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The hypercorrection effect in younger and older adults

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Abstract

The hypercorrection effect, which refers to the finding that errors committed with high confidence are more likely to be corrected than are low confidence errors, has been replicated many times, and with both young adults and children. In the present study, we contrasted older with younger adults. Participants answered general-information questions, made confidence ratings about their answers, were given corrective feedback, and then were retested on questions that they had gotten wrong. While younger adults showed the hypercorrection effect, older adults, despite higher overall accuracy on the general-information questions and excellent basic metacognitive ability, showed a diminished hypercorrection effect. Indeed, the correspondence between their confidence in their errors and the probability of correction was not significantly greater than zero, showing, for the first time, that a particular participant population is selectively impaired on this error-correction task. These results potentially offer leverage both on the mechanisms underlying the hypercorrection effect and on reasons for older adults' memory impairments, as well as on memory functions that are spared.

Keywords

Hypercorrection; Memory; Confidence; Older Adults; Error Correction

People's ability to correct their errors is central for learning in all domains. Much research indicates that corrective feedback is necessary for this updating process (Pashler, Cepeda, Wixted, & Rohrer, 2005), and many studies have demonstrated that the effectiveness of corrective feedback is modulated by people's confidence in their errors. While it seems intuitive that errors committed with high confidence should be more difficult to correct than less entrenched, low confidence errors, the data show the opposite result: correct recall performance is better for errors that were initially committed with high, rather than low confidence. This counterintuitive finding is called the *hypercorrection effect* (Butterfield & Metcalfe, 2001).

In the hypercorrection paradigm, participants answer general-information questions and then rate their confidence in their answers. They are provided with corrective feedback to errors and, at some later time, are re-tested. Butterfield and Metcalfe (2001) found that the correct answer was more likely to be given for high confidence errors, as opposed to low confidence errors. This effect has been replicated with young adults with immediate (Kulhavy & Stock, 1989; Metcalfe & Finn, 2011) and delayed testing (Butterfield & Mangels, 2003; Butler, Fazio & Marsh, 2010; Sitzman & Rhodes, 2010), with false memory items (Fazio & Marsh, 2010), with multiple choice testing (Butler & Roediger, 2008), in the scanner with delayed feedback (Metcalfe, Butterfield, Habeck & Stern, under review), while doing simultaneous tone detection (Butterfield & Metcalfe, 2006), with contextual memory (Fazio & Marsh, 2009), and with children (Metcalfe & Finn, 2011). The question we address here is whether

older adults exhibit the hypercorrection effect to the same extent as younger adults. Finding a group of participants who show a diminished effect is important both with respect to the memory of that population, and for understanding the underlying mechanisms contributing to error correction.

While some of the mechanisms that are thought to underlie the hypercorrection effect suggest that older adults should show the effect, others suggest that they might not. It has been observed that the target items and questions are more familiar and semantically rich for high than for low confidence errors (Butterfield & Metcalfe, 2006; Butterfield & Mangels, 2006), and that the semantic relation between the errors and the correct answer is stronger for high than low confidence errors (Metcalf & Finn, 2011). When people have more knowledge about a domain, confidence in their responses is high (see Metcalfe, Schwartz & Joaquim, 1993; Schwartz & Metcalfe, 1992; Metcalfe & Finn, 2008). Brainerd, Reyna and Howe's (2009) parameter estimates from fuzzy trace theory with younger and older adults, indicated that familiarity is intact with aging. General reviews of older adults' cognitive capabilities have also shown that both general knowledge and semantic memory (Verhaeghen, 2003) are spared. To the extent that semantic familiarity contributes to the hypercorrection effect, then, older adults should show the effect. Similarly, if the hypercorrection effect were attributable to participants' metacognitive ability, older adults should show the effect, since, typically, metacognition is spared in healthy older adults (Hertzog, 2002; Allen-Burge & Storandt, 2000).

Older adults have been shown to exhibit difficulty with new learning (Brainerd, Reyna & Howe, 2009; Gilbert, 1941; MacKay & Burke, 1990; Hedden & Gabrieli, 2004), and it is possible that they might experience difficulty with error correction. However, new learning would appear to be needed for both high and for low confidence error corrections, so a selective difference would not be expected.

The error-correction task requires that incorrect responses be suppressed, and this need for suppression may be selective to high-confidence errors because they are more intrusive than low-confidence errors. We have recently (Metcalf, Butterfield, Habeck & Stern, 2012) shown that the same brain area involved in suppression of unwanted memories in the think/no think paradigm (i.e., right dorsolateral prefrontal cortex, see Anderson, Ochsner, Kuhl, Cooper, et al, 2004) is activated when college-aged students receive feedback to high (but not low) confidence errors. Anderson, Reinholz, Kuhl, and Mayr (2011) have shown that older adults have difficulty in suppressing unwanted memories in the think/no think paradigm (and see, Gazzaley, Clapp, Kelley, McEvoy, Knight & D'Esposito, 2008; Hasher, Zacks and May, 1999; Hasher, Chung, May & Foong, 2002; Healey, Campbell, Hasher & Osher, 2010; Jacoby, Bishara, Hessels & Toth, 2005) suggesting that they might show an impairment in hypercorrection.

Finally, it has been also been proposed that hypercorrection arises because people are surprised when they find that their high confidence errors are wrong, and rally their attentional resources as a result of the surprise. In support of this explanation, Butterfield and Metcalfe (2006) found more impairment in a simultaneous tone-detection task when the tone occurred during high confidence error feedback as compared to during low confidence error feedback. Fazio and Marsh's (2009) data, indicating enhanced memory for the context surrounding high confidence error corrections as contrasted to low-confidence error corrections, also supports an attention explanation. Furthermore, Butterfield and Mangels (2003) found a p3 event related potential (ERP) deflection--a deflection often associated with increased surprise-related attention--that was more prominent following the corrective feedback to high than low confidence errors. Finally, Metcalfe, Butterfield, Habeck and Stern (2012) found activation in an area that is often implicated in processing conflicting

information and surprise reactions--the anterior cingulate-- was associated with the feedback to high confidence error feedback, again suggesting that a surprise reaction is implicated in the hypercorrection effect.

Older adults, including high functioning, cognitively intact participants, sometimes (but not always, see Emery, Hale & Meyerson, 2008) show dampened surprise-related reactions, such as in the release from proactive inhibition paradigm (Hasher, Chung, May & Foong, 2002). They sometimes show a failure to benefit memorially from a novelty item in a von Restorff isolation situation (Cimbalo & Brink, 1982; c.f., Bireta, Surprenant & Neath, 2008). They show impairments in the surprise-related P3 ERP deflections, both in terms of their latency and amplitude, in standard oddball tasks (see Fjell & Walhovd, 2004). They also tend to be less responsive to negative emotional outcomes, in general, than do younger adults (Wood & Kisley, 2006; Grünh, Scheibe & Baltes, 2007). Thus, if the increased attention due to surprise is critical for the hypercorrection effect, older adults might not show the effect.

Method

Participants

The participants were 51 young (40F/11M, average age 20.7) Columbia University and Barnard College students, who participated for course credit, and 31 paid older adults (17F/14M, average age 65.7), who were pre-screened to ensure the absence of any past or current medical, neurological, or psychiatric disorders, including dementia, or treatment with psychoactive drugs. All participants were treated in accordance with APA ethical guidelines.

Materials

Participants were asked general-information questions taken from Nelson and Narens's (1980) set and augmented as described by Metcalfe and Finn (2011). Examples were: "What is the river than runs through Rome?" (answer: Tiber) or "Which actor thanked his parents for not using birth control upon receiving a 1979 Oscar?" (answer: Hoffman).

Procedure

Participants, who were tested individually, were presented, one at a time, with general-information questions. Each question, read aloud by the experimenter, also appeared in the center of the computer screen for the participant to read. The participant answered out loud or was instructed to give his or her best guess to the experimenter, who typed their response into the computer. The participant then made a confidence rating about the correctness of the answer by pointing to a position on a horizontal slider on the computer that ranged from "very unsure" on the left end to "very sure" on the right end. Confidence ratings were coded by the computer from 0–100, with 0 indicating the lowest limit of the slider, at the very unsure end, and 100 indicating the highest limit, at the very sure end. The slider bar was anchored to the middle of the scale at the onset of each question. The experimenter moved the cursor to the position to which the participant pointed. Then, when the participant's answer was correct, a chime sounded and the next question was presented immediately. When the answer was incorrect, the correct answer was presented on the screen and the experimenter read it aloud. Once 15 incorrect items had been accumulated, the program randomized those questions, and retested each in a final cued-recall test. At the end of the experiment, all participants were thanked and debriefed.

Design

We employed a 2×2 between participant factorial design, with Age (young or old) and the amount of Feedback Time (1.5s or 4s) manipulated.

Results

Basic data

As shown in Figure 1, the number of questions that had to be presented to reach 15 erroneous responses (a measure of performance) was significantly greater, indicating better general information knowledge, for the older as compared to the younger adults, (\bar{X} =22.03, SD = 4.96 vs. \bar{X} = 19.33, SD =2.99 respectively; $F(1, 78)$ =8.81, MSE = 15.13, p =.004). Neither the main effect of Feedback Time, nor the interaction between Age and Feedback Time were significant (both F 's < 1). (Note: A total of twelve of 765 trials for younger adults, and 5 of 465 trials for older adults, were eliminated because the experimenter mistyped the answer. Thus, although the participant was correct in their initial answer, the computer program counted the answer as incorrect and retested the participant on the question. These trials are not included in any of the analyses.)

The overall confidence ratings, collapsed over correct and incorrect responses, were \bar{X} =43.79 for older adults and \bar{X} =26.39 for younger adults, ($t(80)$)=-5.36, p <.001). For incorrect responses, older adults averaged \bar{X} =29.91 confidence, while younger adults averaged \bar{X} =15.65. For correct responses older adults averaged \bar{X} =80.02 and younger adults averaged \bar{X} =63.36. There was a main effect of correct vs. incorrect ($F(1, 78)$ =413.46, p <.001), a main effect of Group ($F(1, 78)$ =1137.07, p <.001) and no interaction between correct vs. incorrect and Group (F <1).

To investigate whether older and younger adults' metacognitive abilities were comparable (and whether confidence ratings were predictive of initial test performance), we computed a gamma correlation for every participant between his or her confidence rating on each item and whether or not the item was correct on the initial test. A high positive correlation meant that the individual had high confidence in getting the items correct that they did in fact get correct on the first test, and indicated good metacognition. (In subsequent analyses, we are sometimes unable to report a gamma correlation for some participants because gamma cannot be computed if either all responses are correct or incorrect or if there is no variability in the confidence ratings.)

Average gammas between initial test performance and confidence were high for the older adults (1.5s condition: γ = .85, SD =.15; 5s condition: γ =.81, SD =.16), and for the younger adults (1.5s condition: γ =.79, SD =.16; 5s condition: γ =.79, SD =.24), with all four gammas being significantly greater than zero ($t(12)$ =20.14; $t(16)$ =20.90; $t(22)$ =23.52; $t(25)$ =16.51; all p 's<.001). No significant differences were found among conditions or between Groups (F 's<1). These results indicate that the older adults' basic metacognition was as good as that of young adults: they knew what they knew and what they did not know.

Accuracy on the post-feedback final test was scored leniently by an algorithm created by Brady Butterfield based on letter overlap that allowed as correct what most human scorers would consider to be only spelling mistakes (e.g., Hofman for Hoffman). The data were also hand checked by the experimenters, to ensure that no responses that could have been simply spelling mistakes were considered to be errors. Mean overall final recall performance was the same for older and younger adults (F <1) (see Figure 1). The older adults' mean recall in the 1.5s and 4s conditions were \bar{X} =.76 (SD =.23) and \bar{X} =.80 (SD =.16); for younger adults they were \bar{X} =.77 and \bar{X} =.75 (SD =.12 and .14).

The Hypercorrection Effect

A hypercorrection effect would be in evidence if an individual were more likely to correct high than low confidence errors. Accordingly the gamma correlations between each individual's confidence ratings on his or her original errors and the correctness of responses

on the final test was computed, with positive values indicating hypercorrection. As can be seen in Figure 1, while the younger adults hypercorrected ($\gamma = .51$, $SD = .55$), the older adults showed a significantly smaller hypercorrection effect ($\gamma = .14$, $SD = .68$, $F(1, 63) = 5.87$, $p = .02$). Indeed, t -tests revealed that while younger adults' gammas were significantly greater than zero ($t(41) = 5.99$, $p < .001$), those of the older adults did not differ from zero ($t(24) = 1.05$, ns). Of course, it cannot be determined whether this difference occurred because the older adults corrected high confidence errors less, or because they corrected low confidence errors more. Neither the main effect of Feedback Time ($F(1, 63) = 2.68$, ns) nor the interaction between Age and Feedback Time ($F(1, 63) = 1.36$, ns) was significant.

We also split the data into the highest 7 and lowest 7 confidence errors for each participant (omitting the response in the middle, if it existed) and computed the conditional probabilities over these higher and lower confidence responses. The probability of error correction for the young subjects was .76 and .85, for lower and higher confidence errors ($t(1, 50) = 2.95$, $p = .005$), indicating that the younger participants hypercorrected. The elders' probabilities correct were .81 and .84 for lower and higher confidence errors ($t(1, 30) = 1.07$, $p = .292$). Finally, we computed the difference in original confidence (which was on a scale from 0 to 100) on corrected as compared to uncorrected errors. This difference was 8.41 for the younger adults, which was greater than zero ($t(41) = 5.31$, $p < .001$), indicating hypercorrection, and $-.85$ for the older adults, which was not different from zero ($t(24) = .13$, ns). The between group difference was marginally significant ($t(65) = 1.67$, $p = .09$).

General Discussion

The finding that the older adults showed a diminished hypercorrection effect is new. The question that remains is why older adults do not have preferential correction for the high confidence errors to the same extent as do younger participants. We conducted an additional analysis to investigate the possibility that, despite unimpaired general knowledge and semantic memory (e.g., Verhaeghen, 2003), older adults might assign confidence differently than young adults with regard to familiarity. We performed a Latent Semantic Analysis (LSA) like that used by Metcalfe and Finn (2011) to compare the semantic association strength between the target word and the errors generated, as a function of confidence, by older and younger participants. LSA is a method for extracting contextual-usage meaning of words via statistical computations applied to a large corpus of text (Landauer & Dumais, 1997) that can be used to determine the similarity of meaning of words, as given by the cosines (Landauer & Dumais, 1997, and see <http://cwl-projects.cogsci.rpi.edu/msr/>). We computed these cosines between the high confidence errors and the correct responses and between the low confidence errors and the correct responses. The LSA values for the low confidence errors (taken to be any value less than 50 on the slider scale) were .26 ($SD = .08$) for the younger adults and .20 ($SD = .10$) for the older adults. For higher confidence errors (values 50 and above), the LSA values respectively for younger and older adults were .36 ($SD = .19$) and .34 ($SD = .16$). Only the difference between higher versus lower confidence responses was significant ($F(1,60) = 24.58$, $p < .001$), as found in past research. There were no effects or interactions with age. Thus, it seems unlikely that familiarity differences could explain the difference in the hypercorrection effect between the younger and older adults.

Furthermore, the finding of a diminished hypercorrection effect does not appear to be attributable to poor performance. Older adults did well on this task. They had better general knowledge than younger adults in the first test and corrected their errors, overall, at the same rate as younger adults. Of course, the diminished hypercorrection effect reported here for older adults might have occurred because they corrected the low confidence errors more so than did the younger adults.

There remain two likely reasons for why the older adults may have not shown a hypercorrection effect to the same extent as younger adults. The first, as discussed in the introduction, is that they may have had difficulty suppressing the high confidence errors. To investigate this possibility, we analyzed for the re-emergence of initial errors as intrusions in the final test. However, there were only a very small number of overt intrusions of the original erroneous responses in either group (10 out of 460 total trials for older adults, and 3 out of 753 total trials for younger adults). So, if this is the explanation, it was not detectible in these data.

Finally, the older adults might have experienced less of a surprise reaction at their high confidence errors, or they may be more accustomed to making these types of memory errors and therefore exhibit less of a surprise response (Dodson, Bawa & Krueger, 2007), and hence may have recruited less extra attention to encode the correct responses. This may have lead to the diminished hypercorrection effect either because they were less surprised in general, or because they had less of a reaction to high confidence mistakes as a negative outcome (Charles, Mather & Carstensen, 2003; Mikels, Larkin, Reuter-Lorenz & Carstensen, 2005; Ito, Larsen, Smith, & Cacioppo, 1998). It is also possible that younger adults find high confidence errors to be aversive and are highly motivated to correct these errors, but that older adults—shunning such a negativity bias-- did not find them so emotional and, hence, were less motivated to selectively attend to and correct them. Further research is needed to determine, in detail, if these potential explanations account for older adults' failure to hypercorrect.

In conclusion, we demonstrated for the first time that older adults show a diminished hypercorrection effect. The older adults did not show a deficit in general-information knowledge. They were not impaired in their metacognitive ability. They were able to correct their errors, in general. But, the *pattern* of their error correction was quite different from that of younger adults: the older adults, unlike younger adults and even children, did not selectively correct their *high confidence* errors. These findings of a selective difference in processing may contribute to our understanding of the locus of memory impairments in older adults, may suggest methods of remediation via the spared function, and may also provide leverage into understanding the underlying processes involved in error correction.

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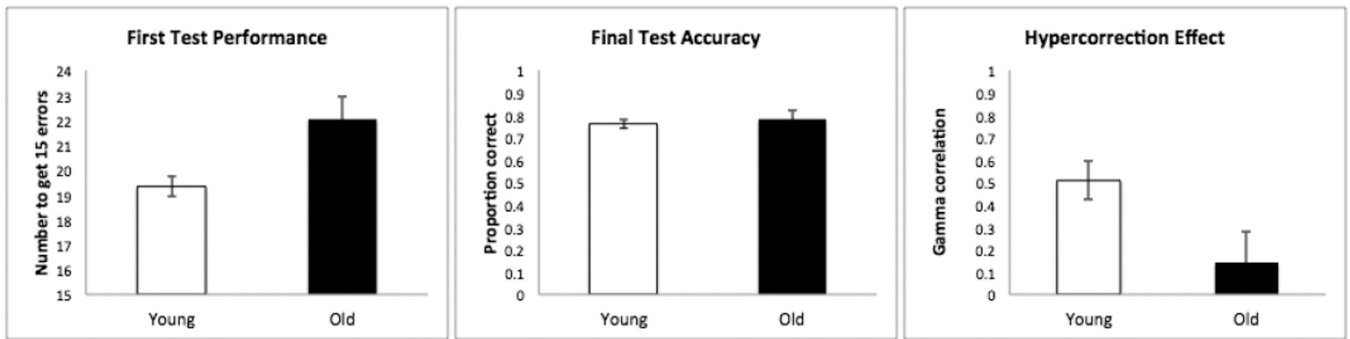


Figure 1.

Performance measures for older and younger adults in the hypercorrection paradigm: The left panel shows performance on the first test; the middle panel shows accuracy on the final test; the right panel shows the hypercorrection effect, where a positive value indicates hypercorrection whereas a zero value indicates no hypercorrection.