Age-Related Differences in the Detection of Homophone Substitution Errors

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Abstract

Preliminary research suggests that older adults perform as well, if not better, than young adults on spelling detection tasks. This experiment investigated young and older adults' detection accuracy of target words embedded in sentence contexts, contrary to previous studies that examined spelling detection of isolated words. Specifically, detection of homophone substitutions was examined by replacing a contextually appropriate word (e.g., *beech*) with its homophone foil (e.g., *beach*) or a pseudo-homophone (e.g., *beetch*). Age and spelling ability were investigated between participants; homophone dominance and the presence or absence of an orthographic prime were manipulated within participants. Spelling ability did not affect older adults' detection of homophone substitutions, with both good and poor older spellers performing better than young adults. However, young good spellers were more accurate detectors than young poor spellers. Both age groups were less likely to detect errors when the dominant homophone replaced the subordinate homophone than when the subordinate replaced the dominant. Orthographic priming did not appear to influence detection of homophone errors for either age group. Results are explained using dual route models.

Age-related changes in linguistic performance have been observed in both healthy older adults and those with age–related illnesses such

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as dementia (e.g., Abrams and Stanley 2004; Burke and Shafto 2004; MacKay, Abrams, and Pedroza 1999; Neils, Roeltegen, and Greer 1995). Longitudinal studies reveal age-related declines in the use of vocabulary and complex grammatical structures (Kemper, Thompson, and Marquis 2001). The language production literature shows older adults as having more difficulty than young adults in producing the proper spellings of words (MacKay and Abrams 1998) and in retrieving familiar words (Burke, MacKay, Worthey, and Wade 1991). Encouraging, however, is that older adults do appear to excel in some areas of language in comparison to their younger counterparts. Specifically, preliminary research suggests that older adults perform just as well, if not better, than young adults on spelling *detection* tasks (i.e., accurately identifying words as being correctly or incorrectly spelled) (MacKay, Abrams, and Pedroza 1999; Margolin and Abrams, in press). This research, however, has been limited to the detection of misspelled and correctly spelled words presented in isolation. The present study expands the research on spelling detection in older adults by investigating whether young and older adults differ in their ability to detect inappropriate spellings (i.e., homophone substitution errors) that are embedded in sentence contexts. Because people are rarely asked to detect a misspelling in isolation, spelling detection in sentence context allows for a more naturalistic observation of everyday errors made when proofreading written documents, letters, e-mails, etc.

Research on age and spelling ability often compares young and older adults' spelling detection with their spelling production. Indeed, older adults have been reported to have deficits in a variety of language production tasks, relative to young adults and relative to language comprehension or detection tasks. Typical language production tasks include word retrieval, picture naming, and spelling production tests. A common complaint among older people is the inability to produce familiar words. This "tip-of-the-tongue" phenomenon also occurs in young adults, but is much more prevalent among older adults (e.g., Burke et al., 1991). In particular, older adults report difficulties in retrieving proper nouns (e.g., names), especially those that have not been used recently or are not used frequently (Burke and Shafto 2004; Burke, Locantore, Austin, and Chae 2004). Age-related language production declines are also seen in picture naming tasks, where older adults are asked to give the name of the object or person portrayed in a picture (Feyereisen 1997; Burke et al. 2004). Furthermore, there is evidence for age-related declines in spelling production (MacKay and Abrams 1998; Stuart-Hamilton and Rabbitt 1997). Spelling production in older adults is typically tested by asking participants to write down previously recorded words that are individually presented over computer speakers. Age-related declines seem to interact with word frequency, such that older adults are more likely to misspell common (high frequency) words than younger adults, but outperform young adults in the spelling of low frequency words (MacKay and Abrams 1998). The latter finding contradicts to the general consensus that older adults perform more poorly than young adults on production tasks. The enhanced performance by older adults of low-frequency production tasks may be explained by their heightened familiarity with low-frequency words in comparison to young adults. White, Zoller, and Abrams (2006) examined spelling production errors in a more naturalistic setting by asking young and older adults to transcribe entire sentences presented auditorily via loud speakers. We examined frequency and priming effects on spelling production of a homophone target word embedded in the sentence. The frequency effects observed were identical to those from MacKay and Abrams (1998): in relation to young adults, older adults were more likely to make homophone substitution errors with high frequency words, but less likely to make homophone substitution errors with low frequency words.

Margolin and Abrams (in press) looked more specifically at age-related declines in spelling ability as related to type of speller (i.e., "good" or "poor" speller based on percentage of correctly spelled words on a spelling test). For poor spellers, young adults performed better than older adults; however, among good spellers, young and older adults performed similarly. Categorization by speller-type seems to provide new insight into age-related deficits in spelling production. For older adults who are good spellers, performance on spelling tasks is very good and does not seem to be affected by increasing age. Among older adults who are poor spellers, however, poor performance on spelling tasks may indicate more potent age-related cognitive deficits for those who already perform poorly on cognitive tests.

The age-related deficits found in much of the spelling production literature do not appear to generalize to tasks that involve spelling detection. Spelling detection involves the identification of correctly-spelled and misspelled written words. MacKay, Abrams, and Pedroza (1999) investigated spelling detection in young and older adults by briefly presenting correctly-spelled (e.g., *endeavor*) or incorrectly-spelled (e.g., *endeavuor*) words. Participants were told to judge if the spelling of the word was right or wrong. Older adults performed just as well as young adults on this task, and no significant age-frequency interaction was observed (see also MacKay and Abrams 1998).

Abrams, White, McDermott, and Wolf (2000) tested spelling detection by giving young and older adults a multiple-choice recognition test in which they were asked to identify the correctly-spelled word among other possible spellings. Older adults identified spellings as being correct/incorrect more accurately than young adults. The Margolin and Abrams (in press) study discussed previously also investigated detection errors. Similar results were found for their detection and production tasks: increased age was detrimental only for poor spellers, and no age differences were found between young and older good spellers. Independent of spelling task, older adults were better than young adults at detecting pseudo-words ("fake" words imitating the phonology and orthography of real words, but having no meaning, e.g., *beese*, *nooth*), but performed similarly when detecting correctly-spelled and misspelled words. Thus, individual spelling ability was more predictive of age-related spelling differences than was type of spelling task.

The spelling detection studies described above all presented participants with isolated words that were either correctly or incorrectly spelled. No published research has investigated older adults' ability to detect misspellings in context, within sentences. Studying spelling errors[1] in context provides a more naturalistic setting for evaluating the kinds of detection errors made in everyday life. Proofreading experiments employ such a naturalistic setting. Given a story passage, participants are instructed to read for meaning and cross out words that do not make sense in context. Each passage contains a homophone (e.g., *beach*), or a word that shares its sound (phonology) with another word (*beech*) that has a different spelling and meaning. Within a passage, correct (target) words are replaced with a spelling control (a word spelled similarly to the correct word, e.g., *batch*), a homophone foil (the contextually inappropriate homophone, *beach*, replaces the contextually appropriate homophone *beech*), or a pseudo-homophone (*beetch* replaces *beach)* (Jared, Levy, and Rayner 1999).

The use of homophone and spelling controls in proofreading experiments provides an opportunity to examine how phonology and orthography affect performance in spelling detection tasks, something that has not been investigated with older adults. An elevated incidence of detection errors (identifying a word as being contextually appropriate when it is actually inappropriate, or vice versa) for homophones in comparison to spelling controls would provide evidence that phonology is used to activate word meaning (Van Orden, Pennington, and Stone 1990). Understanding the role of phonology in activating word meanings gives insight into developing methods that will improve recall of words, particularly for older adults. Much of the evidence from proofreading experiments with younger adults suggests that the phonology of a word is activated even before the meaning of the word is activated, especially for less skilled readers (Daneman and Stainton 1991; Treiman, Freyd, and Baron 1983; Van Orden 1987). Therefore, if a contextually inappropriate homophone (*beach*) stands in the place of the appropriate homophone (*beech)*, a person is likely to leave the error undetected because the phonology of the word is activated and accepted (*beach* sounds like *beech*). These proofreading studies focus on young adults, and do not examine whether or not performance differs with age. Some evidence suggests that more skilled readers are less likely to activate phonology prior to activating a word's meaning; rather, they are able to go directly from the printed word to its meaning (Jared and Seidenberg 1991). As one ages and gains more experience reading, one may be more likely to bypass a word's phonology when activating its meaning. In such a case, older adults would be more likely to detect homophone substitution errors than young adults. This type of finding would contrast with language production studies (e.g., TOT) that generally show equivalent activation of phonology for young and older adults (James and Burke 2000; White and Abrams 2002).

As mentioned above, a word's meaning may be activated through a phonological route (e.g., Jared and Seidenberg 1991; Van Orden 1987;

Van Orden, Pennington, and Stone 1990). In this case, a word's phonology is first activated, and then semantic information is derived based on that phonology. For a homophone (*beech*), phonology is activated for both homophones (*beech* and *beach*). Thus, both word meanings are initially activated, and the appropriate meaning is then chosen based on sentence context. However, this phonological route is just one route to word meaning, as identified by dual route models (Van Orden 1987; Van Orden, Pennington, and Stone 1990). An alternative route to word meaning can also occur more directly, with word meanings activated directly from the printed word. The direct route is a more efficient method of meaning acquisition than the phonological route, and is believed to be the primary method by which good readers activate meaning from printed word (Jared and Seidenberg 1991). Because the phonological route uses a step-by-step process (spelling-sound-meaning) of activating word meaning, it is most useful for beginner and poor readers and when reading irregularly-spelled words (Jared et al. 1999). A correlation exists between reading and spelling ability, such that good readers tend to be good spellers and poor readers tend to be poor spellers (Kashner 1989). Good readers also have better vocabularies than poor readers (Kashner 1989). Therefore, it is logical that good spellers use the direct route as their primary means for activating words. Poor spellers would be more likely to use the phonological route. With presumably a 40-year advantage of reading experience over young adults, it seems logical that older adults would be more likely use the direct route for activating word meanings. Whether this experience advantage is enough to enable older poor spellers to also use a direct route remains to be seen.

Word frequency is another variable that has often been manipulated in these proofreading studies. Jared et al.'s (1999) Experiment 2 asked young adults to read a passage and cross out items that did not make sense. They were also given comprehension questions to make sure they were reading for meaning. Participants were better at detecting errors when a low frequency word (*beech*) replaced a high frequency word (*beach*) than when a high frequency word (*beach*) replaced a low frequency word (*beech*). They were also more likely to detect errors when the target (*beech*) was replaced with a spelling control (*bench*) than when the target word was replaced with the homophone foil (*beach*). The present experiment also investigated frequency in order to see if older adults have similar detection patterns as young adults for high and low frequency homophones. Note that in the present experiment, we use the terms *dominant* and *subordinate* to refer to our homophones. Dominance is often closely related to frequency (Starr and Fleming 2001; White and Abrams 2004a); however, it is possible for two homophones to have similar cumulative frequencies, but for one homophone to be dominant over another according to normative studies (White and Abrams 2004a). For example, *bail* and *bale* have similar cumulative frequencies (Zeno, Ivens, Millard, and Duvvuri 1995), respectively 9 and 5 words per million, but *bail* is considered more dominant based on White and Abrams' normative studies. Additionally, by using homophone dominance, we were able to choose homophones that have been normed on both young and older adults, something that frequency norms do not control. Consistent with previous proofreading studies, we predicted that participants would be less likely to detect errors when the contextually inappropriate dominant homophone (*beach*) stands in place of the contextually appropriate subordinate homophone (*beech*) than when the contextually inappropriate subordinate homophone (*beech*) replaces the contextually appropriate dominant homophone (*beach*).

Although proofreading studies have determined that homophone detection is influenced by word frequency, we were interested in additional variables that might influence detection. Specifically, we investigated whether the detection of substitution errors would be affected by prior exposure to words containing similar orthography to the target word. This orthographic priming has been shown to influence the *production* of homophone substitution errors (White et al. 2006). The current study employs a modified version of the priming paradigm introduced by White et al. (2006). In their production study, prior to spelling a target word (e.g., *beech*), participants wrote a prime word (e.g., *teacher*) that overlapped in orthography with the (contextually inappropriate) homophone (*beach*) of the target. Using this methodology, priming increased the likelihood that participants misspelled the target word in both young and older adults. This result suggests that spelling production errors (*beach* rather than the correct word *beech*) is influenced by the recent presentation of a similar orthography (*teacher*). Furthermore, young and older adults are equally affected by this exposure to orthography. This preliminary evidence suggests that orthographic priming is not reduced with increasing age, similar to phonological priming which has been shown to facilitate resolution of TOTs for both young and older adults (James and Burke 2000; White and Abrams 2002).

In our investigation of priming effects on detection by older adults, participants were exposed to words (e.g., *teacher*) overlapping in orthography and phonology with a contextually inappropriate homophone (*beach*). Following this prime by four to eight words was a target word that was either the contextually appropriate homophone (*beech*), a contextually inappropriate homophone foil (*beach*), or a pseudo-homophone (*beetch*). Using this technique, we were able to establish whether recent activation of related orthography influences the detection of substitution errors, as it does the production of errors. We predicted an influence of orthographic overlap [EA], such that exposure to *teacher* and then *beach* (in a sentence where *beech* is contextually appropriate) would lead to an increased likelihood of detection errors (*beach* would be not identified as an error in the sentence) for both young and older adults.

As for the relationship between spelling ability, age, and performance on our detection task, evidence from Margolin and Abrams (in press) leads us to believe that older adults who are poor spellers will perform worse on detection tasks than young adults who are poor spellers. For good spellers, both young and older, we anticipate similar performances on the detection task. The dual route theory should provide an accurate model for the means by which good spellers activate meaning efficiently through the direct route, and poor spellers activate meaning through the phonological route.

Method

Participants

A total of 60 young and 65 older adults participated in this experiment. Five older adults were excluded from analyses because they either scored lower than 25 on their Mini Mental State Examination (see below) or because they did not complete the task based on their own time constraints. Young adults were recruited from psychology

Table 1: Demographic Characteristics for Young and Older Adults

	Young Adults				Older Adults		
Variable	N	Mean	SD		N	Mean	SD
Age*	60	19.1	1.54		60	71.25	5.25
Education* (years)	60	13.3	1.34		60	15.95	3.09
Vocabulary* (max = 25)	60	14.1	3.17		60	19.8	3.25
Spelling Test (max = 36)	60	14.77	6.35		58	15.29	8.60
Forward digit	60	6.93	1.38		60	7.22	1.42
Backward digit	60	4.82	1.20		60	5.13	1.48
Health (max = 10)	60	7.93	1.41		60	7.82	1.57
MMSE (max = 30)					60	28.22	1.43

(Asterisks indicate significant differences between the age groups, $p < .05$.)

courses at the College of Charleston, and were given course credit or extra credit for their participation. The 50 female and 10 male young adults were between 18- 25 years old (M = 19.1, SD = 1.54). The older adults were volunteers from the Charleston community and members of the College of Charleston's Cognition and Aging Lab participant pool. They earned $10 for their participation. Older adults were between the ages of 62 and 80 (M = 71.25, SD = 5.25), and included 34 females and 26 males. Participants completed questionnaires revealing their age, years of formal education, ethnicity, self-reported health, hearing, and vision. They were also given forward and backward digit-span tests and a 25-item vocabulary test. Older adults were also given the Mini Mental Status Examination (MMSE; Folstein, Folstein, and McHugh, 1989), to obtain a standardized measure of their cognitive abilities. All participants were native English speakers and had normal or corrected-to-normal vision.

The complete means and standard deviations for young and older adults' background information can be found in Table 1. Older adults reported more years of education than young adults, $t(118) = 6.00$, $p < .001$. Older adults also performed better on the vocabulary test than young adults, $t(118) = 9.68$, $p <$ 001. The age groups did not differ on self-reported ratings of health ($p > .692$), forward digit spans ($p > .268$), or backward digit spans ($p > .200$).

Materials

The homophone pairs and sentences from White, Zoller, and Abrams (2006) were adapted for this experiment. Forty-eight homophone groups (e.g., *beach–beech–beetch*) were developed. Example sentences for the homophones *beach* and *beech* are shown in Table 2.

Each homophone group included the dominant homophone (*beach*), the subordinate homophone (*beech*), and a pseudo-homophone (*beetch*). Each sentence had one of three possible targets (dominant, subordinate, or pseudo-homophone), and only one target was contextually appropriate for each sentence. If the sentence contained the contextually appropriate homophone form, that sentence was said to contain the correct homophone. If the sentence contained a homophone that was contextually inappropriate in the sentence, it was referred to as the homophone "foil." Lastly, the sentences containing pseudo-homophones were denoted by the term "pseudo." Sentence context remained neutral up until the presentation of the homophone so that homophones were not predictable from the context that preceded them. For each sentence, a primed version and an unprimed version were constructed. The *primed version* contained a prime word (e.g., *teacher*) that matched in orthography and phonology to the contextually inappropriate homophone (the homophone foil, *beach*), and an *unprimed version* contained a prime word (e.g., *lawyer*) that did not match either the contextually inappropriate (*beach*) or the contextually appropriate (*beech*) homophone in orthography or phonology. The primed/unprimed word preceded the target by four to eight words (M = 6.0, SD = 1.37). Thus, six versions were created for each sentence (12 versions for each homophone group). These six versions differed in dominance condition (*dominant, subordinate*), prime type (*primed*, *unprimed*), and homophone condition (*correct*, *foil*, *pseudo*).

Table 2: Examples of Primed and Unprimed, Dominant and Subordinate Homophone Sentences for Correct, Foil, and Pseudohomophone Conditions

Target Word: *beach* (dominant)
Sentence Example: After presenting her ______ on animal rights, Sue went to the ------ to relax.

Prime	Unprimed	Correct	Foil	Pseudo
speech	talk	beach	beech	beetch

Target Word: *beech* (subordinate)
Sentence Example: The ______ was proud of the ------ tree in his yard.

Prime	Unprimed	Correct	Foil	Pseudo
teacher	lawyer	beech	beach	beetch

As a result of counterbalancing, 12 test versions were created. Each version included a total of 48 sentences, 16 that corresponded to the “correct” condition, 16 that corresponded to the “foil” condition, and 16 that corresponded to the “pseudo” condition. Each of these conditions were divided by prime type and dominance condition, so that each version included 4 sentences that were primed and written for dominant homophone, 4 sentences that were unprimed and written for dominant homophone, 4 sentences that were primed and written for the subordinate homophone, and 4 sentences that were unprimed and written for the subordinate homophone.

There were a total of 48 randomly presented filler sentences whose purpose was to disguise the manipulation of homophones in the other 48 sentences. Half of these filler sentences contained grammatical errors, such as a noun that had incorrect verb tense (e.g., past tense when present tense should have been used), a noun that had the wrong number (e.g., a plural noun that should have be singular), the incorrect use of a pronoun (e.g., the use of "*he*" when "*it*" should have been used), and use of incorrect possession (e.g., the use of the possessive form of a word ('s) when no possession (apostrophe) was needed). The other half of the filler sentences were grammatically correct.

Homophone Recognition Test. To evaluate participants' knowledge of the spelling and meaning of individual homophones, one sentence was constructed for each of the 96 homophones so that the sentence could only be completed with the contextually appropriate homophone (e.g., *The surfers arrived early at the [beach]* or *[Beech] nuts are a good addition to any salad*). The homophone in each sentence was replaced with a blank space. Participants were shown the spellings of both homophones (*beach* and *beech)* and were asked to circle the homophone that fit correctly in the blank. Counterbalancing of the sentences and homophone order resulted in four versions of the recognition test.

Test of Spelling Ability. Participants took an auditory spelling test to assess their basic spelling abilities. 36 low frequency words that had been shown to differentiate spellers in previous studies (e.g., Margolin and Abrams, in press) were audio-recorded and played to participants via headphones. Participants typed the correct spelling of the word and pressed ENTER to confirm their spelling of the word. Tests were scored based on the total number of words spelled correctly by the participant.

Equipment

Sentences were presented on a 17-inch computer monitor via a program written in Visual Basic 5.0.

Procedure

Tests were administered to participants on individual computers, with no more than two participants testing in one room at any time. For the detection task, participants were told to read each sentence carefully and to determine if the sentence was grammatically correct or contained any word that made it ungrammatical. Participants were given examples of error types that would make a sentence ungrammatical, as detailed above: an incorrectly spelled word, an incorrect verb tense, a noun that had the wrong number, the incorrect use of a pronoun, and a word that was marked by incorrect possession. Participants were instructed to either accept the sentence as being grammatically correct by using the mouse to click a button that read "NO ERRORS," or to reject the sentence as grammatically incorrect by clicking on the word that made the sentence ungrammatical. After clicking on the word believed to be incorrect, a box appearing at the top of the screen prompted participants to type in the correct version of the word (e.g., change its spelling, change its verb tense, change its possession, etc.). Participants were told to press the "ENTER" key in order to submit their correction and move onto the next sentence. They were told that each sentence either contained just one error or no error at all. Participants were also reminded that they were checking for grammatical errors and were asked *only* to change words to make them grammatical, and not to introduce any new words when making corrections. Participants were not told that their reaction times were being recorded; however, reaction times were recorded on their first click on the word, then upon pressing ENTER. Before proceeding on with three practice sentences, participants were told to refer to the experimenter if they needed the directions clarified.

The experimenter assisted participants in correcting the practice sentences: one containing a true spelling error (not a homophone substitution error), one containing a verb tense error, and one containing no errors at all. After completing the practice sentences, participants were once again told to ask the experimenter for any needed clarifications before proceeding on with the experimental sentences.

Following administration of the error detection task, participants were given the homophone recognition test to complete at their own pace. The last task was the auditory spelling test, where each word was played as many times as the participants needed via headphones and participants were told to spell the word to the best of their ability.

Results

Using the homophone recognition tests, any target homophones that participants did not choose correctly (either because they were unfamiliar with or did not know the correct spelling of the word) were omitted from the analyses (M_{older} = 0.53, SD_{older} = 0.75; M_{young} = 0.75, SD_{young} = 0.86, or < 1% of the 48 homophone pairs).

A 2 (Age Group: young, older) X 2 (Condition: foil, pseudo-homophone) X 2 (Dominance: dominant, subordinate) X 2 (Prime Type: primed, unprimed) analysis of variance (ANOVA) was performed on the proportion of detection errors. Detection errors occurred when: 1) participants did not detect a substitution error in a sentence containing the contextually inappropriate homophone, or 2) when participants identified what they thought was a substitution error in a sentence that actually contained the contextually appropriate homophone. The correct condition could not be included in the main analysis because of perfect detection by both older and young adults in the dominant-correct (primed and unprimed) conditions. Separate paired-samples t-tests conducted on the subordinate-correct conditions yielded no significant differences between primed (M_{young} = .05, SD_{young} = .11; M_{older} = .04, SD_{older} = .09) and unprimed (M_{young} = .07, SD_{young} = .17; M_{older} = .03, SD_{older} = .11) homophones, *p*s > .402 or between young and older adults, *p*s > .161.

There was a main effect of age, $F(1, 118) = 26.20$, $MSE = .04$, $p < .001$, such that older adults ($M = .047$) had better detection than young adults ($M = .117$). There was also a main effect of dominance, $F(1, 118) = 82.27$, $MSE = .03$, $p < .001$, with fewer detection errors made in the dominant condition (i.e., when the contextually appropriate dominant homophone was replaced with the contextually inappropriate subordinate homophone) ($M = .032$) than in the subordinate condition (when the contextually appropriate subordinate homophone was replaced with the contextually inappropriate dominant homophone) ($M = .131$). A main effect of condition type was also found, $F(1, 118) = 28.81$, $MSE = .02$, $p < .001$, such that fewer detection errors were made in the pseudo-homophone condition ($M = .057$) than in the foil condition ($M = .107$). Additionally, there was a main effect of speller type, $F(1, 116) = 12.14$, $MSE = .04$, $p < .001$, such that good spellers ($M = .06$) made fewer detection errors than poor spellers ($M = 0.10$). The prime type main effect was not significant, $F(1, 118) = 2.20$, $MSE = .02$, $p > .14$.

Several two-way interactions were also found. An interaction was found between age and condition, $F(1, 118) = 3.65$, $MSE = .02$, $p < .059$ (see Figure 1). Figure 1 illustrates the mean proportion of detection errors as a function of age (young, old) and condition (foil, pseudo-homophone). Follow-up comparisons showed that older adults made fewer detection errors in the foil and pseudo-homophone conditions than did young adults, p's $< .001$, with this difference being larger in the foil condition. An interaction between age and dominance was also significant, $F(1, 118) = 14.20$, $p < .001$ (see Figure 2). Figure 2 illustrates the mean proportion of detection errors as a function of age (young, old) and dominance type (dominant, subordinate). Both age groups had better detection in the dominant condition than in the subordinate condition, p's $< .001$. Furthermore, older adults had better detection of dominant and subordinate homophones than young adults, p's $< .001$, with this difference being larger for subordinate homophones. No other two-way interactions were significant. The three-way interactions and the four-way interaction were also not significant.

Figure 1: Mean Proportion of Detection Errors as a Function of Age and Condition Type

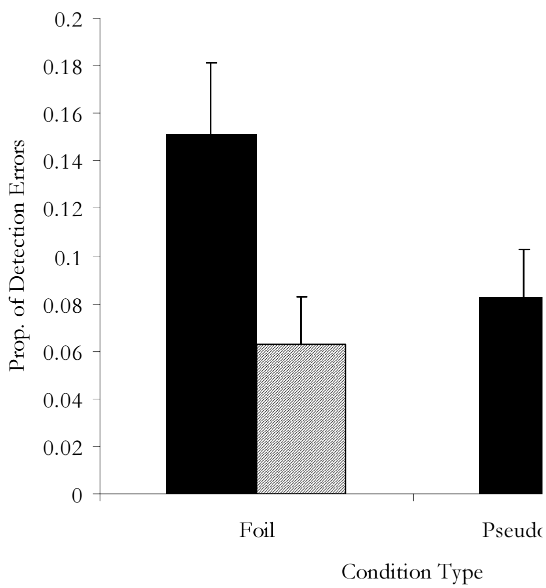
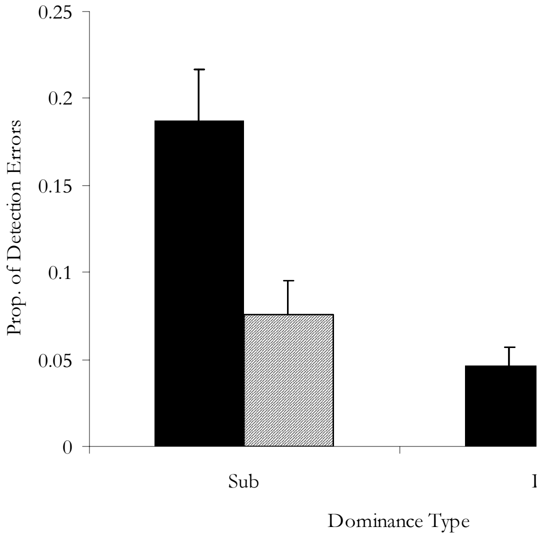


Figure 2: Mean Proportion of Detection Errors as a Function of Age and Homiphone Dominance

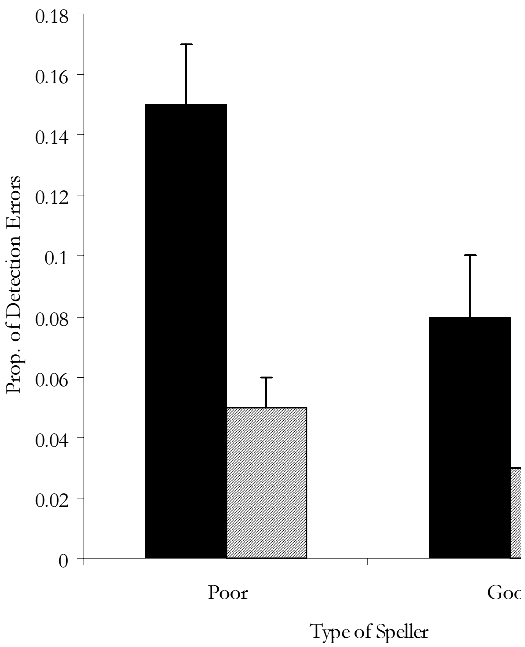


To investigate whether any of these effects differed by type of speller, the median score on the auditory spelling test was determined for each age group (two older adults were excluded for not completing the spelling test). Means and standard deviations for both age groups on the spelling test can be found in Table 1. Both groups had a median score of 14 (or 39% accuracy), with older adults accurately spelling between 1 and 34 words and younger adults spelling between 1 and 30 words correctly. Those scoring between 1 and 14 were categorized as "poor" spellers, whereas those adults scoring between 15 and 34 were categorized as "good" spellers.[2] Independent samples t-tests on *mean* spelling accuracy for each type of speller showed differences in young and older adults who were categorized as good and poor spellers. The 32 young poor spellers (M = 10.21 or 28% accuracy, SD = 3.17) had a higher mean accuracy than the 30 older poor spellers (M = 8.26 or 23% accuracy, SD = 3.83), $t(60) = 2.19, p < .032$. However, the 28 young good spellers had a lower mean accuracy (M = 19.96 or 55% accuracy, SD = 4.90) than the 28 older good spellers (M = 22.82 or 63% accuracy, SD = 5.18), $t(54) = 2.12, p < .039$.[3]

The 2 (Age Group) X 2 (Condition) X 2 (Dominance) X 2 (Prime

Type) X 2 (Speller Type) ANOVA was conducted on the proportion of detection errors. Because speller type is the only new variable in this analysis, only effects including this variable are reported here. The ANOVA revealed a main effect of speller type, $F(1, 114) = 12.14$, $MSE = .04$, $p < .001$, with good spellers outperforming poor spellers on the detection task. An interaction between age and speller type was also found, $F(1, 114) = 5.76$, $MSE = .04$, $p < .018$ (see Figure 3). Figure 3 illustrates the mean proportion of detection errors as a function of age (young, old) and speller type (poor, good). Follow-up analyses indicated that young adults who were good spellers made fewer detection errors than young adults who were poor spellers, $p < .001$; however, older adults made the same amount of detection errors regardless of whether they were good or poor spellers ($p > 0.587$), although there was a trend towards older bad spellers being worse detectors. No other interactions with speller type were significant.

Figure 3: Mean Proportion of Detection Errors as a Function of Age and Speller Type



Discussion

This experiment investigated age-related differences in the detection of homophone substitution errors embedded within sentences. Much of the aging and language literature suggests that older adults show deficits in production, but not in detection (e.g., Burke and Shafto 2004). However, recent research on spelling production and detection indicates that this picture may be more complex, and that changes in linguistic performance may depend more on individual differences (e.g., spelling ability) and specific characteristics of words (e.g., word frequency), rather than age per se (Margolin and Abrams, in press). The present study demonstrated that older adults performed better than young adults on at least one specific detection task: homophone detection in sentence context.

While the present study replicated previous spelling detection studies with regards to aging, we also believe our task to be different from tasks that have been traditionally used to study age differences in spelling (i.e., when difficult-to-spell words are used). We argue that the homophone detection task is more dependent on one's accumulated experience with and knowledge of words, similar to tasks that assess semantic memory. Older adults generally perform similarly, if not better, on tasks that assess their vocabulary and semantic memory (e.g., semantic priming; Laver and Burke 1993; MacKay et al. 1999). The older adults participating in this experiment had an approximately 40-year reading advantage over the young adult participants. Greater reading experience indicates a more through knowledge of vocabulary and spelling (Krashen 1989). It appears that older adults can use this experience to their advantage, at least when the task requires detection of relatively common and easy-to-spell words (e.g., homophones).

The dominance effect in this experiment replicated previous proofreading studies with young adults (e.g., Jared et al. 1999). Participants made more errors (misdetections) when the subordinate homophone was replaced with the dominant homophone than when the dominant homophone was replace with the subordinate homophone. According to the dual route models (Jared et al. 1999), there is a stronger connection between the activated phonology and the dominant homophone, making it likely that the contextually inappropriate dominant homophone goes undetected. Older adults were better than young adults at detecting substitution errors in both dominance conditions, but this age difference was larger when the contextually appropriate subordinate homophone was replaced with the contextually inappropriate dominant homophone. Previous studies (e.g., MacKay and Abrams 1998; MacKay et al. 1999) found that older adults are good and often better than young adults at detecting low frequency (mis)spellings. The current study extends these findings to the detection of homophones within sentences.

The present study's examination of how detection accuracy is influenced by the type of substitution error made (presenting a sentence with the correct, contextually appropriate homophone, or replacing the contextually appropriate word with its homophone foil or a pseudo-homophone) also replicated findings from previous proofreading studies (Jared et al. 1999) and extended these findings to older adults. Both older and young adults had worse detection for homophone foils (e.g., detecting *beach* as being contextually inappropriate) than for pseudo-homophones (*beetch*). Because a pseudo-homophone is a real spelling error, it is therefore more likely to be detected than a homophone foil (*beach*) which is correctly spelled but used incorrectly in the sentence. Detection in the correct conditions (when the sentence contained the contextually appropriate homophone) was excellent for both young and older adults.

Orthographic priming and its influence on the detection of homophone substitution errors was also investigated in this experiment. Though priming has been shown to influence production of homophone substitution errors (White et al. 2006), no effect of priming was observed in the current study. One reason that priming may not have been observed is the distance between the prime and target words in our detection task. Most priming studies (e.g., lexical decision, naming) present a prime word that is immediately followed by a target, and therefore the prime and target come very close in time to one another (see the similar effect of phonological priming in Treiman, Freyd, and Baron 1983). The 4-8 word distance between the prime and target words in the present experiment may have masked any effect of recent presentation of orthography. Thus, it appears that priming in recognition/detection tasks is very short-lived, contrary to similar priming in production tasks (White et al. 2006). White and Abrams

(2004) found phonological priming in a production task across longer intervals (seconds) that is usually only seen under 250 milliseconds in a similar recognition task. Another possible reason why priming was not observed in our detection task is the difference between producing versus detection errors. When producing words, one does not have the advantage of being able to refer back to prime and target words, something that readers are able to do through rereading. Because participants were not timed in the present experiment, it is possible that they repeatedly read each sentence until they felt confident they had detected any errors.

This experiment also investigated the influence of spelling ability on detection accuracy. Good spellers, regardless of age, detected substitution errors more accurately than poor spellers. It makes sense that a more vast knowledge of spelling and vocabulary would lead to a better, more accurate performance in a detection task. Based on dual route models, good readers, who are also good spellers (Krashen, 1989), use the direct route to activate word meaning directly from a printed word. When presented with a common word like *beach*, a good speller is apt to use a direct route to activate word meaning, and therefore recognize the word meaning that has been activated is not an appropriate fit for the sentence context. Poor spellers are more likely to take the phonological route, which leads to the activation of phonology for both *beach* and *beech*, and then to the activation of word meaning for both homophones. Because meanings for both homophones have been activated, poor spellers will be more likely to accept the sentence as being correct and without substitution errors.

The age-related differences observed in detection tasks also extend to speller type. Older adults, whether good or poor spellers, actually detected substitution errors more accurately than young adults with good and poor spelling abilities. It is particularly interesting that the present study's older adults who are poor spellers detected substitution errors more accurately than young adults who are poor spellers, primarily because the young adults who are poor spellers had a slightly higher mean production spelling score. This finding is contrary to our prediction and to the results of Margolin and Abrams (in press), who found young poor spellers to be better detectors than older poor spellers. Perhaps older adults' greater years of reading experience offset potential age-related declines in detection, at least for homophones which are common words that are not difficult to spell.

The results from the present study provide further evidence that the cognitive deficits affecting older adults' performance on production tasks are spared when it comes to detection. One explanation for such drastic differences in age-related performance on production and detection tasks is the difference in cognitive processes needed to carry out both tasks. The type of mental effort (i.e., the use direct route of dual routes method, a more efficient way of activating words) needed to detect errors in sentences that have already been produced may be less taxing on older adults than the type of mental effort needed to come up with an entirely new word. Another explanation for older adults' superior performance over young adults in detection tasks would be the knowledge acquired through more years of exposure to vocabulary and spelling through reading, writing, and other everyday activities. The results from the present study are an extremely encouraging addition to the literature on age-related cognitive change. By taking advantage of areas in which older adults excel (knowledge of word meanings and spelling), there is potential for combating, or at least using strengths, to compensate for age-related declines that have been observed in language production.

Notes

1. Because homophone substitution errors are not spelling errors per se (i.e., the substituted homophone is spelled correctly, just used inappropriately in the sentence), we refer to these errors as substitution errors for the remainder of this paper. Data was also analyzed excluding all participants who scored at the median score (14).

2. "Poor spellers" scored between 1 and 13, and "good spellers" scored between 15 and 34. This analysis yielded the same main effects and interactions that are reported with these participants included in the analyses.

3. Matching a subset of the groups to equate spelling performance (i.e., comparing the accuracy of older and young adults scoring "9" on the auditory spelling test) yielded the same main effects and interactions that are reported when all participants are included in the analyses.

Thus, any age-related differences that occurred within the spelling groups did not affect the overall results.

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