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### Foreign Language Reduces False Memories by Increasing Memory Monitoring

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## Foreign Language Reduces False Memories by Increasing Memory Monitoring

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People have false memories that distort their recollection of past events. Language is an important source of such memories, from providing false inferences to outright misinformation. Here we investigate the impact of using a native or foreign language on bilinguals' susceptibility to false memories. Although language has been argued to impact false memories in multiple ways, our study was inspired by recent work in the decision-making literature, which leads to the novel hypothesis that foreign language encourages people to engage in careful memory monitoring that could reduce false memories. This hypothesis contrasts with a processing load account, which predicts that a foreign language would increase false memories because it is naturally more difficult to process information in a foreign language. We tested these hypotheses using two false memory tasks. Using the DRM task, Experiment 1 found that individuals were more accurate in identifying false memories when using their foreign language compared with their native tongue, consistent with the memory monitoring hypothesis. Using the misinformation task, Experiment 2 found that processing misleading information in one's foreign language eliminated false memories, again supporting the hypothesis that a foreign language increases the use of memory monitoring. These findings support a monitoring hypothesis that has been overlooked in prior studies on bilingualism and false memory, with implications for billions of people who regularly use a foreign language.

Keywords: bilingualism, false memory, monitoring, foreign language, misinformation effect

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Our memories are an imperfect window into the past. While we often have the illusion that our memories serve as a reliable rendering of past events, our memories are susceptible to distortion in the process of creating a cohesive representation of what has previously occurred. For instance, you may remember the most central, salient

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details but forget the more inconspicuous ones (Levine & Edelstein, 2009), recall hearing about an event but confuse who you heard it from (Johnson et al., 1993), or forget the intensity of your feelings after you had received some bad news (Walker & Skowronski, 2009). Importantly, although decades of research have demonstrated that you can recall details that had never occurred, researchers are still discovering what can impact one's susceptibility to false memories.

Here we investigate one such factor—how language shapes false memories—with a focus on the impact of using a native or foreign language. Our interest in the nativeness of language is for both practical and theoretical reasons. Practically, hundreds of millions of people in the world speak more than one language routinely (WHO, 2019). This includes immigrants who speak the local language outside the home, people who use a foreign language for commerce and diplomacy, and residents in border areas that straddle more than one language community. Indeed, multilingualism is the norm around the world, not an exception. It is therefore important to understand not just the role of language in creating false memories, but also the nature of the language involved.

Theoretically, we suggest that in order to understand the relationship between language and memory, it is important to consider whether people are using their native or foreign language. Here we define a foreign language as a language acquired later in life and typically in an academic setting (Pavlenko, 2005). On the face of it, there is little reason to believe that the use of a foreign language would affect the prevalence of false memories. It is the concepts and the content of the information, not the language itself, that presumably induces false memories. So, if a foreign language is completely understood, then the rate of false memories should be the same as with a native tongue.

Yet emerging literature indicates that the language used during memory tasks can impact susceptibility to false memories. As discussed more extensively below, this literature has focused on the strength of conceptual associations in one language versus the other, using tasks that rely on preexisting associations to elicit false memories (Anastasi et al., 2005; Arndt & Beato, 2017; Howe et al., 2008; Sahlin et al., 2005; for a meta-analysis, see Suarez & Beato, 2021). This work is important for showing how language can activate false memories based on the strength of word associations, but we hypothesized that foreign language might have an even broader impact on information processing. Specifically, we propose that using a foreign language might increase the likelihood that people will carefully monitor their memory. This hypothesis implicates a broader impact of foreign language on false memories than has been considered previously, as it should not only apply to tasks that rely on preexisting associations to elicit false memories, but it also should generalize to other kinds of false memories that also are impacted by monitoring.

#### Language Monitoring Hypothesis: More Monitoring, Less Intuition

The monitoring hypothesis that we propose here is based on recent findings that individuals tend to systematically think and respond differently when using a foreign as compared with a native language—an effect dubbed "the foreign language effect" (Costa et al., 2019; Hayakawa et al., 2016; Keysar et al., 2012). To name a few domains in which using a foreign language influences choice, people are more likely to sacrifice one to save many lives when making a moral choice (Costa et al., 2014, Geipel et al., 2015a, 2015b), respond honestly even at a personal cost (Bereby-Meyer et al., 2020), reject superstitious beliefs (Hadjichristidis et al., 2019), and consume sustainable but aversive products (Geipel et al., 2018).

These findings have been largely explained under a dual process theory of reasoning, in which the use of a foreign language inhibits automatically generated, intuitive responses (Hadjichristidis et al., 2017). According to the dual process theory of cognition, individuals rely on two distinct systems of reasoning: one fast, intuitive system (System 1) and another slow, deliberative system (System 2; Evans & Stanovich, 2013; Sloman, 1996). Typically people default to their System 1 choice, as this system is both quicker and less cognitively demanding than System 2, but this comes at the cost of being more error-prone. However, when individuals actively engage in more deliberative processes, are faced with uncertainty, or are given sufficient time for the slower System 2 to "catch up" to System 1, they will instead use the slower, but often more accurate and deliberative response.

When individuals use a foreign language, they are less likely to default to these quick, automatic responses, which in turn can improve decision-making in certain circumstances for two reasons. First, this can prevent them from making errors in decision-making driven by an overextension of a certain heuristic or bias (e.g., framing effect, hot hand fallacy), or making decisions based on deeply ingrained social or moral normative values (e.g., rejecting superstitious beliefs, being more forgiving of taboo behavior; Costa et al., 2014; Gao et al., 2015; Geipel et al., 2015b; Hadjichristidis et al., 2019; Keysar et al., 2012). Second, this suppression of System 1 can even help promote more cognitively demanding goals such as self-regulation, as in choosing healthier foods over a tempting, less

healthy option or being honest even when it comes at a personal cost (Hadjichristidis et al., 2017). In these cases, the suppression of the System 1 response presumably allows individuals to override this intuitive response with a more controlled, deliberative choice. To date, these language effects have been mainly found in the context of making judgment and decision-making. Here we hypothesized that the reduction in intuitive processing that results from using a foreign language also could be relevant to susceptibility to false memories.

In general, intuitive thinking increases susceptibility to false memories (Corbin et al., 2015; Gronchi et al., 2016). This could result from an increased reliance on information that comes to mind more rapidly or with less effort, such as feelings of familiarity (Jacoby, 1991; Yonelinas, 2002), automatic associations (Ayers & Reder, 1998; Roediger & McDermott, 1995), or gist-based processes (Brainerd & Reyna, 2005). According to the activation-monitoring framework, activating such processes can increase the risk of memory distortion, whereas slower and more deliberative recollection-based monitoring processes are used to more carefully edit memory and help avoid false memories (Roediger et al., 2001, see Gallo, 2010 for an overview and extension of this framework). Hence, when misleading or false information comes to mind, people who rely more on perceived familiarity or inferences are more likely to report the false detail as true, whereas those that rely more on deliberative recollection-based monitoring are less susceptible to false memories. Importantly, there are different ways that false memories can be activated across tasks and situations, but cognitively controlled monitoring processes are thought to be involved in keeping these misleading influences in check (see Gallo & Lampinen, 2016).

Based on these considerations, we hypothesized that if individuals rely less on their automatic, intuitive response when using their foreign language, this may in turn allow them to override their quick, intuitive response with a slower, more controlled monitoring-based response. This hypothesis predicts a lower rate of false memories with a foreign language compared with a native language, due to increased reliance on monitoring processes in a foreign language. This is not to say that individuals do not engage in monitoring in their native language, but rather, that processing information in a foreign language might bias people to more heavily engage in these processes, just as it biases people to more heavily engage in analytical, cognitively controlled thinking styles in decision-making tasks.

Note that this is not the only prediction that can be drawn from the literature. An alternative hypothesis, based purely on processing load makes the opposite prediction. According to this account, the use of a foreign language may result in a higher rate of false memories because a higher processing load imposed by using a foreign language may undermine memory monitoring. Indeed, increasing processing load during retrieval can augment the rate of false memories (e.g., speeded responding or divided attention, see Jacoby, 1999; Knott & Dewhurst, 2007). Similarly, sleep deprivation, which typically reduces the availability of cognitive resources, also exacerbates the prevalence of false memories (Frenda et al., 2014). Relative to using a native tongue, using a foreign language requires more attentional resources and can impose a higher processing load on the user (Caldwell-Harris & Ayçiçeği-Dinn, 2009; Takano & Noda, 1993, 1995; see also Arndt & Beato, 2017). A loadbased account, then, predicts that the use of a foreign language will increase false memories by decreasing the capacity to effectively detect erroneous information.

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#### The Current Studies

In order to test these hypotheses, we consider two ways by which language can induce false memory: by indirectly eliciting false memories through preexisting associations (the DRM task) or by directly providing false information (the misinformation task). With the DRM task, a large literature demonstrates that when people memorize a list of words that are associated with each other such as "bed, rest, awake ...," they falsely recall having heard other words that are highly associated with those words, such as "sleep" (Deese, 1959; Roediger & McDermott, 1995). Specifically, they recall this word, called the "critical lure," not because they heard it but because it is primed or activated by the words they did hear, leading them to falsely believe it was on the original list. By contrast, the misinformation task tests memory for more naturalistic events, and it uses explicit misinformation to distort memory. For example, people who witness a robber stealing a necklace, and then listen to a testimony by another witness saying that the robber stole a watch, might later incorrectly come to believe that they saw the robber stealing a watch, not a necklace. Like the DRM false memory task, this "misinformation effect" has been demonstrated numerous times (for a review, see Loftus, 2005).

As we review below in the context of each study, each of these false memory tasks activates false memories in different ways that give rise to unique considerations as to how language might impact false memories. Importantly, though, each of these tasks is thought to involve the use of cognitively controlled memory monitoring processes that can help to reject false memories (for review, see Gallo & Lampinen, 2016). To illustrate, prior studies have shown that explicitly warning people against making errors can reduce but not eliminate false memories on either task (Gallo et al., 2001; Karanian et al., 2020), owing to increased reliance on memory monitoring processes when participants are warned against false memories compared with when they are not. As another example, older adults are more susceptible to each of these kinds of false memories than younger adults, and in each case, these effects have been tied to aging-related impairments in frontal functions that support recollection-based memory monitoring (Butler et al., 2004; Roediger & Geraci, 2007). Because both tasks can be impacted by memory monitoring processes, using a foreign language is predicted to increase monitoring and reduce false memories on each task. By examining how foreign language impacts each of these kinds of false memories, we aimed to uncover fundamental principles about language and false memories that transcend different tasks.

#### Study 1: Impact of Foreign Language on a Modified DRM Task

In this study, we used a modified version of the DRM task, in which participants listened to semantically related word lists in their native or foreign language. We chose the DRM task for the first study because this is a reliable method to produce robust false memories, and indeed, almost all the prior work on the impact of different languages on false memories has been done using the DRM task (Anastasi et al., 2005; Arndt & Beato, 2017; Howe et al., 2008; Sahlin et al., 2005). While ours is not the first study to investigate the impact of different languages on DRM task, no prior work has considered the role of monitoring as we do here. Instead, the focus of prior work has been on how language proficiency can

impact the "activation" process of these kinds of false memories, as one's dominant language is thought to contain stronger word associations and/or conceptual relationships or gist that could activate the critical lure compared with one's foreign language. Suarez and Beato (2021) recently provided an insightful metanalysis of the bilingualism literature in DRM, with a focus on the likelihood of false memories in one's native versus foreign language. The overarching pattern identified by Suarez and Beato (2021) was that false memories in the DRM task were more likely when participants processed the material in their native tongue compared with their foreign tongue, at least when the native tongue was the more dominant language. Their conclusion—which echoed that of earlier papers (e.g., Arndt & Beato, 2017)—was that word associations are stronger in one's dominant language, and hence more likely to activate the critical lure.

Although this conclusion about different degrees of activation across different languages may be true, it is critical to recognize that this pattern of greater false memories in one's native tongue is also predicted by the monitoring hypothesis we proposed here. Critically, the monitoring hypothesis predicts this pattern even in the absence of any activation differences between languages. Because false memories in the DRM task are driven by both activation and monitoring processes, either of these hypotheses could explain the obtained results. In other words, when false memories are reduced, it is difficult to tell using the standard DRM method alone whether the reduction reflects less activation or more effective monitoring. As argued by Gallo (2010) in a review of 15 years of DRM research, the traditional DRM task (as used in these prior studies) is not designed to differentiate the contributions of activation and monitoring to false memories and additional methods often are needed to do so.

The current study was designed to provide the first direct test of the hypothesis that using a foreign language increases memory monitoring. To do this, we used a modified DRM task that allows us to assess the impact of different languages on monitoring processes while accounting for any differences in activation that may occur across languages. We used a modified DRM recall task inspired by a procedure originally developed by Hege and Dodson (2004, see also Gray & Gallo, 2015 and Pierce et al., 2017). With this procedure, after studying each DRM list, participants were instructed not only to recall words that had been previously presented, but also to note any other word that came to mind that they do not think had been on the list. Employing this reality-monitoring procedure allowed a separate evaluation of activation and monitoring: (a) We measured "activation" as the extent to which the lure comes to mind, regardless of whether participants thought it was on the list or not. (b) We determined the effectiveness of monitoring by distinguishing between when participants falsely believed that the lure was a true memory or used monitoring to correctly determine that the lure was not previously presented. This modified task therefore allows us to directly measure the impact of different languages on memory monitoring, while accounting for any potential language differences in activation.

#### Method

#### **Participants**

One hundred twenty-nine native Mandarin Chinese speakers who know English were recruited to participate. None of them had lived in an English-speaking country for more than a year prior to college and were all 18 years or older. Eight participants were excluded prior to analyses, two for reporting higher proficiency in English than in Mandarin Chinese, four for technical issues during the experiment, and three for incomplete responses. This left a sample of 120 participants ( $M_{age} = 23.48$ ,  $n_{female} = 88$ ). The sample size was determined with the aim of recruiting at least 60 participants to reliably detect a medium-sized effect, however, the target sample size was doubled in the event we found an effect of language order which would result in needing to do a between-subjects analysis.

These participants had a mean starting age of acquisition of English of 9.35 years and had a self-reported, aggregated English proficiency across reading, writing, speaking, and listening of 5.19 on a scale from 1 (not at all proficient) to 7 (highly proficient).

#### **Materials**

Word lists used in this study were adapted from DRM lists provided by Roediger et al. (2001). Each list consisted of 15 semantically related words that often trigger individuals to think of a highly semantically related word that is not on the list. This word is referred to as a critical lure. For instance, the following word list *rest, bed, nap, peace, drowsy, blanket, doze, tired, awake, snooze, yawn, slumber, snore, wake, and dream* does not include the critical lure *sleep*. Yet people who study the list often falsely recall the word *sleep* after reviewing that list. The prevalence of such false recall is the main variable of interest.

Three native Chinese research assistants who were fluent in English translated 55 DRM word lists from English into Mandarin Chinese. They discarded lists that contained words with one single Chinese translation that matched several of the English list words (e.g., *garbage, junk, rubbish* all translated to 垃圾in Chinese) or lists with either cultural or idiomatic references particular to English (e.g., *bone* with critical lure *wish*). This left 20 lists of 15 words each for use in the experiment and one list for a practice trial. Because each participant heard lists both in English and in Mandarin Chinese, we divided the 20 lists into two groups, and equated them for their mean false recall rate (0.38) documented in previous research (Roediger et al., 2001). Finally, a fluent Mandarin Chinese. The recordings were normalized to a standard perceived volume and pacing of approximately one word every 2 s.

The session for each participant consisted of two parts, one conducted entirely in their foreign English and one conducted entirely in their native Mandarin Chinese. Language order was randomly assigned, and all communication and materials were presented in the assigned language for that portion of the experiment. Hence, if a participant was assigned to the native language as the starting language, all initial instructions and materials for the first part of the study were presented entirely in Mandarin Chinese, and all instructions and materials for the second part of the study were presented entirely in their foreign English. This was to ensure that subjects were immersed in the target language of each part of the study. The two sets of ten lists were counterbalanced across subjects, languages, and order.

Note that we did not aim to match the materials across languages in terms of associative strength, as has been done in other bilingual studies (see Arndt & Beato, 2017, for a comprehensive analysis with this approach). This is because our modified recall procedure allowed us to measure and account for differences across languages in critical lure activation, in order to more directly assess our hypothesis about languages' impact on monitoring. Indeed, because we translated DRM lists created with English association norms into Mandarin Chinese, we suspected that associative strength might be greater for the English than the Mandarin Chinese version, and hence activation also might be greater for the English version (which was the foreign language for our participants). This activation difference would serve to increase false memories in the foreign language, whereas our monitoring hypothesis predicts the opposite effect. By using the modified DRM procedure, we were able to separately measure critical lure activation and monitoring accuracy and hence disentangle these two possibilities.

#### Procedure

The design and materials were first approved by the university institutional review board (IRB), and prior to beginning the study all participants consented to participate. At the beginning of the study, participants first completed a practice trial and had an opportunity to ask clarifying questions. Participants were then informed that they would be listening to two different sets of word lists, and that one set would be presented in English and that the other set would be presented in Mandarin Chinese. For each list, participants listened to the words and then had two minutes to recall them. They were instructed to write down all the words that came to mind, and to divide them into two columns. In the left-hand column, they wrote down words that they believe had been presented on the list and in the righthand column they wrote down words that came to mind but were not on the list. Participants followed the same procedure for each word list. After the first part of the experiment that was conducted in one of the two languages, participants then completed a 10-minute filler task in the language of the second half of the study. The second part of the study followed the same procedure but included the second set of lists in the other language. At the end, participants completed a demographic survey. Overall, the study took 1 hr to complete. All materials and data from this project can be found on Open Science Framework upon publication: https://osf.io/4ew9c/.

#### Results

We initially conducted a repeated measures analyses of variance (ANOVA) model with Language (NativelForeign) as within-subjects and Language Order (Native FirstlForeign First) as between subjects. This ANOVA indicated there was a significant Language  $\times$  Order interaction. The language effect was apparent in both orders, however, because re-analysis of the first block yielded similar conclusions as the analysis of the full data (see the online supplemental materials) we report an analysis of the whole dataset below for simplicity.

Overall, the critical lure was explicitly activated (i.e., came to mind and was either thought to be on the list or not) in their foreign English (0.39) more than in their native Chinese (0.30; 95% CI [0.04, 0.13], t(119) = 3.76, p < .001, d = 0.41). This effect of language on overall explicit activation likely owes to the material difference described in the methods, and as discussed, this by itself does not reveal the rate of false memory or monitoring. To determine these, we separated all the cases in which the lure came to mind but was falsely recalled (putting the lure in the "on the list" column) and correctly monitored (putting the lure in the "not on the list"

column). While false recall rates of the critical lure were similar across the two languages (Foreign = 0.16; Native = 0.17; 95% CI [-0.02, 0.04], t(119) = 0.51, p = .61, d = 0.06), the critical lure was more likely to be correctly monitored in the foreign language than in the native tongue (Foreign = 0.23; Native = 0.14; 95% CI [0.06, 0.12], t(119) = 5.54, p < .001, d = 0.54; see Table 1).

Because the lure was activated at different rates across languages, a more precise measure of retrieval monitoring accuracy requires taking all the activated critical items in each language (i.e., items reported as having been recalled from the list + items reported as coming to mind but not on the list) and calculating the proportion of this total activation that was correctly monitored. For this analysis, we included participants for whom the lure came to mind at least once in each language (N = 107 of 120). We then calculated for each participant the rate of false recall (putting the lure wrongly on the "on the list" column) and the rate of correct monitoring (putting the lure on "not on the list" column). With this accuracy measure participants correctly monitored the critical lure more in their foreign language (0.58) than in their native language (0.45), again resulting in a significant effect of Language on monitoring of the critical lure (95% CI [0.06, 0.21], t(106) = 3.59, p < .001, d = 0.38). The reciprocal of this, of course, is that the proportion of false recall for lures that were generated at the test was greater in the native (0.55) than in the foreign language (0.42; see Figure 1).

These results clearly support the monitoring hypothesis, as the monitoring of critical lures that came to mind was more effective in the foreign language than in the native language. Note that this effect cannot be attributed to overall differences in critical lure activation across the languages, because activation was greater in the foreign language. Moreover, this foreign language effect persisted even when controlling for differences in activation across languages. This effect also cannot be attributed to better recall in a foreign language, as participants correctly recalled more list words in their native (0.58) than in their foreign language (0.48; 95% CI [0.08, 0.12], t(119) = 9.86, p < .001, d = 0.95). Thus, even though participants were more likely to activate the critical lure and less likely to recall the studied words in their foreign language, they also were better able to monitor the source of activated critical lures in their foreign language.

An alternative explanation for the results could be that participants using a foreign language may have simply been more likely to place words in general in the "not on the list" column, including words that were on the list. This would increase their accuracy in identifying the critical lures but would also increase the rate of incorrectly putting words that were actually on the list in the "not on the list" column. The results do not support this, as the rate of this error was similar across languages. On average, participants were just as likely to

#### Table 1

Proportion of Words Sorted Into Each Column (on the List|Not on the List) by Language (Native|Foreign) and Word Type (Critical Lure|List Word)

Response type	Language	Critical lure	List words
On the list	Native	0.17	0.58
	Foreign	0.16	0.48
Not on the list	Native	0.14	0.02
	Foreign	0.23	0.02

#### Figure 1

Proportion of Crucial Lures, Out of Those That Were Explicitly Generated, That Were Falsely Recalled (False Alarm) or Accurately Monitored (Correct Reject), as a Function of Language



incorrectly put words that were on the list on the "not on the list" column in their native language (2.30) as in their foreign language (2.33) across all 10 word lists (95% CI [-0.46, 0.41], t(119) =0.11, p = .91, d = 0.01).

Finally, we also analyzed noncritical intrusions, which are words other than the critical lure that participants produced. In general, this kind of intrusion occurs infrequently (McKelvie, 2003), and tends to represent a mixture of idiosyncratic associations, intrusions from previous study lists, and mishearing of words. Consistent with this, noncritical intrusions in which people thought the item was "on the list" were very rare compared with list words, with fewer than one of these items produced per list on average (Foreign = 0.90, Native = 0.47; 95% CI [0.34, 0.53], t(119) = 9.04, p < .001, d = 1.03). The lower rate for native than foreign may simply reflect a greater likelihood of mishearing an occasional list word in the foreign language, although these errors were too few to analyze at this level.

Noncritical intrusions that came to mind but were monitored out were more common(about two per list). Participants were more likely to identify them as "not on list," than they were to identify noncritical intrusions as on the list, indicating that participants were overall very effective at correctly monitoring out noncritical intrusions. Moreover, correct monitoring of noncritical intrusions happened more often for foreign (2.44) than native (2.03) lists (95% CI [0.15, 0.67], t(119) = 3.12, p < .001, d = 0.16). However, we caution against the over-interpretation of these noncritical intrusions, as the relatively rare occurrence of these intrusions and their idiosyncratic nature preclude a systematic analysis such as the one conducted with critical lures.

#### Discussion

Using a foreign language improved people's ability to monitor false memories in the DRM task, supporting the monitoring hypothesis. While prior work suggests that false memories are more common with a dominant as compared to less proficient language under the DRM task (Suarez & Beato, 2021), this research does not distinguish between instances in which the lure came to mind and was correctly monitored versus instances in which it did not come to mind in the first place. That is, prior work did not separate language effects on false memory activation from language effects on false memory monitoring. By contrast, our findings demonstrate that a foreign language reduces false memories by more effective monitoring, independent of any effect of differential activation across languages.

This study showed that the use of a foreign language reduces false memories that result from associations between words. To test whether this generalizes to false memories more broadly, the next study evaluated the impact of foreign language use on eyewitness testimony. This study used a false memory task that induces false memories in a very different way than the DRM task, thereby avoiding issues of differential word activation across languages. However, both paradigms are thought to rely on recollection-based, cognitively controlled retrieval monitoring processes, and so the same effect of foreign language on the use of monitoring is predicted.

#### Study 2: Impact of Foreign Language on Eyewitness Recall

In this study, we used an eyewitness testimony paradigm that was used in previous misinformation research (Chan et al., 2012; Loftus & Palmer, 1974; Thomas et al., 2017). Only two papers have measured the extent to which the language bilinguals are using influences false memory under the misinformation effect paradigm (Calvillo & Mills, 2020; Shaw et al., 1997). However, these papers differ from our current research in two important regards. One, these papers focus primarily on situations of language switching, namely reading post-event information in one language and testing memory in another language. While a language switch could introduce memory effects, this is not our focus. Second, while Calvillo and Mills (2020) and Shaw et al. (1997; Study 3) had within-language conditions to determine if there was a language effect, these studies yielded inconsistent findings, with one study finding reduced false recall in the dominant language and the other study finding no language effect. Hence, with this study we aim to focus on the impact of language nativeness-as opposed to language match-on false recall, utilizing a larger sample of participants to determine if the results from Study 1 reflect a more general false memory phenomenon.

In our task, participants first viewed two silent videos of crimes followed by verbal testimonies by another person who described the crime. These testimonies included both true and false details about the crimes as seen in the videos, and each testimony was either in the participants' native or foreign language. Participants then received a memory test, consisting of a series of questions probing their memory of what they saw in the videos. The memory test used the same language as the verbal testimonies. We used this test to evaluate the extent to which participants incorrectly recalled that the false information from the narrative testimony had actually occurred in the video they watched.

The use of silent videos for the crime scenarios ensured that initial encoding would be held constant across the language conditions, so that the impact of the language manipulation would be specific to monitoring that might occur during the misinformation and retrieval phases of the study. Because the misinformation was explicitly presented in all conditions, and this task does not rely on word associations like the DRM task, we assumed that misinformation was equally activated across the conditions of our study. As such, differential rates of false memory across language conditions could be attributed to differences in memory monitoring. We also had participants rate the perceived trustworthiness, likability, intelligence, and credibility of the eyewitness testimony, as these factors can impact the misinformation effect and might vary across languages.

#### Method

#### **Participants**

One hundred thirty-one native Mandarin Chinese speakers who know English were recruited to participate using the same prescreening procedure as Study 1. Eleven participants were excluded prior to analyses for reporting higher proficiency in their foreign English than their native Mandarin Chinese. This left a final sample of 120 participants ( $M_{age} = 23.13$ ,  $n_{female} = 101$ ). The sample size was determined using the sample rationale as Study 1.

These participants had a mean starting age of acquisition of English of 8.46 years and had a self-reported, aggregated English proficiency across reading, writing, speaking, and listening of 5.28 on a scale from 1 (*not at all proficient*) to 7 (*highly proficient*).

#### **Materials**

We used two silent crime video clips. One was adapted by Chan et al. (2012) from the movie Pink Panther (1963) and the other one was adapted by Thomas et al. (2017) from the movie Rififi (1955). Each clip is approximately 9.5 min long. For each clip, we created two narratives that describe the events of the movie. Each narrative contained nine details that contradicted what occurred in the video clips ("misinformation" items) and nine details that were correct but did not specify the key detail measured later in memory ("control" items). These nine misinformation details and nine control details were counterbalanced across the narratives, and hence the nine details that appeared as control details in one narrative were revised as misinformation details in the other narrative and vice versa. For example, in the Pink Panther clip, there is a scene which depicts two large Greek statues behind two guards. In the misinformation condition, the narration incorrectly states for this item that there were two large suits of armor behind two guards. In the control condition, the narration states there were two large "objects" behind two guards.

A native Mandarin-Chinese research assistant fluent in English translated the two narratives into Chinese. Then, two native Mandarin Chinese research assistants fluent in English reviewed the materials for errors. Finally, materials were backtranslated into English and final corrections were made to ensure the narratives were as equivalent as possible (Brislin, 1970). Once finalized, twelve speakers recorded each of the narratives in a neutral tone. Half of the speakers were native Mandarin Chinese speakers and half were native English speakers, and within each language half of the speakers were female and half of the speakers were male. They all recorded the narratives in their native tongue. All recorded narratives were normalized to a standard perceived volume across speakers.

To assess memory for the videos we created 32 questions of four types for each video. For each question, participants were given a question on a key detail from the video with a suggested answer and were asked to state whether they recalled seeing that detail in the video. For example, one question from the *Pink Panther* video was: *Two museum guards talk while the robber is exploring the museum. What large objects are near the two guards as they are talking? TWO LARGE SUITS OF ARMOR.* Participants selected "Yes" or "No" to indicate whether they recalled this detail as having appeared in the video. We also included two additional sets of questions, one in which the narrative accurately described the video ("Consistent"), as well as filler questions about details that appeared only in the video but were not referred to at all in the narrative ("Video Only"). Following each memory question, participants were asked how confident they were in their memory of the event in question on a scale from 1 (*not at all confident*) to 10 (*very confident*).

#### Procedure

The first 19 subjects participated in the lab but due to the COVID-19 pandemic the rest of the subjects participated via Zoom (a video conferencing platform) to protect their safety and that of the research assistants. Minus the move to Zoom, the procedure was the same for all participants. Similar to Study 1, all procedures and materials were approved by the university IRB prior to beginning the study, and all participants consented to participate prior to beginning the study.

For the first part of the experiment, participants watched both silent videos, with half beginning with the *Pink Panther* video clip and half with the *Rififi* video clip. Participants were able to control the onset of the video, but they could not replay or pause any part of it. After watching both videos, participants listened to two narratives, each corresponding to the video clip, in the same order as the video presentation. One narrative was in English and the other was in Mandarin Chinese. The language of the narratives as well as the version of the narrative was counterbalanced across participants.

Following the video and narratives, the experimenter confirmed with participants that they did not have any technical difficulties with the video or audio players. Participants who reported technical difficulties that prevented them from watching the videos or listening to the narratives were removed from the study and replaced (n = 10). Participants then answered the series of memory questions regarding each video and provided confidence ratings. Prior to each set of memory items, participants were informed to only report recalling a detail if they remembered it from the videos and matched the language of the narrative. There was a 32nd break between the questions about the first video and the questions about the second video.

Once participants completed the memory questions, they listened to a brief clip of each narrator and rated them for perceived trustworthiness, likability, intelligence, and credibility. Finally, participants answered a series of demographic questions. In total, the experiment took approximately one hour to complete. See Figure 2 for a flowchart of the experimental procedure. All materials and data from this project can be found on Open Science Framework upon publication: https://osf.io/4ew9c/.

#### Figure 2 Flowchart of Experimental Procedure Used in Study 2



#### Results

We initially conducted a repeated measures ANOVA with Language (NativelForeign, within subjects) and Language Order (Native FirstlForeign First, between subjects), along with Item Type (MisinformationlControl, within subjects) included for the misinformation and control item analyses. Because Language Order had no significant effect and its interaction with Language was not significant in any of the subsequent models, Language Order was removed as a factor. Therefore, we report the results of a 2 (Language)  $\times$  2 (Item Type) for the misinformation and control items and separate paired *t*-tests for the consistent and video-only items.

#### Misinformation Effect

Overall, participants were significantly more likely to mistakenly recall the misinformation items (0.56) than the control items (0.50)as having occurred in the video (F(1, 476) = 8.26, p = .004,  $\eta_p^2 =$ 0.02). This replicates the misinformation effect. Furthermore, while there was no main effect of language, F(1, 476) = 1.04, p = .31,  $\eta_p^2 = 0.002$ ), there was a significant interaction between Language and Item Type  $(F(1, 476) = 26.86, p < .001, \eta_p^2 =$ 0.05). Specifically, when the narrative was in the native language, there was a robust misinformation effect as participants were more likely to falsely recall false details implied by the misinformation items (0.60) than the control items (0.43; MD = 0.17; 95% CI [0.12, 0.21], t(119) = 7.59, p < .001, d = 0.73). In contrast, participants who had listened to the narrative in their foreign language did not demonstrate a misinformation effect; in fact, reporting false details was slightly lower within the misinformation items (0.52) than the control items (0.56; MD = 0.04; 95% CI [0.004, 0.09], t (119) = 2.16, p = .03, d = 0.21; See Figure 3).

Though participants showed the misinformation effect more in their native language than in their foreign language, they were also more confident about their memory in their native language (M = 6.33 (1.11)) than in their foreign language (M = 5.85(0.11); 95% CI [0.29, 0.68], t(119) = 4.82, p < .001, d = 0.40). This higher confidence was specific to instances of false memory, as when participants accurately identified the false information as not appearing

#### Figure 3



Mean Proportion of Times Subjects Endorsed Incorrect Information as Having Occurred in the Video as a Function of Language (Native|Foreign) and Item Type (Misinformation| Control)

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in the video they were just as confident in their responses in the two languages (Foreign: M = 5.81(1.15), Native: M = 5.98(0.15), 95% CI [-0.13, 0.47], t(118) = 1.13, p = .26, d = 0.10).

#### Consistent and Video Only

For the "video-only" items in which the detail was shown in the video but never mentioned in the narrative, participants were just as accurate at recalling the detail in both languages (Native = 0.62, Foreign = 0.63; 95% CI [-0.05, 0.02], t(119) = 0.71, p = .48, d = 0.07). They were also just as confident when accurately identifying the video-only details in both languages (Native = 6.33 (0.16), Foreign = 6.21 (0.16), 95% CI [-0.23, 0.48], t(119) = 0.68, p = .50, d = 0.07). This is important as it demonstrates that the language effect on memory that we document only occurred with items associated with verbal information from the misinformation stage.

For the consistent items, in which the detail was accurately specified in the narratives, participants were more likely to accurately attribute the item to the video in their native language (0.75) than in their foreign language (0.67; 95% CI [0.04, 0.13], t(119) = 3.51, p < .001,d = 0.44). They were also more confident when they correctly identified the consistent details as having occurred in the video in their native language (M = 7.87 (0.14)) than their foreign language (M =7.13(0.17), 95% CI [0.36, 1.11], t(119) = 3.85, p < .001, d = 0.25). This shows that a foreign language did not increase the accuracy of memory overall, rather it only increased the ability to detect false information. In fact, because participants should not have relied on the eyewitness narrative when making their memory decisions for any items, presenting these true items in the narrative might have made them susceptible to the same monitoring process that we hypothesized would impact the actual misinformation (e.g., increased reliance on memory for the video, and decreased reliance on the eyewitness account, when in the foreign language).

#### Speaker Characteristics

It is possible that the impact of language on misinformation was not the result of the language used but rather an effect of how the speaker of the narrative was perceived. This is because the credibility of the source of the misinformation could affect endorsing false information (Echterhoff et al., 2005; Greene et al., 1982), and perceived power and social attractiveness of a voice influences susceptibility to later reporting false information (Vornik et al., 2003). Therefore, we evaluated if language affected the inferred characteristics of the speaker. We conducted a series of paired t-tests on the perception of how trustworthy, likable, intelligent, and credible the native language as compared to foreign language narrators were perceived.

We found no evidence that the language of the narrators affected their perceived attributes (Trustworthy: 95% CI [-0.36, 0.47], t (119) = 0.28, p = .78, d = 0.03; Likeable: 95% CI [-0.18, 0.46], t (119) = 0.88, p = .38, d = 0.09; Intelligent: 95% CI [-0.28, 0.37], t(119) = 0.25, p = .80, d = 0.03; Credible: 95% CI [-0.20, 0.48], t (119) = 0.83, p = .41, d = 0.09). See Table 2 for means and standard error by language.

#### **General Discussion**

Using two different paradigms, the studies we report show that the use of a foreign language reduces false memories. In Study 1, we

#### Table 2

Perception of Speakers' Characteristics by Language (Native Foreign)

Language	Speaker characteristics			
	Trustworthy	Likable	Intelligent	Credible
Native Foreign Difference	5.26 (0.16) 5.32 (0.17) -0.06	5.41 (0.15) 5.55 (0.12) -0.14	5.40 (0.14) 5.44 (0.15) -0.04	5.38 (0.16) 5.53 (0.15) -0.15

demonstrated that individuals more accurately monitored falsely activated items in the DRM task when participants used a foreign language. Though the lure came to mind more often in a foreign than native language, potentially because we used the standard DRM lists which were based on word associations in English, participants also were more likely to accurately identify these falsely generated items as not studied when they used a foreign language. In other words, false memory was reduced with a foreign language. In Study 2, false memory was all but eliminated in an eyewitness testimony paradigm when participants used a foreign language. While false testimony induced false memories of the event when the testimony was provided in their native tongue, it did not lead to false memories when it was provided in a foreign language.

These results were predicted by the monitoring account and are inconsistent with the processing load account. It is intuitive that using a foreign language is more difficult than using a native tongue and that a foreign language induces extra processing load on the cognitive systems (Caldwell-Harris & Ayçiçeği-Dinn, 2009; Takano & Noda, 1993, 1995). This would predict that foreign language users would have a harder time recruiting the additional monitoring resources needed to monitor out false memories. Yet both in the DRM and eyewitness testimony tasks the opposite happened.

Our findings do not necessarily contradict prior research that attributed decreased DRM false memories in a foreign or nondominant language to decreased activation of the associated lures (see review, Suarez and Beato, 2021). Indeed, this hypothesis makes intuitive sense, as conceptual associations may be richer in the native tongue. Our study was not designed to address this question, as this would require balancing the associative strength of materials across languages or other methods. Instead, our study was designed to address the monitoring question, using a modified DRM procedure to separate activation from monitoring processes, as well as a different false memory task to generalize the monitoring hypothesis. Our results provide the first evidence that increased monitoring in a foreign language can reduce false memories, and that applies to false memories that result from word associations (DRM) and false memories that result from misleading information. This finding has important implications for understanding false memory creation in a foreign language, and it also highlights the importance of considering the differential use of monitoring processes in studies of bilingualism and false memory.

Overall, our results suggest that people are less likely to default to quick assessments of familiarity or intuition when evaluating false information in a foreign language than their native tongue. Instead, they are more effective in engaging monitoring processes to identify the source of the false information. To the extent that these language differences impact false memory monitoring, they could have far-reaching impacts on how reality is constructed from memory when different languages are involved.

#### **Areas of Future Research**

While these studies provide important insights into the relationship between language and memory, there are still some questions warranting future research. First, our studies focused specifically on native Mandarin Chinese speakers who knew English as a foreign language. Future research could examine other language combinations to test the generalizability of these findings to both other language pairings and cultures. We believe that the foreign language effect on monitoring observed here is based on the use of a foreign language, per se, and not specific to any particular language. Thus, the effect should generalize across other combinations of languages. Along these lines, an important direction for future work would be to use the modified DRM procedure to separate both activation and monitoring processes (as in the current study), and also to carefully balance associative strength between the two languages (as in some prior bilingual studies). By combining these two approaches, researchers can simultaneously test for differences in critical lure activation as a function of language as has been proposed in the prior literature (native > foreign) as well as difference in monitoring (foreign > native) as proposed in the current study. Foreign language might impact both activation and monitoring processes, and the current study only speaks to the latter.

Second, future studies could explore an alternate mechanism for the misinformation findings from Study 2. The monitoring account we propose argues that the use of a foreign language biased participants to focus more on specific recollections and less on false or misleading information in either task, and this hypothesis was based on prior research showing that both the DRM and misinformation effect tasks rely on monitoring-based mechanisms to override false memories (see Gallo & Lampinen, 2016). Nevertheless, an ongoing debate specific to the misinformation effect literature is the extent to which the false information provided in the eyewitness narrative overwrites one's prior visual memory of the event in question (Loftus et al., 1985; McCloskey & Zaragoza, 1985). As noted by a reviewer, it may be that participants found the narrative more convincing or salient in their native compared with a foreign tongue, and hence more likely to "automatically overwrite" visual memories and produce false memories. Such an effect might be conceptualized as a difference in false memory activation, as opposed to a difference in monitoring. While this overwriting explanation is less parsimonious than the monitoring account-which predicted the same foreign language effect on false memories regardless of the memory task-we cannot rule it out based on the present analysis. Therefore, it would be of interest to examine the possibility that information shared in a native language is more likely to override a prior visual memory of an event altogether.

#### Conclusion

In sum, our findings provide a novel insight into the relationship between language and memory, by demonstrating that people differentially engage in monitoring depending on the language they are using. These findings have important implications for the hundreds of millions of people who routinely use two or more languages, who may be surprised to learn that they may be more likely to fall for a false memory when it was shared through their foreign language.

#### Context

This project began as a collaboration between two research groups —one with a focus on bilingualism and decision-making and the other on memory and memory monitoring-to combine the insights from our respective areas to understand the relationship between language nativeness and memory. At the time of this research, the literature on bilingualism and false memories had focused primarily on differences in false memory activation utilizing the standard DRM task, however, we sought to test a different hypothesis. Specifically, based on previous work in our two research groups, we hypothesized that foreign language use may influence memory monitoring by decreasing the likelihood to default onto quick, intuitive judgments of familiarity and instead activating slower, more deliberative monitoring processes when judging the veracity of a memory that comes to mind. Across two studies, we tested this monitoring hypothesis using two different types of false memory tasks to demonstrate the generalizability of our findings. Through this research, we hope to provide a novel insight into how one important factor-engagement of memory monitoring- may influence susceptibility to false memories when utilizing either a native or a foreign language.

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