwise comparisons using Fisher's LSD correction revealed that participants who predicted a

positive effect of the manipulation reported significantly higher confidence ($M = 72.03$, $SD = 16.67$) than those who predicted a negative effect ($M = 57.86$, $SD = 24.78$), $t(185) = 1.99$, $p = .049$, $d = .77$. Confidence was also significantly higher among those who predicted a positive effect compared to those who predicted no effect ($M = 57.29$, $SD = 24.79$), $t(192) = 2.95$, $p = .004$, $d = .82$. There was no significant difference in confidence between participants who predicted a negative effect and those who predicted no effect, $t(19) = 0.14$, $p = .89$, $d = .06$.

Discussion

In Experiment 1, I examined whether the presence of a causal explanation in participants' justifications was associated with higher confidence in their memory prediction. Overall, participants' confidence in their prediction did not significantly differ between those who provided a causal explanation and those who provided a non-causal explanation. There was also an unequal distribution of participants across explanation types, with significantly fewer participants providing causal explanations (25%) compared to non-causal ones (75%). As our initial power analysis did not account for the possibility of such uneven group sizes, the study may have been underpowered to reliably detect the small association between confidence and causal explanation presence. To address this limitation, in my next experiment I conducted a power analysis that accounted for the observed group proportions, allowing for a more accurate estimation of the sample size needed to detect potential differences. Additionally, I examined whether the word count of participants' explanations differed depending on whether they were classified as causal. Overall, I found that the presence of a causal explanation in participants' justifications was associated with significantly higher word counts. That said, the word count of participants' explanations was also not significantly correlated with confidence in their memory prediction. Finally, I examined whether the act of generating an explanation influenced

participants' confidence, in the same vein as the Illusion of Explanatory Depth (IOED), in which individuals' ratings of their understanding decrease after being asked to generate an explanation for a mechanistic process (e.g., how a zipper works). Interestingly, I found instead that participants were marginally more confident after generating an explanation as opposed to before.

Beyond the preregistered analyses examining how participants' confidence in their prediction related to their explanations, I also explored whether confidence varied based on the nature of the prediction itself. Specifically, whether participants predicted a benefit, a cost, or no effect on memory as a result of the task manipulation (i.e., word repetition). I choose a manipulation that I expected would generate a high consensus among the participants, which I found with 89% of participants predicting that words shown twice in a memory task would be better remembered than words only shown once. Overall, I found that participants who predicted a benefit of repetition on memory reported significantly higher confidence in their prediction compared to both those who predicted a cost and no effect of repetition. These findings suggest that the nature of one's prediction may be associated with confidence levels. This raised the question of whether altering the framing of the prediction itself might also affect confidence. To explore this possibility, the next experiment not only increased the sample size to address prior power limitations but also introduced a framing manipulation: participants were randomly assigned to predict either their own future performance on the described memory task or the performance of past participants.

Experiment 2

Methods

Participants

A total of 466 participants were recruited through Prolific to take part in this online study. Prior to data collection, an a-priori power analysis was conducted using G*Power to determine the necessary sample size to detect a small effect ($d = .30$) with 80% power ($\alpha = .05$) using an independent samples t-test. The analysis assumed unequal group sizes, with an allocation ratio of 3:1, comparing confidence between participants who did and did not use causal language in their explanations. This allocation ratio reflected expected differences in group sizes based on observations from Experiment 1. Participants were pre-screened to have completed between 100–1000 previous submissions on Prolific and to have a 98–100% approval rating. Participants ranged in age from 18 to 93 ($M = 42$, $SD = 13$)

Table 2*Demographic Data for Experiment 2 Sample*

Demographic Variable	Chosen Option	Percentage
Gender	Man or Transman	40%
	Woman or Transwoman	54%
	Another option	7%
Ethnicity	White	80%
	Black	7%
	Asian	6%
	Another provided option	4%
Education	No formal education	1%
	High school diploma	16%
	College diploma	14%
	Bachelor's degree	45%
	Master's degree	19%
	Doctoral degree	3%

Stimuli, Measures and Procedures

I used the same Stimuli, Measures, and Procedures as in Experiment 1, with one key addition: a framing manipulation wherein participants were randomly assigned to either a third-person framing condition, in which they predicted the memory performance of past participants (e.g., “Participants would remember more words presented [once/twice]”), or a first-person framing condition, in which they predicted how they themselves would perform on the task (e.g., “You would recall more words presented [once/twice]”).

Results

A total of 466 participants completed the study. There were 237 [51%] participants assigned to the first-person frame and 229 [49%] assigned to the third-person frame. I again compared the confidence of those who provided a causal explanation for their memory prediction versus those who did not. As I did in Experiment 1, I conducted an independent samples t-test to compare the confidence of participants who provided a causal explanation with those who did not. However, due to violations of the normality assumption in confidence scores, I also performed a Wilcoxon Rank Sum Test, which yielded qualitatively similar results. The open responses provided by participants were coded by two independent raters who were blind to all conditions. The raters agreed on the classification of 82% of responses, with a moderate level of agreement ($\kappa = .56$). Researchers met with the coders to resolve any coding disagreements. Of the total sample, 132 [28%] participants provided causal explanations for their prediction, whereas 335 [72%] did not. All analyses were conducted using both the full sample and a subset that excluded participants who predicted no difference in memory performance across word conditions (i.e., no expected benefit or cost of repetition). This subset included 441 participants who predicted either a benefit or a cost of word repetition, excluding the 25 participants who predicted no difference. This study's design and its analyses were all pre-registered on Open Science Framework.

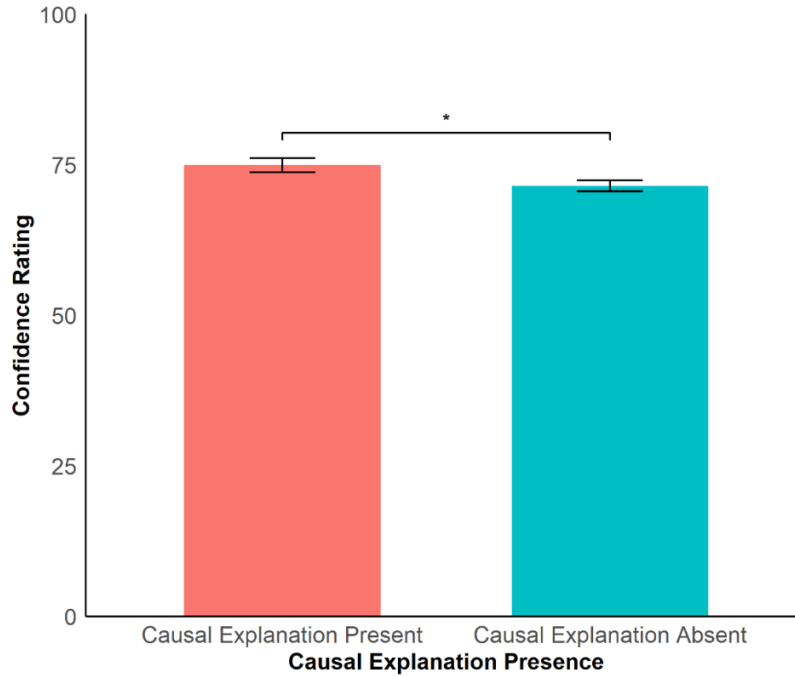
Relation between the presence of a causal explanation and confidence

In the full sample, the presence of a causal explanation in participants' justifications had a significant effect on confidence in their memory prediction, $t(465) = 2.11, p = .035, d = .27$, such that participants reported higher confidence when they provided a causal explanation for their prediction ($M = 74.9, SD = 13.3$) compared to when they did not ($M = 71.5, SD = 16.7$). In the

subset of participants who predicted a difference across word conditions showed the same pattern of results, $t(440) = 2.82$, $p = .005$, $d = 0.32$ [causal explanation: $M = 76.4$, $SD = 12.0$; non-causal explanation: $M = 71.6$, $SD = 16.8$].

Figure 3

Confidence Ratings by Presence of Causal Explanations (E2: Whole Sample)



Note. Error bars are 95% confidence intervals.

Word count variation in causal and non-causal explanations

Across both the full sample and the subset of participants who predicted a cost or benefit of repetition, causal explanations were significantly associated with longer word counts (full sample: $M = 37.1$, $SD = 18.7$; subset: $M = 37.0$, $SD = 18.7$) compared to non-causal explanations (full: $M = 26.8$, $SD = 14.5$; subset: $M = 27.3$, $SD = 14.5$), [full sample: $t(465) = 6.32$, $p < .001$, $d = .65$; subset: $t(440) = 5.81$, $p < .001$, $d = .62$].

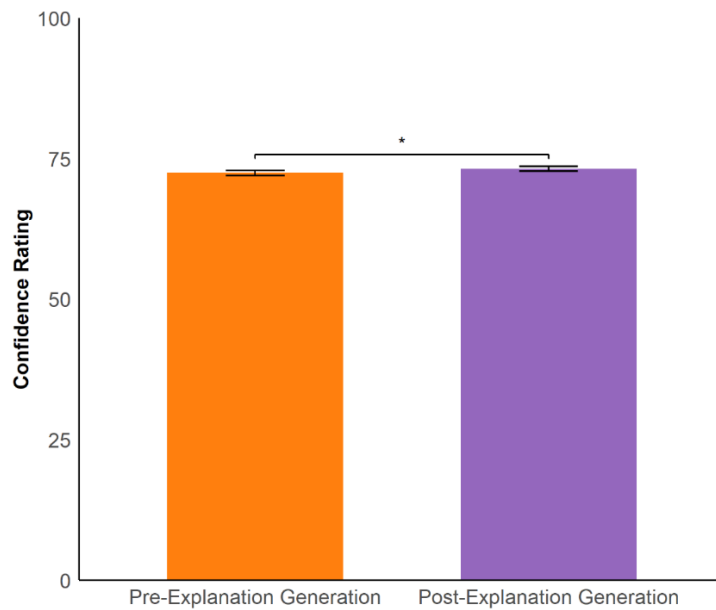
To determine whether the association between the presence of a causal explanation in participants' justifications and their confidence could be accounted for by the longer word count of those explanations, I conducted a linear regression predicting confidence from the presence of a causal explanation in the justification, controlling for word count. In both the full sample and the subset, the presence of a causal explanation in participants' justifications was a significant predictor of confidence [full: $t(464) = 2.07, p = .039, b = 3.51$; subset: $t(439) = 4.83, p = .006, b = 4.83$]. In contrast, the word count of the explanations did not significantly predict confidence [full sample: $t(464) = .15, p = .879, b < .01$; subset: $t(439) = .26, p = .792, b = .01$].

Effect of explanation generation on confidence

To examine whether participants' confidence in their memory prediction is associated by the mere act of generating an explanation, I conducted a dependent samples t-test comparing participants' confidence before and after generating an explanation. There was a significant effect of explanation generation on confidence, $t(466) = 2.39, p = .017, d = .11$, such that participants were more confident after generating an explanation ($M = 73.2, SD = 15.3$) compared to before ($M = 72.5, SD = 15.9$). The results of the subset showed the same pattern, $t(441) = 2.09, p = .037, d = 0.10$, with confidence scores increasing from before ($M = 72.9, SD = 15.7$) to after ($M = 73.6, SD = 15.3$).

Figure 4

Confidence Ratings Before versus After Explanation Generation (E2: Whole Sample)



Note. Error bars are 95% confidence intervals.

Effect of type of memory prediction

The majority of participants (93%) predicted that the manipulation would have a positive effect, while 1% predicted a negative effect and 5% predicted no effect. As in Experiment 1, there was a significant effect of the type of memory prediction participants made, $F(464) = 3.39$, $p < .001$, $\eta^2 = .01$. Pairwise comparisons using Fisher's LSD correction revealed that participants who predicted a positive effect of the manipulation reported significantly higher confidence ($M = 72.91$, $SD = 15.78$) than those who predicted no effect ($M = 64.48$, $SD = 17.05$), $t(460) = 2.59$, $p = .010$, $d = .53$. There was no significant difference in confidence between participants who predicted a positive effect and those who predicted a negative effect, $t(28) = 0.23$, $p = .23$, $d = .60$, nor between those who predicted a negative effect and those who predicted no effect.

Specifically, those who predicted an effect of the task manipulation were significantly more confident in their prediction ($M = 72.9$, $SD = 15.7$) compared to those who predicted no difference across word conditions ($M = 64.5$, $SD = 17.1$).

Effect of prediction framing

Participants were asked to make their prediction using different perspectives (first-person: predicting their own performance; third-person: predicting past participants' performance). I conducted an exploratory analysis to examine whether this manipulation influenced confidence. Overall, across both samples, there was no significant effect of framing of the prediction on participants' confidence in their memory prediction, [full: $t(465) = 1.10$, $p = 0.272$, $d = .10$; effect only: $t(440) = 1.04$, $p = .30$, $d = .09$]. I conducted a chi-square test of independence to examine whether the likelihood of participants providing a causal explanation in their justifications varied based on the framing condition. The test revealed no significant difference in the frequency of causal explanations across framing conditions, $\chi^2(466) = 0.00$, $p = 1.00$. In the third-person frame prediction condition, 28% of participants ($n = 65$) provided causal explanations, while 72% ($n = 165$) did not. The same distribution was observed in the first-person prediction condition, with 28% ($n = 67$) offering causal explanations and 72% ($n = 170$) offering non-causal ones.

Discussion

In Experiment 1, the study may have been underpowered to detect an association between participants' confidence in their memory prediction and the presence of causal explanations in their justifications for the prediction. Specifically, the substantial imbalance in group sizes, particularly the smaller number of participants who provided causal compared to non-causal explanations, likely limited the study's ability to detect this small effect. To address this limitation, Experiment 2 incorporated a power analysis that took the observed group proportions into account, enabling a more precise estimation of the sample size required to reliably detect meaningful differences. Overall, the presence of a causal explanation in participants' justifications was significantly associated with higher confidence in their prediction. I also observed a similar distribution of explanation types as in the Experiment 1 sample, with 28% of participants offering causal explanations and 72% providing non-causal ones. Additionally, I replicated the finding that causal explanations were associated with higher word counts, suggesting that they tend to be more elaborative. Importantly, the association between the presence of a causal explanation and participants' confidence remained significant even after controlling for word count, indicating that it is not merely the length of the explanation that is linked to greater confidence, but the presence of causal reasoning itself. I also examined whether the act of generating an explanation would influence participants' confidence in their prediction. This question was inspired by research on the Illusion of Explanatory Depth (IOED), which shows that people often feel less confident in their understanding after attempting to explain how a complex mechanism works (e.g., a zipper). In contrast to this pattern, I replicated the finding found in Experiment 1 in which participants reported higher confidence in their prediction after

generating an explanation, suggesting that explaining a belief may reinforce rather than undermine one's confidence in it.

In Experiment 1, I found evidence suggesting that the nature of participants' predictions was associated with differences in confidence levels. Specifically, participants who predicted a benefit from the task manipulation reported higher confidence than those who predicted either a cost of repetition or no effect at all. In Experiment 2, I replicated the finding that those who predicted a benefit of the manipulation reported higher confidence compared to those that predicted no effect. However, I did not find a significant difference between those that predicted a benefit versus those that predicted a cost. In this study, I also framed the memory prediction in two ways: in one condition, participants were asked to predict how others would perform in the described task (i.e., third-person frame), and in the other, they were asked to predict how they themselves would perform (i.e., first-person frame). Overall, I found no effect of framing on participants' confidence in their predictions where confidence levels were similar whether participants were asked to predict others' performance or their own. The distribution of participants who provided a causal explanation versus those who did not was also identical across both prediction framing conditions and matched the distribution observed in the full sample (i.e., 28% causal explanations, 72% non-causal explanations).

General Discussion

The present investigation extends research on confidence in one's beliefs into the domain of metamemory and introduces a novel potential correlate of that confidence: the presence of causal reasoning. CNT proposes that sense-making and decision-making are shaped by narratives, defined as structured mental models that incorporate causal, temporal, analogical, and emotional elements. In the context of metamemory, individuals may construct internal narratives to explain why certain strategies, such as self-testing, improve memory. These narratives not only describe events but also offer causal explanations (e.g., "testing helps memory because it strengthens retrieval pathways"), often supported by analogies to past experiences and positive emotional evaluations. Such narrative structure may enhance the coherence and plausibility of the belief, thereby increasing confidence in it. Importantly, CNT highlights causal structure as a key feature in strengthening conviction. Guided by this framework, the present study examined whether individuals who include causal reasoning in their explanations of memory beliefs also report higher confidence in those beliefs.

The reported experiments yielded multiple novel insights, most notably that participants who offered causal explanations for their memory predictions, used here as an indicator of their underlying memory beliefs, tended to report higher confidence in those predictions. This relation was evident in Experiment 2, which was adequately powered to detect the small association between causal reasoning and confidence. Under this present definition, only about one-quarter of participants provided such causal explanations for their predictions, raising the question of why such reasoning was relatively rare. One possibility is that this low rate reflects individual differences in how people reason about their beliefs, suggesting that most participants either did not spontaneously engage in causal reasoning when justifying their memory beliefs or did not

have causal explanations underlying those beliefs stored in memory. Another possibility is that the task vignette itself influenced the likelihood of generating causal explanations. In Mueller and colleagues' (2014) study, participants explained predictions about how font-size rather than repetition, would affect word memory. In this study, only 25% of participants gave non-causal explanations (i.e., stating that the manipulation itself made the words easier to remember), while the majority provided causal explanations, attributing the predicted effect of large font size to factors beyond the experimental manipulation such as the distinctiveness or readability of the words, or the increased attention they received. In contrast, our repetition vignette appeared to encourage circular reasoning, with participants often citing repetition itself as the reason for the predicted effect of repetition on memory, suggesting that this particular task vignette may have been less conducive to generating causal explanation. Notably, the causal explanations that were produced were longer on average than non-causal ones, suggesting that participants who engaged in causal reasoning may have invested more cognitive effort in generating their explanations. However, explanation length alone was not reliably associated with confidence, indicating that it was specifically the presence of causal reasoning, rather than greater elaboration in general, that was linked to increased confidence.

Effect of explanation generation on prediction confidence

Beyond examining how the characteristics of participants' explanations were related to confidence, I also investigated whether the act of generating an explanation itself influenced participants' confidence in their memory prediction. This question was initially motivated by research on the Illusion of Explanatory Depth (IOED), which shows that individuals often overestimate their understanding of how things work, and that their confidence decreases after attempting to explain a mechanistic process (e.g., how a zipper works; Rozenblit & Keil, 2002).

However, the present findings revealed the opposite pattern: participants reported increased confidence after generating an explanation, compared to before. This apparent discrepancy may stem from differences in the outcome measures employed. Whereas IOED studies focus on examining the changes in participants' perceived understanding of mechanistic processes, the present study examined changes in participants' confidence in their memory prediction instead. It is possible that when measuring confidence rather than understanding, the act of generating an explanation serves to reinforce, rather than diminish, participants' confidence. This possibility is supported by prior research demonstrating that constructing supportive arguments for a given hypothesis can enhance individuals' confidence in its truth. For example, Shermann and colleagues (1983) found that participants who explained how one football team might win an upcoming game when given a description of the game assigned a higher probability of that team winning, relative to those who explained an opposing outcome. Similar effects, where participants who explain a particular outcome exhibit greater confidence in that outcome compared to those who explain the alternative, have been documented across multiple studies (e.g., Campbell & Fairey, 1985; Hirt & Sherman, 1985; Sherman et al., 1981), suggesting that generating explanations can strengthen commitment to a hypothesis. According to Koehler (1991), this increase in confidence occurs because individuals evaluate information within a conditional reference frame, one in which the explained outcome is assumed to be true. In doing so, people tend to search memory selectively for supporting evidence and downplay contradictory information. This process can create an inflated sense of evidential support, thereby increasing the perceived plausibility and coherence of the hypothesis. Applied to the present study, asking participants to explain their memory prediction may have made evidence

supporting their hypothesis more salient, reinforcing the assumption that their belief was correct and ultimately resulting in heightened confidence after the explanation.

A second possibility as to why we may have not seen a decrease in confidence after explanation generation, similar to IOED studies, relates to the complexity of the phenomenon being explained and the language required to describe it. Mechanistic processes, such as the workings of a zipper or a quartz watch, are relatively complex and require technical or less familiar language, making explanations more difficult and leading to decreased confidence when people recognize gaps in their understanding. In contrast, explaining the memory prediction task in the present study is relatively simple and can be described in plain, familiar language. These factors may have facilitated explanation generation and contributed to the observed increase in confidence after.

Relation between prediction type and prediction confidence

In addition to exploring how participants' explanations related to confidence in their prediction, I also investigated whether the type of prediction participants made was associated with differing levels of confidence. As mentioned previously, I chose a vignette where there would be a high consensus in people's beliefs (i.e., people generally believe that repetition is beneficial to memory) to avoid having to consider differences in participants' belief. Consistent with this, approximately 90% of participants across both experiments predicted a benefit of repetition in the described word memorization task. Participants who made this prediction also reported higher confidence in their prediction compared to those who predicted no effect of repetition. There are at least two possible interpretations of these findings. The first is that the higher confidence observed for predictions of a repetition benefit, relative to predictions of no effect, reflect differences in consensus. Koriath (2008) demonstrated that people tend to be more

confident in responses that align with the majority, even when the majority-selected response is incorrect. Majority-endorsed responses were not only associated with higher confidence but were also more consistently selected by the same individual across repeated judgments. According to the Self-Consistency Model (SCM) of confidence judgments (Koriat, 2012), people assess confidence based on the consistency of retrieved representations from memory. When a belief is widely held, such as the belief that repetition improves memory, it is more likely to be reinforced through various sources like personal experience, formal education, and media exposure. This broad reinforcement increases the likelihood of retrieving convergent representations, leading to greater internal consistency and, consequently, higher confidence in that belief. A second possibility is that participants who predicted an effect of repetition, whether it be a benefit or cost, found it easier to generate causal explanations for their predictions compared to those who predicted no effect of repetition. This relative ease of explanation generation may itself enhance confidence, particularly when participants can identify mechanisms that go beyond the experimental manipulation. Nevertheless, because statistical comparisons between participants predicting a benefit and those predicting a cost did not yield consistent differences in confidence, firm conclusions about how or why the nature of participants' predictions relates to confidence remain elusive.

The finding that participants who predicted a benefit of repetition reported higher confidence than those who predicted no effect suggests that the nature of a prediction may be associated with varying levels of confidence. This raised the related question of whether confidence is also shaped by how the prediction is framed, specifically, whether participants are asked to predict their own memory performance or that of someone else. However, the results showed no significant framing effect with participants reporting similar levels of confidence

regardless of whether the prediction concerned themselves or others' performance. This pattern suggests that participants may have drawn on the same underlying information or reasoning processes when making both types of predictions. Consistent with this rationale, the proportion of participants who generated causal explanations remained identical across the two framing conditions.

Limitations

One potential limitation of the present study concerns the challenges involved in coding participants' justifications for their memory prediction. In particular, it was often difficult to infer participants' underlying beliefs from the brief responses they provided, which were typically limited to a single sentence. These short justifications rarely included sufficient detail, requiring the extraction of meaning and intent with minimal context. As a result, there is a risk that some explanations were misclassified due to missing important nuances in participants' reasoning. Moreover, the ease of classifying explanations varied depending on the type of prediction participants made. Specifically, it was easier to identify a cause to explain participants' predictions of a memory benefit or cost from repetition, whereas identifying a cause that explained a lack of a difference across the word conditions was much more difficult. This discrepancy may have resulted in higher classification accuracy and coder agreement for justifications supporting benefit and cost predictions compared to those explaining no-effect predictions, revealing a potential source of variability in the coding process. Therefore, future research investigating how the features of individuals' narratives, such as the presence of causal reasoning, relate to confidence in their metamemory beliefs would benefit from employing methods that elicit more detailed and comprehensive participant responses.

Another potential limitation of the present study is the use of a single cognitive task vignette across both studies. Cognitive task vignettes can vary in a number of ways. For instance, they may differ in complexity, the ease with which participants are able to generate causal explanations for them, or how easily they can be described or explained in plain language. Consequently, the observed association between confidence in metamemory beliefs and the presence of causal reasoning may be attributable to specific features of the repetition task, and a different vignette with other features may produce different outcomes. Some vignette features, such as how easy it is to explain the described phenomenon, might even act as moderators for this association, increasing both causal reasoning and confidence. As a result, it is difficult to generalize these findings beyond the repetition task vignette used here. Therefore, future research could benefit from incorporating multiple cognitive task vignettes in a within-subjects design to more fully assess the robustness and generalizability of these reported effects.

Future Directions

Beyond the scope of the present study, multiple directions exist for future research to further expand on the reported findings. One potential direction for future research is to investigate whether the magnitude of participants' predicted effects of the task manipulation is associated with confidence. In the present study, participants indicated whether they expected a memory benefit (i.e., remembering more words presented twice), a memory cost (i.e., remembering more words presented once), or no difference across conditions, but they did not specify the magnitude of the expected effect. That is, how many more words they expect to be remembered in one condition compared to the other. Future studies could then ask participants to predict the number of words they expect to remember in each condition, as done in previous research. This would allow researchers to test whether larger predicted differences between

conditions correspond to higher confidence, providing insight into whether the strength of expected outcomes influences metamemory judgments.

Another potential direction for this research is to explore the content of participants' justifications in greater detail. If methods are developed to elicit more comprehensive participant responses, researchers could conduct a content analysis of their justifications to examine whether the type of causal explanation provided, such as attributing a benefit of repetition to longer study time versus increased attention to the words, is associated with differences in confidence.

Conclusion

In the present study, I examined a potential novel correlate of individuals' confidence in their metamemory beliefs: the presence of causal reasoning. Specifically, I investigated whether participants who provided causal explanations when justifying their memory prediction, used here as an indicator of their underlying memory beliefs, also expressed greater confidence in those predictions. The results provided some evidence for this association. However, only about one-quarter of participants provided causal explanations. This suggests that although causal reasoning may be linked to stronger confidence in metamemory beliefs, most individuals either do not spontaneously engage in this type of reasoning for metamemory beliefs or may not have causal explanations underlying those beliefs stored in memory at all.

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