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Older Adults' Detection of Misspellings During Reading

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Abstract

**Objectives.** Previous research has suggested that older adults' ability to detect a word as correctly or incorrectly spelled is intact, relative to younger adults. The purpose of the present experiment was to investigate the stability of misspelling detection processes across older adulthood when misspellings are presented in the context of reading.

**Methods.** Participants included 180 older adults represented equally from three decades: young-old adults in their 60s, middle-old adults in their 70s, and old-old adults in their 80s. They read sentences about health-related topics one word at a time and pressed a key to detect misspellings. A repeated-measures analysis of variance was conducted on misspelling detection accuracy as well as response times for correctly detected misspellings.

**Results.** There was a consistent age-related decline in misspelling detection, where middle-old and old-old adults were less accurate and slower than young-old adults in detecting misspellings.

**Discussion.** Requiring misspelling detection during reading increases the working memory demands that are necessary for successful comprehension. In resource-demanding contexts, the top-down verification process of confirming a word's orthographic features becomes more difficult with increasing age.

Keywords: aging; misspelling detection; reading; working memory

## Older Adults' Detection of Misspellings During Reading

One positive aspect of language processing in healthy older adults is the stability of the cognitive processes underlying perception and comprehension of individual words relative to their production (see Abrams & Farrell, in press; Burke & Shafto, 2008, for recent reviews). Despite considerable research on other perception tasks, research on older adults' spelling detection has received little attention. In the studies that have been conducted, older adults' detection of a word's spelling as correct or misspelled is generally equivalent to college students (e.g., MacKay, Abrams, & Pedroza, 1999; Margolin & Abrams, 2007) or sometimes superior (Abrams & White, in press). However, conclusions about older adults' performance have been made using relatively young groups of older adults. Furthermore, these studies assessed detection of single words' spellings, not words embedded in any context. The purpose of the present experiment was to investigate whether misspelling detection processes remain stable *within* the older adult life span and in naturalistic settings such as reading, which more accurately represent conditions in which misspellings are encountered.

There are reasons to suspect that the effects of age on misspelling detection may become more pronounced when looking at a broader range of ages. Theoretically, the transmission deficit hypothesis proposes that relative to bottom-up activation, top-down connectivity between the semantic representation of words and their constituent phonological and orthographic components become particularly vulnerable to age-linked decline (MacKay & Burke, 1990). Perception is less affected by age than production because the perception of a word begins with bottom-up processing of its features and results in a spread of activation to its corresponding lexical and semantic representations (e.g., Dell, 1986; Levelt, Roelofs, & Meyer, 1999; MacKay, 1987). However, although some perception tasks are completed at lexical access, spelling

detection requires a *top-down* verification process (e.g., Paap, Newsome, McDonald, & Schvaneveldt, 1982), where the orthographic features of the word are confirmed. This latter spelling verification process may therefore be adversely influenced by aging and result in decreased misspelling detection with increasing age. Empirical support for this claim comes from Abrams and Stanley (2004), who conducted a signal detection analysis on younger adults' and two groups of older adults' judgments from a misspelling detection task. Of relevance here are the differences that emerged between the two older groups, where adults aged 73-85 years were less sensitive and more conservative than adults aged 61-72 years in detecting misspellings under some conditions. Adults in their 70s and 80s also show larger age-related declines relative to adults in their 60s on other cognitive tasks, such as implicit memory (e.g., Davis et al., 1990) and word naming (e.g., Au et al., 1995). Comparing older adults of different age ranges with each other can also be advantageous in that age-related changes to spelling processes can be examined without potential confounds from variables on which younger and older adults might differ, such as vocabulary, educational level, processing speed, working memory, and interest/relevance in the content. Furthermore, even when differences do occur between older adults of different age ranges on these variables, these differences are likely to be less pronounced than those between younger and older adults.

The context in which misspelled words are presented may also be important for determining when age differences will occur. The majority of research on misspelling detection in old age has involved briefly showing words one at a time. When asked to judge the correctness of a word's spelling, younger and older adults were equivalently accurate at detecting misspelled words (MacKay et al., 1999; Margolin & Abrams, 2007; see Abrams & Stanley, 2004, for an exception with rapid presentation rates). However, single-word presentation studies

represent a limited context to assess misspelling detection and do not capture language processes in more real-world situations, such as reading, where detecting misspellings in sentences may become more difficult with advancing age because of the working memory resources required for successful comprehension (e.g., Just & Carpenter, 1992). The current experiment presented misspellings embedded in sentences about health-related topics to be read for recall. To assess possible influences of resource demands on misspelling detection during reading, we manipulated the position of the misspellings within the sentence, where misspellings could occur near the beginning, middle, or end of the sentence. We hypothesized that detecting misspellings near the end of the sentence may be particularly demanding of working memory because the reader has to hold the entire sentence until this point and synthesize its meaning for comprehension. Working memory capacity generally declines with advancing age even within older adulthood (e.g., De Beni, Borella, & Carretti, 2007), so old-old adults and middle-old adults may have exacerbated difficulty in detecting misspellings that occur later in the sentence relative to young-old adults.

## Method

### *Participants*

Participants included 60 young-old adults in their 60s ( $M = 66.3$  years,  $SD = 2.7$ , range = 60-69), 60 middle-old adults in their 70s ( $M = 74.3$  years,  $SD = 2.9$ , range = 70-79), and 60 old-old adults in their 80s ( $M = 82.8$  years,  $SD = 2.5$ , range = 80-88). They were recruited from the University of Florida Cognition and Aging Laboratory participant pool, a database of older adult volunteers from the Gainesville community and surrounding areas. All participants spoke fluent English and had normal or corrected-to-normal vision. There were no age differences in vocabulary as measured by a 25-item multiple choice vocabulary test,  $p_s > .12$ , or in backward

digit span, a task in which the central executive component of working memory is thought to play a significant role (e.g., Groeger, Field, & Hammond, 1999). However, young-old adults had higher Mini-Mental Status Exam (MMSE) scores than old-old adults,  $p < .013$ , and more years of education than both middle-old and old-old adults,  $ps < .016$ .

### *Apparatus and Materials*

The experiment was performed on Pentium II, 350 MHz, PC-compatible computers using a program written in Visual Basic 5.0. Eighty-nine sentences ranging in length from 9 to 20 words ( $M = 14.5$ ,  $SD = 3.8$ ) were taken from different passages on three websites (WebMD.com, Walgreens.com, and the National Institute on Aging website) involving health-related topics of interest to older adults. Sentences contained 168 target words (mean length = 7.9 letters, mean Francis and Kucera (1982) word frequency = 46.4; there were 88 nouns, 43 adjectives, 31 verbs, and 6 adverbs), which were modified to contain misspellings involving a single letter that was added, deleted, or substituted for another letter. Sentences contained three target words, of which one, two, or three were misspelled, with position of misspellings within each sentence counterbalanced across experimental versions. For example, the three-misspelling sentence "Although surgicial methods of treatment for prostate cancer can be sucessful, the surgery can be risky" shows the three possible positions for targets (underlined here). In one-misspelling versions of this sentence, the misspelled target could appear either in the early position, the middle position, or the late position (and the remaining positions would be correctly spelled). Similarly for two-misspelling sentences, targets could appear in the early and middle positions, the early and late positions, or the middle and late positions.

### *Procedure*

Each sentence appeared one word at a time in the center of the screen at a rate of 800 ms/word, which was pilot-tested as a manageable reading rate for older adults without time pressure to minimize effects of age-related declines in visual acuity. Participants were instructed to watch each word carefully and to press a designated key on the keyboard whenever a word was misspelled; the key was dependent on handedness so that detection would occur using the participants' dominant hand. After the last word in the sentence was presented, a string of question marks appeared, which was the cue for participants to recall the sentence verbatim. Requiring recall ensured that participants were reading sentences for comprehension, rather than solely focusing on detecting misspellings of individual words. (The recall task was designed to test a separate issue and therefore will not be discussed further.)

## Results

### *Misspelling Detection Accuracy*

A 3 (Age Group: young-old, middle-old, and old-old) x 3 (Position of Misspelling: early, middle, and late) repeated-measures analysis of variance (ANOVA) was conducted by participants on the mean proportion of targets correctly detected as misspelled. Means and standard deviations from this analysis are shown in percents in Table 1. Both the main effect of age group,  $F(2, 168) = 6.68$ ,  $MSE = .15$ ,  $p < .002$ , and position,  $F(2, 336) = 109.72$ ,  $MSE = .01$ ,  $p < .001$ , were significant. Young-old adults ( $M = 66\%$ ) were more accurate in detecting misspellings than either middle-old adults ( $M = 57\%$ ),  $p < .029$ , or old-old adults ( $M = 51\%$ ),  $p < .001$ , who did not differ,  $p > .133$ . In terms of position, misspellings in the middle position ( $M = 63\%$ ) were detected more accurately than misspellings in the early position ( $M = 61\%$ ),  $p < .012$ , which in turn were detected more accurately than misspellings in the late position ( $M = 50\%$ ),  $p < .001$ . Position did not interact with age group,  $F < 1$ .

*Response Times for Correctly Detected Misspellings*

Response times for misspelling detection were also recorded via keypress. Responses times that were  $\pm 2.5$  SD from the overall mean (814 ms) were deemed outliers and were removed prior to analysis. This resulted in the removal of 1.5% of responses for young-old, 2.6% of responses for middle-old, and 4.9% of responses for old-old adults. A 3 (Age Group: young-old, middle-old, and old-old)  $\times$  3 (Position of Misspelling: early, middle, and late) repeated-measures ANOVA was conducted by participants on mean response times to correctly detect target misspellings. Means and standard deviations are shown in Table 1. The main effect of age group was significant,  $F(2, 161) = 17.66$ ,  $MSE = 20062.09$ ,  $p < .001$ , with young-old adults ( $M = 782$  ms) having faster misspelling detection than middle-old adults ( $M = 817$  ms),  $p < .026$ , who in turn were faster than old-old adults ( $M = 875$  ms),  $p < .001$ . There was also a main effect of position,  $F(2, 322) = 11.3$ ,  $MSE = 2810.53$ ,  $p < .001$ , where misspellings in the middle ( $M = 817$  ms) or late ( $M = 817$  ms) position (which did not differ,  $p > .938$ ) were detected more quickly than misspellings in the early position ( $M = 841$  ms),  $ps < .001$ . Age group and position did not interact,  $F(4, 322) = 1.63$ ,  $MSE = 2810.53$ ,  $p > .166$ . Furthermore, for both the accuracy and response time analyses, the main effect of age group remained significant when MMSE and education were included as covariates.

## Discussion

Contrary to previous research comparing younger adults with a relatively young group of older adults (e.g., MacKay et al., 1999), the present experiment demonstrated age-linked declines in misspelling detection, where adults in their 70s and 80s were slower and less accurate at identifying misspellings during reading, compared with adults in their 60s. Findings of exacerbated declines with increasing age converge with cognitive aging studies of language

production (e.g., Au et al., 1995; Davis et al., 1990) and extend them to "input" processes required for detecting misspellings.

Why do age-related declines in misspelling detection become increasingly pronounced in late adulthood when reading misspellings in context? One possibility is that embedding misspellings into ecologically-valid contexts makes the misspelling detection task more challenging because of the resource demands imposed by comprehension (Just & Carpenter, 1992), which typically increase with age (De Beni et al., 2007). The context of reading does make misspelling detection more difficult, evidenced by misspellings near the end of the sentence being the least likely to be detected, a sentence location where readers typically allocate more time to integrate the beginning part of the sentence and construct a cohesive representation of the text. Although misspellings in the early position were also less accurately detected than misspellings in the middle position, this difference was much smaller and could be caused by difficulties focusing sufficient attention on the first few words while acclimating to the dual-task demands of both misspelling detection and reading for recall. Support for this interpretation comes from the response time data, where readers took significantly longer to correctly detect misspellings in the early position than misspellings in the other positions.

However, even though misspelling position affected its probability of detection, these position effects occurred for all age groups to the same degree. Failure to find an interaction may be due to older participants not differing on our measure of working memory (contrary to De Beni et al., 2007, who used a reading span task). In any case, the age-related decline in misspelling detection found in the present study cannot be explained by age-related differences in working memory. Instead, our findings are consistent with the idea that the top-down verification process of confirming a word's orthographic features becomes more difficult with

age in resource-demanding contexts, consistent with the transmission deficit hypothesis's overarching principle of top-down connections to lower-level representations being more susceptible to age-related declines (MacKay & Burke, 1990).

The present results highlight the importance of acknowledging potential changes in language processing that occur in late adulthood and the heterogeneity that exists within older adults. Comparing several groups of older adults across a larger age range helps to more precisely define the onset of specific age-related cognitive declines, especially in tasks relevant to older adults' functioning in real-world contexts. People regularly encounter misspellings in their daily lives, such as reading the newspaper, browsing websites, and reading and writing emails, situations that require comprehension in the presence of misspellings. An interesting question for future research is whether older adults' reduced ability to detect misspellings during reading may actually be adaptive in these situations, allowing them to focus more on the content to enhance comprehension, which would parallel other findings (e.g., Smiler, Gagne, & Stine-Morrow, 2003) that demonstrate older adults' ability to self-regulate cognitive resource allocation during challenging tasks.

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Table 1

*Older Adults' Accuracy (in %) and Response Times (in milliseconds) for Detecting Misspelled Targets as a Function of Position of Misspelling in Sentence*

	Age Group					
	Young-Old Adults		Middle-Old Adults		Old-Old Adults	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<b>Accuracy</b>						
Early Position	69.2	21.2	59.2	25.4	54.2	23.3
Middle Position	70.9	21.5	62.0	24.9	56.0	24.3
Late Position	58.1	22.1	50.0	23.1	42.2	22.4
<b>Response Times</b>						
Early Position	800.9	73.0	831.4	83.0	890.6	93.2
Middle Position	782.5	91.1	808.2	89.6	859.2	89.2
Late Position	763.7	87.8	811.6	101.0	875.9	119.7