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Influences of Word Frequency, Context, and Age on Spelling

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ABSTRACT

Previous research has suggested that similar to other age-related declines in language production, the ability to produce the correct spellings of words decreases in old age (e.g., Abrams & Stanley, 2004; MacKay & Abrams, 1998; MacKay, Abrams, & Pedroza, 1999; Stuart-Hamilton & Rabbitt, 1997). However, aging alone does not predict spelling deficits. For example, spelling ability interacts with age, where older adults who are categorized as good spellers do not show declines in spelling relative to younger adults (Margolin & Abrams, 2007). This chapter presents an experiment that explored other factors that potentially might interact with age: word frequency and the degree of context, i.e., support, provided for spelling retrieval. Sixty younger adults (18-25 years) and 60 older adults (60-86 years) completed three tasks involving the spelling of words that were either relatively low or high in frequency. In the full recall task, words were presented auditorily, and participants were asked to write down the correct spelling of these words. In the partial recall task, auditorily presented words were given in conjunction with a word fragment that omitted a portion of the word (1-6 letters), and participants attempted to fill in the missing letters. In the recognition task, words were presented in a multiple-choice format, with one correctly spelled word and four misspelled variants, and participants were asked to select the word that was correctly spelled. The results showed that for both age groups, lower-frequency words were spelled correctly less often than higher-frequency words in all tasks, with greater frequency effects on the recall tasks than the recognition task. However, the negative effect of spelling lower-frequency words was especially pronounced for younger adults. Furthermore, older adults outperformed younger adults on all spelling tasks, particularly full recall and recognition. These findings suggest that compensatory factors like high word frequency and greater retrieval support are most beneficial to people with greater spelling

difficulties, who were the younger adults in the present study. Older adults' greater familiarity with words and their spellings can therefore be advantageous to their spelling recognition and retrieval.

INTRODUCTION

There is considerable evidence of age-related declines in the retrieval of words during spoken production. For example, compared to younger adults, older adults experience more word-finding problems such as tip-of-the-tongue (TOT) states (e.g., Burke, MacKay, Worthley, & Wade, 1991), name pictures of objects less accurately and more slowly (e.g., Feyereisen, 1997), and produce more dysfluencies or interruptions in otherwise fluent speech (e.g., Mortensen, Meyer, & Humphreys, 2006). In comparison to speech, considerably less is known about older adults' ability to produce words during writing. One area of research has focused on older adults' ability to produce the correct spellings of words (e.g., MacKay & Abrams, 1998; MacKay, Abrams, & Pedroza, 1999; Stuart-Hamilton & Rabbitt, 1997). Parallel to studies of speech production in aging, these studies have generally demonstrated an age-linked decline in spelling, where older adults were less accurate in spelling words correctly. These deficits are thought to be caused by weakened connections between words and their orthographic representations (e.g., MacKay & Abrams, 1998), which can be remediated by other factors, such as an auditory cue (Abrams & Stanley, 2004) or spelling ability (Margolin & Abrams, 2007). The present chapter extends previous research on factors that influence age-related declines in spelling. Specifically, we present a new experiment that investigates the role of two factors, word frequency and context (i.e., support for retrieval), on younger and older adults' spelling. These factors have been shown to influence spoken production and may therefore have comparable influences on spelling.

Word Frequency

Word frequency, or the number of times with which a word occurs in the language, has a pervasive influence on speech production: High-frequency words are considerably easier to

access and produce than low-frequency words. These effects of word frequency have been demonstrated for both speed and accuracy, where low-frequency words are produced more slowly (e.g., Jescheniak & Levelt, 1994; Lachman, Shaffer, & Hennrikus, 1974; Oldfield & Wingfield, 1965) and less accurately (e.g., Dell, 1988; Vitevitch, 1997, 2002; Vitevitch & Sommers, 2003) than high-frequency words. Word frequency also influences the probability of successful retrieval: TOT states are more likely to occur for low- than high-frequency words (e.g., Vitevitch & Sommers, 2003), as are phonological speech errors (e.g., Dell, 1990; Stemberger & MacWhinney, 1986). Although the locus of the word frequency effect is controversial (e.g., Bonin & Fayol, 2002; Navarrete, Basagni, Alario, & Costa, 2006), one explanation is that word frequency facilitates the processes underlying phonological encoding, such that the phonological constituents within high-frequency words can be assembled more quickly and accurately than those within low-frequency words (e.g., LaGrone & Spieler, 2006).

Although the effects of word frequency on speech production are well-established, the interactive effects of aging and word frequency on production are less clear. Considerably more research has been conducted using word recognition tasks, and the majority of those studies have found equivalent frequency effects for younger and older adults (Allen, Madden, & Crozier, 1991; Allen, Madden, Weber, & Groth, 1993; Bowles & Poon, 1981; Tainturier, Tremblay, & Lecours, 1989; but see Balota & Ferraro, 1993; Spieler & Balota, 2000, for exceptions where word frequency exerted a stronger influence in older adults than in younger adults). Similar findings have emerged for speech production tasks. Using three naming tasks (picture naming, naming to open-ended sentences, and naming to category exemplars), Newman and German (2005) found equivalent frequency effects in younger and older adults. Similarly, LaGrone and

Spieler (2006) found no significant age differences in the influence of frequency using a speeded picture naming task.

In contrast to speech production, the effects of word frequency on spelling production in aging are more pronounced but less consistent across studies. Stuart-Hamilton and Rabbitt (1997) compared adults in their 50s, 60s, and 70s (but no younger adults) on their written production of correct spelling, showing an age-linked decline with respect to low-frequency words but not high-frequency words. MacKay and Abrams (1998) observed the opposite pattern, where adults aged 73-88 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. Using two spelling recognition tasks and two spelling production tasks, Margolin and Abrams (2007) found higher spelling accuracy for high-frequency words than low-frequency words for both younger and older adults, but this frequency effect was larger for younger adults, and there were no significant age differences for either frequency category. MacKay and Abrams (1998) suggested that differential familiarity with the low-frequency words may contribute to findings of no age differences in spelling production. If younger adults are less familiar with the low-frequency words than older adults (which is likely given older adults' larger vocabularies, e.g., Verhaeghen, 2003), then the age-linked decline in spelling production that would have appeared if both age groups were equally familiar with the words cannot be detected. Older adults' increased vocabularies enabled them to recognize and produce the spellings of rare words with which younger adults were unfamiliar, resulting in no age differences for low-frequency words.

Context

One variable that consistently mediates older adults' performance on language and memory tasks is context, defined here specifically as support provided at retrieval. With respect to language, context has been shown to reduce age differences in comprehension of language when words are embedded in the context of natural speech compared to when words are to be recognized in isolation (Pichora-Fuller, Schneider, & Daneman, 1995; Wingfield, Aberdeen, & Stine, 1991). Similarly, even though older adults have poorer recall for words presented in random lists, especially at fast speech rates, they can perform nearly at the level of younger adults for text with strong semantic constraints (Wingfield & Lindfield, 1995; Wingfield, Poon, Lombardi, & Lowe, 1985).

With respect to memory, older adults can benefit from contextual support provided at the time of recollection. This support can come in various forms, most often as cues that are used to prompt retrieval of a specific target word (e.g., *pond*). Cues such as a word (e.g., *water*) or phrase (e.g., *a body of water*) related in meaning to the target benefit retrieval, as do cues that contain several of the target's letters (e.g., *po*____). Compared to recall, recognition tasks provide maximal support by giving the correct response in its entirety (albeit immersed within other responses). Whereas older adults consistently perform worse than younger adults on recall tasks, this age decrement is minimized or eliminated when studied items are recognized (e.g., Craik & McDowd, 1987, Wahlin, Bäckman, & Winblad, 1995). For example, Craik and McDowd (1987) had participants undergo cued recall or give yes/no recognition judgments to a list of words that were previously presented. An age decrement was found on the cued recall test but not on the recognition test. Explanations for this center around the amount of processing required for each task, with more effortful processing (e.g., Hasher & Zacks, 1979), more self-initiated processing (Craik, 1983, 1994), or more attentional resources (Anderson, Craik, &

Naveh-Benjamin, 1998) required for recall than for recognition. Older adults are thought to have fewer resources for processing, thus leading to differential impairment on tasks that require more resources (Craik, 1983; Craik & McDowd, 1987).

In contrast to previous conceptualizations of contextual support, where a cue is provided to facilitate recall of a target, the present study defined contextual support as the amount of orthography, i.e., letters, that is presented during retrieval. Defining context in this way reveals an age-linked asymmetry in retrieving spelling, similar to retrieving words from memory. Retrieval of a word's entire spelling (i.e., no letters are provided) shows pronounced age-related declines as described earlier, whereas older adults' ability to recognize spelling (i.e., all of the letters are provided) is generally preserved (e.g., MacKay et al., 1999; Margolin & Abrams, 2007). Studies that have investigated older adults' spelling recognition displayed either correctly spelled or misspelled words one at a time on a computer screen for a relatively brief period. Younger and older adults were equivalently accurate when asked to judge the correctness of a word's spelling, both for correctly-spelled words (Abrams & Stanley, 2004; MacKay et al., 1999; Margolin & Abrams, 2007) and misspelled words (MacKay et al., 1999; Margolin & Abrams, 2007). One exception is the findings of Abrams, Farrell, and Margolin (2009), who showed age-related declines within the older adult group, such that adults in their 70s and 80s were less accurate than adults in their 60s in detecting misspellings that were presented in sentences.

Cues related in meaning would likely provide no benefit to retrieving a target's spelling because the target's meaning is independent of its spelling. In contrast, cues that provide letters have been shown to influence the ability to produce correct spelling. Abrams, Trunk, and White (2008) investigated the effect of orthographic cues on retrieving low-frequency spellings, ones that are not common spellings for a particular sound, such as the "ai" in *chaplain*. They found

that correctly spelling a word containing a low-frequency spelling increased the ability to produce similarly-spelled words containing that spelling, such as *porcelain*. Parallel effects have been observed in recent studies exploring the production of homophone substitution errors (White, Abrams, McWhite, & Hagler, in press; White, Abrams, Zoller, & Gibson, 2008). These errors occur when the wrong homophone (*grown*) is produced in a context that specifically elicits the other homophone, e.g., "he began to *groan*"). Writing sentences containing a cue (e.g., *blown*) that shared several letters with the contextually-inappropriate homophone increased homophone substitution errors. Similar effects on speech production have been found using phonological cues, where similar-sounding words can help to resolve TOT states (Abrams, 2008; Abrams, White, & Eitel, 2003; Heine, Ober, & Shenaut, 1999; James & Burke, 2000; White & Abrams, 2002) or can hinder TOT resolution in some circumstances (Abrams & Rodriguez, 2005; Abrams, Trunk, & Merrill, 2007).

The Current Study

The present experiment assessed younger and older adults' spelling of lower- and higher-frequency words in three contexts that varied in terms of the number of letters required for retrieval: (1) a full recall task, where an auditorily presented word was to be spelled in full, (2) a partial recall task, where an auditorily presented word was followed by a visually presented version of the word with several letters blanked out for participants to fill in, and (3) a multiple-choice recognition task where a correctly spelled word was presented along with four misspelled versions of the same word, and participants had to select the correct spelling. Previous research has demonstrated that providing contextual support at recollection can minimize age differences (e.g., Craik & McDowd, 1987). Furthermore, both younger and older adults have been shown to benefit as the number of letters in a cue increases, facilitating retrieval of a target word (e.g.,

Park & Shaw, 1992). Additionally, the present study diverged from previous studies that asked participants to recognize whether a single visually-presented word was spelled correctly; the recognition task in our study required participants to choose the correctly-spelled word from among five alternatives. The presence of multiple spellings of the same word, four of which were misspelled, makes our recognition task more demanding than previously-used tasks that require a yes/no judgment as to whether a word is spelled (in)correctly.

Using both lower- and higher-frequency words in all three spelling contexts allows closer examination of the familiarity hypothesis of MacKay and Abrams (1998). If younger adults are less familiar with the lower-frequency words and their spellings, then the pattern of age differences (or lack of) should emerge even in recognition, as lack of familiarity with the words suggests that younger adults will also have difficulty recognizing the correct spellings. However, age differences are expected to be more pronounced as retrieval support decreases, i.e., with greater differences for full recall than partial recall, and for both recall tasks relative to recognition. Alternatively, the familiarity hypothesis may be influenced by age group differences in spelling ability (e.g., Margolin & Abrams, 2007). Familiarity with words may be linked with spelling ability, where poorer spellers are less familiar with the words. A measure of overall spelling ability for both age groups was obtained using a separate set of words not included in the experimental tasks. We predicted that the age group who has lower overall spelling ability will be less familiar with both higher- and lower-frequency words and therefore more dependent on the effects of frequency and retrieval support.

METHOD

Participants

Sixty younger adults who ranged in age from 18 to 24 (M = 19.25, SD = 1.41) were enrolled in an introductory psychology course at the University of Florida and received course credit for their participation. Sixty older adults who ranged in age from 61 to 86 (M =72.42, SD = 7.00) were recruited from the University of Florida Cognition and Aging Lab participant pool and were paid $8 an hour for their participation. All participants completed a background information questionnaire asking for age, education, ethnicity, native language, health status, and current medications as well as several cognitive tests: a 25-item vocabulary test and forward and backward digit span tests to assess working memory. Older adults' cognitive impairment was tested via the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Table 1 presents the means and standard deviations for these demographic characteristics. Independent samples t tests indicated that younger adults had fewer years of education, t (118) = 8.56, $p < .001$, and lower vocabulary scores, t (118) = 13.52, $p < .001$, than older adults. Younger and older adults did not differ on self-reported health, $p > .883$, forward digit span, $p > .431$, or backward digit span, $p > .495$.

Materials and Design

The stimuli consisted of 90 single words, 60 of which served as experimental stimuli and 30 that were fillers and later served as the measure for assessing participants' overall spelling ability. The words were selected from a book listing commonly misspelled words (Norback, 1974). In order to avoid ceiling effects, all stimuli were relatively low in frequency based on normative estimates provided by Francis and Kucera (1982). However, the 60 experimental words were categorized as lower frequency (0 – 9, M = 4.3, SD = 3.4) or higher frequency (21 – 122, M = 50.0, SD = 23.5). Lower-frequency words ranged in length from seven to 12 letters (M

= 9.5, *SD* = 1.5), and higher-frequency words ranged in length from seven to 14 letters (*M* = 9.6, *SD* = 1.7). The thirty filler words' ranged in frequency from 10 to 20 (*M* = 13.5, *SD* = 3.0) and ranged in word length from seven to 13 letters (*M* = 9.6, *SD* = 1.5).

Three separate spelling tasks were created that varied in the amount of retrieval (i.e., number of letters) required: a full recall task, a partial recall task, and a recognition task. Each participant was given 30 words in each task (20 experimental, 10 of which were higher-frequency and 10 that were lower-frequency, and 10 fillers), with the stimuli being counterbalanced among the three tasks across participants. Task order was also counterbalanced across participants. The full recall task required participants to retrieve the entire spelling for each word. The partial recall task omitted between one and six letters of each word, where the omitted letters were indicated by a single line (which did not reveal how many letters were missing, e.g., ab__n__e for *absence*). For each item on the recognition task, the correctly spelled word was written along with four misspelled words. Misspelled alternatives were misspelled according to one of six different error types that were selected from Jacoby and Hollingshead (1990): (1) an extra letter (e.g., *absc<u>e</u>nce*), (2) an omitted letter (e.g., *aquire*), (3) a different combination of letters (e.g., *rythem*), (4) a reversal of letters (e.g. *for<u>ie</u>gn*), (5) a doubled consonant (e.g., *am<u>m</u>ount*), or (6) a wrong letter (e.g., *spe<u>a</u>ch*). All misspellings were phonologically compatible with the correct spelling in order to ensure that each misspelling was plausible. The position of the correct spelling in the recognition task was counterbalanced across participants so that the correct answer appeared equally often in each of the five possible locations. Experimental stimuli are shown in Appendix A, and filler words are shown in Appendix B.

Procedure

Participants first completed the background information questionnaire and cognitive tests. Participants were then instructed to complete three spelling tasks, which were presented one at a time. During the full recall task, a list of words was presented one at a time via a tape recorder. Each word was read aloud twice, with a 10 second pause after the first reading and a 20 second pause after the second reading. Participants attempted to write down each word's spelling as accurately as possible. During the partial recall task, participants were given a sheet of paper with a list of words where each word was missing some letters indicated by a line. Each word was read aloud via a tape recorder, and participants were given 30 seconds to fill in the missing letters of the fragmented word on the written sheet. For the recognition task, participants were asked to circle the correct spelling from a list of five alternatives. They were then debriefed and thanked for their participation.

RESULTS

Words that were misheard as a different word (0.07% for younger adults, 1.5% for older adults) were excluded from analyses. Additionally, words on the partial recall task that were written out in their entirety instead of filling in the blanks (2.5% of words for younger adults, 3.6% of words for older adults) were also excluded from analyses. Because of this exclusion, one older adult was removed from analyses because of no valid data in the partial recall condition for lower-frequency words.

A 2 (Age Group: younger, older) x 2 (Word Frequency: lower, higher) x 3 (Spelling Task: full recall, partial recall, recognition) repeated measures analysis of variance (ANOVA) was conducted on the proportion of accurate spelling or recognition by participants ($F1$) and items ($F2$). Means and standard deviations for younger and older adults' spelling accuracy by

task and word frequency converted into percents are presented in Table 2. This analysis revealed significant main effects of age group, F_1 (1, 117) = 16.03, *MSE* = .09, $p < .001$, F_2 (1, 56) = 33.64, *MSE* = .02, $p < .001$, spelling task, F_1 (2, 234) = 50.82, *MSE* = .02, $p < .001$, F_2 (2, 112) = 55.38, *MSE* = .02, $p < .001$, and word frequency, F_1 (1, 117) = 599.57, *MSE* = .02, $p < .001$, F_2 (1, 56) = 25.29, *MSE* = .22, $p < .001$. These main effects were moderated by two-way interactions between the variables: age group x word frequency (significant in the participant analysis only), F_1 (1, 117) = 4.10, *MSE* = .02, $p < .045$, F_2 (1, 56) = 2.09, *MSE* = .02, $p < .154$, age group x spelling task, F_1 (2, 234) = 3.78, *MSE* = .02, $p < .024$, F_2 (2, 112) = 4.01, *MSE* = .01, $p < .021$, and spelling task x word frequency, F_1 (2, 234) = 13.74, *MSE* = .03, $p < .001$, F_2 (2, 112) = 15.05, *MSE* = .02, $p < .001$. The three-way interaction was not significant, $F_1 < 1$, $F_2 < 1$.[1]

Follow-up tests on the age group x word frequency interaction (which is displayed in Figure 1) revealed that older adults had more accurate spelling performance than younger adults for both higher-frequency, $p_1 < .001$, and lower-frequency words, $p_1 < .003$, although the age difference was greater for lower-frequency words. Furthermore, spelling accuracy was greater for higher-frequency words than lower-frequency words for both age groups, p_1s < .001, but this effect of frequency was smaller for older than younger adults.

Follow-up tests on the age group x spelling task interaction (see Figure 2) showed that older adults had greater spelling accuracy than younger adults on all three tasks, with the largest age differences occurring for full recall, $p_1 < .001$, $p_2 < .001$, and recognition, $p_1 < .001$, $p_2 < .001$. In contrast, older adults were only slightly more accurate for partial recall than younger adults, $p_1 < .069$, $p_2 < .001$. For both age groups, accuracy was highest on the recognition task, but age differences occurred in terms of the task that was least accurate. For older adults, accuracy in recognition was greater than full recall, $p_1 < .001$ $p_2 < .001$, which in turn was

greater than partial recall, $p_1 < .009$, $p_2 < .002$. For younger adults, accuracy in recognition was greater than partial recall, $p_1 < .001$, $p_2 < .001$, which was greater than full recall, $p_1 < .028$, $p_2 > .767$.

Independent of age group, spelling task interacted with word frequency (see Figure 3) such that higher-frequency words resulted in better accuracy than lower-frequency words for full recall, $p_1 < .001$, $p_2 < .001$, partial recall, $p_1 < .001$, $p_2 < .001$, and recognition, $p_1 < .001$, $p_2 < .005$, with full recall and partial recall having larger frequency effects than recognition. Alternatively, there were spelling task differences for both higher- and lower-frequency words. For lower-frequency words, recognition had higher accuracy than either full recall, $p_1 < .001$, $p_2 < .004$, or partial recall, $p_1 < .001$, $p_2 < .001$, with no difference between the two recall tasks, $p_1 > .841$, $p_2 > .06$. A similar pattern occurred for higher-frequency words, which yielded the highest accuracy for recognition compared to full recall, $p_1 < .012$, $p_1 < .004$, and partial recall, $p_1 < .007$, $p_2 < .006$, which did not differ, $p_1 > .868$, $p_2 > .545$. However, the advantage of recognition over the other tasks was greater for higher-frequency words than for lower-frequency words.

We then computed an overall "spelling ability" score using the filler words (words not included in the above analyses), calculating the mean percent correct on the full recall task. An independent samples *t* test revealed that older adults ($M = 69.5\%$, $SD = 22.2\%$) had greater spelling ability scores than younger adults ($M = 60.5\%$, $SD = 19.0\%$), $t\ (117) = 2.38$, $p < .019$. To determine whether these age differences in spelling ability could account for the previously described age interactions with word frequency and context, a 2 (Age) x 2 (Frequency) x 3 (Task) repeated measures analysis of covariance (ANCOVA) was conducted, using spelling ability score as the covariate. Controlling for spelling ability did not eliminate the age difference

overall, as the main effect of age group, $F(1, 116) = 10.11$, $MSE = .01$, $p < .002$, along with the interactions with age group remained significant. When including only lower-frequency words, the age group effect again remained significant, $F(1, 116) = 10.86$, $MSE = .04$, $p < .001$, but when including only higher-frequency words, the age group effect became marginally significant, $F(1, 116) = 3.46$, $MSE = .03$, $p < .065$.

A 2 (Age) x 2 (Frequency) x 3 (Task) repeated measures ANCOVA was also conducted using vocabulary score as the covariate. Controlling for vocabulary eliminated the age difference when including all words, $F < 1$, as well as when higher-frequency words and lower-frequency words were analyzed separately (Fs < 1).

CONCLUSION

The results demonstrate an interesting reversal relative to previous studies: Older adults were *better* than younger adults in both recognizing and retrieving spelling. Older adults demonstrated their spelling advantage in all tasks, but especially in full recall and in recognition. Subsequently, the effects of word frequency and context via retrieval support were differential for the two age groups. The detrimental effect of spelling lower-frequency words occurred for both age groups but was particularly pronounced for younger adults. These findings support MacKay and Abrams' (1998) familiarity hypothesis in that younger adults' lack of familiarity with lower-frequency words leads them to have difficulties in both recognition and recall of these words. Also consistent with the familiarity hypothesis is the finding that vocabulary was more predictive of age differences than spelling ability, as controlling for vocabulary eliminated age differences in spelling lower-frequency words, whereas controlling for spelling ability did not.

However, younger adults also had reduced familiarity of the higher-frequency words used in this study, evidenced by poorer recognition and recall of these words compared to older adults and the finding that age differences in spelling higher-frequency words disappeared when vocabulary was treated a covariate. The reduced familiarity for higher-frequency words may have masked the potential to observe age-related declines seen in some previous spelling studies (e.g., MacKay & Abrams, 1998) but is consistent with Margolin and Abrams' (2007) claim regarding the importance of spelling ability to age differences. Unlike lower-frequency words, controlling for spelling ability did reduce the age difference in spelling higher-frequency words to a marginal effect. Thus, for higher-frequency words, better spelling ability may not only offset age-related declines in spelling, but may also allow older adults to maintain their knowledge of words and their spellings to the degree of obtaining better performance than younger adults. Perhaps there is a similar trajectory for aging that parallels the one suggested by Burt and Butterworth (1996), where children who are good spellers can maintain their level of spelling knowledge and ability to use phonological information for spelling as they reach adulthood. An interesting question for future study is whether there is a similar individual difference variable that can offset age-related declines in speech production (e.g., Burke et al., 1991; Feyereisen, 1997; Mortensen et al., 2006)

The effect of word frequency in spelling paralleled the advantages of high-frequency words found in speech production (e.g., Dell, 1988; Jescheniak & Levelt, 1994; Oldfield & Wingfield, 1965; Vitevitch & Sommers, 2003), demonstrating that higher-frequency words were easier to spell in all three spelling tasks. Higher frequency had its smallest advantage for recognition, indicating that context can offset some of the difficulties in retrieving lower-frequency words. However, the interactive effects of aging and word frequency on spelling are

quite different from those found in speech production, where there are often no age differences (e.g., LaGrone & Spieler, 2006; Newman & German, 2005). Age differences typically emerge in spelling production but have been diverse in nature, with older adults having poorer performance only on low-frequency words (Stuart-Hamilton & Rabbitt, 1997), only on high-frequency words (MacKay & Abrams, 1998), or no age differences for either type of word (Margolin & Abrams, 2007). The present study was no exception, as it was the first to report greater spelling performance for older adults than younger adults, for both lower- and higher-frequency words. The inconsistencies of frequency's effect point to the importance of considering mediating effects of other factors, such as vocabulary or spelling ability, on younger and older adults' spelling. Additionally, it is important to note that studies often use different ranges for categorizing low and high frequency, making direct comparisons across studies, as well as the specification of the conditions under which the familiarity hypothesis will hold or fail, difficult. It is also worth noting that unlike spelling, age-related impairments in speech production, such as increased TOT states or slowed naming times, are much more reliable. One explanation may be that English contains many inconsistent sound-to-spelling mappings, which can make spelling unfamiliar words difficult and require a person to have multiple exposures to a word before learning its spelling. Thus, when older adults have greater familiarity with the words, they also have greater knowledge of their spellings, and age differences favoring younger adults disappear. In contrast, the nature of speech production tasks involves retrieving a word's sounds, which a person learns after hearing a word once, so older adults cannot use greater familiarity to their advantage, consistent with equivalent effects of word frequency for younger and older adults (e.g., LaGrone & Spieler, 2006; Newman & German, 2005).

With respect to context's effect on spelling, both younger and older adults benefited from the full context provided by the recognition task, especially for lower-frequency words. We expected compensatory factors like context to be especially important for people who are poor spellers, which turned out to be younger adults, not older adults. Consequently, younger adults' spelling was affected by the amount of context available at the time of production, such that their most accurate spelling was in recognition and their least accurate spelling was in full recall. In contrast, older adults showed a different pattern, where their performance was the poorest on the partial recall task compared to full recall and recognition. In this task, participants had to fill in missing letters that occurred in random positions within the target words. One possibility for this result is that older adults are more biased toward holistic visual word recognition than younger adults (e.g., Allen et al., 1993; Allen, Smith, Groth, Pickle, Grabbe, & Madden, 2002). Using case-mixing in a lexical decision task, these studies have shown that mixed-case presentation (which disrupts holistic processing) exacerbates age-related slowing in lexical decision relative to lowercase presentation (which allows holistic processing). A similar bias therefore may occur in spelling production, making the partial recall task relatively more difficult for older adults because holistic processing is disrupted by requiring only a subset of letters to be produced. It is worth noting that this pattern did not occur for younger adults, where full recall exhibited the poorest accuracy relative to partial recall and recognition. The finding that younger adults were less disrupted by partial recall suggests that the reliance on holistic processing may increase with age.

These findings of preserved spelling in older adults in the present study, contrary to previous research showing age-related deficits (e.g., Abrams & Stanley, 2004; MacKay & Abrams, 1998; MacKay et al., 1999), have some significant implications. First, these seemingly

contradictory results are consistent with some theories of cognitive aging, such as Baltes and Baltes' (1990) theory of selective optimization with compensation. Within this developmental theory of successful aging, compensation serves to counteract losses in functional abilities due to aging by using stronger abilities to compensate for those that have weakened. In the present experiment, older adults' reliance on their greater knowledge of and familiarity with words could be described as a type of compensation that allows them to maintain access to spelling. Second, attempting to equate word familiarity when assessing age-related changes in language production is essential. One way to equate experience might be to test multiple older adult groups, as was done by Stuart-Hamilton and Rabbitt (1997), who found no age difference for low-frequency words, presumably because the groups were equivalently familiar with those words. However, there is converging evidence that there are greater age-related declines among adults in their 70s and 80s relative to adults in their 60s on various measures, such as word naming (e.g., Au et al., 1995), implicit memory (e.g., Davis et al., 1990; Hultsch, Masson, & Small, 1991), and TOT states (e.g., Abrams et al., 2007; Heine et al., 1999; White & Abrams, 2002). Thus, when changes do emerge between groups of older adults, they are more likely to result from age-related declines rather than differences in familiarity or vocabulary. Lastly, the present results serve as a reminder about the complexity of the processes underlying cognitive aging and the importance of establishing the conditions under which certain aspects of language and memory functioning are impaired versus spared. Concluding that older adults are universally impaired in all situations is not only misleading but can also lead to negative stereotypes about older adults and their cognitive capabilities.

In conclusion, the present study reveals some interesting differences in the production of spelling with respect to aging, relative to the production of speech. Whereas age-related declines

in speech production are quite consistent and occur across various tasks, age-related declines in spelling production are more variable and do not always occur. Spelling is a domain where older adults' greater knowledge and familiarity with words can offset potential age-related declines, especially those that typically would be exacerbated by impoverished conditions, such as reduced context or low frequency. Future research might incorporate a set of words with which younger and older adults report equal familiarity to avoid the problem of older adults' greater vocabularies giving them more experience with all words and their spellings, in particular low-frequency words. Furthermore, research should continue to explore the similarities and differences between speech and spelling to better understand how the cognitive processes underlying these types of production change with healthy aging.

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Footnote

1. This pattern of results was replicated using a different frequency measure (Zeno, Ivens, Milliard, & Duvvuri, 1995) to categorize word frequency, demonstrating that these findings are consistent when more recent measures of word frequency are used.

Appendix A

Experimental Word	**Word Frequency**	**Partial Recall**	**Recognition Task Misspellings**			
acrimonious	0	a____mon_ous	acrimoneous	acromonious	accromonious	acramonious
iridescent	0	i__descent	irrasistable	irrisistible	irresistable	iresistable
margarine	0	marg_____	marrige	marridge	mariage	marriadge
picnicking	0	pic____ing	preferance	prefference	preferrance	preferrence
unforeseeable	0	unfor_____ble	uneccessary	unecessary	unneccesary	uneccesary
corduroy	1	_or__roy	korduroy	chorduroy	corderoy	coreduroy
counterfeit	1	c__nterf__t	counterfet	counterfiet	counterfit	conterfiet
harassment	1	ha__a__ment	hemorrage	hemorraige	hemorage	hemorhage
ostracize	1	ostr____e	perssonel	personel	personnal	persanel
affidavit	2	a___davi_	affidavid	affadavid	afidavit	affadavit
descendant	2	de__end_nt	dissappoint	disapoint	dissepoint	dissapoint
reprieve	2	re_____e	scaresly	scarecely	scearsely	scearcely
erratic	3	_____ic	excelence	exellence	exellance	excellance
mischievous	3	mi_____ous	nesessarily	necesarily	nesesarily	nessessarily
chronicle	4	__roni___	chronickle	chronical	cronicle	cronickle
fluorescent	4	fl__re__ent	hankerchief	hankercheif	handkirchief	handkercheif
silhouette	4	s___oue__e	soverein	soveraign	sovereighn	soverain
hemorrhage	5	hemor___ge	imediate	inmediate	immedeate	immidiate
ecstasy	6	e__ta_y	eficiency	efficeincy	effitiency	eficeincy
supersede	6	super_e__	simphony	symmfony	symmphony	simmphony
exuberant	7	e__be__nt	fluoresent	fluoressent	floresent	floressent
bacteria	8	ba_t___a	bacterria	bakteria	bacterea	bactirea
irresistible	8	i___sist_ble	leggislateur	legislateur	ledgislature	leggislature
maneuvers	8	ma___vers	margerin	margarin	margareen	margerine
reciprocal	8	r__iproc__	recognise	rekognize	recognice	reccognize
annoyance	9	a__oy_nce	annoyence	anoyence	anoyance	annoyeance
avocado	9	av__a_o	avaccado	avoccado	avocaddo	avacado
cynical	9	___ical	decendant	decendent	descindent	desendent

handkerchief	9	han_k_rch__f	harrassment	harrasment	harasment	harassement
preference	9	pre_e__nce	prelimenary	preliminery	prelimenery	priliminary
scarcely	21	s_ar__ly	sherif	sherrif	sherriff	shereff
autumn	22	au____	autemn	automn	autum	auttumn
preliminary	23	pr_lim_n_ry	priveledge	privillege	privelege	priviledge
discipline	25	di____line	eckstacy	ecstacy	ekstasy	ekstacy
recommend	25	re_o__end	repitition	reppitition	reppetition	repettition
transferred	27	trans_e__ed	tyrrany	tirany	tirrany	tyrany
innocence	28	i__o_ence	iradescent	irradescent	irredescent	irridescent
occurrence	29	o__u___nce	omminous	ominnous	omenous	omennous
adjustment	30	a_____ment	ajustment	adjusment	ajusment	adjustement
questionnaire	33	question_____	resciprocal	riciprocal	resiprocal	reciprocle
occasional	37	o__a_ional	occurrance	ocurrence	occurance	occurence
conscience	38	con___en_e	concience	conscence	consience	consciense
orchestra	40	or__estr_	ostracise	ostricize	ostrasize	ostresize
efficiency	48	e__i___ncy	emmbarass	emmbarrass	embarass	emberass
necessarily	50	ne_e__arily	negligeble	neglegeable	neglegable	neglegible
absence	53	ab__n_e	absense	abscence	abscense	absance
confidence	56	con____nce	confidance	confedence	confedance	confiddance
achievement	57	a_____ment	achivement	archivement	acheivement	achievment
apparent	57	a_____nt	aparent	aparrent	apparrent	appearant
maintenance	57	maint_n_nce	manneuvers	manuvers	manoovers	manuevers
emphasis	58	emph__is	irradic	eradic	irratic	eratic
ultimate	59	ult_m_t_	unforseable	unforseeable	unforeseable	unforeseeble
recognize	62	re_ogni_e	reccommend	recomend	reckommend	reccomend
sufficient	63	su__i__ent	superceede	superceed	superseed	superseede
adequate	66	a___ua__	adiquate	adecuate	addequate	adequait
characteristic	68	__ar__t_ristic	charecteristic	charectaristic	caracteristic	charackteristic
personnel	70	per_o___l	picknicing	picknicking	picnicking	picniking
immediate	81	i___d_ate	inocence	innosence	innossence	inosence
successful	95	su__e__fu_	suficient	suffitient	sufficent	suffisient
marriage	122	ma__i_ge	medieval	midieval	medeeval	mideival

Appendix B

Filler Words	Word Frequency
archaeology	10
miscellaneous	10
negligible	10
symphony	10
tyranny	10
vengeance	10
beneficial	11
cemetery	11
conceivable	11
sovereign	11
adjacent	12
legislature	12
lieutenant	12
ominous	12
commitment	13
excellence	13
repetition	13
therapeutic	13
accommodate	14
boundary	15
disappoint	15
sheriff	15
unnecessary	16
medieval	17
spontaneous	17
adolescence	18
privilege	18
tournament	18
convenience	19

embarrass	19

Table 1

Demographic characteristics for younger and older adults.

	Age Group					
	Younger Adults			Older Adults		
Variable	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Education (years)*	60	13.47	1.19	60	16.98	2.94
Vocabulary* (max = 25)	60	14.25	2.97	60	20.83	2.32
Forward digit span	60	7.53	1.43	59	7.34	1.24
Backward digit span	60	5.12	1.50	59	5.29	1.22
Health rating (max = 10)	60	8.32	1.16	59	8.28	1.51
MMSE (max = 30)				59	28.39	1.37

Note. Asterisks indicate significant differences between the age groups, $p < .05$. Participants who were missing data from particular characteristics were excluded from that analysis.

Table 2

Younger and older adults' mean spelling accuracy (in percent, with standard deviations in parentheses) of lower and higher-frequency words in full recall, partial recall, and recognition tasks.

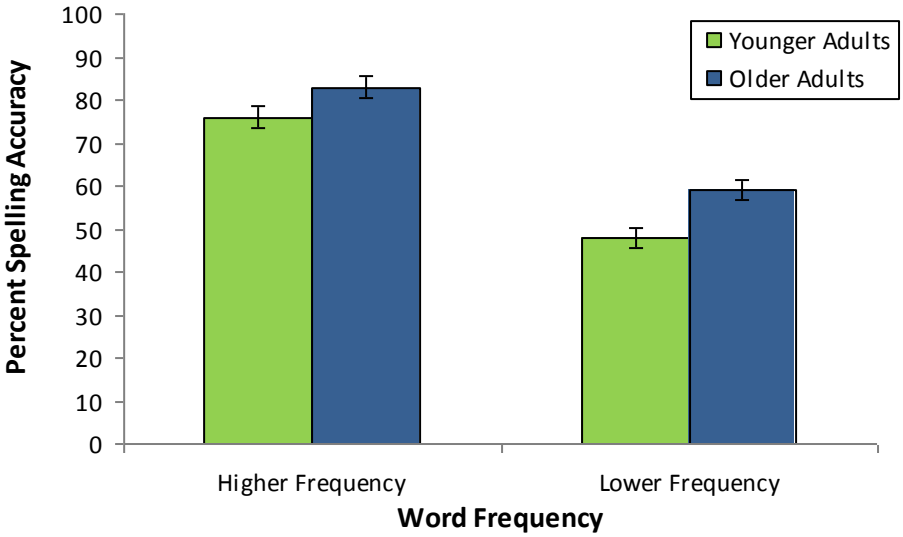
	Age Group	
	Younger Adults	Older Adults
Lower Frequency		
Full Recall	39.5 (21.1)	54.5 (22.6)
Partial Recall	43.4 (17.9)	49.7 (19.6)
Recognition	60.3 (18.7)	72.0 (19.2)
Higher Frequency		
Full Recall	72.6 (17.9)	82.8 (18.2)
Partial Recall	75.7 (17.2)	79.0 (18.1)
Recognition	79.8 (16.9)	86.5 (16.6)

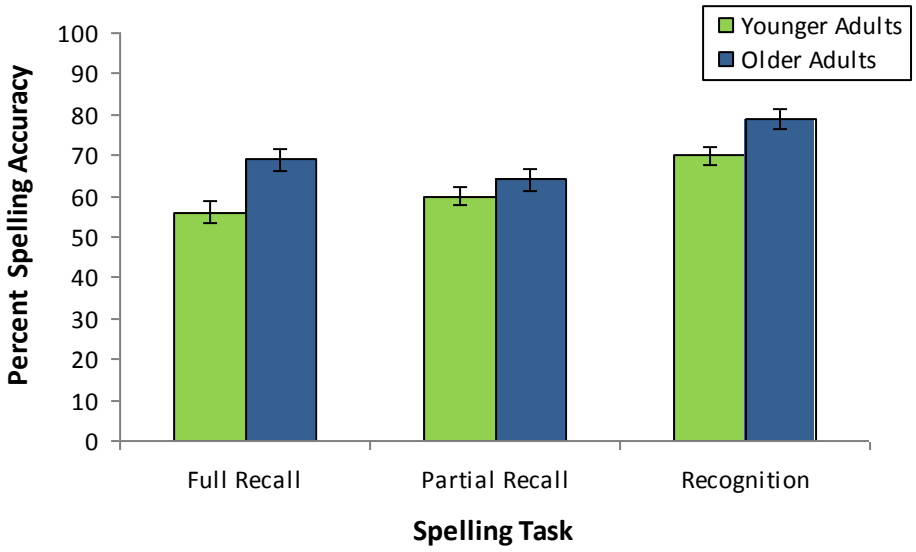
Figure Captions

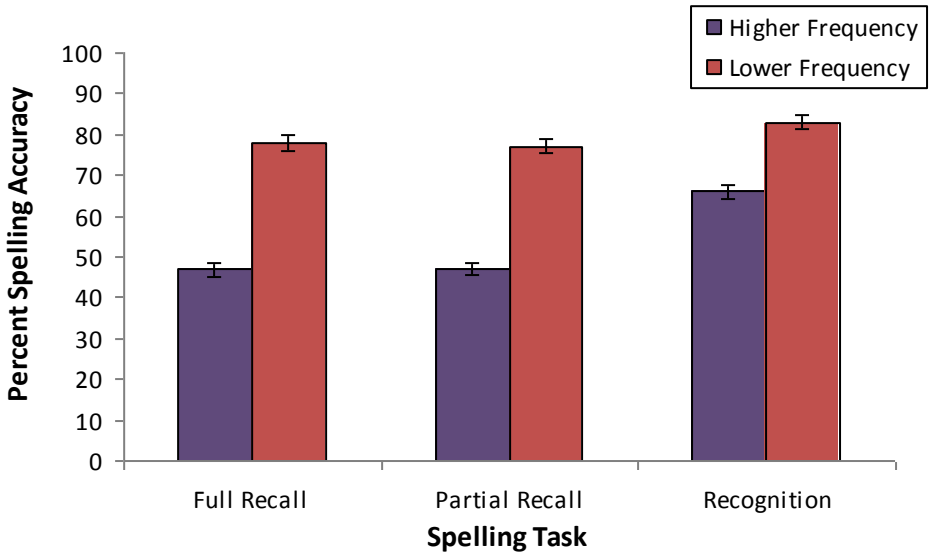
1. Younger and older adults' spelling accuracy as a function of word frequency.

2. Younger and older adults' spelling accuracy as a function of spelling task.

3. Spelling accuracy of higher- and lower-frequency words as a function of spelling task.


Percent Spelling Accuracy
100
90
80
70
60
50
40
30
20
10
0
Younger Adults
Older Adults
Higher Frequency
Lower Frequency
Word Frequency


Younger Adults
Older Adults
Percent Spelling Accuracy
100
90
80
70
60
50
40
30
20
10
0
Full Recall
Partial Recall
Recognition
Spelling Task


Higher Frequency
Lower Frequency
Percent Spelling Accuracy
100
90
80
70
60
50
40
30
20
10
0
Full Recall
Partial Recall
Recognition
Spelling Task