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Ageing and the Moses Illusion: Older adults fall for Moses but if asked directly, stick with Noah

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Many people respond ''two'' to the question ''How many animals of each kind did Moses take on the ark?'', even though they know the reference should be to Noah. The *Moses Illusion* demonstrates a failure to apply stored knowledge (Erickson & Mattson, 1981). Of interest was whether older adults' robust knowledge bases would protect them from vulnerability to this illusion. Of secondary interest were any age differences in the memorial consequences of the illusion, and whether older adults' prior knowledge would protect them from later reproducing information from distorted questions (e.g., later saying that Moses took two animals of each kind on the ark). Surprisingly, older adults fell for the Moses Illusion more often than did younger adults. However, falling for the illusion did not affect older adults' later memory; they were less suggestible than young adults. Most importantly, older adults were more likely to recover from exposure to distorted questions and respond correctly. Explanations of these findings, drawing on theories of cognitive ageing, are discussed.

Keywords: Ageing; Knowledge; False memory.

Time and time again older adults show increased vulnerability to suggestion compared to younger adults. After exposure to misleading information they make more memory errors, whether being asked to remember simulated events in the laboratory (Mueller-Johnson & Ceci, 2004), videos (Loftus, Levidow, & Duesing, 1993), actions (Schacter, Koutstaal, Johnson, Gross, & Angell, 1997), or lists of related pictures (Koutstaal, Schacter, & Brenner, 2001). In contrast, older adults are less likely to reproduce errors that contradict general knowledge; after reading stories containing errors about the world (e.g., a reference to the *Atlantic* Ocean as the largest ocean on earth), older adults are less likely to answer related general knowledge questions (e.g., What is the largest ocean on earth?) with story errors compared to their younger counterparts (Marsh, Balota, & Roediger, 2005; Umanath & Marsh, 2012).

There are many differences across false memory paradigms, and it is unclear which factor is key in driving older adults' suggestibility; our focus is on the possibility that the crucial difference lies in the episodic (e.g., details of recently encountered information) versus semantic (e.g., general knowledge related) nature of the misleading content. To further our understanding of this issue we wanted to examine the more general phenomena of semantic illusions. Semantic

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illusions involve situations in which given information contradicts pre-existing knowledge; the illusion occurs when people fail to notice a contradiction with what they already know. For example, it is a semantic illusion when a reader answers the question ''Where were the survivors buried?'' after reading a short passage about a plane crash (Barton & Sanford, 1993), because this question contains a presupposition that contradicts the stored meaning of the word ''survivor''.

The robust *Moses Illusion* is the best-known semantic illusion in which young adults often fail to notice contradictions with their pre-existing knowledge when answering distorted questions like ''How many animals of each kind did Moses take on the ark?'' and answer ''two'' (even though they later demonstrate that they know it was *Noah* who took animals on the ark). This illusion demonstrates a failure to bring to bear stored knowledge (Erickson & Mattson, 1981). Our first goal is to examine whether there are any age differences in susceptibility to this semantic illusion. Unfortunately, the theoretical underpinnings of the Moses Illusion are rather underdeveloped and do not lend themselves to clear predictions about possible age differences in susceptibility to the Moses Illusion. For instance, consider the dominant explanation of the illusion, the Partial Match Hypothesis (Reder & Kusbit, 1991). This theory claims that the Moses Illusion occurs because of an imperfect memory match process, with a failure to notice a mismatch between what is retrieved from memory (e.g., details related to the Noah and the ark story) and the actual probe (e.g., a reference to Moses as the protagonist). This matching is on the order of concepts and features, not specific words, such that highly semantically similar terms slip by unnoticed. It is unclear how age might affect this process, and if age does affect the Moses Illusion, it would suggest a need to refine the theory.

Instead we base our predictions about possible age differences in the illusion on a number of related literatures. Most importantly, older adults have intact error detection abilities in a variety of situations: When noting errors in rhythm synchronisations (Turgeon, Wing, & Taylor, 2010), correcting their mistakes in identifying certain digits on a screen (Rabbitt, 1979), and marking misspelled words (Mackay, Abrams, & Pedroza, 1999), older adults perform as well as younger adults in monitoring for errors. It is entirely plausible that their error detection abilities will extend to detecting contradictions in the Moses Illusion paradigm, especially since knowledge bases are maintained or even improved with age (e.g., Light & Anderson, 1983; McIntyre & Craik, 1987; Mitchell, 1989). Here ''knowledge'' refers broadly to general knowledge about the world, vocabulary, schemas, work-related skills, and practical abilities gained over a lifetime. Knowledge plays a key role in the Moses Illusion, in that participants are more likely to notice errors when they are less semantically associated with the correct references (e.g., Nixon or Abraham versus Moses in place of Noah; Erickson & Mattson, 1981; van Oostendorp & de Mul, 1990). Similarly, there is some speculation that experts may be less susceptible to semantic illusions (Reder & Cleeremans, 1990), and older adults can be considered ''knowledge experts'' (Hoyer, Rybash, & Roodin, 1989; Perlmutter, 1988; Schaie & Labouvie-Vief, 1974). Combined, these preserved abilities in older adults may make them particularly likely to catch contradictions with general knowledge. Schwartz (2002, p. 140) provided intriguing anecdotal evidence for this possibility:

> In my work on illusory tip-of-the-tongues, I developed a set of trick questions for which there was no correct answer (e.g., What is the name of Mercury's moon?) … only one college student out of nearly 200 detected a discrepancy (that Mercury has no moons). However, when I tried to conduct the study at a local senior center … the study was a washout because virtually every older adult detected the falsity of the questions.

Thus older adults' intact knowledge could potentially make errors in distorted questions especially salient to them, reducing the Moses Illusion.

Our second goal was to examine whether there are any age differences in suggestibility, meaning age differences in memorial consequences of the Moses Illusion. We examined whether exposure to factual inaccuracies (in the distorted questions) affects participants' later answers to general knowledge questions. Answering distorted questions has the potential to teach misinformation to the learner, in the same sense that reading errors in stories or encountering them in other sources often later misleads learners. This type of suggestibility has been demonstrated in younger adults, who are more likely to later answer ''Who is said to have taken two animals of each kind on the ark?'' with ''Moses'' after answering the distorted

question (Bottoms, Eslick, & Marsh, 2010; see also Kamas, Reder & Ayers, 1996). This question is particularly interesting to ask with older adults, given evidence that older adults make fewer memory errors when misinformation contradicts pre-existing knowledge (discussed above; Marsh et al., 2005). Additionally, older adults may be more likely to recover and produce their prior knowledge even after exposure to distorted questions (e.g., producing more correct responses to related general knowledge questions; Umanath & Marsh, 2012).

In this study, we investigated the occurrence of the Moses Illusion in older and younger adults, as well as its memorial consequences. The experiment had three phases. First, the Moses Illusion was measured through an initial error detection phase wherein participants answered undistorted and distorted general knowledge questions while being explicitly asked to note errors; of primary interest were older and younger adults' responses to distorted questions. Second, the memorial consequences of exposure to distorted questions were observed in a subsequent general knowledge test asking related short-answer questions (e.g., Who took two animals of each kind on the Ark?). Third, participants took a multiple choice knowledge check to confirm what they knew, so that all analyses could be restricted to items for which individuals had demonstrated knowledge.

METHOD

Participants

A total of 97 Duke University undergraduates participated for course credit or monetary compensation, and 65 older adults recruited through Duke University's Center for Aging registry participated for monetary compensation. Older adult participants were at least 65 years of age (38 females and 27 males; average age: 77).

Design

A 2 (Age: Younger, Older Adult)×3 (Error Detection Question Form: Undistorted, Not Presented, Distorted) mixed design was used. Age was a between-participants factor while error detection question form during the initial phase was manipulated within participants. Of particular interest were age differences in error detection ability (measured from responses to distorted trials in the initial phase) and performance on the short-answer test (representing suggestibility).

Materials

A total of 60 Moses Illusion questions were adapted from Bottoms et al. (2010) and are included in the Appendix. Each critical question had an undistorted and distorted form; the *undistorted* question form included a correct reference to a fact (e.g., "*What phrase followed 'To be or not to be' in Hamlet's famous soliloquy?*") whereas the *distorted* question form contained a plausible but misleading reference (e.g., "*What phrase followed 'To be or not to be' in Macbeth's famous soliloquy?*"). Across participants each question was rotated through the three conditions (undistorted, distorted, not presented). The error prevalence was 50%, consistent with prior work (e.g., Bottoms et al., 2010; Hannon & Daneman, 2001; Kamas et al., 1996; Reder & Kusbit, 1991; van Jaarsveld, Dijkstra, & Hermans, 1997), meaning that participants encountered 20 undistorted and 20 distorted questions during the error detection phase. Question order was randomised for each participant.

The short-answer general knowledge questions targeted the facts referenced in the critical questions (e.g., "*Whose famous soliloquy contained the phrase, 'To be or not to be, That is the question'?*"). Participants answered 30 short-answer questions referencing 10 previously undistorted questions, 10 previously distorted questions, and 10 questions that had not been presented during the error detection phase.

Knowledge check items included the prompts from the short-answer test questions paired with three answer choices: the correct answer (e.g., *Hamlet*), the misinformation from the distorted question (e.g., *Macbeth*), and "I don't know". All 60 critical questions were asked about on this knowledge check.

Procedure

Participants were told that they would take three different general knowledge tests. The first test was the error detection phase. Participants were warned that during this first general knowledge test, some questions would contain errors making them unanswerable, and were given the following

example: ''You might be asked, 'In what mythology was Venus known as the Goddess of War?' However, Venus was the Goddess of Love, not War.'' Participants were told to answer only undistorted questions and to type ''wrong'' in response to distorted questions. Participants were discouraged from guessing wildly and instructed to type ''I don't know'' if needed. After this phase participants worked on a filler task consisting of visuo-spatial puzzles for three minutes. Next participants completed a second general knowledge test: the short-answer test, with a warning against guessing and the instruction to type ''I don't know'' as needed. Finally participants took the multiple-choice knowledge check and then were debriefed. The entire experiment took about 30 minutes for younger adults and 45 minutes for older adults and was programmed using MediaLab and DirectRT experimental software (Jarvis, 2008a, 2008b).

RESULTS

One coder coded all responses, blind to condition. A second coder coded 10% of the trials, and Cohen's kappa was calculated to assess inter-rater reliability. Reliability was high for each phase of the experiment (=.99 for the initial error detection phase and =.98 for the short answer test), and the first author resolved the disagreements in coding.

Knowledge check

Participants answered 79% of multiple-choice questions correctly on the knowledge check. Consistent with prior work showing that older adults typically demonstrate more knowledge, older adults answered more of these multiple-choice questions correctly ($M = .83$, $SD = .10$) than did younger adults ($M = .74$, $SD = .11$), $t(160) = 5.37$, $SED = .02$, Cohen's $d = .86$, $p = .001$.[1]

Critically, the analyses that follow include *only* those items that participants answered *correctly* on the final knowledge check. That is, they match older and younger adults on prior knowledge.

The Moses Illusion

We analysed responses to distorted and undistorted trials during the initial error detection phase separately, consistent with prior work (e.g., Kamas et al., 1996; van Oostendorp & de Mul, 1990).

During the error detection phase undistorted questions (which contained correct references) were answered in one of four ways: correctly, incorrectly, falsely detecting an error, or saying ''don't know''. The relevant data are in the top portion of Table 1; these data represent averages across participants, but similar conclusions were reached when the data were analysed with items as the unit of analysis. Older adults answered more undistorted questions correctly ($M = .74$) than did younger adults ($M = .66$), $t(160) = 2.89$, $SED = .03$, Cohen's $d = .49$, $p = .004$. Participants made very few false alarms ($M = .04$), and this did not differ as a function of age, $t(1, 160) = 1.48$, $SED = .01$, $p = .14$.

More important for present purposes are responses to the *distorted* questions (see the bottom portion of Table 1). For these unanswerable questions correct answers were not possible. Thus each distorted question was answered in one of three ways: incorrectly (if *any* response was given; a Moses Illusion), detected (if ''wrong'' was typed), or with an ''I don't know'' response. Following the coding scheme of Erickson and Mattson (1981), *any* answer to a distorted question other than ''wrong'' or ''I don't know'' was counted as an occurrence of the Moses Illusion. First, the Moses Illusion was observed in both age groups. Younger adults answered 41% of the distorted questions, in line with the typical size of the Moses Illusion (e.g., Bottoms et al., 2010), even though these were all items for which they later demonstrated knowledge on the knowledge check. Interestingly, older adults succumbed to the Moses Illusion more often, providing answers for 50% of the distorted questions, $t(160) = 2.51$, $SED = .04$, Cohen's $d = .40$, $p = .01$. However, there were no age differences in ability to *catch* the errors; older and younger adults were equally

[1] As has been noted in prior work (Bottoms et al., 2010), the knowledge check is affected by the earlier experimental tasks. That is, exposure to distorted questions during the error detection phase reduces correct answers (for those specific questions) on the knowledge check, as compared to questions that tap information not encountered previously within the experiment (a baseline measure of knowledge). Key for present purposes is that older and younger adults were similarly affected by prior exposure to the distorted questions, answering about 7% fewer questions correctly on the knowledge check (OAs: from .84 to .77; YAs: from .74 to .66).

TABLE 1 Proportion of questions answered correctly, incorrectly, identified as "wrong" and labelled as "I don't know"

	Correct	*Moses Illusion*	*"Wrong"*	*"I don't know"*
Undistorted questions				
Older adults	.74 (.17)	–	.04 (.05)	.14 (.12)
Younger adults	.66 (.16)	–	.03 (.04)	.24 (.13)
Distorted questions				
Older adults	–	.50 (.24)	.38 (.27)	.13 (.11)
Younger adults	–	.41 (.21)	.38 (.25)	.20 (.17)

Data are from the error detection phase as a function of age and question type, conditionalised on correct answers during knowledge check. Standard deviations are presented in parentheses. Correct answers were impossible for distorted questions; "Wrong" responses to undistorted questions represent false alarms. "Wrong" responses for distorted questions represent successful detection.

likely to say "wrong" to the distorted questions ($M = .38$), $t < 1$. Finally, older adults were less likely to say "I don't know" than were younger adults; $t(160) = -3.33$, $SED = .02$, Cohen's $d = -.80$, $p = .001$.

Memorial consequences: Short-answer test responses

The second research question involved an examination of memorial consequences. Did prior exposure to distorted questions differentially influence older and younger adults' responses on the subsequent short-answer general knowledge test which referenced content from the error detection phase? Again, the following analyses are restricted to items for which the participants successfully identified the correct answers on the knowledge check. Again, similar conclusions were reached regardless of whether participants or items were treated as the unit of analysis.

Memorial consequences were observed: the error detection phase affected people's responses on the general knowledge test. Table 2 shows the entire data set; this table includes correct responses for the interested reader, but our focus here and the reported analyses involve misinformation answers (defined as the specific wrong answer suggested in the distorted version of each question; e.g., Moses). A 2(Age)×3(Error Detection Question Form: undistorted, not seen, distorted) ANOVA was computed on these data (bottom portion of Table 2). This ANOVA violated the sphericity assumption, and a Geisser-Greenhouse correction was applied. Even though participants knew the correct references (as confirmed on the knowledge check), they answered more questions with misinformation after exposure to distorted questions ($M = .05$) than after seeing undistorted questions ($M = .01$); $t(161) = 6.09$, $SEM = .01$, Cohen's $d = .82$, $p = .001$, or when the related questions had not appeared ($M = .02$); $t(161) = 4.93$, $SEM = .01$, Cohen's $d = .62$, $p = .001$; $F(2, 320) = 24.14$, $MSE = .004$, $\eta_p^2 = .13$, $p = .001$.

Of interest were age differences in misinformation production (suggestibility). Younger adults showed a trend towards answering more short-answer questions with errors from the distorted questions ($M = .06$) than did older adults ($M = .04$), indicating that younger adults were slightly more

TABLE 2 Proportion of correct and misinformation answers produced on the short-answer knowledge test as a function of age and error detection question form

	Undistorted question	*Not presented*	*Distorted question*
Correct answers			
Older adults	.81 (.19)	.73 (.21)	.75 (.22)
Younger adults	.87 (.13)	.73 (.19)	.71 (.23)
M	.84 (.16)	.73 (.20)	.73 (.22)
Misinformation answers			
Older adults	.01 (.04)	.02 (.04)	.04 (.07)
Younger adults	.001 (.001)	.01 (.04)	.06 (.11)
M	.01 (.02)	.02 (.04)	.05 (.09)

Standard deviations are presented in parentheses.

suggestible than older adults. This was reflected in a marginally significant interaction between age and error detection question form, $F(2, 320) = 2.87$, $MSE = .004$, $\eta_p^2 = .02$, $p = .058$. Although suggestibility is low here, of note is that this suggestibility occurred despite the fact that analyses were limited to items for which participants were able to demonstrate correct knowledge.

To better understand this pattern, we re-examined suggestibility based on whether errors were initially noticed or missed during the error detection phase, conducting 2(Age)×2(Error Detected: Successful, Missed) ANOVAs on the proportion of short-answer questions answered correctly and the proportion answered with misinformation (see Figure 1). This analysis was limited to items for which participants had seen distorted questions during the error detection phase. When participants caught the errors, correct responding was high and suggestibility was low, and there were no age differences. Regardless of age, catching an error was associated with correct responding on the short answer test.

However, there were clear age differences in memorial consequences after errors were *missed* during the error detection phase. After missing an error, older adults were more likely to later recover and produce the correct answer ($M = .75$, $SD = .25$) than were younger adults ($M = .64$, $SD = .30$); $t(155) = 1.82$, $SED = .05$, Cohen's $d = .40$, $p = .07$, resulting in a significant interaction between age and successful detection, $F(1, 127) = 4.86$, $MSE = .06$, $\eta_p^2 = .04$, $p = .03$. In contrast, as shown in the right panel, younger adults were more likely to reproduce misinformation after missing the errors ($M = .10$, $SD = .17$) than were older adults ($M = .05$, $SD = .09$); $t(155) = -2.06$, $SED = .02$, Cohen's $d = .39$, $p = .04$, resulting in a significant interaction between age and successful detection, $F(1,127) = 5.44$, $MSE = .01$, $\eta_p^2 = .04$, $p = .02$. In short, older adults showed fewer memorial consequences, even though they demonstrated a larger semantic illusion rate during the error detection phase.

DISCUSSION

This study examined two main questions: First, are older adults more vulnerable to the Moses Illusion compared to younger adults? Second, do older and younger adults show the same memorial consequences following exposure to misleading information in distorted questions?

Regarding the first question, older adults demonstrated greater vulnerability to the Moses Illusion compared to younger adults. That is, they were more likely to answer distorted questions than were younger adults (e.g., answering "What is the name of the Mexican dip made with mashed-up artichokes?" with "guacamole"). While this result seems surprising based on older adults' intact error-detecting abilities and maintained general knowledge, the result is consistent with theories of cognitive ageing, specifically, with older adults' increased susceptibility to proactive interference (see Winocur, 1982) and age-related inhibitory deficits (Hasher & Zacks, 1979, 1988).

Knowledge constitutes strong traces in memory, and older adults tend to apply their pre-existing knowledge to facilitate memory, often filling in gaps in their memories with schema-

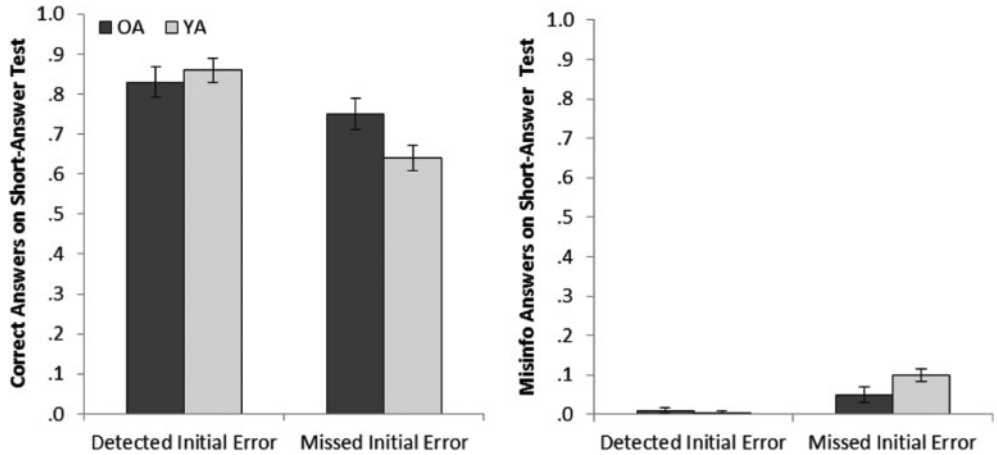

Figure 1. Correct answers (left) and misinformation answers (right) produced on the short-answer knowledge test as a function of age and error detection success.

consistent information (e.g., Hess & Slaughter, 1990; Koutstaal et al., 2003). Thus older adults may be more likely than younger adults to experience proactive interference from the concept of ''avocados'' while processing a distorted question like ''What is the name of the Mexican dip made with mashed-up artichokes?'' In other words, older adults may be more likely than younger adults to experience partial matches. The key problem for older adults is that the situation requires inhibiting prepotent responses. That is, older adults likely find it very challenging not to reply to questions once the associated answer (e.g., guacamole) comes to mind, since they have difficulty refraining from producing responses (e.g., Hasher, Stoltzfus, Zacks, & Rypma, 1991). That is, once information is partially active, older adults tend to struggle to inhibit or suppress that potentially irrelevant information (e.g., Balota, Dolan, & Duchek, 2000; Kensinger & Schacter, 1999; Malmstrom & LaVoie, 2002), even when explicitly asked to do so (e.g., Anderson, Reinholz, Kuhl, & Mayr, 2011; Duchek, Balota, Faust, & Ferraro, 1995).

In addition, in Moses Illusion studies participants are required to perform two active tasks: answering the presented questions *and* detecting the errors. Decreasing task demands reduces the Moses Illusion in younger adults; participants are much more likely to detect the errors when verifying statements rather than answering questions at the same time as detecting errors. Verifying statements removes the urge to answer distorted questions (Buttner, 2007). Similarly, lower working memory capacity seems to contribute to increased vulnerability to the illusion in younger adults (Hannon & Daneman, 2001). Older adults often have difficulties when performing multiple tasks simultaneously (for reviews, see McDowd & Shaw, 2000; Verhaegen & Cerella, 2002) and show declines in working memory capacity (e.g. Dobbs & Rule, 1989; Salthouse & Babcock, 1991). In the case of the Moses Illusion, these factors, among others, may lead older adults to struggle in coordinating answering the questions, efficiently monitoring for errors, and inhibiting answers when necessary. Of note here is that this age difference in vulnerability to the illusion existed in the face of demonstrated knowledge of the correct reference (e.g., avocados) for a question on the final knowledge check.

Regarding the second main question, as predicted older adults were less suggestible than younger adults, albeit marginally so, reproducing fewer suggested errors on the later general knowledge test. This finding adds weight to the claim that the relationship between ageing and suggestibility may be different when misinformation targets knowledge rather than episodic experience. Although suggestibility was low in this study, and the age difference was small, it is consistent with past work (Marsh et al., 2005; Umanath & Marsh, 2012). More interesting for present purposes, compared to younger adults older adults were better able to recover after missing errors during the error detection phase. Missed errors were reproduced at a higher rate by younger adults, whereas older adults were more likely to produce correct answers after missing errors initially. Older adults do not suffer from memorial consequences of exposure to the errors to the extent that their younger counterparts do, even though all participants had the requisite knowledge stored in memory. Thus, although older adults' prior knowledge did not protect them from falling for the illusion, it protected them on later memory tests.

This work opens up a number of directions for future research. First, in terms of semantic illusions, this is just the first step in thinking about how individual differences might modulate the illusion. For example, if we consider older adults to be knowledge ''experts'', our findings also inform the previous speculation that expertise would reduce vulnerability to the illusion (see Reder & Cleeremans, 1990). Instead the current evidence suggests that experts in a domain might fall for the illusion just as much or even more than non-experts, but later show reduced memorial consequences just like the older adults here. This remains an open question to be examined. Second, future work should explore the specific mechanism underlying the age differences observed here, both during the initial error detection phase and the consequent suggestibility. We suggested that older adults may be more prone to partial matches (due to their larger knowledge bases), and struggle to inhibit prepotent responses in a dual task situation. We chose that explanation because it fits with the main theory of the Moses Illusion, the Partial Match Hypothesis. However, another possibility is that older adults do not experience partial matches, and in fact never encode the distorted terms in the first place. Finally, this work contributes to a small but growing literature that illustrates circumstances under which older adults show *reduced*

suggestibility (e.g., Marsh et al., 2005, Parks & Toth, 2006, Umanath & Marsh, 2012), which lies in stark contrast to their greater vulnerability to suggestion in other paradigms. Finding this age difference in suggestibility in a very different paradigm (the Moses Illusion) supports the idea that there is something different about situations where misinformation contradicts knowledge rather than recent experience. Future research should examine whether this age reversal occurs in other semantic illusions and focus on pinpointing the mechanism underlying older adults' impressive recovery after being led astray.

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REFERENCES

Anderson, M. C., Reinholz, J., Kuhl, B. A., & Mayr, U. (2011). Intentional suppression of unwanted memories grows more difficult as we age. *Psychology and Ageing*, *26*, 397–405.

Balota, D. A., Dolan, P. O., & Duchek, J. M. (2000). Memory changes in healthy older adults. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 395–409). New York, NY: Oxford University Press.

Barton, S. B., & Sanford, A. J. (1993). A case study of anomaly detection: Shallow semantic processing and cohesion establishment. *Memory & Cognition*, *21*, 477–487.

Bottoms, H. C., Eslick, A. N., & Marsh, E. J. (2010). Memory and the Moses Illusion: Failures to detect contradictions with stored knowledge yield negative memorial consequences. *Memory*, *18*, 670–678.

Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults. *Journal of Memory and Language*, *30*, 542–579.

Buttner, A. C. (2007). Questions versus statements: Challenging an assumption about semantic illusions. *The Quarterly Journal of Experimental Psychology*, *60*, 779–789.

Dobbs, A. R., & Rule, B. G. (1989). Adult age differences in working memory. *Psychology and Aging*, *4*, 500–503.

Duchek, J. M., Balota, D. A., Faust, M. E., & Ferraro, F. R. (1995). Inhibitory processes in young and older adults in a picture-world task. *Ageing and Cognition*, *2*, 156–167.

Erickson, T. D., & Mattson, M. E. (1981). From words to meaning: A semantic illusion. *Journal of Verbal Learning & Verbal Behavior*, *20*, 540–551.

Frick-Horbury, D. & Guttentag, R. E. (1998). The effects of restricting hand gesture production on lexical retrieval and free recall. *The American Journal of Psychology*, *111*, 43–62.

Hannon, B., & Daneman, M. (2001). Susceptibility to semantic illusions: An individual-differences perspective. *Memory & Cognition*, *29*, 449–461.

Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*, 163–169.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortless processes in memory. *Journal of Experimental Psychology: General*, *108*, 356–388.

Hasher, L. & Zacks, R. T. (1988). Working memory, comprehension, and ageing: A review and a new view. *The Psychology of Learning and Motivation: Advances in Research and Theory*, *22*, 193–225.

Hess, T. M., & Slaughter, S. J. (1990). Schematic knowledge influences on memory for scene information in young and older adults. *Developmental Psychology*, *26*, 855–865.

Hoyer, W. J., Rybash, J. M., & Roodin, P. A. (1989). Cognitive change as a function of knowledge access. In M. L. Commons, J. D. Sinnott, F. A. Richards, & C. Armon (Eds.), *Adult development: Comparisons and applications of developmental models* (Vol. 1, pp. 293–305). New York, NY: Praeger Publishers & the Dare Association, Inc.

Jarvis, B. G. (2008a). *DirectRT (Version 2008.1.0.13) [computer software]*. New York, NY: Empirisoft Corporation.

Jarvis, B. G. (2008b). *MediaLab (Version 2008.1.33) [computer software]*. New York, NY: Empirisoft Corporation.

Kamas, E. N., Reder, L. M., & Ayers, M. S. (1996). Partial matching in the Moses illusion: Response bias not sensitivity. *Memory & Cognition*, *24*, 687–699.

Kensinger, E. A., & Schacter, D. L. (1999). When true memories suppress false memories: Effects of ageing. *Cognitive Neuropsychology*, *16*, 399–415.

Koutstaal, W., Reddy, C., Jackson, E. M., Prince, S., Cendan, D. L., & Schacter, D. L. (2003). False recognition of abstract versus common objects in older and younger adults: Testing the semantic categorization account. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 499–510.

Koutstaal, W., Schacter, D. L., & Brenner, C. (2001). Dual task demands and gist-based false recognition of pictures in younger and older adults. *Journal of Memory and Language*, *44*, 399–426.

Light, L. L., & Anderson, P. A. (1983). Memory for scripts in young and older persons. *Memory & Cognition*, *11*, 435–444.

Loftus, E. F., Levidow, B., & Duesing, S. (1992). Who remembers best? Individual differences in memory for events that occurred in a science museum. *Applied Cognitive Psychology*, *6*, 93–107.

MacKay, D. G., Abrams, L., & Pedroza, M. J. (1999). Ageing on the input versus output side: Theoretical implications of age-linked asymmetries between detecting versus retrieving orthographic information. *Psychology and Ageing*, *14*, 3–17.

Malmstrom, T., & LaVoie, D. J. (2002). Age differences in inhibition of schema-activated distractors. *Experimental Ageing Research*, *28*, 281–298.

Marsh, E. J., Balota, D. A., & Roediger, H. L. III (2005). Learning facts from fiction: Effects of healthy ageing and early-stage dementia of the Alzheimer type. *Neuropsychology*, *19*, 115–129.

McDowd, J., & Shaw, R. J. (2000). Attention and ageing: A functional perspective. In F. I. M. Craik, & T. A. Salthouse (Eds.), *Attention and ageing: A functional perspective* (pp. 221–292). Mahwah, NJ: Erlbaum.

McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology*, *41*, 175–192.

Mitchell, D. B. (1989). How many memory systems? Evidence from ageing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 31–49.

Mueller-Johnson, K., & Ceci, S. J. (2004). Memory and suggestibility in older adults: Live event participation and repeated interview. *Applied Cognitive Psychology*, *18*, 1109–1127.

Park, H., & Reder, L. M. (2004). Moses illusion: Implications for human cognition. In R. F. Pohl (Ed.), *Cognitive illusions: A handbook on fallacies and biases in thinking, judgment, and memory* (pp. 275–292). Hove, UK: Psychology Press.

Parks, C. M., & Toth, J. P. (2006). Fluency, familiarity, ageing, and the illusion of truth. *Ageing, Neuropsychology, and Cognition*, *13*, 225–253.

Perlmutter, M. (1988). Cognitive potential throughout life. In J. E. Birren, & V. L. Bengtson (Eds.), *Emergent theories of aging* (pp. 247–268). New York, NY: Springer.

Rabbitt, P. (1979). How old and young subjects monitor and control responses for accuracy and speed. *British Journal of Psychology*, *70*, 305–311.

Reder, L. M., & Cleeremans, A. (1990). The role of partial matches in comprehension: The moses illusion revisited. In A. Graesser, & G. Bower (Eds.), *The psychology of learning and motivation* (pp. 233–258). New York, NY: Academic Press.

Reder, L. M., & Kusbit, G. W. (1991). Locus of the Moses illusion: Imperfect encoding, retrieval, or match? *Journal of Memory and Language*, *30*, 385–406.

Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *27*, 763–776.

Schacter, D. L., Koutstaal, W., Johnson, M. K., Gross, M. S., & Angell, K. E. (1997). False recollection induced by photographs: A comparison of older and younger adults. *Psychology and Aging*, *12*, 203–215.

Schaie, K. W., & Labouvie-Vief, G. (1974). Generational versus ontogenetic components of change in adult cognitive behavior: A fourteen-year cross-sequential study. *Developmental Psychology*, *10*, 305–320.

Schwartz, B. L. (2002). *Tip-of-the-tongue states: Phenomenology, mechanism, and lexical retrieval*. Mahwah, NJ: Erlbaum.

Turgeon, M., Wing, A. M., & Taylor, L. W. (2010). Timing and ageing: slowing of fastest regular tapping rate with preserved timing error detection and correction. *Psychology and Aging*, *26*, 150–161.

Umanath, S., & Marsh, E. J. (2012). Ageing and the memorial consequences of catching contradictions with prior knowledge. *Psychology and Aging*, *27*, 1033–1038.

van Jaarsveld, H. J., Dijkstra, T., & Hermans, D. (1997). The detection of semantic illusions: Task-specific effects for similarity and position of distorted terms. *Psychological Research*, *59*, 219–230.

van Oostendorp, H., & de Mul, S. (1990). Moses beats Adam: A semantic relatedness effect on a semantic illusion. *Acta Psychologica*, *74*, 35–46.

Verhaegen, P., & Cerella, J. (2002). Ageing, executive control, and attention: A review of meta-analyses. *Neuroscience and Biobehavioral Reviews*, *26*, 849–857.

Winocur, G. (1982). The amnesic syndrome: A deficit in cue utilization. In L. S. Cermak (Ed.), *Human memory and amnesia* (pp. 139–166). Hillsdale, NJ: Erlbaum.

APPENDIX

All Moses Illusion items

Error detection question	*Distorted word*	*Undistorted word*	*Short-answer question*	*Source*
Which XXXX wrote a book called "A Brief History of Time"?	Historian	physicist	What is the occupation of Steven Hawking?	Bottoms et al. (2010)
The Olympic rings represent XXXX of what?	7	5	How many rings are there in the Olympic symbol?	Bottoms et al. (2010)
Water contains 2 atoms of XXXX and how many atoms of oxygen?	Helium	Hydrogen	Water is composed of oxygen and what other element?	Bottoms et al. (2010)
What is the last name of the XXXX critic who has co-hosted a number of film-review TV shows with Roger Ebert?	Music	Film	What kind of critic were Roger Ebert and Gene Siskel?	Burke, MacKay, Worthley, & Wade (1991)
XXXX invented the light bulb in which country?	Alexander Graham Bell	Thomas Edison	Who invented the light bulb?	Buttner (2007)
The boxer Rocky Balboa was a character made famous by which XXXX actor?	German	American	What nationality is Sylvester Stallone, the actor who made boxer Rocky Balboa famous?	Buttner (2007)
Which XXXX century author wrote "Jane Eyre"?	twentieth	nineteenth	In what century did Charlotte Bronte write "Jane Eyre"?	Buttner (2007)
XXXX slept for how long after she pricked her finger?	Snow White	Sleeping Beauty	What fairy tale character slept for 100 years after she pricked her finger?	Buttner (2007)
In which museum is XXXX's portrait of the enigmatically smiling Mona Lisa?	Michelangelo	da Vinci	Who painted the portrait of the enigmatically smiling Mona Lisa in the Louvre?	Buttner (2007)
With what weapon did the Bethlehem shepherd David kill the giant XXXX?	Samson	Goliath	Who was the giant that the Bethlehem shepherd David killed?	Buttner (2007)
How many animals of each kind did XXXX take on the Ark?	Moses	Noah	What Biblical character took two animals of each kind on the Ark?	Erickson & Mattson (1981)
In the Biblical story, what swallowed XXXX?	Joshua	Jonah	In the Biblical story, whom did a whale swallow?	Erickson & Mattson (1981)
What is the nationality of XXXX, inventor of the telephone?	Thomas Edison	Alexander Graham Bell	Who invented the telephone?	Erickson & Mattson (1981)
What are the long, narrow flat-bottomed boats used on the canals of XXXX called?	Rome	Venice	Long, flat-bottomed boats are used in canals of which Italian city?	Frick-Horbury & Guttentag (1998)
What board game includes XXXX, rooks, pawns, knights, kings, and queens?	Cardinal	Bishop	The game of chess uses rooks, pawns, knights, kings, queens, and what other class of pieces?	Hannon & Daneman (2001)
What teddy-like bear eats eucalyptus leaves, represents Qantas airlines, and lives in XXXX?	Africa/Europe	Australia	On what continent do koala bears live?	Hannon & Daneman (2001)
What dinosaur movie, starring raptors and T-Rexes, did XXXX direct?	M. Night Shyamalan	Steven Spielberg	Who directed the movie "Jurassic Park"?	Hannon & Daneman (2001)
What black and white Chinese bear is nearly extinct because it eats only XXXX shoots?	palm/olive	bamboo	What do Panda bears eat that is leading to their extinction?	Hannon & Daneman (2001)
What hot southern country has wild XXXX called "dingoes" roaming its deserts?	Cat/horse	dog	What type of animal is a dingo?	Hannon & Daneman (2001)
What was discovered when the apple fell on the head of the sitting scientist XXXX?	Galileo	Newton	What scientist was sitting under a tree when an apple fell on his head, leading to the discovery of the Law of Universal Gravitation?	Hannon & Daneman (2001)
What sport uses a black, XXXX-holed ball for knocking down ten white pins?	5	3	How many holes does a bowling ball have?	Hannon & Daneman (2001)

APPENDIX (*Continued*)

Error detection question	*Distorted word*	*Undistorted word*	*Short-answer question*	*Source*
When did the XXXX bomb the American naval base Pearl Harbor?	Germany	Japan	What country bombed the American naval base Pearl Harbor?	Hannon & Daneman (2001)
In the 1950s sci-fi movies, what XXXX city did the giant lizard "Godzilla" terrorize?	Chinese	Japan	What country did Godzilla terrorise in the 1950s sci-fi movies?	Hannon & Daneman (2001)
What mythical kingdom includes Arthur, Lancelot, and XXXX of the round table?	princes	knights	What type of men were at the round table with Arthur and Lancelot?	Hannon & Daneman (2001)
Clark Kent becomes what blue-tighted hero when he changes in a XXXX booth?	toll	phone	In what type of booth does Clark Kent change to become a superhero?	Hannon & Daneman (2001)
What caped crusader has a sidekick named Robin and protects XXXX?	Metropolis	Gotham	What city do Batman and his sidekick named Robin protect?	Hannon & Daneman (2001)
What small animal hides acorns from XXXX trees for his winter food supply?	elm	Oak	From what type of tree do acorns come?	Hannon & Daneman (2001)
What country includes the XXXX River, sphinxes, pyramids, mummies, pharaohs, and Cleopatra?	Congo	Nile	What major river runs through Egypt?	Hannon & Daneman (2001)
What winter weather phenomenon is very dangerous for growers of Sunkist XXXX?	pineapples	Oranges	What type of fruit does Sunkist grow?	Hannon & Daneman (2001)
What vital, "beating" organ pumps blood and has XXXX chambers?	3	4	How many chambers does the heart have?	Hannon & Daneman (2001)
What movie includes a XXXX tinman, Dorothy, a cowardly lion, and munchkins?	brainless	heartless	In "The Wizard of Oz", what was the tinman's ailment?	Hannon & Daneman (2001)
What large, ferocious, white bear lives near the icy XXXX Pole?	South	North	At what Pole do polar bears live?	Hannon & Daneman (2001)
Which portion of his body did the famous artist XXXX supposedly cut off?	Gauguin	Van Gogh	What famous artist supposedly cut off his ear?	Park & Reder (2004)
What is the name of the island that lies close to the "toe of the boot" of XXXX Italy?	Northern	Southern	In what region of Italy is the "toe of the boot" and the island of Sicily located near?	Park & Reder (2004)
What is the name of the famous wall in XXXX Germany that was torn down in 1989?	west	east	On what side of Germany was the Berlin Wall when it was torn down in 1989?	Park & Reder (2004)
Who won numerous XXXX awards for his breakthrough album "Thriller"?	Emmy	Grammy	What type of award is given for outstanding musical achievements?	Park & Reder (2004)
What kind of meat is in the XXXX sandwich known as the Whopper?	McDonald's	Burger King	What famous burger chain features the Whopper sandwich?	Park & Reder (2004)
What is the name of the famous prize issued by XXXX for contributions to science?	Denmark	Sweden	What country issues the Nobel Prize for contributions to science?	Reder & Kusbit (1991)
What is the name of the ferocious striped feline found in XXXX?	Africa	India	Where are tigers found?	Reder & Kusbit (1991)
XXXX is the capital of what state?	Anchorage	Juneau	What is the capital of Alaska?	Reder & Kusbit (1991)
In a criminal trial when a man pleads the XXXX Amendment, who is he refusing to incriminate?	4th	5th	Which Amendment does a man plead to protect from incriminating himself in a criminal trial?	Reder & Kusbit (1991)

APPENDIX (*Continued*)

Error detection question	*Distorted word*	*Undistorted word*	*Short-answer question*	*Source*
What year did Thomas Jefferson write the XXXX?	Constitution	Declaration of Independence	What document did Thomas Jefferson write in 1776?	Reder & Kusbit (1991)
What kind of tree did XXXX chop down?	Lincoln	Washington	Who famously chopped down the cherry tree?	Reder & Kusbit (1991)
What statue given to us by XXXX symbolises freedom to immigrants arriving in New York harbour?	England	France	What country gave the United States the Statue of Liberty?	Reder & Kusbit (1991)
What is the name of the Mexican dip made with mashed-up XXXX?	artichokes	avocados	What is the main ingredient used to make the Mexican dip guacamole?	Reder & Kusbit (1991)
What is the name of the object whose XXXX is pi-*r*-squared?	Circumference	Area	The formula ''pi-*r*-squared'' helps determine what property of a circle?	Reder & Kusbit (1991)
How many digits are there in the XXXX code required to call another state long distance?	Zip	Area	What type of three-digit code is used to call another state long distance?	Reder & Kusbit (1991)
In which state did General XXXX surrender to bring an end to the Civil War?	Grant	Lee	What General surrendered in Virginia to bring an end to the Civil War?	Reder & Kusbit (1991)
From what state was Ronald Reagan a XXXX?	senator	governor	What type of official was Ronald Reagan in California?	Reder & Kusbit (1991)
What is the title of the judge who heads the other XXXX on the Supreme Court?	8	9	How many justices are on the Supreme Court?	Reder & Kusbit (1991)
Who began an address with ''Four score and XXXX years ago''?	twenty	seven	Lincoln began an address with ''Four score'' and how many years ago?	Reder & Kusbit (1991)
When Alexander Haig resigned in protest from President XXXX's cabinet, what office did he hold?	Ford	Reagan	From what president's cabinet did Secretary of State Alexander Haig resign in protest?	Reder & Kusbit (1991)
The Bay of Pigs invasion was orchestrated by XXXX against what country?	RFK	JFK	Which Kennedy orchestrated the Bay of Pigs invasion against Cuba?	Reder & Kusbit (1991)
At what Fahrenheit temperature on the XXXX does water freeze?	thermostat	thermometer	On what type of instrument does water freeze at 32 degrees?	Reder & Kusbit (1991)
What is King Henry VIII of England famous for having XXXX of?	8	6	How many wives did King Henry VIII of England have?	Reder & Kusbit (1991)
At what university in Ohio were 4 XXXX killed during a war protest?	National Guardsmen	Students	Who were killed during a war protest at Kent State University in Ohio?	Reder & Kusbit (1991)
What phrase followed ''To be or not to be'' in XXXX's famous soliloquy?	MacBeth	Hamlet	Whose famous soliloquy contained the phrase, ''To be or not to be, That is the question''?	Reder & Kusbit (1991)