Spoken Word Recognition Deficits in Mild Cognitive Impairment: Some Preliminary Findings Using a Sentence Repetition Task

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Abstract. Word frequency and neighborhood density (ND) are known to be reliable predictors of spoken word recognition. Mild cognitive impairment (MCI) has recently been defined as a stage between normal aging and dementia; even in individuals with MCI, language has been found to typically be altered. The current study examined frequency and ND effects on spoken word recognition in MCI and compared the results to healthy controls. Four MCI patients (mean age: 76.75 ± 6.24), nine young adults (mean age: 24.11 ± 6.01), and four healthy elderly adults (mean age: 68.75 ± 10.18) completed a lexical discrimination task measuring the accuracy of word recognition in sentences masked by multi-talker babble (-3 SNR). All participants also completed a battery of neuropsychological tests. Young adults displayed the highest accuracy on the lexical discrimination task while the healthy elderly adults outperformed MCI patients. In all participants, a word frequency effect was observed, and accuracy on high-ND words was slightly lower than accuracy on low-ND words. The results of this preliminary study suggest that aging and cognitive impairment leads to a decline in spoken word recognition, i.e., the cognitive abilities used to recognize words in sentences.

Introduction

Spoken language is unique to humans, and the underlying components that allow us to understand spoken language must be investigated if we are to understand why some individuals have trouble understanding spoken language. Lexical discrimination refers to the process of distinguishing a stimulus word from other phonologically similar words (Luce & Pisoni, 1998). The current study attempts to understand declines in lexical discrimination abilities in healthy aging adults and mild cognitive impairment (MCI) patients. Three groups of participants, healthy young controls, healthy elderly controls, and MCI patients, were compared on an experimental task assessing lexical discrimination abilities with sentence materials.

Spoken Word Recognition

Spoken word recognition is important for humans to communicate successfully. Investigations of the mental lexicon, humans’ psychological knowledge of words, have found that the frequency of word use in the English language and the number of similar neighbors, or neighborhood density (ND), play an important role in spoken word recognition when background noise is present (Luce & Pisoni, 1998). Luce and Pisoni defined lexical discrimination as the process of correctly identifying words in the mental lexicon to match the phonological input of a stimulus.

Many earlier studies have demonstrated processing advantages for high-frequency words over low-frequency words (Broadbent, 1967; Catlin, 1969; Goldiamond & Hawkins, 1958; Newbigging, 1961; Pollack, Rubenstein & Decker, 1960; Savin, 1963; Soloman & Postman, 1952; Triesman, 1971, 1978a, b). The criterion-bias theory states that the cause of the word-frequency effect is a response bias, which is a tendency to respond with common words rather than rare ones (Broadbent, 1967). Savin (1963) found that when participants gave incorrect responses, they were likely to give the same incorrect responses as one another. The number of times that a word is encountered, that is its experienced frequency, does not
solely account for the word frequency effect. The ND of a word and its similarity to other words combines with the word frequency effect in spoken word recognition tasks (Luce & Pisoni, 1998).

Luce and Pisoni (1998) developed the neighborhood activation model (NAM), which states that a word is recognized relationally in the context of other words in long-term memory and that, when a stimulus is recognized, the lexical neighborhood containing similar-sounding words is activated. Luce and Pisoni defined the neighborhood of a target word (i.e. the word being presented to the participant) as the set of words that differ from it by the addition, deletion, or substitution of a single phoneme. The number of words occurring in a target word’s neighborhood is referred to as the neighborhood density of the target word. NAM predicts that words with a high ND are more difficult to process (perceive and recognize) than words with a low ND. The phonetic similarity in neighboring competing words makes them easily confusable between one another.

Neighborhood competition has been shown to play a major role in spoken word recognition (Vitevich & Luce, 1998; Goldinger et al, 1989; Luce and Pisoni, 1998; Dirks et al, 2001). Bell and Wilson (2001) found a processing advantage for low ND words when they were presented in sentences under both degraded and quiet conditions. Metsala (1997) found that both adults and children showed higher error rates for words with many lexical neighbors. Sommers (1996) found elderly adults to be at a disadvantage when recognizing lexically hard words relative to young adults. These findings suggest that age differences among adults could affect lexical discrimination in sentences. However, a recent study conducted in our lab found no significant differences in lexical competition perception or production among healthy young adults and healthy elderly adults (Taler, Aaron, & Pisoni, submitted). Taler et al.’s findings are consistent with previous studies showing that language production is similar across the lifespan (Newman & German, 2005; Vitevitch & Sommers, 2003). Other previous studies found that elderly adults do not do as well as young adults with the perception of high ND isolated words, which is likely due to inhibitory decline (Sommers, 1996; Sommers & Danielson, 1999). However, there has been little research examining lexical competition deficits in patients with age-related disorders, such as MCI. The present study was carried out to examine lexical discrimination in individuals with MCI. Below, we discuss MCI and the deficits associated with this cognitive decline.

**Mild Cognitive Impairment (MCI)**

MCI is a term used to describe the clinical cognitive state between that of healthy aging adults and adults with dementia. Petersen and colleagues (1999) were the first researchers to introduce formal criteria for the diagnosis of MCI. The formal criteria are as follows:

1. An individual’s subjective complaint of memory decline
2. An objective impairment of memory ability
3. No depression or other major psychological disorders
4. No significant decline in daily living activities
5. Individual does not meet the criteria for dementia

Petersen (2003) suggests the etiology of MCI to be heterogeneous. This may be in part because of the wide range of annual conversion rates to Alzheimer’s disease (AD), or that MCI may be an early stage of a different type of dementia other than AD. Different subtypes of MCI have been identified, either with or without memory impairment (i.e. amnestic MCI and non-amnestic MCI respectively) (Petersen, et al., 2001a).

The Mini Mental State Examination (MMSE) is a physicians’ screening tool for separating individuals with normal cognitive function from those with dementia, and clinicians commonly use this screening tool. A score of 24 or below (out of 30) is considered a sign that the patient is demented (Folstein, Folstein, & McHugh, 1975). Many individuals who meet the clinical criteria for MCI scored
above a 26 on the MMSE (Ihl, et al., 1992; Nasreddine et al., 2005); therefore Nasreddine and colleagues (2005) created a brief ten-minute screening tool, the Montreal Cognitive Assessment (MoCA), which was specifically designed to screen patients with MCI that would score within the normal range on the MMSE. They determined that a cutoff score of 26 provided the best specificity (100%) and sensitivity (90%) balance for the AD and MCI groups.

Neuropsychological tests of memory and verbal fluency that are sensitive and specific in the differential diagnosis of various types of dementia may be useful for the detection of MCI (DeJager, Hogervorst, Combrinck, & Budge, 2003). The MoCA tests the cognitive domains of attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation.

Previous research suggests that multiple areas of cognition are affected in MCI patients. Bozoki et al. (2001) found that memory loss alone was a risk factor for dementia, but when memory loss was combined with other clear cognitive impairments, the risk of dementia significantly increased. Scores on all cognitive domains are significantly lower at baseline in persons with MCI (Bennett, et al., 2002). Memory impairment is necessary to predict dementia, but the presence of impairments in other cognitive domains such as language, visuospatial cognition, and executive function are the best positive predictors for dementia (Sacuiu et al., 2005). Multiple-domain MCI may represent a more advanced stage of prodromal dementia because these individuals are the most likely clinical subtypes to convert to dementia (Alexopoulos et al., 2006). A steep decline on memory and executive function tasks has been found in individuals who will soon convert to AD (Chen et al., 2001).

Language impairment begins early in the course of AD and is common among individuals with AD (Taler & Phillips, 2008). Assessing the performance of MCI individuals on language tasks may help assess early signs of cognitive impairment in AD. Verbal fluency tasks are commonly used to assess language abilities in individuals with dementia (Henry, Crawford, & Phillips, 2004). Letter and category fluency are two common types of verbal fluency tasks. Letter fluency tasks require participants to name as many words as they can that begin with a particular letter of the alphabet; category fluency tasks require participants to name as many words as they can from a particular semantic category (e.g. animals, foods, or vehicles). Letter fluency requires phonemic search strategies whereas category fluency requires semantic search strategies (Rohrer, Salmon, Wixted, & Paulsen, 1999). Verbal fluency deficits have been found in individuals with AD, especially deficits in category fluency (Taler & Phillips, 2008). In one study, letter fluency was also found to reliably predict conversion to dementia (Small et al., 2001), but other studies have shown that this is not a reliable predictor of dementia onset (Chen et al., 2001; & Goldman et al., 2001).

MCI and AD patients also show declines in other language abilities, particularly naming abilities. MCI patients show deficits on the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983), and decline more rapidly on other semantic abilities than healthy elderly adults (Bennett et al., 2002). As cognitive impairment progresses, there is a more rapid rate of decline on the BNT (Storandt, Grant, Miller, & Morris, 2002). In contrast, Rubin et al. (1998) found that individuals show no differences in naming until after diagnosis of dementia. In a more recent study, Beinhoff et al. (2005) found no differences on the 15-item BNT between MCI, normal controls, and individuals diagnosed with major depressive disorder.

Lexical discrimination tasks that have been used to assess spoken word recognition in healthy young adults have not often been used to test AD patients and have never been used with MCI patients. Sommers (1998) found that individuals with mild AD and healthy aging adults did not differ on lexical discrimination tasks, but those with a more severe form of AD performed significantly worse than healthy
aging adults. Sommers’ results may be affected by declines in inhibitory function, which are known to occur in individuals with MCI (Traykov et al., 2007).

Most researchers agree that MCI presents risk factors for AD, but there is still controversy over whether all cases of MCI represent prodromal AD (Taler & Phillips, 2008). Chertkow (2002) suggested that the variability in findings of the MCI conversion rate to AD results from the different clinical criteria used to diagnose MCI. Intervention with preventive therapies may be ideal during the early MCI stages; even though there has been controversy, the risk factors associated with the progression of MCI to AD are becoming more evident. Subtypes of MCI have recently been identified with respect to conversion rate to AD and severity of the disorder. Amnestic MCI, the subtype used in the current study, is thought to be the most likely subtype to convert to AD (Peteresen, 2003), although Fischer et al. (2007) found subtypes to be poor predictors of conversion to specific dementia types.

Petersen and colleagues have studied conversion rates to AD in several studies. In one study, they found an average annual conversion rate of 14% (Petersen et al., 2001b). In another study, they found an average conversion rate of 12% per year, and after 6 years the total conversion was 80% (Petersen & Morris, 2003). Geslani et al. (2005) reported a much higher conversion rate of 41% after one year and 64% after two years. Chertkow et al. (2001) found inconsistent results with regards to conversion rate; 25% of MCI individuals did not convert to AD even ten years after the onset of their memory problems. These findings may be contrasted to the more recent findings of Morris et al. (2007), who found a 100% long-term conversion rate, where long-term was defined as 9.5 years.

Current Study

In the current study, we tested the hypothesis that lexical discrimination is compromised during spoken word recognition in MCI patients relative to healthy elderly adults. We also predicted that younger adults would perform better than both healthy elderly adults and MCI patients on lexical discrimination tasks due both to age and to declines in several core cognitive functions. We assessed this hypothesis by measuring the effects of lexical competition on spoken word recognition in healthy young adult controls, healthy elderly adult controls, and MCI patients.

To assess lexical discrimination participants were given a sentence repetition task. We used a modified version of an auditory sentence repetition task based on the concepts from the NAM, the Veterans Affair Sentence Test (VAST, Bell & Wilson, 2001). The VAST has been found to provide accurate measures of speech intelligibility in laboratory settings (Bell & Wilson, 2001; Bell, 1996; Lin, 2000).

Spoken word recognition was examined by looking at deficits in lexical discrimination, which may be caused by alterations in language processing. Declines in lexical discrimination would demonstrate alterations in the effects of lexical competition, which is of clinical and theoretical significance for our understanding of language function in preclinical AD. We hope that this work will lead to early prediction of the development of AD from assessing MCI patients’ spoken word recognition. Understanding communication declines in AD populations will help families and loved ones better understand AD patients’ struggles to communicate and may suggest novel behaviorally based interventions to prevent further decline.
Methods

Participants

Study participants were native speakers of American English. All participants provided written informed consent and were compensated $10 per hour for their time. In order to eliminate the influence of hearing impairment on spoken word recognition performance, the experimenter gave participants a hearing screening before testing began. Young adults whose thresholds exceeded 20 dB and elderly adults whose thresholds exceeded 25 dB for 500, 1000, and 2000 Hz or exceeded 45 dB for 4000 Hz were excluded. All participants had no history of neurological or psychiatric disorders. Age and years of education did not differ between any of the groups.

Young Control Participants: Ten healthy young adults were recruited through flyers and email at Indiana University in the Psychological and Brain Sciences Department. Using the SPSS outlier function, we found one young adult to be an outlier and therefore excluded him/her from further analyses, yielding a final young adult control group of nine participants (mean age: 24.11 ± 6.01; 1 male, 8 females).

Healthy Elderly Control Participants: Six healthy elderly adults were recruited using flyers through local retirement communities, exercise classes, community service organizations, and the Neurology Clinic at Indiana University Hospital. One healthy elderly adult did not meet the requirements for hearing thresholds and therefore was excluded from further analyses. Using the SPSS outlier function, we found one healthy elderly adult to be an outlier and he/she was excluded from further analyses, yielding a final elderly adult control group of four participants (mean age: 68.75 ± 10.18; 4 females).

MCI Participants: Seven MCI patients were recruited through the Neurology Clinic at Indiana University Hospital. Three MCI participants did not meet the hearing screening requirements and therefore were excluded from further analyses, yielding a MCI group of four participants (mean age: 76.75 ± 6.24; 1 male, 3 females). MCI patients also underwent a comprehensive clinical assessment including physical and neurological examination by a physician, informant interview, neuropsychological testing, and laboratory studies. All MCI participants met criteria for amnestic MCI similar to that of Petersen and colleagues (1999) listed in Table 1.

Apparatus

An AMBCO AB audiometer (Model 650A) was used for the audiometric screening. A Shure MX 185 Microflex Lavalier microphone was used to record the neuropsychological assessments and the lexical discrimination task. A TASCAM digital tape recorder was used for the recording. The following standardized neuropsychological tests were administered to all participants by the experimenter: the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983), the Stroop Color and Word Test (Golden & Freshwater, 2002), forward and backward digit span taken from the Wechsler Memory Scale-Third Edition (WMS-III; Wechsler, 1997), and the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). For the lexical discrimination sentence task, sentences were played through Beyer Dynamic DT-100 headphones using PsyScript 5.1d3 (Bates & D’Oliveira, 2003) on a laptop computer (Apple PowerBook G4, Cupertino, CA). Table 2 displays a summary of the neuropsychological performance of all three groups.
Table 2. Study participant information. Note: Hearing thresholds are for the better ear at each frequency. Hearing thresholds were not available for two young adults, although all participants met the minimum threshold requirements stated in the text. One MCI participant reported having tinnitus and was unable to hear the pure-tones at 4000 Hz, but still performed well on all tasks and all other pure tone thresholds met requirements. BNT: Boston Naming Test; MoCA: Montreal Cognitive Assessment; PTA: pure tone average; M: males; F: females.

Stimulus Materials

Lexical discrimination was assessed by a sentence repetition task that was based on the materials in the Veterans Affairs Sentence Test (VAST; Bell & Wilson, 2001). The VAST is a spoken word recognition test that was designed to examine lexical competition effects. The test is based on the principles of the NAM. The VAST consists of 320 sentences, each containing 3 target words distributed in 4 conditions: high frequency/ high competition, high frequency/ low competition, low frequency/ high competition, and low frequency/ low competition. All target words were rated as highly familiar in a norming study using students from Indiana University (Nusbaum, Pisoni, & Davis, 1984).

Because the original VAST sentences were not normed for cloze probability, we had 400 undergraduate college students complete a cloze norming task and we calculated the average cloze probability for each sentence (i.e., the average across the 3 keywords). All sentences had low cloze probability. The current study included the 80 lowest and the 80 highest cloze probability sentences, for a total of 160 sentences distributed across the 8 conditions, as illustrated in Table 3. One female native English speaker produced all of the sentences. In order to avoid ceiling effects in the lexical discrimination task, we masked the sentences using multi-talker babble at a signal-to-noise ratio (SNR) of -3dB. Multi-talker babble is believed to have greater validity than other types of noise, such as Gaussian white noise or speech-shaped noise (e.g. Kalikow, Stevens, & Elliot, 1997).
Table 3. The conditions included in the experiment and corresponding sample sentences. Target words are italicized.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>High Cloze Probability</th>
<th>Low Cloze Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High frequency, High ND</td>
<td>The <em>map</em> is on the <em>deck</em> of the <em>ship</em>.</td>
<td><em>Pile</em> the <em>load</em> into the <em>hut</em>.</td>
</tr>
<tr>
<td>High frequency, Low ND</td>
<td>The <em>couple</em> gathered <em>nuts</em> in the <em>woods</em>.</td>
<td><em>He stole</em> each <em>check</em> issued to the <em>gang</em>.</td>
</tr>
<tr>
<td>Low frequency, High ND</td>
<td>Hang the <em>cage</em> on a <em>hook</em> in the <em>yacht</em>.</td>
<td>The <em>tag</em> on the <em>vest</em> made it <em>sag</em>.</td>
</tr>
<tr>
<td>Low frequency, Low ND</td>
<td>The wind will <em>rustle</em> the flap on the <em>bib</em>.</td>
<td><em>Prop up the trash</em> to keep in the <em>sludge</em>.</td>
</tr>
</tbody>
</table>

Procedure

All participants completed the neuropsychological battery immediately following the audiological screening. The testing occurred in a quiet room inside the Speech Research Laboratory for most control participants; those healthy elderly adult participants (N=2) and MCI patients (N=7) who were not able to travel to the laboratory were tested in their homes by the experimenter. In order to record the entire session, the participants wore a lapel microphone, which was connected to a portable DAT recorder.

The experimenter administered the tests in the following order: (1) The BNT (Kaplan et al., 1983), in which participants produced names for the items presented. The 60-item standard form was used, presenting first all the odd numbers and then all the even numbers. Participants were instructed to say the name of the picture presented on the page. (2) The Stroop test (Golden & Freshwater, 2002), in which participants read color words (red, green, blue), named the color of X’s printed on the page, and named the font color of color words where the ink color and the word do not match (e.g., the word “red” printed in green ink). The participants were given 45 seconds to read as many stimuli as they could in each category. (3) An immediate serial recall test (digit span; Wechsler, 1997) was given to assess short term and working memory. The experimenter read a list of numbers aloud at a rate of one number per second. For the forward digit span, the participants were instructed to repeat back what they heard in the exact same order. Backward digit span, which assessed working memory capacity, was given by instructing participants to repeat back the numbers they heard in reverse order. For both forward and backward digit spans, testing stopped once the participant responded incorrectly on two consecutive lists of the same length. (4) Category fluency, in which participants were given categories (animals, occupations, cities, vehicles, and foods) and asked to name as many words as they could within that category in two minutes. (5) Category fluency (switching) where participants were asked to switch between the categories vegetables/ musical instruments and weapons/tools (e.g., produce one item from the first category, one from the second, and continue switching for the full two minutes). (6) The MoCA (Nasreddine et al., 2005), a brief neuropsychological battery that has high sensitivity and specificity for MCI. The component tasks included the following: trail-making (joining letters and numbers in ascending order), copying a cube, clock drawing, naming (pictures of three animals), delayed recall (five words), digit span (repeating a list of 5 digits forward and 3 digits backward), attention (hearing a list of letters and tapping the table each time the letter A was heard), serial subtraction (counting backward from 100 in increments of 7), language (repeating sentences; naming as many words starting with F as possible in one minute), similarities (stating how two words are semantically similar), and orientation (stating the date and where the participant was).
The lexical discrimination task was administered immediately following the MoCA. The experimenter and participants used headphones to listen to the sentences. The sentences were played through the headphones from a laptop computer and the microphone was used to record the participants’ responses. Participants were instructed to listen to each sentence and simply repeat back what they heard as quickly and accurately as possible. They were also told to repeat back any words they heard, even if they did not understand the entire sentence. The sentence stimuli were divided into two lists, one containing all high-cloze stimuli (Block A) and the other containing all low-cloze stimuli (Block B). Participants received both blocks in counterbalanced order, and stimuli within each block were presented in randomized order. A break was given between each block (i.e., after the first 80 sentences).

Results

Repeated-measures ANOVAs were conducted on accuracy scores, with participant group as a between-subjects variable, and frequency and ND as within-subjects variables. Significant effects and interactions were decomposed using least square difference (LSD) post hoc analyses. A one-way ANOVA was used to assess differences in difficulty cost between groups. All analyses were conducted using SPSS Version 12.0.1 for Windows (SPSS, 2003).

Demographics

Education did not differ significantly between any of the groups ($p = 0.23$; mean: 16 years ± 2.45). Healthy elderly adult and MCI participants did not significantly differ in age ($p = 0.75$; mean: 73 years ± 8.91). There were more females (N = 15) than males (N = 2) overall, although no group differences were observed ($\chi^2(2, N = 17) = 1.21, p = 0.55$).

Total Word Accuracy Between Groups

Figure 1 presents word recognition accuracy for each group as a function of condition for the four sentence conditions. A repeated-measures ANOVA revealed main effects of group ($F(1,14) = 31.59, p < .001$), word frequency ($F(1,14) = 172.41, p < .001$), and ND ($F(1,14) = 24.40, p < .001$). Higher accuracy was observed in young adults than healthy elderly adults and MCI participants, and in healthy elderly adults than MCI participants; in high than low frequency items; and in low than high ND items. The interaction between ND and group was significant ($F(2,14) = 5.40, p < .05$) and is shown separately in Figure 2. The ND effect was stronger in the healthy elderly adults and MCI patients than in the young adults.

Difficulty Cost

A difficulty cost index was calculated for each participant by subtracting accuracy scores for the most difficult condition (low frequency/ high ND) from the score for the easiest condition (high frequency/ low ND). Difficulty cost is presented in Figure 3. The groups differed significantly from one another on difficulty cost ($F(2,14) = 7.36, p < .01$). The post hoc LSD revealed significant differences when young adults were compared to the healthy elderly adults and MCI patients ($p < .01$), but not between healthy elderly adults and MCI patients ($p = .92$).
Performance on Sentence Repetition Task

Figure 1. YC and HEC groups differ on the LH sentence type. HEC and MCI groups differ on all sentence types. Note: Error bars represent standard error; YC: young controls; HEC: healthy elderly controls; HH: high frequency/ high ND; HL: high frequency/ low ND; LH: low frequency/ high ND; LL: low frequency/ low ND.

Interaction Between ND and Group

Figure 2. The significant group by ND interaction. High ND items were harder to understand than low ND items. Note: YC: young controls; HEC: healthy elderly controls; LH: low frequency/ high ND; LL: low frequency/ low density.
Average Difficulty Costs

Figure 3. Difficulty cost is a measure of lexical discrimination. Young adults differ significantly from healthy elderly adults ($p = .007$) and MCI patients ($p = .009$). Healthy elderly controls and MCI patients did not differ significantly ($p = .920$). Note: YC: young controls; HEC: healthy elderly controls; Error bars represent standard error.

Correlations with Neuropsychological Measures

The difficulty cost was correlated with the demographics and the measures of neuropsychological function collected for all of the participants combined together. The correlations are shown in Table 4. Difficulty cost correlated significantly with age and scores on the MoCA and Stroop color/word scores. Difficulty cost did not correlate significantly with any of the other neuropsychological measures.

<table>
<thead>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>1</td>
<td>.284</td>
<td>-.852**</td>
<td>-.104</td>
<td>-.757**</td>
<td>-.433</td>
<td>-.509*</td>
<td>.773**</td>
</tr>
<tr>
<td>2. Education</td>
<td>1</td>
<td>-.240</td>
<td>-.306</td>
<td>-.159</td>
<td>.299</td>
<td>.151</td>
<td>.469</td>
<td></td>
</tr>
<tr>
<td>3. Stroop</td>
<td>1</td>
<td>.284</td>
<td>.709**</td>
<td>.454</td>
<td>.653**</td>
<td>-.551*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. BNT</td>
<td>1</td>
<td>.370</td>
<td>.145</td>
<td>.134</td>
<td>-.142</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. MoCA</td>
<td>1</td>
<td>.533*</td>
<td>.510*</td>
<td>-.576*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ForwDS</td>
<td>1</td>
<td>.611**</td>
<td>-.266</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7. BackDS</td>
<td>1</td>
<td>-.239</td>
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<tr>
<td>8. Difficulty Cost</td>
<td>1</td>
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</table>

Table 4. Correlations between performance on the experimental task, demographic information, and neuropsychological measures. Note: *$p < .05$; **$p < .01$; Stroop measures are color/word raw scores; BNT: Boston Naming Task; MoCA: Montreal Cognitive Assessment; ForwDS: Forward Digit Span; BackDS: Backward Digit Span.
Discussion

The current study found that overall, spoken word recognition in sentences was lowest in MCI patients, intermediate in healthy elderly adults, and highest in healthy young adults. This pattern of results supports our hypothesis that both age and cognitive function play a role in spoken word recognition. It appears that age most strongly affects lexical discrimination because the young adults have the lowest difficulty cost, but the healthy elderly adults and the MCI patients have nearly the same difficulty cost. This does not support our hypothesis that lexical discrimination is compromised during spoken word recognition in MCI patients.

The total accuracy on the lexical discrimination task differed between all groups. This suggests that age plays a role in spoken word recognition, and the ability to distinguish words declines with age. Age differences were not found between the healthy elderly adults and MCI patients, and this suggests that age plays a role in spoken word recognition. These findings are consistent with previous research (Newman & German, 2005; Vitevitch & Sommers, 2003). Since we found differences between healthy elderly adults’ and MCI patients’ overall accuracy, cognitive decline likely affects spoken word recognition.

The word frequency effect found in the current study is consistent with the predictions of the NAM (Luce & Pisoni, 1998) and other previous studies (Broadbent, 1967; Catlin, 1969; Goldiamond & Hawkins, 1958; Newbigging, 1961; Pollack, Rubenstein & Decker, 1960; Savin, 1963; Soloman & Postman, 1952; Triesman, 1971, 1978a, b). All participants identified high frequency words in sentences more accurately when presented in background noise than low frequency words. The participants performed better on words with low ND than high ND, which is also consistent with the NAM (Luce & Pisoni, 1998). The finding that low ND words are easier to identify than high ND words replicates previous findings (Vitevich & Luce, 1998; Goldinger et al, 1989; Luce and Pisoni, 1998; Dirks et al, 2001).

In this study, we also measured lexical discrimination abilities using a difficulty cost measure – the difference between the hardest and easiest sentences. This was done to normalize for overall group differences in spoken word recognition. We found lower difficulty costs in young adults than in the other two groups. However, we failed to find a difference between healthy elderly adults and MCI patients using this index. Thus, lexical discrimination does not appear to be strongly impacted by declining cognitive ability, although it decreases with age.

Although our previous research did not find age to be a factor in lexical discrimination (Taler, Aaron, & Pisoni, submitted), the current study found correlations between the difficulty cost index and age. This strengthens the idea that age is a factor in the declining abilities of lexical discrimination. Scores on the MoCA neuropsychological assessment were also correlated with the difficulty cost even though we did not find lexical discrimination differences between healthy elderly adults and MCI patients. The Stroop color/word scores correlated with difficulty cost, which would be expected since inhibitory function has been found to decline in individuals with MCI (Traykov, 2007).

Although the MCI and healthy elderly groups did not differ on difficulty cost measures, we did find correlations between cognitive measures and lexical difficulty costs when all subjects were combined. The small sample size likely has an impact on the results, especially in the healthy elderly adult and MCI groups. Recruitment is ongoing for this study.

The significant difference in lexical discrimination between young and older adults (with or without cognitive impairment) raises questions about whether the sentence repetition task was appropriate
for measuring the lexical discrimination abilities between the three groups. The SNR was set to -3dB for this study. This may not have been the optimal SNR for MCI patients. Their mean total accuracy was below 50%, meaning that floor effects may be present for certain participants. Another limitation to the current study is the disproportionate female-to-male ratio. There were no males in the healthy elderly adult group and only one male in the MCI group. Cognitive decline in the aging population is as common in males as females (Barnes, 2003); therefore, this sample is not representative of the total population.

Future research should be undertaken to improve our understanding of spoken word recognition performance in MCI patients. Declines in spoken word recognition are known to occur in AD (Sommers, 1998). Adding a fourth group in the present study, AD patients, to compare to the other three groups would allow us to assess how quickly spoken word recognition declines in individuals suffering from cognitive impairment. The conversion rate in the MCI patients to AD should be studied to help determine what factors of spoken word recognition might be early predictors of AD.

To better assess lexical discrimination in these populations, a study should be conducted to find the optimal SNR for MCI and AD patients. Another possible avenue for future research is to explore the links between lexical discrimination and everyday communication skills. Future work will include an analysis of reaction times and the collection of more data from healthy elderly adults, MCI patients, and AD patients.

References


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