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Individual Differences in Young and Older Adults' Spelling: Do Good Spellers Age Better than Poor Spellers?

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Abstract

Young and older adults' ability to retrieve the spellings of high- and low-frequency words was assessed via tests of spelling recognition and production. One of the spelling production tests required participants to write down the correct spellings of auditorily presented words, and accuracy was used to categorize participants in both age groups as good or poor spellers. The results showed that individual spelling ability and word frequency contributed to age differences. Older adults who were poor spellers were less accurate in recognizing and producing correct spelling than young adults who were poor spellers. In contrast, no age differences occurred for good spellers. Furthermore, low-frequency words were especially difficult for young adults and poor spellers, relative to older adults and good spellers. These results indicate that aging alone is not detrimental to the processes underlying recognition or production of spelling but instead compounds existing problems caused by poor spelling.

Individual Differences in Young and Older Adults' Spelling: Do Good Spellers Age Better than Poor Spellers?

To date, research on spelling in adults has focused almost exclusively on patients with brain damage (e.g., Badecker, Hillis, & Caramazza, 1990; Caramazza & Hillis, 1990; Katz, 1991; Levine, Mani, & Calvanio, 1988; Neils, Boller, Gerdeman, & Cole, 1989; Neils, Roeltgen, & Greer, 1995; Tainturier & Rapp, 2004). This literature documents decrements in spelling in people with neurological damage, such as Alzheimer's disease. Patients with Alzheimer's disease exhibit significant impairments in spelling ability, including increased production of spelling errors, especially for longer words, and a greater proportion of errors that are phonologically incompatible with the correct spelling (e.g., Neils et al., 1989; Neils et al., 1995). Although these declines in spelling ability are useful for understanding cognitive changes following brain damage, they do not further our knowledge about patients' age-matched counterparts, healthy older adults. Furthermore, these studies focus solely on written spelling production, with direct instruction to try and produce correct spelling. The purpose of the present experiment was to examine the effects of individual differences in spelling ability on young and older adults' recognition and production of spelling, using three spelling tasks different from the traditional single-word spelling production test.

Very few studies concerning spelling in healthy older adults have been conducted (Abrams & Stanley, 2004; MacKay & Abrams, 1998; MacKay, Abrams, & Pedroza, 1999; Stuart-Hamilton & Rabbitt, 1997). These studies have shown that older adults' ability to recognize a word as correctly spelled is less susceptible to age declines than producing correct spelling (e.g., MacKay et al., 1999). Using spelling recognition tasks (Abrams & Stanley, 2004; MacKay et al., 1999), participants were asked to indicate whether briefly presented words

(ranging from 50-390 msec) were spelled correctly or incorrectly. In both studies, older adults were equivalent to young adults in recognizing words as correctly spelled, suggesting that spelling recognition processes are relatively intact in older adults. However, rapid presentation of targets that disappeared from the screen before a response was given is not the most naturalistic test of spelling recognition; people are not typically time-pressured to detect spelling during everyday tasks, such as reading. In contrast to recognition, MacKay and Abrams (1998) found that young-old (mean age 67.2) and old-old (mean age 77.0) adults were less able to write down the correct spellings of auditorily presented words than college students. Similarly, Stuart-Hamilton and Rabbitt (1997) found that adults in their 70s produced written correct spellings less often than adults in their 60s, who were less accurate than adults in their 50s. Again, these tests of spelling differ from everyday tasks involving writing, such as taking notes in class or writing down phone messages, where whole sentences are produced, and attention is not directly focused on spelling.

In conjunction with age, spelling retrieval is likely to be influenced by other factors, such as individual differences in spelling ability and word frequency. Individual differences in spelling have been studied in children and young adults by classifying individuals as good or poor spellers, usually by using scores on a written test of spelling production following auditorily presented words (e.g., Burden, 1989; Cobb, Kincaid, & Washburn, 1918; Dietrich & Brady, 2001; Holmes & Malone, 2004; Holmes & Ng, 1993; Kamhi & Hinton, 2000; Ormrod, 1990). The decrement in spelling production for poor spellers has been attributed to incomplete orthographic representations of words (e.g., Holmes & Malone, 2004), insufficient knowledge about the rules of spelling (e.g., Kamhi & Hinton, 2000), and inadequate phonological awareness (e.g., Allyn & Burt, 1998). One possibility is that these difficulties associated with poor spellers

are compounded by age, such that older adults who are poor spellers will have increased spelling difficulties relative to young adult poor spellers. In contrast, older adults who are good spellers may be able to offset age-related declines in spelling, analogous to Burt and Butterworth's (1996) suggestion that children who are good spellers may be able to maintain in adulthood their level of spelling knowledge and ability to use phonological information for spelling. This variable of spelling ability may explain the *lack* of age differences in spelling production observed in several unpublished studies (e.g., Abrams, White, McDermott, & Wolf, 2000; Kramer, Burke, & Taylor, 2000).

Another factor shown to influence spelling retrieval is word frequency, or how often a word is encountered in a language (by use of reading, speech, etc.), but its interactions with aging on spelling have yielded mixed results. Stuart-Hamilton and Rabbitt (1997) compared adults in their 50s, 60s, and 70s (but no young adults), showing an age-linked decline in spelling production with respect to low-frequency words but not high-frequency words. However, MacKay and Abrams (1998) observed the opposite pattern, where old-old adults exhibited a spelling production deficit relative to college students for high-frequency words, but not low-frequency words, although low-frequency words were spelled correctly less often than high-frequency words for all age groups. MacKay and Abrams (1998) suggested that the young adults were less familiar with the low-frequency words than older adults, masking the age-linked decline in spelling production that would have appeared if both age groups were equally familiar with the words. Nonetheless, the appearance of age differences in these studies as a function of frequency suggests the importance of manipulating word frequency in assessing older adults' spelling capabilities.

Two theories can be used to understand the processes underlying spelling production. One framework, dual route theories (e.g., Barry, 1994; Barry & Seymour, 1988; Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993), proposes two routes to produce spelling: a lexical process and a nonlexical process. In the lexical process, spellings of words are retrieved directly from a storage base of words, i.e., a word's spelling is retrieved directly from memory. The nonlexical process functions by assembling the spellings of words from sound-to-spelling conversions, i.e., words are spelled by following rules that are stored in memory. The nonlexical route works well for words that are spelled the way they sound, but cannot be the sole route for retrieving spelling; using this route to spell irregularly-spelled words (words spelled differently from how they sound, e.g., *yacht*) would result in phonologically plausible misspellings (Barry, 1994). Therefore, the lexical process is used for words that are not spelled the way they sound, so that they can be spelled correctly by retrieving the whole word directly from memory.

An alternate theory of spelling is derived from Node Structure Theory (NST; Burke, MacKay, & James, 2000; MacKay, 1987; MacKay & Abrams, 1998), a connectionist framework where words, their sounds (phonology), their spellings (orthography), and their meanings (semantics) are stored in nodes that are interconnected at multiple levels. The connections between a word and its orthography can become weakened, e.g., through low frequency of use or non-recent use, causing less accurate retrieval of a word's spelling. The Transmission Deficit Hypothesis (TDH; MacKay & Burke, 1990) proposes that the normal aging process also weakens connections between nodes by decreasing the transmission of priming across connections, suggesting that older adults will be especially vulnerable to declines in spelling retrieval, consisting with previous research (e.g., MacKay & Abrams, 1998).

Whereas both theories predict greater spelling accuracy for (1) high-frequency words relative to low-frequency words, and (2) good spellers relative to poor spellers, dual route theories do not specifically address spelling in older adults. In contrast, NST and TDH propose interactions of these variables with age. NST and TDH predict that the spelling of low-frequency words will be more difficult to retrieve or recognize, especially for older adults, because these connections to orthography are weakened both by infrequent use and by aging. NST and TDH also predict that poor spelling ability will be especially detrimental to older adults. Poor spellers in general have weakened connections to orthography, whereas older adult poor spellers have exacerbated weakening of their connections due to age. In contrast, good spellers have strong orthographic connections, minimizing any weakening that may have been caused by age. In sum, any variable that adversely affects spelling retrieval will have a greater influence on older adults.

Method

Participants

Sixty-four younger and 64 older adults participated in this experiment. Young adults ranged from 17 to 24 years (M = 19.6, SD = 1.6, 21 males and 43 females), were recruited from general psychology and sensory processes courses, and received partial course credit for their participation. Older adults were selected from the University of Florida Cognition and Aging Laboratory participant pool, a group of 600 community-dwelling older adults who were recruited from churches, clubs, libraries, the University of Florida Alumni Association, as well as other laboratories in the Psychology Department. Their ages ranged from 61 to 91 years (M = 75.3, SD = 6.5, 30 males and 34 females), and these participants received $8 per hour as compensation for their participation. All participants were fluent speakers of American English and reported normal or corrected-to-normal vision and hearing.

Materials

One hundred twenty-eight target words were used in this experiment (32 in each of four spelling tasks, discussed below). Half of them were categorized as low frequency using Kucera and Francis's (1967) word frequency norms (M = 3.4, SD = 2.8, Range = 0-9), whereas the other half were designated as high frequency (M = 76.3, SD = 37.4, Range = 40-191). A misspelling was created for each target word using 41 misspellings that were tested/produced in previous research studies (MacKay & Abrams, 1998, Katz & Frost, 2001) and 79 misspellings taken from Webster's Bad Speller's Dictionary (1992). The remaining 8 misspellings were generated by the experimenter. All the misspellings were phonologically plausible and did not change more than two letters of the original spelling of the word. In addition, 20 correctly-spelled filler words and 20 pseudowords (taken from Seidenberg, Plaut, Petersen, McClelland, & McRae, 1994), which were nonwords containing plausible spellings of words in orthographically legal combinations, were used in the two tasks where misspellings were presented (see Appendix for sample stimuli).

Participants engaged in four separate spelling-related tasks: modified lexical decision, spelling recognition, sentence production, and spelling production (the last of which was used to determine individual spelling ability). The modified lexical decision and spelling recognition tasks tested spelling via recognition, where participants made judgments about words and pseudowords based on their visual representations. Each of these tasks presented 52 words, including 16 correctly-spelled targets, 16 misspelled targets, 10 pseudowords, and 10 correctly-spelled fillers. Correctness of a target's spelling (either correct or misspelled) was counterbalanced across participants. Sentence production assessed spelling by having participants write down auditorily presented words in the context of a sentence. The sentences ranged from six to 14 words in length (M = 10.3, SD = 1.6). Within each sentence, the target was

positioned near the beginning (the third position on average) to ensure that participants would write down the target in the time allotted. The traditional spelling ability test, spelling production, assessed spelling by having participants write down 32 auditorily presented target words, as has been done in previous studies.

Young and older participants were tested on several measures of cognitive ability, including a 25-item multiple-choice vocabulary test and forward and backward digit span tests to measure working memory capacity. In addition, older participants completed the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1972), a 30-point questionnaire surveying older adults' orientation, attention and calculation, recall, and language processing abilities. Participants were also asked to give ratings of their health compared to other people their age on a scale of 1 (poor) to 10 (excellent), as well as ratings of their spelling training (1 = lax, 10 = rigorous), ratings of their spelling abilities now (1 = poor, 9 = excellent), and ratings of their spelling abilities when they were in their 20s (1 = poor, 9 = excellent). Other background demographics, such as age and years of education, hours each day spent reading, writing, watching television, and doing crossword puzzles, were also recorded.

Design

A 2x2x2 factorial design was used, with age group (young and older) and type of speller (good and poor) as between-participants factors, and word frequency (high and low) as a within-participants factor. The dependent variable was accuracy in correctly recognizing or producing the target words' spelling.

Procedure

In the modified lexical decision task[1], correctly spelled words, misspelled words, pseudowords, or fillers were randomly presented one at a time on the computer screen for a maximum of 4000 msec, or until the participant responded, whichever came first. Participants

were asked to decide as quickly as possible whether the presented string of letters was exactly as it would appear in the dictionary. Participants were to press a key marked "y" (for correctly spelled words and fillers) or "n" (for misspelled words and pseudowords) to indicate their response, then the next string of letters immediately came onto the screen. If they gave no response after 4000 msec, the word disappeared, and they received a message indicating that they lost their opportunity to respond to that stimulus and had to press the space bar to continue. If they pressed a key other than "y" or "n", the computer produced a beep, and participants were reminded again of the correct keys to make their responses. After four practice trials consisting of one of each type of stimulus (correctly spelled word, misspelled word, filler word, and pseudoword), participants began the experimental trials. The spelling recognition task was identical to the modified lexical decision, except participants determined whether or not the string of letters was spelled correctly, indicated by pressing keys marked either "y" or "n" on the keyboard as quickly as possible.

In the sentence production task, sentences were presented auditorily via computer one at a time, and participants were asked to write the sentence as quickly and neatly as possible. Participants were told that they had limited time to write each sentence and that they needed to focus on producing as much of the sentence as possible in the allotted time. They were also told that printing was preferred for legibility; however, many older adults were uncomfortable printing and therefore used cursive. The experimenter observed the participants' writing to make sure it was legible. If it was not legible, the experimenter asked the participant to clarify what was written. Participants had the opportunity to hear each sentence as many times as they wanted before they began writing by clicking a button on the computer screen, but once they began writing, they had only 20 seconds to complete each sentence. After 20 seconds, the computer

produced a beep, and participants were required to stop writing. The time limit was implemented to simulate everyday tasks involving writing, which often involve time pressure. Participants were given three practice trials before data collection began to ensure that they understood the instructions.

The spelling production task required participants to write as neatly as possible words that were presented auditorily one at a time. Participants were able to listen to these words as many times as they wanted by clicking on a button on the computer screen both before and while they were writing the spelling of each word. No time limit was instituted, although most participants took less than 30 seconds on average to write each word. If participants wanted to change the spelling of a word they had written down, they were asked not to cross anything out and to circle their final spelling. When the participants were satisfied with their spelling, they were instructed to press the "enter" key on the keyboard to hear the next word. Three practice trials were given before data collection began. After the participants completed all four tasks, they were presented with a verbal and written debriefing of the experiment.

Results

Two older adult and three young adult participants were excluded from all data analyses because of a computer error in which the data from all four tasks were not recorded. For tasks involving auditory presentation, mishearings were excluded from all analyses. Overall, the amount of mishearings was small for both age groups: Older adults experienced mishearings on 1.4% of words, and young adults had mishearings on 1.1% of words.

Type of speller was calculated using percent of words correctly spelled on the spelling production test. Within each age group, the median spelling accuracy was computed separately for both age groups ($Median_{young}$ = 78.1%, $Median_{older}$ = 81.0%). Good spellers were participants

whose mean accuracy in spelling production was above the median for a particular age group, whereas poor spellers' means were below the median. Four young adults' means were at the median and were therefore excluded from analyses because they could not be categorized as above or below the median. Independent-samples t-tests on *mean* spelling production accuracy were conducted within each type of speller to see whether young and older adults were equivalent spellers. For poor spellers, young adults (M = 66%, SD = 8.7%) and older adults (M = 63.7%, SD = 13.6%) had similar spelling production scores, t (58) = .78, $p > .425$, whereas for good spellers, older adults (M = 89.3%, SD = 5.0%) were more accurate than young adults (M = 86.2%, SD = 6.6%), t (52) = 2.16, $p < .033$.

Demographics

An Age Group (young and older) x Type of Speller (good and poor) ANOVA was conducted for each of 11 demographic characteristics, with the means and standard deviations from these analyses shown in Table 1. The interaction of age group and type of speller was significant only for vocabulary score, F (1, 116) = 8.05, MSE = 6.52, $p < .005$, such that older adults had higher vocabulary scores than young adults, for both good and poor spellers, but the age difference was larger for poor spellers, ps < .001. Within each age group, good spellers did not differ from poor spellers in vocabulary scores, ps > .188. No other measure showed a significant interaction of age group and spelling ability, ps > .10. In terms of main effects of age group, the results showed that older adults had greater vocabulary scores than young adults, F (1, 116) = 310.94, MSE = 4.72, $p < .001$, reported more years of education, F (1, 116) = 785.75, MSE = 6.52, $p < .001$, more time watching television, F (1, 116) = 16.76, MSE = 2.57, $p < .001$, more time doing crossword puzzles, F (1, 116) = 10.04, MSE = .634, $p < .002$, and higher ratings of spelling training, F (1, 116) = 7.08, MSE = 5.92, $p < .009$. In contrast, young adults reported

spending more time writing than older adults, F (1, 116) = 15.66, MSE = 2.16, $p < .001$. There were no age differences for forward digit span, backward digit span, time spent reading, reports of current spelling ability, or health ratings, ps > .329.

In terms of main effects of type of speller, results showed that good spellers had higher vocabulary scores than did poor spellers, F (1, 116) = 9.01, MSE = 6.52, $p < .003$, and higher forward digit spans, F (1, 116) = 4.01, MSE = 1.24, $p < .048$. There were no type of speller differences on any other measure, ps > .117. An additional test was done for older adults only, who rated their spelling ability now and when they were in their 20s. A 2 (type of speller) x 2 (rating of spelling ability) ANOVA revealed a main effect of type of speller, F (1, 61) = 23.27, MSE = 6.39, $p < .001$, such that good spellers had higher ratings than poor spellers, and a main effect of rating of spelling ability, F (1, 61) = 27.61, MSE = 1.22, p < .001, such that ratings of spelling ability today were lower than ratings of spelling when they were in their 20s. The nonsignificant interaction, $F < 1$, suggests this perceived decline in spelling ability over time was similar in both types of spellers.

Spelling Accuracy

A 2 (age group) x 2 (type of speller) x 2 (word frequency) x 3 (spelling task: modified lexical decision, spelling recognition, and sentence production) repeated-measures ANOVA was conducted by participants (F_1) and by items (F_2) on the proportion of target accuracy, and the means and standard deviations from this analysis (converted into percents) are displayed in Table 2. Analyses revealed significant main effects of word frequency, F_1 (1, 116) = 312.42, MSE = .001, $p < .001$, F_2 (1, 126) = 36.62, MSE = .21, $p < .001$, spelling task, F_1 (2, 232) = 43.84, MSE = .02, $p < .001$, F_2 (2, 252) = 8.71, MSE = .05, $p < .001$, and type of speller, F_1 (1, 116) = 61.78, MSE = .04, $p < .001$, F_2 (1, 126) = 226.71, MSE = .03, $p < .001$. These main effects were

moderated by several interactions. With respect to age group, the Age Group x Type of Speller interaction was significant and is shown in Figure 1, $F_1(1, 116) = 6.51$, $MSE = .04$, $p < .012$, $F_2(1, 126) = 19.37$, $MSE = .02$, $p < .001$. For poor spellers, young adults had greater spelling accuracy than older adults, $p_1 < .048$, $p_2 < .063$, but there was no age difference for good spellers, $p_1 > .22$, $p_2 > .739$. There was also an Age Group x Word Frequency interaction in the participant analysis only, $F_1(1, 116) = 5.76$, $MSE = .01$, $p < .018$; $F_2(1, 126) = 1.91$, $MSE = .03$, $p > .169$, which revealed higher spelling accuracy for high-frequency words than low-frequency words for both young and older adults, but this frequency effect was larger for young adults. No significant age difference emerged either for low-frequency words, $p > .625$, or high-frequency words, $p > .14$.

Independent of age group, there was a significant Word Frequency x Spelling Task interaction, $F_1(2, 232) = 52.40$, $MSE = .01$, $p < .001$, $F_2(2, 252) = 24.96$, $MSE = .05$, $p < .001$, such that higher accuracy was demonstrated for high-frequency words than low-frequency words for all three spelling tasks, but the largest frequency effect occurred in the sentence production task. There was also a significant Type of Speller x Word Frequency interaction, $F_1(1, 116) = 7.88$, $MSE = .01$, $p < .006$, $F_2(1, 126) = 13.00$, $MSE = .03$, $p < .001$, where good spellers were more accurate than poor spellers for both low- and high-frequency words, but the type of speller difference was larger for low-frequency words, ps $< .001$. The Type of Speller x Spelling Task interaction was also significant, $F_1(2, 232) = 6.99$, $MSE = .02$, $p < .001$, $F_2(2, 252) = 7.40$, $MSE = .03$, $p < .001$, revealing that good spellers were more accurate than poor spellers on modified lexical decision, $p_1 < .001$, $p_2 < .008$, sentence generation, $p_1 < .001$, $p_2 < .001$, and spelling recognition (in the participant analysis only, $p_1 < .001$, $p_2 > .127$), with the largest type of speller difference occurring for sentence production. No other interactions were significant in the

participant analysis, p_1s > .313; the interaction of type of speller, task, and word frequency was significant only in the item analysis[2], $p_2 < .024$.

Recognition Accuracy

Because the recognition tasks involved multiple types of stimuli (i.e., correctly spelled words, misspelled words, and pseudowords), a 2 (age group) x 2 (type of speller) x 2 (spelling task) x 3 (type of stimulus) ANOVA was conducted by participants and by items to examine differences in recognition accuracy between the three kinds of stimuli. Frequency could not be included as a variable because pseudowords did not have a word frequency. Table 3 contains the means and standard deviations (in percents) from this analysis. Because type of stimulus is the only new variable in this ANOVA, only effects relevant to this variable were tested and reported here. The ANOVAs revealed a main effect of type of stimulus, F_1 (2, 232) = 227.22, MSE = .03, $p < .001$, F_2 (1, 253) = 159.21, MSE = .26, $p < .001$, where judgments about correctly spelled words were more accurate than judgments about pseudowords, which were more accurate than judgments about misspelled words, p_1s < .002, p_2s < .001.

The Type of Stimulus x Age Group interaction was significant (in the participant analysis, F_1 (2, 232) = 6.27, MSE = .03, $p < .002$, but not the item analysis, $F_2 < 1$) and is shown in Figure 2. Older adults showed greater accuracy than young adults in recognizing pseudowords, $p_1 < .001$, but there were no age differences in recognition of correctly spelled words, $p_1 > .798$, or misspelled words, $p_1 > .733$. The Type of Stimulus x Type of Speller interaction was also significant, F_1 (2, 232) = 19.63, MSE = .03, $p < .001$, F_2 (1, 253) = 68.1, MSE = .04, $p < .001$, revealing that good spellers had greater recognition accuracy than poor spellers for correctly spelled words, $p_1 < .001$, $p_2 < .001$, and misspelled words, $p_1 < .001$, $p_2 < .001$, but were equivalent in recognizing pseudowords, ps > .657. Type of stimulus did not

significantly interact with spelling task, either with or without age group in the participant analysis, *p*s > .136 (although *p*s < .072 in the item analysis), demonstrating that the effects for type of stimulus were similar whether the task was modified lexical decision or spelling recognition.

Discussion

The purpose of the present experiment was to assess potential age differences in spelling using three different tasks in more naturalistic contexts, two involving recognition of correct spelling and one involving production of spelling in sentences, in order to expand our knowledge of spelling beyond the traditional spelling tests of written production (e.g., Burden, 1989; Cobb, Kincaid, & Washburn, 1918; Dietrich & Brady, 2001; Holmes & Malone, 2004; Holmes & Ng, 1993; Kamhi & Hinton, 2000; Ormrod, 1990). The results were similar for all three tasks: aging per se was not detrimental to the processes underlying recognition or production of spelling. Other factors, specifically spelling ability and word frequency, were more predictive of age differences in spelling. Compared to young adults, older adults' spelling retrieval was most impaired when they were poor spellers, resulting in age differences among poor spellers. In contrast, no age differences occurred when comparing good spellers in both age groups. As predicted by NST and TDH (e.g., MacKay & Burke, 1990), these results suggest that being a poor speller is especially problematic in old age, where aging compounds the existing problems caused by poor spelling (which affected both spelling recognition and production). Individual differences in spelling ability therefore contributed to the lack of age differences in spelling in the present study, unlike previous research that found reduced spelling production in older adults (e.g., MacKay & Abrams, 1998; Stuart-Hamilton & Rabbitt, 1997; but see Abrams et al. 2000; Kramer et al., 2000, for exceptions).

In terms of the effects of word frequency, there was no significant age difference for either high- or low-frequency words, although young adults were more negatively affected by low-frequency, contrary to NST and TDH but consistent with MacKay and Abrams (1998). As proposed by MacKay and Abrams (1998), older adults' increased vocabularies enabled them to recognize and produce the spellings of rare words that young adults were unfamiliar with, resulting in no age differences for low-frequency words. In contrast, frequency interacted differently with type of speller, where poor spellers demonstrated an exacerbated decline in spelling low-frequency words. Unlike older adults, poor spellers do not have increased knowledge of words to offset difficulties in spelling low-frequency words relative to good spellers. Ideally, future research should test words for which young and older adults are equivalently familiar to truly determine whether an age difference exists in spelling low-frequency words.

A similar point can be observed in the analyses of recognition tasks. Consistent with previous research (e.g., Abrams & Stanley, 2004; MacKay et al., 1999), young and older adults were equivalently able to recognize spelling for both correctly spelled and misspelled words. However, older adults were more accurate than young adults in recognizing pseudowords because older adults' increased vocabulary allowed them to discriminate pseudowords from real words more easily. When comparing good and poor spellers, the opposite pattern emerged: good spellers had more accurate recognition of both correctly spelled words and misspelled words than poor spellers, but the two groups of spellers were equivalent in recognizing pseudowords. These findings support the idea that declines in spelling that result from aging are fundamentally different than those caused by individual spelling ability.

There are several limitations of the present research. First, it is important to note that these results may not necessarily generalize to all older adults, but rather represent a best case scenario of spelling in old age because the participants used in the present research were well-educated and possessed large vocabularies. Second, there are a number of other variables that are likely to influence spelling recognition and production, such as the regularity of a word's spelling (whether a word is spelled the way it sounds) or its familiarity. These variables are difficult to separate from word frequency; words that are regular and familiar are also likely to be high in frequency. Therefore, the effects of frequency found in the present experiment may be a product of other variables' influences on spelling, which in turn may also potentially interact with aging.

The results of the present experiment suggest some interesting questions for future research. If being a poor speller compounds age declines in spelling, then the same principle may also apply to other cognitive processes, i.e., do young adults with poorer memories exhibit more pronounced memory declines as they age than young adults with good memories? Another issue is whether older adults who are good spellers preserve their spelling abilities because they were always good spellers (as do children who were good spellers when they enter adulthood, e.g., Burt & Butterworth, 1996), or if continual practice with spelling via language use is necessary to minimize age declines. Interestingly, in the present experiment, older adults who were good spellers reported a decline in their spelling ability over time; whether or not these subjective ratings are consistent with objective spelling measures is a question for a longitudinal study of spelling in adulthood. In any case, further research on how spelling ability is affected by normal aging is significant for older adults' functioning in everyday life and for understanding the differences between normal and pathological aging in spelling retrieval.

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Appendix

Example Targets, Fillers, and Pseudowords

TARGETS:

Correct Spelling	Frequency	Misspelling	Sentence (for Implicit Production)
argument	63	arguement	I avoided the argument that my brothers were having.
embarrassed	7	embarassed	He was embarrassed when he fell in front of the audience.
language	149	langauge	Learning a foreign language like German can be very difficult.
porcelain	2	porcelin	She has been collecting porcelain dolls since she was five years old.
satellite	7	satelite	This satellite is used to transmit information from one location to another.
testimony	47	testamony	Her testimony helped him win the case against the thief.

FILLER WORDS:

Word	Frequency
cyclone	0
infinite	0
twilight	3
display	41
hear	153
island	167

PSEUDOWORDS:
beese
creighth
konze
nooth
skose
zuss

Author Notes

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Footnotes

1. This task was inspired by Burt and Tate (2002), who concluded that spelling is relevant to lexical decisions. In their study, participants were slower to make lexical decisions for words that they had previously misspelled.
2. There were several analyses where the participant and item analyses did not agree with each other, i.e., one was significant and the other was not. To handle these discrepant findings in a consistent manner, we established the following policy. Because participants were the focus of interest in this experiment, we used the significance of the participant analysis to guide further analysis, so that no follow-ups were conducted if only the item analysis was significant.

Table 1

Young and Older Adults' Demographic Characteristics Broken Down by Type of Speller

	Age Group							
	Young Adults				Older Adults			
	Good Spellers		Poor Spellers		Good Spellers		Poor Spellers	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Vocabulary (out of 25)	16.7	3.4	14.0	3.0	28.5	1.7	28.4	1.8
Years of Education	14.0	1.5	13.6	1.3	21.1	2.5	20.5	2.8
Forward Digit Span	7.5	1.1	7.2	1.1	7.4	1.2	6.9	1.1
Backward Digit Span	5.0	1.4	5.0	1.1	5.4	1.5	4.9	0.9
Health Rating (out of 10)	7.3	1.6	7.8	1.4	7.9	1.8	7.5	1.6
MMSE (out of 30)	n/a	n/a	n/a	n/a	28.3	2.0	28.6	1.6
Hours Spent Writing	2.3	1.8	2.4	1.9	1.3	1.1	1.3	0.8
Hours Spent Reading	3.2	1.9	2.3	1.5	2.8	1.8	2.8	1.2
Hours Watching T.V.	1.8	1.0	2.0	1.6	3.0	1.9	3.2	1.8
Hours Doing Crosswords	0.2	0.6	0.1	0.3	0.5	0.8	0.7	1.2
Spelling Training (out of 10)	6.0	2.5	5.3	1.8	6.8	2.7	6.8	2.6
Spelling Ability Now (out of 10)	6.2	1.7	5.6	1.7	6.8	1.7	5.7	2.1
Spelling Ability in Their 20s (out of 10)	n/a	n/a	n/a	n/a	7.7	1.5	6.5	2.4

Table 2

Spelling Accuracy (in %) as a Function of Age Group, Type of Speller, Spelling Task, and Word Frequency

	Age Group							
	Young Adults				Older Adults			
	Good Speller		Poor Speller		Good Speller		Poor Speller	
Spelling Task	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Word Frequency								
Modified Lexical Decision								
High	85.2	11.0	83.4	9.1	89.1	9.5	78.3	15.2
Low	77.8	10.5	68.8	7.7	82.3	8.8	70.6	13.7
Sentence Production								
High	90.3	7.8	84.1	12.6	92.3	5.8	74.3	14.4
Low	70.6	20.9	53.8	17.7	71.1	17.7	48.1	19.9
Spelling Recognition								
High	92.1	6.7	86.0	9.4	91.3	7.0	80.2	16.7
Low	81.6	10.1	76.0	9.2	87.4	8.6	73.2	16.0

Table 3

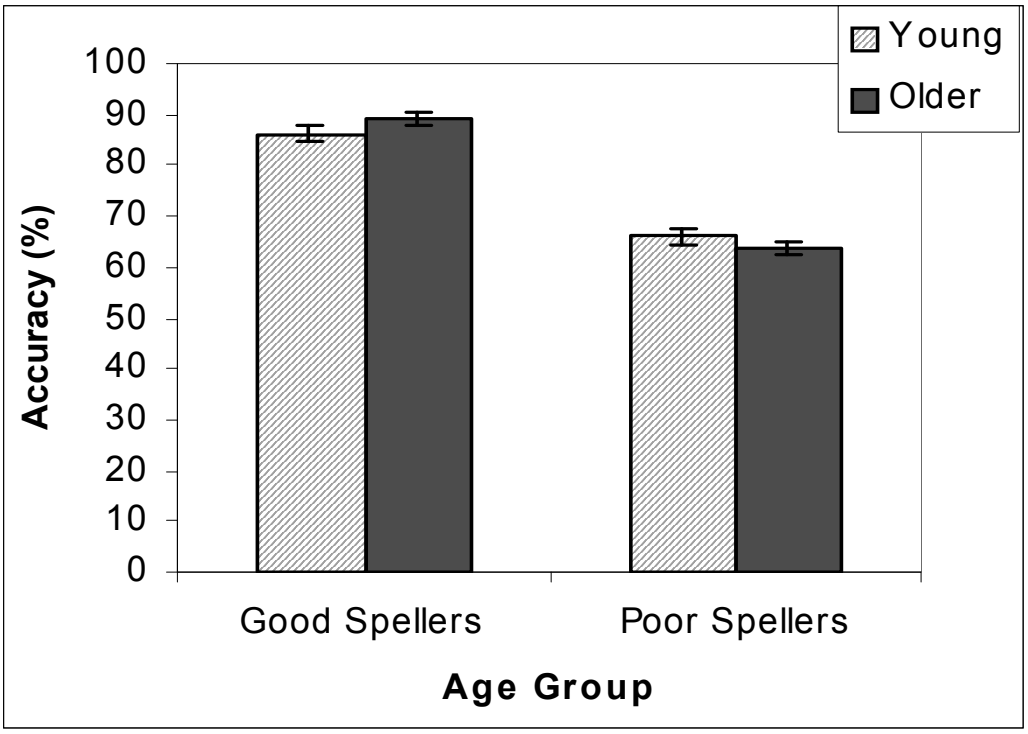
Accuracy (in %) in Recognition Tasks as a Function of Age Group, Type of Speller, Type of Stimulus, and Spelling Task

	Age Group							
	Young Adults				Older Adults			
	Good Speller		Poor Speller		Good Speller		Poor Speller	
Type of Stimulus Spelling Task	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Correct Spelling								
Modified LD	92.2	5.4	89.2	6.5	93.0	5.0	89.2	16.8
Spelling Recognition	94.8	4.6	91.6	6.5	96.7	4.0	90.7	17.1
Misspelling								
Modified LD	63.6	23.4	53.9	19.3	72.1	22.2	49.0	24.6
Spelling Recognition	73.7	15.0	63.4	16.6	76.6	14.0	52.0	21.7
Pseudoword								
Modified LD	76.9	24.8	85.8	10.2	93.2	9.4	89.0	19.9
Spelling Recognition	84.8	17.4	90.3	10.5	97.7	4.97	92.6	16.1

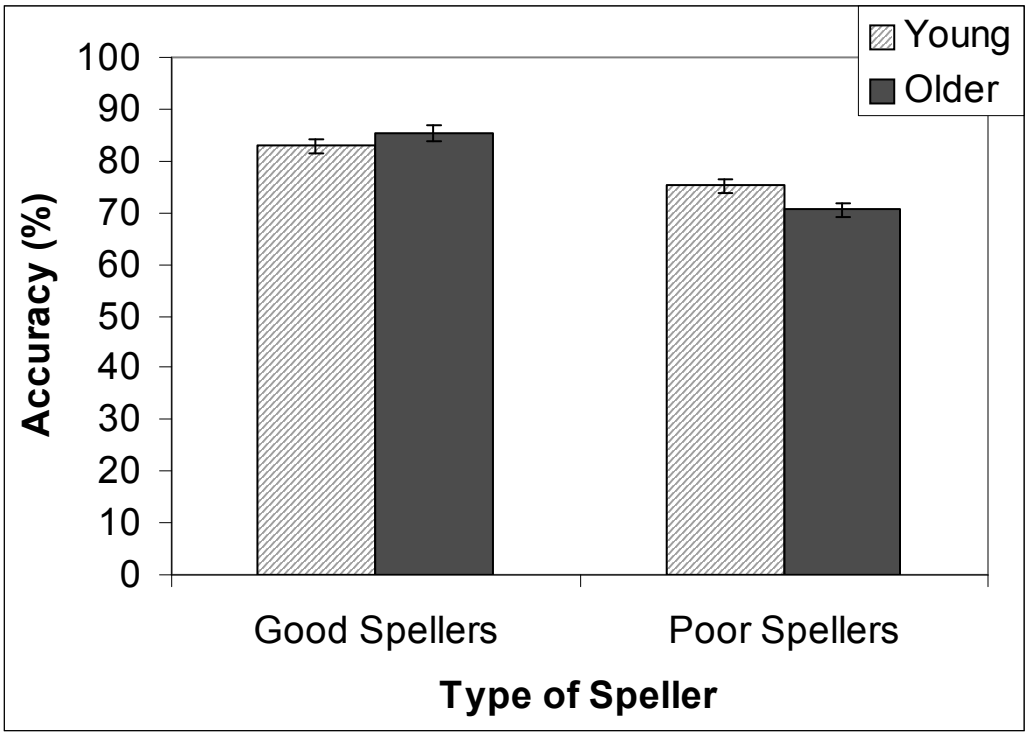
Figure Captions

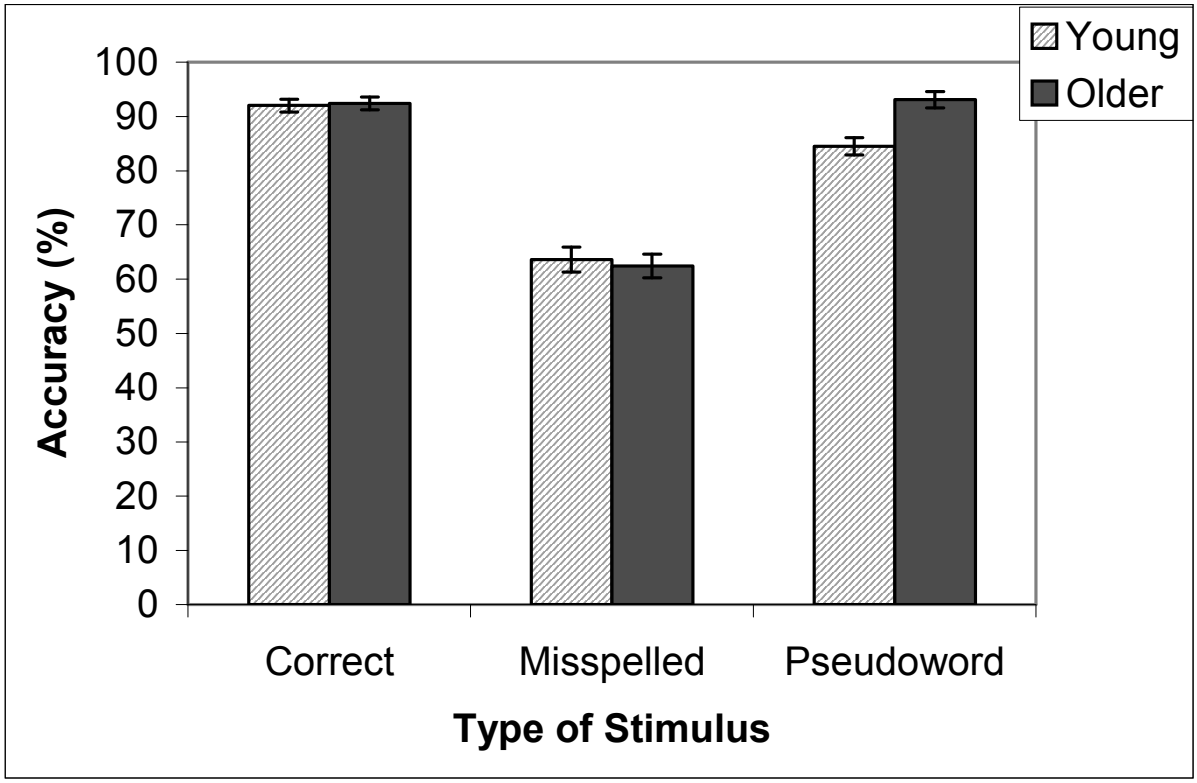
Figure 1. Spelling accuracy (in %) for young and older adults categorized as good and poor spellers, averaged across spelling tasks

Figure 2. Young and older adults' recognition accuracy (in %) for correctly spelled words, misspelled words, and pseudowords.



Revised fig – above one is WRONG:




Young
Older
100
90
80
70
60
50
40
30
20
10
0
Accuracy (%)
Correct
Misspelled
Pseudoword
Type of Stimulus