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Expectation in Auditory Processing of Environmental Sounds in People with Fluent Aphasia

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EXPECTATION IN AUDITORY PROCESSING OF ENVIRONMENTAL SOUNDS IN PEOPLE WITH FLUENT APHASIA

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ABSTRACT

The purpose of this study was to examine the integrity of the nonverbal auditory system in subjects with fluent aphasia, and determine the relative preservation of the nonverbal auditory system in comparison to the lexical system. This was attempted through the task of expectation, a high level processing skill. Two groups of participants were examined: a group with fluent aphasia, and a group of non-neurologically damaged individuals. Participants were administered two nonverbal auditory conditions devoid of lexical information, a simple condition and a complex condition in which they were required to determine if the last sound heard in a sequence of four was expected or unexpected. Two lexical conditions were also administered in a similar manner. In the simple lexical condition, participants were required to identify if the last word heard in a sequence of four was expected or unexpected. In the complex lexical condition, participants were instructed to identify if a sentence ended in a logical or illogical word. The measures in this study included reaction times, percent correct, and incongruent percent correct for each condition. Results revealed that subjects with aphasia may have deficits in auditory processing of both nonverbal and lexical information. A significant difference was found in that subjects with aphasia performed better on lexical tasks as compared to nonverbal auditory tasks. Subjects with aphasia appeared to have a damaged nonverbal auditory system; however, it is inconclusive as to if these results were exacerbated by the complexity of the nonverbal stimuli or the manner in which these complex stimuli were presented devoid of visual and situational contexts

INTRODUCTION

Many patients with fluent aphasia demonstrate impaired abilities in auditory and reading comprehension, but have relatively fluent, though paraphasic, speech (Davis, 2000). Due to comprehension deficits, and potentially non-functional verbal output, communication with these patients can be problematic, with a need for alternative methods of communication and for potential revision of the foci of language therapy (Brookshire, 1997). Because environmental sounds are universal, it is important to be able to understand these sounds in daily living (Ballas, 1993). Therefore, environmental sounds should be incorporated within the therapy setting. By examining patients' processing of auditory environmental stimuli, the degree of preservation of the nonverbal auditory system will be more clearly understood. Further, although more generalized nonverbal auditory deficits may be apparent in individuals with fluent aphasia, to identify those with mild nonverbal auditory deficits, an examination of higher level processing skills, such as in expectation, may be necessary.

The purpose of this study is to examine the degree of preservation of the auditory system, specifically for comprehending environmental sounds in people with fluent aphasia. The introduction is divided into seven sections. First, it is necessary to define aphasia and discuss the subtypes of the disorder. It is essential to review how non-neurologically damaged individuals process auditory material, so that we can better interpret the theories proposed to account for the deficits in auditory comprehension associated with aphasia. For this reason we will consider auditory processing in non-neurologically damaged individuals and in people with aphasia in that order. Next, auditory agnosia will be discussed to argue that if specific impairments of such isolated systems can occur, then it needs to be determined if these isolated systems can be spared in the face of aphasia. For later comparison of the participants with aphasia to the non-neurologically damaged population, we will review normal abilities of formulating expectations

in section five and we then will review people with aphasias' abilities in section six. The final section will consider the need for further research in these areas. Within this section, the questions and predictions of the proposed research are specified.

REVIEW OF LITERATURE

Definition of Aphasia

Aphasia is defined as "an acquired impairment in language comprehension, production, and the other cognitive processes that underlie language" (Murray & Chapey, 2001, p.55). Aphasia occurs secondary to brain damage, including tumor, aneurysm, or most frequently stroke. Aphasia is considered a multi-modality disorder because it affects several systems including, listening, speaking, reading, writing, and gesturing in varying degrees depending on modality (Murray & Chapey, 2001). Because of the numerous language modalities possibly affected, sub-categories have been proposed to increase effectiveness of documentation and treatment. The neoclassical terminology associated with the 'Boston School' led by Goodglass and other clinicians at the Veterans Hospital in Boston is based on the patient's phrase length and is on a dichotomous scale of fluent versus non-fluent (Edwards, 2005). Non-fluent aphasia is synonymous with anterior aphasia, as fluent is with posterior aphasia. As with the Boston model, later researchers began to describe aphasia in terms of both language and site of anatomical lesion (Damasio, 2001). Though much debate has arisen about both validity and necessity, the broad-based categorizations of individuals with aphasia has been useful in describing language abilities and anatomical sites of lesion. For the purpose of this study, the terms fluent and non-fluent aphasia will be used because of their descriptions of behavior as opposed to site of lesion.

Aphasia Subtypes

People with non-fluent aphasia tend to exhibit lesions in or near the left frontal lobe. The deficits resulting from damage to this area often lead to poor articulation, limited vocabulary, agrammatism, and mild to moderate disruption in auditory comprehension and reading ability (Goodglass & Kaplan, 1983).

People with fluent aphasia are described as having disproportionately impaired auditory comprehension in comparison to their fluent speech. Sites of lesions for people with fluent aphasia tend to be in the left auditory cortex (Heschl's gyrus), and portions of the second temporal gyri. Because the focus of this paper is fluent aphasia, subdivisions of this classification will be discussed. Subdivisions include transcortical sensory aphasia, anomia, and the more common Wernicke's aphasia and conduction aphasia. Conduction aphasia is characterized by poor repetition skills, the severity of which far exceeds comprehension and spontaneous speech disruptions. Conversely, transcortical sensory aphasia is typified by good repetition skills. Comprehension deficits in conduction and transcortical sensory aphasias are not as severe as Wernicke's aphasia. Anomic aphasia is characterized by fluent speech and good comprehension, but also with deficits in accessing lexical items (Edwards, 2005). Wernicke's aphasia is the most severe form of fluent aphasia. These patients have poor language comprehension, may produce semantic and neologistic paraphasias (word errors), and sometimes jargon (nonsensical speech). They may also exhibit a lack of awareness of their disorder (Davis, 2000). "The fluent jargon has recognizable sentence structure, indicative of a dissociation of word-finding from fundamental syntactic construction. A patient may continue talking when it is his turn to listen, known as press for speech" (Davis, 2000, p. 37).

According to Edwards (2005), although fluent aphasia is common, there is relatively little research on it as compared to non-fluent aphasia, or Broca's aphasia. Wallesch, Bak, and Schulle-Mouting (1992) found that the majority of patients who survived one-year post-brain trauma had a fluent aphasia. The lack of literature makes it unclear how best to provide support and therapy to individuals with fluent aphasia. The high occurrence of fluent aphasia contributes to the need for innovative therapeutic strategies and improved methods of communication.

Processing of Environmental Sounds in Non-Neurologically Damaged Individuals

Ballas (1993) reports that a theory of how listeners interpret everyday sounds has not been developed because the research thus far has concentrated on such a limited set of sounds that no affirmative conclusions can be made. Nevertheless, in an attempt to identify the common factors involved in processing everyday sounds, a series of experiments have been conducted. Ballas (1993) carried out five studies using participants with no known brain damage or history of a hearing disorder. Stimuli utilized throughout the studies were 41 common everyday sounds (e.g., telephone ring, water drip, church bell, door closing, footsteps, etc.).

In the first experiment, identification time and accuracy were measured for each of the 41 sounds. The casual uncertainty values and spectral and temporal properties of these brief everyday sounds were also calculated. The second experiment was a survey given to determine the frequency of occurrence of the sounds, referred to as ecological frequency by Ballas (1993). The perceptual and cognitive processes involved in sound identification were investigated in the third experiment using a series of rating scales. Factor analyses of perceptual-cognitive ratings and spectral parameters were obtained. Identification times and uncertainty were found to be highly correlated. These two factors are also highly related to ecological frequency, the harmonics, and similar spectral bursts. Experiments 4 and 5 used a priming task to determine the correlation between identification time and uncertainty and assessed the effect of sound typicality.

Through this research, Ballas (1993) found that acoustic variables, ecological frequency, uncertainty, and sound typicality were all factors that contribute to the nature of sound identification. Based on these finding, Ballas (1993) called for a “hybrid” theory to describe everyday sound identification due to the wide array of environmental sounds.

A variety of factors are present in the interpretation of environmental sounds; a deficit in any one of these factors could compound an impairment in auditory processing. Because of the numerous factors involved, assessment of both verbal and nonverbal auditory performance should be obtained to determine the presence of a breakdown.

Theories on Deficits in Auditory Processing in People with Aphasia

Although it may be relatively simple to determine the presence of a comprehension deficit through conversation and simple tests, the underlying nature of the deficit is not as easily determined. According to Edwards (2005), a large body of research has been conducted on Wernicke's aphasia subjects' comprehension of single words, which is widely accepted as an area of deficit. It follows that if there is a breakdown in associating meaning to words then comprehension of language is likely to be impaired. Grammar also plays a role in the comprehension of language, but Edwards (2005) reported that there is no universal agreement as to the type of sentences that prove most difficult for those with comprehension deficits. Edwards (2005) suggested that there may be nonlinguistic factors such as sentence length and familiarity that play a role in the comprehension. There is currently scant agreement reported on the principal causes of errors in comprehension, whether it is an interference of central representation, a disruption in the argument structures, semantic parsing, a disturbance in the access to the lexicon, or a cognitive problem secondary to brain damage that is independent of aphasia.

Edwards (2005) presents four explanations of comprehension processing problems. One explanation presents a case for damage to central representation of knowledge. A language impairment may result from lesions in one or more language domains. If there is damage to more than one language domain, then a listener with aphasia will not have full access to word meanings, or meaning of different types of sentences, because of a lexical or syntactic loss. This

case suggests that knowledge or operations are wiped-out in the face of damage. It is difficult to maintain this view because when patients with aphasia are examined, it is seen that their written language, spoken language, and comprehension are affected differently, with varying degrees of impairment in each individual.

A second explanation for comprehension deficits is that the lexicon and grammar remain intact in a person with aphasia, but access to one or both is disrupted. A third explanation is that the grammar and lexicon remain intact, but some language-dedicated processing abilities are damaged. The specifics of language-dedicated processes are not clear, "The data to date suggest that comprehension deficits arise from processing limitations, processing that is dedicated to language and thus involves syntactic and other linguistic constraints" (Edwards, 2005, p.158).

The final potential explanation for comprehension deficits may be because the brain damage causes a disturbance in general processing abilities. Working memory may have an influence on certain types of language processors. It has been found that people with fluent aphasia can have a reduced working memory capacity, as demonstrated by word recall and sentence complexity tasks. Reaction times during psycholinguistic tasks have also been examined by several researchers who concluded that performance depends on the type of the aphasia and sentence type (Swinney, Zurif, & Nicol, 1989; Shapiro & Levine, 1990; Shapiro, Gordon, Hack, & Killackey, 1993).

Evident in these explanations, is that a range of interacting factors affect comprehension deficits. However, these explanations are based on evidence from linguistic tasks such as the comprehension of isolated words or sentences. In cases where the linguistic auditory comprehension of these patients is severely compromised, it is important to determine if nonlinguistic information, such as environmental sounds are compromised as well. Whether or not comprehension of nonverbal material is spared to some degree in those with fluent aphasia is

not known. It should be determined if people with fluent aphasia understand what is going on around them and if they are able to predict or infer the happenings in their environment based on the comprehension of nonverbal sounds.

Aphasia & Auditory Processing

It has been well documented that at least 60-70% of all people with aphasia demonstrate at least some degree of impaired auditory comprehension. This assessment has been included in all major test batteries associated with the diagnosis of aphasia. The term auditory comprehension is generally associated with verbal material being spoken or heard by an individual. This intentional or unintentional ignoring of the possibility of a general central auditory processing problem extending into nonverbal knowledge is problematic for both the assessment and treatment of those with aphasia (Divenyi & Robinson, 1989).

Evidence is mixed regarding the level of damage to nonverbal auditory skills in patients with aphasia. Evidence supports preserved frequency discrimination ability in people with aphasia (Milner, 1962). Conversely, studies on transition to frequency, temporal segregation, and discrimination of filled duration have provided strong evidence of impaired nonverbal auditory abilities (Divenyi & Signoret, 1980; Lackner & Teuber, 1973; van Allen, Benton, & Gordon, 1966).

A study by Pierce and DeStefano (1987) sought to investigate the interactive nature of the auditory system in individuals with aphasia. Because a full understanding of auditory information depends on several variables, both internal and external to the sound presented, it is necessary to examine these variables more closely in individuals with aphasia to determine the factors affecting the comprehension of auditory material. Context and the auditory signal as it related to specific words in narratives were examined as specific factors affecting auditory comprehension (Pierce & DeStefano, 1987).

Pierce and DeStefano (1987) examined eleven subjects with non-fluent aphasia resulting from a left hemisphere CVA were tested. Ages ranged between 53 to 84 years and six of the subjects were male. Contextual influence was manipulated by varying the degree to which target words were predicted by the narratives. The auditory influences were manipulated by varying the amount of auditory signal that was available to the listener (Pierce & DeStefano, 1987).

Three levels of narratives were formed based on the results of testing on 53 non-neurologically damaged subjects. These narratives were high-context, medium context, and low context. Each level was then divided into two sublevels containing an auditory signal that was either the whole word or the initial sound. Subjects were presented the material via tape and headphones. After listening to the narrative, the subjects were asked to respond to a question by pointing to the answer from a choice of four printed words (Pierce & DeStefano, 1987).

The subjects with aphasia performed with a mean accuracy of 83% on those narratives that were whole word and low-context. When the whole word-condition was exchanged for the initial sound-condition, the performance of the subjects dropped to 59% accuracy. The increase in initial sound errors and semantic errors suggested that the subjects attempt to use what little auditory information was available to compensate for the missing information by using context. Increasing the degree of contextual support from low to high also caused a significant deterioration in performance. Subjects were significantly less successful when context was highly predictive as opposed to less predictive. The overall picture that emerged from this study suggests that people with aphasia were influenced more by context than by the auditory signal (Pierce & DeStefano, 1987).

Though context and auditory factors play a role in the comprehension of auditory material there are certainly numerous other factors that play a role in the understanding of the

auditory signal. More research is needed to consider these various elements so that researchers can better understand the interactive nature of the auditory system in those with aphasia.

Divenyi and Robinson (1989) looked at the relation between auditory abilities and receptive language. To assess the nonlinguistic auditory capabilities of patients with aphasia, eleven left-hemisphere CVA patients with aphasia, four right-hemisphere CVA patients without aphasia, and eight non-neurologically damaged males were examined. Psycholinguistic tests were administered to evaluate frequency discrimination, gap detection, gap discrimination, frequency sweep discrimination, assessment of the magnitude of the frequency uncertainty effect in the detectability of tones in noise, and assessment of frequency selectivity through simultaneous marked thresholds (Divenyi & Robinson, 1989).

The results were compared to measures of auditory comprehension from the Boston Diagnostic Aphasia Examination, the Porch Index of Communicative Ability, and the Token Test. Results of the multiple testing revealed that different deficits in auditory comprehension exist in individuals with aphasia and right-hemisphere disorders. Frequency sweep discrimination, frequency discrimination, and frequency uncertainty effect in left-hemisphere people with aphasia was the best predictor of verbal auditory comprehension deficits. The right-hemisphere patients showed marked deficits in all pitch related tasks (Divenyi & Robinson, 1989).

The results of this study suggest that though certain aspects of the nonlinguistic auditory system may be damaged, other aspects are more intact and may not parallel the damage to verbal auditory deficits. Divenyi and Robinson (1989) conclude that a general auditory dysfunction may aggravate verbal auditory comprehension. They further suggest as an aside, that intensive therapy in nonlinguistic listening tasks may benefit people with aphasia's skills in linguistic auditory comprehension, which in turn supports testing for nonverbal auditory deficits as a part

of diagnostics. If non-parallel damage of certain skills is present, then the use of nonlinguistic tasks in therapy could provide strength to the linguistic system itself, enabling the patient to use alternative communication and be more successful in activities of daily living.

Sound recognition is another frequently impaired skill domain in Wernicke's aphasia (Spinnler & Vignolo, 1966; Varney & Damasio, 1986). It has been suggested that damage to the primary auditory cortex could cause pure word deafness, while damage to the auditory association cortex could cause difficulty with nonverbal material (Coslett, Brashear, & Heiman, 1984). In an attempt to isolate the variables affecting sound recognition, three separate parameters were analyzed for their effect on identification. The study defined three parameters that influence recognition of auditory stimuli: semantic identification, the capacity to recognize an object by its sound; asemantic recognition, the ability to identify if two acoustically different sounds belong to the same object; segregation of sound object, the ability to separate or group together acoustic signals that belong to the same object (Clarke, Bellman, Ribauipierre, & Assal, 1996).

Eighty subjects were examined in this study. Sixty people with no history of neurological impairment served as controls. Twenty patients with neurological impairments were examined; nine had lesions isolated to the left-hemisphere, eight had lesions isolated to the right-hemisphere, and three had bilateral lesions (Clarke et al., 1996). For the semantic identification section of the study, subjects were provided with a set of five pictures and asked to point to the picture corresponding to a sound presented. The set of five pictures contained objects that were either positively or negatively similar to the target acoustically and semantically. For the asemantic portion of the testing, subjects had to respond by saying "same" or "different" to two successively occurring sounds. The section on segregation of sounds

presented three different types of tones and had the subjects respond by saying if “one” or “two” tones had been presented (Clarke et al., 1996).

On the semantic identification section, fifteen of the twenty neurologically impaired subjects scored within normal limits; five demonstrated severe deficits. Of these five patients three had right hemispheric lesions, one had conduction aphasia and the other one had global aphasia. Non-neurologically damaged subjects preformed within normal limits. On the asemantic identification task two subjects’ performance was categorized as severely deficient and four as moderately deficient; fourteen subjects performed within normal limits. Again, all non-neurologically impaired subjects scored within normal limits. Of the six deficient patients, one had global aphasia, three had right-hemisphere lesions and two had bilateral lesions. The final test, sound segregation contained three tasks. In the first task, one brain damaged patient was severely deficient, two were moderately deficient and seventeen patients performed within normal limits. There was no difference found between patients with a right versus left hemisphere lesions. There was a significant difference between the older and younger normal adults, with the younger group performing more accurately and faster. In the second task, one of the brain damaged individuals scored severely deficient, while the remaining performed within normal limits. No difference was noted between right and left hemisphere lesions. Younger normal adults responded significantly quicker than older normal adults. On the third test, seven of the brain damaged patients scored as severely deficient, one as moderately deficient, and twelve within normal limits. Younger normal adults responded significantly quicker than older normal adults. Individuals with left hemisphere lesions performed lower on this test than individuals with right hemisphere lesions. Though an observed difference in performance of right and left hemispheric lesions was noted by the researchers, no statistical significance was shown (Clarke et al., 1996).

According to the results of the study, there was no strong correlation between deficits in aphasia/auditory-verbal comprehension and nonverbal auditory recognition; only one-third of patients with a deficit in verbal comprehension also had a deficit in nonverbal auditory recognition. Furthermore, there was no significant relationship between any particular aspect of verbal comprehension and nonverbal recognition (Clarke et al., 1996).

The issue of parallel verbal and nonverbal damage is controversial. As represented in the previously discussed studies there is ample research to suggest at least a partial differentiation in preservation of the systems. Whether aphasia represents an overall deficit in auditory processing or if unparalleled deficits in verbal and environmental abilities exist is a question Saygin, Dick, Wilson, Dronkers, and Bates (2003) attempted to answer.

The study assesses the online relationship between verbal and nonverbal auditory processing. Subjects were asked to listen to sounds and press a button as soon as they thought that they could identify the source. After the sound ended, subjects were asked to verbally describe it. Differences in accuracy and reaction time were analyzed. Participants included twelve individuals with anomic aphasia, ten individuals with Broca's aphasia, and six people with Wernicke's aphasia. Twenty-one age-matched controls, ages 53-78 with no history of neurological impairment served as controls (Saygin et al., 2003).

The groups differed overall in the accuracy of responses. People with anomic aphasia and right-hemisphere disorders did not differ significantly from each other and overall had very few errors. People with Broca's and Wernicke's aphasia were less accurate than all other groups and people with Wernicke's aphasia did significantly worse than those patients with Broca's aphasia. Subjects with Wernicke's aphasia had the longest reaction time. Within the left-hemisphere disordered group, accuracy in verbal and nonverbal material were tightly correlated (Saygin et al., 2003).

The results of the study indicate that verbal and nonverbal abilities decline in unison. There was only a single case where verbal and nonverbal deficits were not in agreement and this data was not mirrored in the reaction time scores. The lack of statistically significant data for verbal and nonverbal processing does not necessarily imply similarity in processing. Saygin et al., (2003) concluded that perhaps these processes draw on some of the same systems for processing. Another explanation offered was that subjects may have been engaging in verbal/sub-vocal mediation to process environmental sounds. A final explanation offered was not that these processes share resources, but are separate systems, simply damaged because of the size of lesion (Saygin et al., 2003).

The study conducted by Saygin et al. (2003) suggests that there is a parallel decline of abilities post stroke in verbal and nonverbal processing. This study is in direct opposition to other research (Clarke et al., 1996; Divenyi & Robinson, 1989). This could be attributed to several factors, such as differences in methodology and subjects. These differences may contribute to the success that people with aphasia have in processing nonverbal material as well as that ability in comparison to their verbal aptitudes. This disagreement in ability is a driving force in this current study.

There is an ongoing debate among researchers regarding shifts in cerebral dominance for language following stroke, which would imply a reorganization of the entire language processing system. Subtle effects such as shifts are not known and are difficult to examine because of neurological damage. Yeager and Rubin (2005) attempted to isolate how people with aphasia process environmental sounds, what impact a possible shift may have on that processing, and whether an interference effect would be present.

Participants in the study included four neurologically normal adults that were age and education matched to the experimental participants. Experimental participants included those

that had suffered a left middle cerebral artery CVA and were at least six months post onset. All participants were between the ages of 45 and 50 years. The primary measurements conducted were the group's ear accuracy scores and reaction times. The group was examined using dichotic listening tasks. These tasks revealed an ear dominance contra lateral to the location of the language processing in the brain (Yeager & Rubin, 2005).

Reaction time tests were conducted for determining motoric reaction times versus processing reaction times. Reaction time was also examined by words and graphical representation on a screen. For the dichotic listening task, while presenting the auditory stimuli, the word or picture would appear on a computer monitor. Participants were instructed to determine whether or not the picture or word matched to the sound they were hearing. Clicking a green button indicated agreement and the red button indicated disagreement (Yeager & Rubin, 2005).

Results of the study demonstrated that the control group had a right ear advantage for both conditions. The aphasic group demonstrated a left ear advantage in both conditions and large interference effects. Results also indicated that the recognition tasks were significantly easier than the perceptual inference tasks. There were also significant reaction time effects; word recognition was faster than environmental sound recognition. Yeager and Rubin (2005) went on to suggest that their study indicated that support of the right-hemisphere post stroke could lead to greater outcomes. Therapies such as Melodic Intonation Therapy, which may tap into the rights hemisphere, should be used more frequently to help forge a transfer of language abilities to the right hemisphere. This investigation justifies greater clinical focus on nonlinguistic aptitudes as a therapy for improving overall function of the language system.

Auditory Agnosia & Isolated System Damage

Auditory agnosia refers to the inability to map sounds, either verbal or nonverbal to meaning, in the presence of normal hearing as measured by audiometric tests (Clarke et al., 1996; Bauer & Rubens, 1985). Auditory agnosia can be found in several forms including: amusia, an inability to recognize music; auditory sound agnosia, an inability to assign meaning to nonverbal sounds; and pure word deafness, the inability to recognize and repeat spoken language (Albert & Bear, 1974; Buchman, Garron, Trost-Cardamone, Wichter, & Schwartz, 1986; Gates & Bradshaw, 1977). Sites of lesions accountable for auditory agnosia for nonverbal sounds have been documented to be primarily in the right temporal lobe (Wortis & Pfeffer, 1948; Spreen, Benton, & Fincham, 1965; Fujii, Fukatsu, Watabe, et al. 1990), left temporal lobe (Albert, 1972), and bilateral insular regions (Habib, Daquin, Milandre, et al.1995).

Albert, Sparks, von Stockert and Sax (1972) performed an extensive evaluation on a 58-year-old male who sustained bilateral posterior cortical lesions, which resulted in an impaired ability to process nonverbal sounds. In order to better understand the underlying cause of the disorder, Albert et al., (1972) administered several examinations: an aphasia examination, audiological examination, tests for sound localization, dichotic signals tests, recognition of nonverbal sounds and popular sounds, sections of the *Seashore Measures of Musical Talents*, a test of the participants capability to send and receive Morse code (given a pre-morbid ability), and an examination of auditory evoked cortical responses. In order to test the participant's prosody, delayed and accelerated auditory feed-back tasks were employed. Initially post-stroke, the participant exhibited characteristics including word deafness, auditory neglect, and defective recognition of the meaning of nonverbal sounds. The word deafness did not persist long; however the sound localization, sound meaning recognition, and left side auditory neglect remained impaired. Tests that evaluated the integrity of the auditory system revealed extinction

of left ear processing when presented with dichotic stimuli, and an impaired capacity to comprehend nonverbal sounds in spite of good comprehension of words, phrases, and sentences.

The participants' ability to comprehend nonverbal sounds was tested using a method previously employed by Albert, Goldblum, Hecaen, and Benson (1971). The participant was presented with twenty pictures of sound-producing objects, animals, and events. Before testing the sounds, the participant was asked to name each object and point to the correct picture when the name was given which was done with 100% accuracy.

To test the participants' ability to associate a sound to its correct referent the following methods were used. A sound was presented via tape recorder and the participant was asked to identify the picture that matched the natural source of the sound. For each sound presented there were four picture choices available. The choices included four types of pictures, 1) the natural source of the sound, 2) the source of a sound in the same acoustic category as the stimulus sound, 3) the source of a sound in the same semantic category as the stimulus sound, and 4) the source of a sound with no relationship to the stimulus sound. The test was presented three different times. The participant failed nine out of ten trials during the first presentation. There was a slight improvement with the second presentation, with seven errors out of ten trials. The sounds correctly identified were all musical instruments. On the third presentation some improvement was noted with five errors out of ten trials.

A different test, previously used by Spinnler and Vignolo (1966), was administered to the participant. This test was similar to the first; however, there was only one obvious choice in the four pictures presented for each sound. With this more limited choice selection the participant correctly identified 88% of the correct pictures. When no pictures were given and the participant was asked to verbally identify a sound, the percent accuracy dropped to 25%.

A clear case of auditory agnosia was presented by Albert, Sparks, von Stockert and Sax (1972) in their case history of a participant who had intact hearing evidenced by audiometric tests, intact auditory comprehension demonstrated by an aphasia evaluation, and normal intelligence as indicated by the WAIS. Yet, this participant was not able to name or point to a sound-producing object when its sound was heard, despite being able to correctly identify the picture and point to it upon hearing the name.

The participant was not able to attach meaning to nonverbal sounds, but was able to attach meaning to words, it is suggested that the brain is organized in such a way that acoustic inputs are processed differently for linguistic and nonlinguistic stimuli. Previous literature by Albert (1972) and Wood, Goff and Day (1971) support the hypothesis that there are two central auditory processing mechanisms, one linguistic and one nonlinguistic.

Previous studies, centered on the evaluation of neuroimaging, have indicated that both the primary auditory cortex and the auditory association areas are necessary in the proscessing of environmental sounds, with a significant right asymmetry (Engelien, Silbersweig, Stern, Huber, Doring, Frith, et al., 1995; Tzourio, Massioui, Crivello, Joliot, Renault, & Mazoyer, 1997). Other imaging studies have found that the left auditory association cortex plays a critical role in the comprehension of speech (Kojima, Hirano, Shoji, Naito, Honjo, Kamoto, et al. , 1997; Muller, Rothermel, Behen, Muzik, Mangner, & Chugani, 1997).

Current research suggests that nonverbal stimuli are processed bilaterally beginning in the temporal lobes (Albert, 1972). Then, the incompletely processed impulses from the right hemisphere are transferred by the corpus callosum to the left-hemisphere where they interact with the incompletely processed impulses in the left-hemisphere. Next, associations are developed between the acoustic impulses and other characteristics found in association areas of other sensory systems of the left-hemisphere. It is at this stage that meaning should be attached

to the perceived sounds. These processes take a distinct amount of time in non-neurologically damaged individuals.

In the case of the patient examined by Sparks, von Stockert, and Sax (1972), cortical evoked potentials revealed a delay in the central auditory processing in both hemispheres. Such a delay may hinder the transfer of impulses and thus the necessary associations within the left-hemisphere. Thus, the nonverbal sound may be heard but not be understood. Because there are many verbal auditory impulses processed in the left hemisphere (Albert et al., 1971; Kimura, 1961) and because linguistic and nonlinguistic stimuli are processed separately (Wood et al., 1971), then the auditory verbal impulses would not be disrupted by a delay in the transfer of nonlinguistic impulses from the right-hemisphere to the left. Therefore, linguistic processing may remain unaffected.

The findings by Albert, Sparks, von Stockert, and Sax (1972) support the hypothesis that there are two central auditory processing systems, indicating that linguistic and nonlinguistic processes are separate and can function independently of one another. This was clearly illustrated in the previous study.

Taniwaki, Koichi, Sato, and Iino (2000) reported the case study of a woman who suffered bilateral subcortical lesions resulting in a progression of deficits which first began with cortical deafness, which developed into generalized auditory agnosia for verbal and environmental sounds, and finally progressed to an auditory agnosia for environmental sounds only. During the cortical deafness phase the participant did not show any response to any sounds or voices. As processing improved, the participant was able to respond to sound but was still unable to differentiate between speech and environmental sounds. The participant then recovered verbal understanding, but not environmental. Six months after onset, the participant regained the ability to understand environmental sounds.

To test the participant's ability to process environmental sounds, a sound recognition test was given. This test consisted of twenty familiar meaningful nonverbal sounds: human voices, animals, instruments, nature sounds, and other noises. The patient was instructed to name the sound after the presentation. During the participant's first stage of impairment (cortical deafness), no environmental sounds were identified. After the cortical deafness improved, the participant was able to detect the presence of sounds 38% of the time and discriminate between sounds 55% of the time. During the participants' last stage of impairment, sounds of nature and other noises proved to be the most difficult to identify. Errors were found to center on acoustical similarity.

Two types of auditory agnosia pertaining to nonverbal sounds have been described; one dealt with deficits in discrimination of the acoustic structure of sounds, and the other with deficits in associating a well-perceived acoustic pattern with its meaning (Vignolo, 1982). Spinnler and Vignolo (1966) advocated that acoustic errors were a result of a discrimination disorder, while semantic errors were a result of an association disorder. The patient examined in Taniwaki et al. (2000) study displayed an inability to discriminate between acoustically similar sounds, leading to the conclusion that she had a discrimination disorder.

If there can be such a specific impairment as the inability to process nonlinguistic sounds, then it may be that there is at least some isolation of these abilities within the brain. Although people with aphasia demonstrate a range of abilities in processing nonlinguistic sounds, the case of agnosias brings into question the extent to which these abilities may be spared in those with aphasia. If nonlinguistic material is isolated and can be damaged, might it not be preserved in some patients who demonstrate impairments in other systems resulting in aphasia?

Inference & Expectation

Merrian-Webster (1998) defines *inference* as "the act of passing from one proposition, statement, or judgment considered as true to another whose truth is believed to follow from that of the former." (Merrian-Webster, 1998, p.598). *Expectation* is defined as, "to consider probable or certain, or to consider reasonable." ((Merrian-Webster, 1998, p.408). These abilities are necessary for daily life activities. One must be able to expect or infer meaning from everyday situations such as seeing a crosswalk, yellow traffic light, hearing a siren, or flashing lights. The ability to know what happens next based on commonly occurring situations, world knowledge, and training allows us to navigate our world and not be surprised at outcomes.

Compared to younger-adults, older-adults demonstrate impaired abilities in memory, cognition, and linguistic abilities. Certain declines in functions are associated with normal aging. Declining abilities in working memory have been well documented (Brebion, Ehrlich, & Tardieu, 1995; Grant & Dagenbach, 2000). Additionally, much research has focused on the decline of written language comprehension (Cohen, 1979; Light, 1990; Light & Anderson, 1985), auditory-verbal discourse comprehension (North, Ulatowska, Macaluso-Haynes, & Bell, 1986), speed of processing (Kemper, Jackson, Cheung, & Anagnopoulus, 1993), and inferencing (Hamm & Hasher, 1992; Ulatowski, Cannito, Hayashi, & Flemming, 1986).

Though it is important for individuals to be able to read, it is equally if not more important for individuals to have functional auditory comprehension. This requires higher-level cognition skills such as inferencing, as well as memory and attention. Whether inferencing in older adults is negatively affected by storage and recall mechanisms or by an overall decrease in cognitive efficiency is debated. Related to this issue, Wright and Newhoff (2002) investigated the inferencing abilities of older adults through the auditory processing mode. The study used fifteen normally aging adults and fifteen young adults. The mean age for the aging group was

69.87 years, while the mean age for the younger group was 22.33 years. All participants were neurologically normal, English speakers, had normal IQs, and visual and hearing skills within normal limits (Wright & Newhoff, 2002). Participants were given a pair of sentences and required to answer four questions about each, two of which were comprehension questions, and two which required inference. All questions required yes/no responses.

Though older adults did not complete the inference tasks as well as the young adults they performed significantly better than expected. The aging group scored a mean of 26.13 incorrect while the young adults received a mean of 13.86 incorrect. Wright and Newhoff (2002) attributed possible success by the older-adults due to presentation form and decreased complexity with increased priming. Their findings are consistent with past research, suggesting that older adults have a greater difficulty making inferences than younger adults. Another conclusion that can be drawn from the results is that older adults are more successful at auditory inferencing tasks than written inferencing tasks. This would seem logical based on the proven deficits in written language abilities (Wright & Newhoff, 2002).

Though it is shown that older adults do have deficits in inference processing and revision, it is also important to note their relative success on this particular task. More research must be done to examine the role of inhibition, processing speed, and working memory in aging adults, and the ways that these variables may affect inferential processing. Aging negatively affects a person's ability to perform higher cognitive tasks, such as inference, and though this deficit could be attributed to several areas of processing decline, the general cognitive deterioration attributed to aging leads to diminished abilities to accurately perform the higher-cognitive tasks required for a complete understanding and manipulation of the complexity of one's environment.

Inference in Aphasia

The ability to comprehend sentences and discourse often requires the employment of inferences. The well documented comprehension problem in aphasia, particularly fluent aphasia, would suggest that processing problems may potentially affect the ability to inference. Several studies examining people with aphasia's ability to generate inference have been conducted (Cutler & Swinney, 1978; Swinny & Osterhout, 1990; Long, Oppy, & Seely, 1994).

Wright and Newhoff (2004) investigated the nature of people with aphasias' processing breakdowns, by examining inference process revision (the ability to revise a previously made inference). A lexical priming task was employed to elicit inference revision. Thirty adults participated in the study, ten non-neurologically damaged adults and twenty with unilateral left brain damage. Ten of the neurologically impaired adults were classified as having a non-fluent aphasia and ten as fluent aphasia as confirmed by performance on the Western Aphasia Battery (Wright & Newhoff, 2004).

In an inference revision task coupled with a cross-modal lexical priming paradigm, sentence pairs were presented auditorily in which the pair required an inference revision in order to obtain correct meaning. Following the presentation, participants were asked to complete a visual lexical decision task. Four yes/no questions were asked pertaining to the first inference, second inference, and created meanings of the sentence pair (Wright & Newhoff, 2004).

Their results showed that both non-neurologically damaged adults and the non-fluent aphasia group were able to activate the intended meaning of the sentence pair. The fluent aphasia group however, was able to activate the initial inference, but was unable to revise this into the correct second inference. Wright and Newhoff (2004) suggest that the strategic processing mechanisms required to generate cognitive inferences no longer exist in most people with fluent aphasia (Wright & Newhoff, 2004).

Results of the comprehension tasks demonstrated that, as expected, people with aphasia performed far worse than non-neurologically damaged adults. Though the amount of items missed were significant and indicated overall comprehension deficits, the participants with aphasia scored only mild-moderately impaired above chance on this task. This suggests that comprehension of the sentence pair was possible, however inconsistent, and that the task was not sensitive enough to detect the subtle differences in comprehension performance in adults with aphasia (Wright & Newhoff, 2004).

Wright and Newhoff (2004) conclude their study by commenting on the variable nature of performance in individuals with aphasia and the further need for investigation into the processing abilities of people with fluent aphasia. By noting that individuals with fluent aphasia have the ability to activate but not to revise an inference, suggests the more high-level the task and more processing required, the less likely the success by a person with aphasia.

Puskaric and Pierce (1997) examined the influence of constraint and expectation on sentence reading comprehension in patients with aphasia. When performing a task that requires the logical completion of a sentence, three factors have been identified to influence performance in non-neurologically damaged individuals. These factors include: congruence, constraint, and expectation (Schwanenflugel & LaCount, 1988; Schanenflugel & Shoben, 1985). Congruence refers to whether a given word is the logical completion to a sentence. Constraint is the whether the sentence to be completed can be completed by many words or just a limited amount. Expectation refers to whether the final word in an open-ended sentence is a likely completion. Pierce (1988) and Pierce and Beekman (1985) found that patients with aphasias performance on sentence completion tasks were enhanced when the target word was highly constrained and predicted. However, comprehension decreases in patients with aphasia when sentences are

introduced that have the possibility of having more than one semantically correct answer (Pierce & DeStefano, 1987).

In a study by Puskaric and Pierce (1997), participants included sixteen patients with aphasia, ten with non-fluent aphasia, and six with fluent aphasia. Constraint and expectation were established in the experimental sentences by first testing thirty-six non-neurologically damaged individuals to determine the number of different nouns they produced (constraint) and the relative frequency of each noun (expectation). Puskaric and Pierce (1997) used a design composed of four experimental conditions, which included: 1) high-constraint, expected response; 2) high-constraint, unexpected response; 3) low-constraint, expected response; 4) low-constraint, unexpected response. Participants were presented with the stimulus sentence and four choices, and then asked to point to the word that best completed each sentence.

Puskaric and Pierce (1997) found that patients with aphasia performed the worst on low-constraint, unexpected responses. Their performance significantly improved on completion of sentences with increased constraint and increased likelihood. Therefore, the fewer possible correct choices, and the more the choices were expected as sentence completions, the more likely patients with aphasia were able to correctly perform the task. If this is the case with lexical information, then there is a call for future research to determine how inferencing abilities are affected with nonlinguistic information in people with aphasia.

Summary

The review has documented that people with fluent aphasia can have severely compromised auditory comprehension of language. Moreover, several unresolved issues were identified within the research literature.

Thus far, several theories have been proposed attempting to explain why these comprehension deficits occur in people with fluent aphasia. The competing theories have

debated whether there is damage to the whole auditory language domain, specific domains, or if there is restricted access to language domains. It is not known if auditory comprehension is damaged to varying degrees in each individual depending on site of lesion, type of aphasia, or other factors. No agreement exists on how these comprehension deficits arise, but it should be noted that the primary focus of these explanations have focused on comprehension of auditory linguistic material, not necessarily on nonverbal sounds. The researchers Saygin et al. (2003) have gone as far as to say that linguistic and nonlinguistic auditory comprehension is equally impaired to the same degree. Because of the known auditory comprehension deficits in people with fluent aphasia, it is important to determine if there is any degree of preservation of the nonverbal auditory system since that system may prove to be a more effective means for communication and therapy post stroke.

Several issues were consistently identified within the literature outlined. One issue addressed the various competing theories on the ability of people with aphasia to process auditory materials, while another relates to the factors affecting the ability to understand auditory material. A final unresolved issue is whether deficits in verbal and environmental sound processing in people with aphasia are dissociable.

The literature in agnosia has illustrated that there are specific subsystems in regard to auditory comprehension. It has been documented that just one subsystem of the auditory system can be impaired while the other subsystems remain intact. Since such specific impairments can occur in auditory comprehension, may we conclude that these fine systems can be spared based on site of lesion? This is an important detail to note because it means that though aphasia may result in widespread loss of language ability, it may not result in the complete loss of nonverbal skills, such as the auditory processing of environmental sounds.

Research on inference and expectation has also raised issues concerning performance of individuals with aphasia. A general reduction in inferencing abilities, a higher level processing skills has been identified in the aging population. Further, aphasia has been tied to damage of high-level processing skills, including inference, particularly in people with fluent aphasia. Though these abilities have been shown to be compromised in aphasia, testing has been primarily focused on linguistic inferencing and expectation. Since inferencing is not isolated to only the linguistic system, it is important to determine the amount of preservation in other types of auditory comprehension within the neurologically damaged population. Since inferencing abilities are a high-level skill, this ability, when examined nonverbally, will provide a more complete picture of the preservation of the overall nonverbal auditory system in aphasia.

CURRENT RESEARCH

To date, the ability of people with aphasia to process environmental auditory material has not been fully investigated. Some research has indicated that there may be deficits in overall processing of auditory stimuli (Saygin et al., 2003; Pierce & DeStafano, 1987). Other research has opposed this idea in favor of separate systems that can be damaged to different degrees (Clarke et al., 1996; Divenyi & Robinson, 1989). It may be that studies involving simple processing of nonverbal auditory stimuli do not truly evaluate the depth of damage that the system may or may not have. Previous studies have also not isolated the system, and have relied to a great extent on linguistic variables.

The purpose of the present study is to examine how subjects with fluent aphasia are able to infer nonverbal auditory items. This high level expectation task will provide a means of examining the integrity of the nonverbal auditory system. This study intends to investigate the integrity of the nonverbal auditory system in a way that minimizes lexical interaction.
The current research addresses the following questions: (a) do subjects with aphasia demonstrate processing of nonverbal auditory incongruencies, (b) will variability exist among subjects with aphasia in their ability to process nonverbal auditory material, and (c) is it that the nonverbal auditory system is more resilient to the neurological damage causing fluent aphasia?

Based on these research questions it is hypothesized that people with aphasia will take longer to process and react to incongruent auditory stimuli than non-neurologically damaged individuals. It is also hypothesized that variability will exist in processing abilities among those subjects with aphasia. In addition, it is also hypothesized that people with aphasia will perform with greater efficiency and accuracy to simple/complex auditory stimuli as compared to lexical stimuli.

METHODS

Subjects

The participants of this study included three people with fluent aphasia and three non-neurologically damaged adults. The two groups of participants were age matched (+/- 2 years), gender matched, and educationally matched by level of completion (some high school, high school graduate, some college, etc.). Participants met the following criteria: were right handed as determined by the Edinburgh Handiness Inventory (+40 or greater; Oldfield, 1971) passed a hearing screening at 40dB SPL @ 500, 1000, 2000, and 4000 Hz, had vision sufficient to perform the task (corrected or uncorrected) as assessed by the Rosenbaum Vision Pocket Screening (20/200; Rosenbaum, 1982), and were a native English speaker.

Table 1**.** Biographical and Descriptive Information for Each Participant per Group

			Aphasia		
Number	Gender	Age	Educ[a]	Edin[b]	Taps[c]
1.0	Male	60.0	18	100	119
2.0	Female	61.0	16	100	142
3.0	Female	60.0	14	100	155
Mean (SD)		60.3(0.5)	16(2)	100(0)	138.7(18.2)

			Control	
Number	Gender	Age	Educ	Taps
1.0	Male	61	18	192
2.0	Female	60	16	154
3.0	Female	61	14	152
Mean (SD)		60.7(0.5)	16(2)	166(22.5)

a-Years of Education
b-Edinburgh Handiness Inventory Score
c-Number of Finger Taps per 30 Seconds

Participants with aphasia were fluent as classified by the Aphasia Diagnostic Profile (Helm-Estabrooks, 1992).

Table 2. Aphasia Diagnostic Profile Scores

Number	ADP-AS[a]	ADP-LR[b]	ADP-AC[c]	Class[d]
1.0	111	14	121	Fluent
2.0	104	11	95	Fluent
3.0	118	14	101	Fluent
Mean (SD)	111(7)	13(1.7)	105.7(13.6)	

a-Aphasia Diagnostic Profile-Aphasia Severity Standard Score
b-Aphasia Diagnostic Profile-Lexical Retrieval Standard Score (M= 10 SD= 3)
c-Aphasia Diagnostic Profile-Alternative Communication Standard Score
d- Aphasia Classification as Determined by Aphasia Diagnostic Profile

Non-neurologically damaged participants were included based on a score of 26 and above on the Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) and a passing score on the Miami Veteran's Administration Medical Center Communication Screener (Bollinger, 1988).

Table 3. Control Performance on Test Measures

Number	Edin	MMSE[a]	Miami[b]
1.0	100	30	Pass
2.0	80	30	Pass
3.0	90	30	Pass
Mean (SD)	90(10)	30(0)	Pass

a-Mini Mental State Examination
b-Miami Veteran's Administration Communication Screener

All participants had no history of prior neurological damage other than aphasia, no previous history of language/learning problems, no history of long term drug/alcohol abuse, and no psychological disturbances in the past five years. All subjects with aphasia were at least one year post onset of symptoms.

Participants were recruited from Louisiana State University (LSU)-Baton Rouge. Ads were placed in local newspapers and flyers were displayed in public places in Baton Rouge. Brochures were given to Neurologists/other doctor's offices, churches, and volunteer centers.

Instrumentation

The following measures were used for classification of aphasia type and screening purposes: Aphasia Diagnostic Profile (Helm-Estabrooks, 1992), Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), Miami Veteran's Administration Medical Center Communication Screener (Bollinger, 1988), Rosenbaum Vision Pocket Screening (Rosenbaum, 1982), Edinburgh Handedness Inventory (Oldfield, 1971), and a pure tone screening.

- The Aphasia Diagnostic Profile (ADP) (Helm-Estabrooks, 1992) is a test devised to assess language and communication impairments associated with aphasia. The ADP consists of a number of small tests which examines different areas of communication including: reading, speaking, and writing abilities to provide personal information (i.e. where participant lives); various areas of talking including describing and naming pictures, repeating words, phrases, sentences, singing, and conveying experiences of the participant and others; understanding words, sentences, stories told aloud, and making gestures to verbal commands. Scores from the subtests are used to obtain standard scores, percentile ranks, and aphasia classification type.
- The Mini-Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) is a brief measure used to assess cognitive status in adults. It is also used to screen for any cognitive impairment and to approximate degree of severity.
- The Miami Veteran's Administration Medical Center Communication Screener (Bollinger, 1988) is used to rule out the presence of cognitive deficits such as dementia and Alzheimer's in otherwise neurologically normal adults.
- The Rosenbaum Vision Pocket Screening (Rosenbaum, 1982) is a card displaying letters and numbers used to assess visual acuity. This is used to rule out any participants who have near sighted vision problems who do wear corrective lenses (20/200).

- The Edinburgh Handedness Inventory (Oldfield, 1971) is a questionnaire that determines handedness. This brief questionnaire is used to rule out any participants who are not right-handed as indicated by a score below +40.
- Pure tone screenings are conducted at 40 dB SPL @ 500, 1000, 2000, and 4000 Hz using a portable audiometer.
- A laptop computer was used to present stimuli and measure response times. The laptop computer was a Dell Inspiron 5160 Pentium III processor with E-prime software installed. E-prime software, version 1.0 Beta 4.4 (Psychology Software Tools, Incorporated) is a research program used for the presentation of visual or auditory stimuli. Responses were recorded using green and red mouse pad buttons located on the laptop computer.
- Auditory stimuli were presented binaurally through TDK 1500 headphones.

Creation of Stimuli

Stimuli for the study were created by the investigator, which include the following types: Simple Auditory (SA), Complex Auditory (CA), Simple Lexical (SLA), and Complex Lexical (CLA). The investigator assembled sequences of sounds using the following: sound effects compact discs BBC. (1991). *BBC 03-Household* (CD)., BBC Enterprises LTD. BBC. (1991). *BBC 01-BBC Sound Effects* (CD)., BBC Enterprises LTD. BBC. (1997). *BBC 45-'Dial 999'* (CD)., BBC Worldwide. BBC. (1991). *BBC 08-Comedy, Fantasy and Humour* (CD)., BBC Enterprises LTD. BBC. (1991). *BBC 05-Transport* (CD). BBC Enterprises LTD. BBC. (1995)., *100 Sound Effects Spectacular Disc* 2 (CD). St.-Laurent, Quebec, Canada: Madacy Music Group, Inc., a sound effects website (http://www.sounddogs.com/catsearch.asp?Type=1), and personal recordings of environmental sounds using an Olympus Digital Voice Recorder DS-2 and an audio-technica Vocal/Instrument Microphone ATR20. Environmental sounds consisted

of sounds produced by humans, animals, nature, and objects. Sound sequences were digitized using Adobe Audition 1.5 and stored as .wav files.

Lexical items in SLA consisted of sequences of words belonging to the same category. Lexical items in CLA consisted of sentences that ended in a Dolch noun (http://www.amug.org/~jbpratt/education/langarts/dolchnouns.pdf). Dolch nouns were chosen because of their equally high frequency of occurrence in the English language. Dolch nouns were originally identified by Edward William Dolch in 1948. The list of nouns was originally published in his book "Problems in Reading" (1948). Dolch complied the list based on children's book of his era. The list contained words that have to be easily recognized for reading fluency.

All sequences were standardized by using undergraduate classes of approximately 50 students at Louisiana State University. Acceptance level for a stimulus sequence was 80% agreement.

<u>Stimuli: Simple Auditory Conditions</u>

Simple auditory expected sequences consisted of four environmental sounds belonging to the same category, with the fourth sound being the target (ex. meow, bark, chirp, **moo**). Simple auditory unexpected sequences consisted of three environmental sounds belonging to the same category and the fourth being the incongruent (ex. meow, bark, chirp, **sneeze**). Simple auditory stimuli consisted of standardized millisecond presentations ranging in length from 0.5 seconds to 5 seconds in length depending on the stimulus, and occurring sequentially in sets of four. Stimuli were presented at 75 dB SPL binaurally through TDK1500 headphones.

<u>Stimuli: Complex Auditory Conditions</u>

Complex auditory expected sequences consisted of four sequentially occurring environmental sounds, with the fourth sound being the target (ex: car door open, close, engine

start, **acceleration**). Complex auditory unexpected sequences consisted of three sequentially occurring environmental sounds and the fourth being incongruent (ex: car door open, close, engine start, **elephant**). Complex auditory stimuli consisted of standardized millisecond presentations ranging in length from 0.5 seconds to 10 seconds in length depending on the stimulus, and occurring sequentially in sequences of four. Stimuli were presented at 75 dB SPL binaurally through TDK 1500 headphones.

Stimuli: Simple Lexical Conditions

Simple lexical auditory expected sequences consisted of four words belonging to the same category, with the fourth word being the target (ex. dog, cat, bird, **cow**). Unexpected sequences consisted of three words belonging to the same category and the four being the incongruent (ex. dog, cat, bird, **plane**). Simple lexical auditory stimuli consisted of standardized millisecond presentations ranging in length from 0.5 seconds to 5 seconds in length depending on the stimulus, and occurring sequentially in sets of four. Words were verbalized by an individual whose voice was standardized for tone, inflection, and length using Adobe Audition 1.5. Stimuli were presented at 75 dB SPL binaurally through TDK 1500 headphones.

Stimuli: Complex Lexical Conditions

Complex lexical auditory stimuli consisted of standardized millisecond presentations ranging in length from 0.5 seconds to 5 seconds in length depending on the stimulus. Sentences were verbalized by an individual whose voice was normalized for tone, inflection, and length using Adobe Audition 1.5. Stimuli were presented at 75 dB SPL binaurally through TDK 1500 headphones. Each sentences final target was a dolch noun. Dolch nouns were used to ensure participant knowledge because of their equally high frequency of occurrence. The complex lexical auditory expected sentences final word was a dolch noun (ex. The mom picked up the

baby). The complex lexical auditory unexpected sentences contained an incongruent dolch noun for its target (ex. The mom picked up the **day**).

Procedures

Paradigm

Each experimental section consisted of 80 total sequences, 60 of which ended in expected targets, and 20 of which ended in unexpected targets. Each sequence was presented three times, two times with an expected ending and one time with an unexpected ending. This was done to reduce the participant's ability to guess whether the ending target would be expected or unexpected based on prior presentations. The auditory portion of the study included the simple auditory (SA), complex auditory (CA), simple lexical (SLA) and complex lexical (CLA) conditions, all presented through headphones. After participants heard a sequence a green button was pressed on the laptop if it was believed the final stimulus was expected or the red button if it was unexpected. Following the final target sound, a yellow screen appeared on the laptop which indicated that was time in which a decision was to be made about whether it was expected or unexpected. Experimental procedures remained identical throughout all testing sections. Administration of SA, CA, SLA, and CLA were quasi randomized to avoid an order effect.

Participants with Aphasia

The first session for participants with aphasia began by having a consent form and questionnaire completed by either the participant in the presence of a caregiver or the caregiver. A brief vision screening was administered using the Rosenbaum Vision Pocket Screening and a hearing screening was performed using a portable audiometer. Then, the participant answered questions on the Edinburgh Handedness Inventory. Once all paperwork was completed, and the participant had demonstrated an understanding of the study, the Aphasia Diagnostic Profile (ADP) was administered.

At the beginning of each of the experimental sessions, a training session took place. Prior to each condition's administration, verbal directions were accompanied by hand gestures specific to that task as well as a demonstration and physical training. During training, auditory sequences were presented through a set of speakers as opposed to the head phones. This was used in order for the subject and experimenter to communicate. During this explanation the experimenter sat at the computer and demonstrated task items using gestures. The experimenter said, "listen to the four items, the fourth one will either make sense or it won't. If you think that it makes sense, press the green button as fast as you can. If you think it doesn't make sense, press the red button as fast as you can." During this explanation the experimenter pointed to the appropriate buttons on the laptop. The experimenter then demonstrated two task items by initiating the computer sequences. The experimenter gestured to listen as each item was presented auditorily. When the fourth item was presented, the experimenter said, "This makes sense!" and pressed the green button (exaggeratedly). Another sequence was presented in the same fashion with the fourth item being unexpected. After the presentation of the fourth item the examiner said, "This one doesn't fit!" and pressed the red button (exaggeratedly). Following the experimenter's demonstration, the subject then practiced on eight training sequences. Four of the sequences were expected during the training, while four were unexpected. If after eight sequences, the experimenter judged the participant to adequately understand the task, then the initiation of the experiment began. If after eight training sequences, the experimenter judged the subject's understanding of the task to be insufficient, then the eight sequences were repeated. If after the repeated training, the participant still did not demonstrate a reliable understanding of the task, the experimenter discharged the subject due to inadequate comprehension skills to complete the experiment. The responses on the training sections were not calculated into the results.

Subjects also participated in a parallel study examining environmental symbolic expectation (Expectation in Symbolic Processing of Environmental Symbols in People with Fluent Aphasia by Amanda Stead). Presentations of the auditory and symbolic experimental sections were quasi randomized to avoid an order effect.

Non-Neurologically Damaged Individuals

The session for non-neurologically damaged participants began by completing a consent form and questionnaire. A brief vision screening was administered using the Rosenbaum Vision Pocket Screening, the participant answered questions on the Edinburgh Handedness Inventory, and a hearing screening was performed using a portable audiometer. Once all paperwork was completed and the participant demonstrated an understanding of the study, the Mini-Mental State Examination and the Miami Veteran's Administration Medical Center Communication Screener were administered to ensure no neurological deficits. Following the administration of qualifying materials, the experimental conditions of the study were conducted in varying order. Experimental procedures were identical to those used for the subjects with aphasia.

Data Analysis

A non-parametric repeated measures Kruskal-Wallis procedure with chi-square statistic was used to differentiate variance between the groups for each of the experimental conditions. Due to the small sample size (N=6), effect size indicators (Cohen, 1988) were used to examine for practical relationships between variables given a lack of statistical significance. The three outcome measures compared across groups were reaction time speed (in milliseconds, ms), accuracy of response (% correct), and accuracy of incongruent stimuli (incongruent % correct). The non-parametric repeated-measures Kruskal-Wallis included each of the 4 experimental procedures. A series of a-priori pair-wise comparisons examined differences between groups for each of the 4 experimental conditions (SA, CA, SLA, CLA). An alpha level was set at ($p<.05$).

RESULTS & DISCUSSION

Results

A non-parametric repeated measures Kruskal-Wallis procedure with chi-square statistics was used to differentiate variance between the groups for each of the experimental conditions. Due to the small N, effect size indicators were used to examine for practical relationships between variables when given a lack of statistical significance.

Table 4. Kruskal-Wallis Test Statistics

Condition	Chi-Square	DF	Sig.
CA	1.19	1	.275
SA	2.33	1	.127
CLA	2.33	1	.127
SLA	.05	1	.827
CAPC	.44	1	.507
SAPC	3.97	1	.046
CLAPC	2.4	1	.121
SLAPC	3.97	1	.046
CAIP	.05	1	.822
SAIP	.78	1	.376
CLAIP	4.36	1	.037
SLAIP	1	1	.317

CA-Complex Auditory
SA-Simple Auditory
CLA-Complex Lexical Auditory
SLA-Simple Lexical Auditory
CAPC-Complex Auditory Percent Correct
SAPC-Simple Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct
CAIP-Complex Auditory Incongruent Percent
SAIP-Simple Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent

A statically significant relationship was evident between the groups for the Simple Auditory Percent Correct (SAPC) with the patients with aphasia (M=72.92, SD=13.83) scoring lower than the non-neurologically damaged individuals (M=90.42, SD=.72) [$X^2(1)=3.97$, p=.046].

A significant difference in performance was found between the groups for the Simple Lexical Auditory Percent Correct (SLAPC) with the patients with aphasia (M=87.5, SD=12.31) scoring lower than the non-neurologically damaged individuals (M=99.17, SD= .72) [$X^2(1)=3.97$, *p*=.046].

Table 5. Descriptive Statistics and Standard Deviations (SD) for Percent Correct for Each Group in Each Condition

	Group 1(Control)	Group 2(Aphasics)
CAPC	80.83 (5.05)	73.75 (24.97)
SAPC	90.42 (0.72)	72.92 (13.83)
CLAPC	99.17 (1.44)	91.25 (9.92)
SLAPC	99.17 (0.72)	87.50 (12.31)

CAPC-Complex Auditory Percent Correct
SAPC-Simple Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct

For the condition of Complex Lexical Auditory Incongruent Percent (CLAIP) there was a significant relationship between the groups with the patients with aphasia (M=78.33, SD= 24.66) scoring lower on unexpected stimuli than the non-neurologically damaged individuals (M=100, SD= 0) [$X^2(1)=4.36$, *p*=.037] .

Table 6. Descriptive Statistics and Standard Deviations (SD) for Incongruent Percent Correct for Each Group in Each Condition

	Group 1(Control)	Group 2(Aphasics)
CAIP	83.33 (7.64)	85.00 (10.00)
SAIP	78.33 (7.64)	61.67 (25.17)
CLAIP	100.00 (.00)	78.33 (24.66)
SLAIP	100.00 (.00)	98.33 (2.87)

CAIP-Complex Auditory Incongruent Percent
SAIP-Simple Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent

Though analyses did not yield statistical significance, there appeared to be a functional difference between the groups for the Simple Auditory (SA) condition with the patients with aphasia (M=1522.3, SD=173.76) demonstrating longer reaction times than the non-neurologically damaged individuals (M=1050.98, SD=326.9) [$X^2(1)=2.33$, $p=.127$].

Though analyses did not yield statistical significance, there appeared to be a functional difference between the groups for the Complex Lexical Auditory (CLA) condition with the patients with aphasia (M=1034.05, SD=141.59) demonstrating longer reaction times than the non-neurologically damaged individuals (M=737.76, SD=249.22) [$X^2(1)=2.33$, $p=.127$].

Table 7. Descriptive Statistics and Standard Deviations (SD) for Reaction Times for Each Group in Each Condition

	Group 1(Control)	Group 2(Aphasics)
CA	1252.32 (393.85)	1737.56 (370.33)
SA	1050.98 (326.90)	1522.30 (173.76)
CLA	737.76 (249.22)	1034.05 (141.59)
SLA	841.17 (268.46)	1110.18 (436.54)

CA-Complex Auditory
SA-Simple Auditory
CLA-Complex Lexical Auditory
SLA-Simple Lexical Auditory

There appeared to be a functional difference between the groups for the Complex Lexical Auditory Percent Correct (CLAPC) condition with the patients with aphasia (M=91.25, SD= 9.92) scoring lower than the non-neurologically damaged individuals (M=80.83, SD=5.05) [$X^2(1)=2.40$, $p=.121$]. No other analyses approached statistical significance.

An analysis of baseline motoric reaction time was performed with an independent sample t-test. There was a non-significant difference of baseline motoric reaction time, $t(4)=.406$, $p=.559$ between the two groups, thus no measures of co-variance were deemed necessary.

Table 8. Motoric Baseline Reaction Times in Milliseconds

Group	Mean	Std. Dev.	Std. Error mean
Aphasia	138.67	18.23	10.53
Normal	166	22.54	13.01

A-priori paired-sample t-tests were performed in an attempt to answer the research questions. The following findings will be addressed in regard to differences within each of the groups for reaction time, percent correct, and incongruent percent correct. Using reaction time scores of opposing conditions, a paired-sample t-test indicated a significant difference between CA versus CLA, $t(2) = 4.62$, $p = .04$, $r_{pb}^2 = .96$

A paired-sample t-test which indicated a significant difference between SAPC versus SLAPC, $t(2) = -5.0$, $p = .038$, $r_{pb}^2 = .96$.

A paired-sample t-test also indicated an approaching significant difference in incongruent percent correct scores of opposing conditions between SAIP versus SLAIP, $t(2) = -2.48$, $p = .132$, $r_{pb}^2 = .86$.

Table 9. A Priori Paired Samples Test for Individuals with Aphasia

Condition		Mean	N	Std. Dev.	Std. Error Mean
Pair 1	CA	1737.56	3	370.33	213.81
	CLA	1034.05	3	141.59	81.75
Pair 2	SA	1522.30	3	173.76	100.32
	SLA	1110.18	3	436.54	252.04
Pair 3	CAPC	73.75	3	24.97	14.42
	CLAPC	91.25	3	9.92	5.73
Pair 4	SAPC	72.92	3	13.83	7.98
	SLAPC	87.5	3	12.31	7.10
Pair 5	CAIP	85	3	10	5.77
	CLAIP	78.33	3	24.66	14.24
Pair 6	SAIP	61.67	3	25.16	14.53
	SLAIP	98.33	3	2.89	1.67

CA-Complex Auditory
SA-Simple Auditory
CLA-Complex Lexical Auditory
SLA-Simple Lexical Auditory
CAPC-Complex Auditory Percent Correct
SAPC-Simple Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct
CAIP-Complex Auditory Incongruent Percent
SAIP-Simple Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent

To examine the relationship between conditions within the group with aphasia paired-sample correlations were conducted. Strong correlations were evident for the following: CAPC versus CLAPC (.97, p=.17), SAPC versus SLAPC (.93, p=.24), CA versus CLA (.834, p=.37), and CAIP versus CLAIP (.81, p=.398).

Table 10. Paired Sample Correlations for Individuals with Aphasia

Condition	N	Correlation	Sig
Pair 1 CA & CLA	3	.83	.372
Pair 2 SA & SLA	3	.30	.803
Pair 3 CAPC & CLAPC	3	.97	.169
Pair 4 SAPC & SLAPC	3	.93	.237
Pair 5 CAIP & CLAIP	3	.81	.398
Pair 6 SAIP & SLAIP	3	-.12	.927

CA-Complex Auditory
SA-Simple Auditory
CLA-Complex Lexical Auditory
SLA-Simple Lexical Auditory
CAPC-Complex Auditory Percent Correct
SAPC-Simple Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct
CAIP-Complex Auditory Incongruent Percent
SAIP-Simple Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent

An analysis of the difference scores between performances on nonverbal stimuli versus lexical stimuli were compared between the two groups for simple and complex conditions for percent correct and incongruent percent correct using independent sample t-tests. There appeared to be a functional difference on the difference scores on SAPC versus SLAPC, $t(4)=1.941$, $p=.124$, $r_{pb}^2=.49$, and on SAIP versus SLAIP $t(4)=.970$, $p=.387$, $r_{pb}^2=.19$ between the two groups, indicating that there was a greater disparity in the patients with aphasias' performance than the non-neurologically damaged individuals performance. Although statistical significance was not reached, a functional difference was noted on the difference scores on CAIP versus CLAIP, $t(4)=-2.220$, $p=.090$, $r_{pb}^2=.55$ between the groups. This indicates that patients with aphasias' performance between incongruent nonverbal and lexical stimuli were inferior to the difference in performance by the non-neurologically damaged individuals. No other analyses approached statistical significance.

Table 11. Independent Sample Test for Difference Scores in Conditions between Individuals with Aphasia and Non-Neurologically Damaged Individuals

Group	Condition	Mean	N	Std. Dev.	Std. Error Mean
A	CAPC vs.CLAPC	17.50	3	15.61	9.01
N	CAPC vs.CLAPC	18.33	3	3.61	2.08
A	SAPC vs.SLAPC	14.58	3	5.05	2.92
N	SAPC vs.SLAPC	8.75	3	1.25	.72
A	CAIP vs. CLAIP	-5.00	3	15.00	8.66
N	CAIP vs. CLAIP	16.67	3	7.64	4.41
A	SAIP vs.SLAIP	36.67	3	25.66	14.81
N	SAIP vs.SLAIP	21.67	3	7.64	4.41

CAPC-Complex Auditory Percent Correct
SAPC-Simple Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct
CAIP-Complex Auditory Incongruent Percent
SAIP-Simple Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent
A-Group with Aphasia
N-Group with non-neurological damage

Discussion

The findings will be discussed in relation to the research questions and hypotheses presented in this study. Possible explanations of outcomes and participant performance patterns will be discussed for each condition. Interesting observations will also be addressed in this chapter. In conclusion, there will be a section on limitations of the study and directions for future research.

Statistical analyses revealed a significant difference in the SLAPC condition between individuals with aphasia and non-neurologically damaged individuals. It is suggested that in the condition SLAPC, individuals with aphasia were less accurate in identifying expected and unexpected endings of simple lexical sequences as compared to non-neurologically damaged

individuals. This could be attributed to a compromised lexical processing system, consistent with the presence of known comprehension difficulties in people with fluent aphasia (Edwards, 2005). If these trends were continued with a larger N, it could be proposed that a reduction in the use of spoken language in therapy practices could be beneficial in order to diminish fatigue and frustration due to the taxing nature of auditory lexical information (Duffy & Coelho, 2001).

A statistical difference was demonstrated between groups in the condition CLAIP. This indicates that individuals with aphasia were less accurate in identifying sentences ending in illogical words as compared to non-neurologically damaged individuals. These results could be accounted for by the complex nature of lexical tasks including incongruencies and the increased amount of auditory information heard at one time.

Statistical findings indicated a significant difference between groups within the condition SAPC. This outcome suggests that individuals with aphasia were not as accurate as non-neurologically damaged individuals in identifying expected and unexpected sequences of simple auditory stimuli. If these trends were to continue with a larger sample size it could be suggestive of an overall diminished integrity of the auditory system including nonverbal information.

Though no statistically significant results were recorded, several conditions appeared to have a functional significance. These conditions include SA, CLA, and CLAPC. For the conditions SA and CLA, the diminished performance in reaction time could be suggestive of deficits in auditory processing of nonverbal information (Yeager & Rubin, 2005) and verbal information, since no baseline motoric differences were evident between groups. In the condition CLAPC, individuals with aphasia performed less accurately as compared to non-neurologically damaged individuals, possibly indicating an inability to distinguish incongruent and congruent stimuli.

A-Priori analyses were used to answer the questions posed by this research study. Reaction times for conditions were compared within the group of individuals with aphasia. For the conditions CA versus CLA, statistical significance was reached with longer responses times being recorded for complex auditory stimuli as opposed to complex lexical information. Comparisons within the aphasia group were also conducted for percent correct between conditions. It was found that SAPC versus SLAPC yielded statistical significance with individuals with aphasia scoring more accurately on lexical information than auditory stimuli. Comparisons within the aphasia group were conducted for incongruent percent correct. Statistical significance was noted between the conditions SAIP versus SLAIP, with individuals with aphasia more accurately identifying incongruent lexical endings than incongruent auditory endings.

Though these results were not expected, it could be attributed to the extremely complex nature of the auditory stimuli. As previously discussed, to isolate the nonverbal auditory system, stimuli were presented null of context and visual cues which may have increased the conditions difficulty. Conversely, it may be concluded that the lexical system is in fact functioning more intact than the auditory nonverbal system. This may be possible due to the general site of lesion being located near the center for the auditory processing systems.

Correlations were conducted to measure the relationships between conditions. Positive correlations were noted for the following conditions: CAPC versus CLAPC, SAPC versus SLAPC, CA versus CLA, and CAIP versus CLAIP. By examining a group's performance on one of these conditions, the corresponding condition would be determinable based on a predictable pattern of correlation. As their performance increased or decreased per that condition the other condition would follow the same pattern of change. With these highly correlated conditions, it is implied that the individual's success could be determined on other

tasks based on their performance on one. If these correlations continued to be strong with a larger sample size, it would indicate an opportunity to reduce extensive testing in clinical trials and therapy.

The difference between performance and on nonverbal auditory conditions and lexical conditions were compared between individuals with aphasia and non-neurologically damaged individuals. Although no statistical significance was reached, a few comparisons appeared to have a functional difference. These conditions included: SAPC versus SLAPC, SAIP versus SLAIP, and CAIP versus CLAIP. When comparing the difference in performance on SAPC versus SLAPC between the groups it was found that the difference in performance between the nonverbal auditory sounds versus lexical conditions was lower to a greater extent in individuals with aphasia than non-neurologically damaged individuals. When examining only the responses to incongruent stimuli, individuals with aphasia maintained a larger difference in performance between nonverbal auditory stimuli and lexical stimuli in both the simple and complex conditions (SAIP vs. SLAIP, CAIP vs. CLAIP) inferior to non-neurologically damaged individuals. While non-neurologically damaged individuals performed poorly on the nonverbal auditory conditions, individuals with aphasia demonstrated a greater degree of difficulty on these conditions.

Examination of the individual scores within the group of people with aphasia revealed variability in individual performance. Because of variability in severity of aphasia, sites of lesions, years in therapy, and other factors, it is likely that individuals with aphasia will perform with some degree of inconsistency on tasks. Differences in ability of each patient in the aphasia group are demonstrated when scores in each condition are compared. Overall, the group of individuals with aphasia scored with the same relative strengths and weaknesses in testing, it is

evident in looking at their individual scores that differences do exist in performance, and these variations will be evident in their activities of daily living.

Table 12. Individual Scores of Reaction Times for Individuals with Aphasia and Non-Neurologically Damaged Individuals

Subject	SA	SLA	CA	CLA
A1	1671.04	901.61	2163.29	1178.3
A2	1564.55	1611.88	1489.89	1028.58
A3	1331.31	817.04	1559.5	895.28
N1	835.49	906.86	1080.05	553.68
N2	890.33	545.96	973.95	638.23
N3	1427.13	1070.68	1702.96	1021.36

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3
SA-Simple Auditory
SLA-Simple Lexical Auditory
CA-Complex Auditory
CLA-Complex Lexical Auditory

Table 13. Individual Scores of Percent Correct for Individuals with Aphasia and Non-Neurologically Damaged Individuals

Subject	SAPC	SLAPC	CAPC	CLAPC
A1	87.5	97.5	90.0	95.0
A2	60.0	73.75	45.0	80.0
A3	71.25	91.25	86.25	98.75
N1	90.0	98.75	83.75	100.0
N2	91.25	98.75	83.75	100.0
N3	90.0	100.0	75.0	97.5

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3
SAPC-Simple Auditory Percent Correct
SLAPC-Simple Lexical Auditory Percent Correct
CAPC-Complex Auditory Percent Correct
CLAPC-Complex Lexical Auditory Percent Correct

Table 14. Individual Scores of Incongruent Percent Correct for Individuals with Aphasia and Non-Neurologically Damaged Individuals

Subject	SAIP	SLAIP	CAIP	CLAIP
A1	85.0	100.0	95.0	90.0
A2	65.0	95.0	75.0	50.0
A3	35.0	100.0	85.0	95.0
N1	80.0	100.0	90.0	100.0
N2	85.0	100.0	85.0	100.0
N3	70.0	100.0	75.0	100.0

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3
SAIP-Simple Auditory Incongruent Percent
SLAIP-Simple Lexical Auditory Incongruent Percent
CAIP-Complex Auditory Incongruent Percent
CLAIP-Complex Lexical Auditory Incongruent Percent

SUMMARY

Summary

Several research questions were proposed in this study. First, do subjects with aphasia demonstrate processing of nonverbal auditory incongruencies as effectively as those without aphasia? It was concluded that individuals with aphasia did not exhibit equally accurate processing of incongruent nonverbal auditory incongruencies as compared to non-neurologically damaged individuals. This may indicate a deficit in the ability of individuals with aphasia to process incongruencies.

Second, will variability exist among subjects with aphasia in their ability to process nonverbal auditory material? Variability among participants with aphasia in their ability to process nonverbal information was demonstrated within both the simple and complex conditions.

Is it that the nonverbal auditory system is more resilient to neurological damage causing fluent aphasia? The results of this study suggested that the nonverbal auditory system is not more resilient in the face of neurological damage. This lack of resiliency could be attributed to the complex nature of the stimuli presented within the conditions and the relative lack of real world presentation (i.e. an auditory sound occurring without a visual cue).

Nonverbal sounds are ubiquitous in our everyday world and it is essential that people understand these sounds in order to successfully carry out activities in daily living. Since the results of this study suggest a deficit in processing of nonverbal auditory information it should be a focus in therapy. Because of the variability of performance between each individual with aphasia it is crucial that therapy identify each individual's relative strengths and weaknesses and train these skills as needed.

Interesting Observations

Several interesting observations were noted throughout testing. During the testing process it would appear as though participants were merely responding in an automatic style in reply to the response screen. However, when redirected to the task at hand participants would begin responding more accurately. It appeared as though some of the individuals with aphasia were responding in a preservative manner or demonstrated delayed processing skills. Throughout the study, it was noted that both individuals with aphasia and non-neurologically damaged individuals would verbally comment when they had just made an error in response. Perhaps this could be attributed to a faster motoric response time as opposed to processing time.

Limitations of the Study and Directions for Future Research

There were numerous limitations in the current study. First, a small number of participants were included in the study, which negatively impacted the statistical power. Given that a participant in each group performed notably different than the rest of their group, the small N did not allow for a potential outlier to have less impact on the means and standard deviations of the data. Second, in attempt to isolate the environmental auditory system, sounds were presented devoid of visual and situational contexts which may have increased the complexity of auditory stimuli. Since environmental sounds heard in daily life are typically accompanied with visual contexts, it is difficult to determine if individuals would perform better on the task if it were presented in a real world context. Third, in order to reduce the predictability of incongruent stimuli, sets of stimuli were created with a sixty to twenty ratio; therefore, making conditions rather lengthy. Because of the known fatigue effects and preservations in individuals with aphasia, (Duffy, 2001) these lengthy conditions may have affected their performance.

There are several directions for future research. These directions could include replicating the study with a larger sample size, including stimuli that are more real world

applicable or more easily identifiable, determine if individuals with other types of aphasia or neurological disorders follow similar patterns in nonverbal processing, and to determine whether the use of nonverbal materials would be beneficial in therapy to individuals with aphasia.

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APPENDIX A
PARTICIPANT QUESTIONNAIRE

Subject #_______

Questionnaire
Background Information

Thank you for participating in this research. You should have already read and signed the Consent Form. Please ask the examiner if you have any questions about your participation in this study, or is you have questions about any part of this questionnaire. Please do not write your name on this form. Participation is completely voluntary.

Sex (circle one) male female
Date of Birth (mm/dd/yy)______________________
Highest level of education completed (circle one)
Elementary school High school Some college Technical School
College Graduate Post graduate studies Graduate degree
Where do you currently love? City_____________________ State____________
If you have lived at this location for less than 5 years, where did you previously reside?
City_____________________ State____________
Is English your primary language? Yes No
If NO, what is your primary language?____
What is your occupation?____

Do you have normal vision? (circle one) Yes No
If NOT, is it corrected by contact lenses or glasses?_____________________________________

Have you ever had a stroke? (circle one) Yes No If YES, when________________________
If yes, please describe (include date) ____
____
____
____
Have you been diagnosed with "aphasia" Yes No

Have you ever had a head injury Yes No If YES, how long ago__________________
If yes, please describe (include date) ____
____
____
Are you currently taking any medications? Yes No If YES, please list name and dose____
____

Do you have any history of the following (circle either Yes or No for each)

Learning Disability Yes No Seizure Disorder Yes No
Language Disorder Yes No Psychiatric Illness Yes No
Drug or Alcohol Abuse Yes No

If yes to any of the above, please explain____
____
____

Your responses to this questionnaire will only be identifiable by Subject Number and will be kept completely confidential.

Thank you again for your participation

APPENDIX B

EDINBURGH HANDEDNESS INVENTORY

Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column*. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks*. If in any case you are really indifferent, *put a check in both columns*.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	☐ ☐	☐ ☐
2. Drawing	☐ ☐	☐ ☐
3. Throwing	☐ ☐	☐ ☐
4. Scissors	☐ ☐	☐ ☐
5. Toothbrush	☐ ☐	☐ ☐
6. Knife (without fork)	☐ ☐	☐ ☐
7. Spoon	☐ ☐	☐ ☐
8. Broom (upper hand)	☐ ☐	☐ ☐
9. Striking Match (match)	☐ ☐	☐ ☐
10. Opening box (lid)	☐ ☐	☐ ☐
TOTAL(count checks in both columns)		

Difference	Cumulative TOTAL	Result

Scoring:

Add up the number of checks in the “Left” and “Right” columns and enter in the “TOTAL” row for each column. Add the left total and the right total and enter in the “Cumulative TOTAL” cell. Subtract the left total from the right total and enter in the “Difference” cell. Divide the “Difference” cell by the “Cumulative TOTAL” cell (round to 2 digits if necessary) and multiply by 100; enter the result in the “Result” cell.

Interpretation (based on Result):

- below -40 = left-handed
- between -40 and +40 = ambidextrous
- above +40 = right-handed

APPENDIX C
ROSENBAUM POCKET VISION SCREENING

APPENDIX D
APHASIA DIAGNOSTIC PROFILES

ADP

Normed Edition

Nancy Helm-Estabrooks

RECORD FORM

Name ______

Address ______ Telephone ______

Date of Birth ______ Age ______ Sex ______ Soc. Sec. No. ______

Test Date ______ Examiner's Name ______

Time Exam Began ______ Time Exam Finished ______ Test Conditions ______

Diagnosis ______

______

Site of Lesion ______ Onset Date ______

Dominant Hand ______ Presence/Side of Hemiparesis ______ Family Handedness ______

Present/Former Occupation ______

Years of Education ______ Marital Status ______ Military Duty ______

Native Language ______ Other Languages ______

Other Medical Problems ______

______

Current Medications ______

Names and Ages of Immediate Family (including siblings and children) ______

______

______

Contact Person ______ Phone ______

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GENERAL INSTRUCTIONS FOR ADMINISTERING, RECORDING, AND SCORING

ADMINISTERING ADP

Present all questions and stimuli using normal, conversational rate and stress patterns. All instructions and items to be read by the clinician are printed in *blue, boldface, italic type.*

When using stimulus cards for Fluency Item 2, Naming, Comprehension of Single Words, and Singing, present the cards one at a time. Do not allow the patient to hold cards.

RECORDING RESPONSES

Record all responses verbatim, either at the time of testing or from an audiotape if used. (This includes Naming and Repetition responses.) Note any correct representational gestures made on the Naming subtest.

SCORING

Space is provided on each page for scoring responses. Score all verbal responses (except for those made during the Auditory Language Comprehension subtest and the Singing subtest) according to the following system:

3 = immediately, fully correct
2 = mostly correct immediately, fully correct with prolonged delay, or self-corrected
1 = some correct
0 = fully incorrect
N = no response

Other codes not related to assigning a score should be used to more fully describe the administration or patient's responses:

G = correct representational gesture (Naming subtest) (*Note: Do not score gestures)*
R = repeated stimulus (Auditory Language Comprehension, Repetition subtests)

The scoring systems for Auditory Language Comprehension (pages 10-11) and Singing (page 13) are explained on the pages with those subtests.

Classify all errors made on the Naming subtest, on Comprehension of Single Words, and on the Repetition subtest according to the error categories marked for each. More than one error type may be produced and recorded for a single item.

RECORDING AND ANALYZING RESPONSES ON FLUENCY SUBTEST **(pages 6–8)**

Transcribe the patient's responses verbatim. It is important to note all significant pauses in order to determine average longest phrase length and classify the speech output as fluent vs. nonfluent. The phrase length is based on the number of words that occur in a breath unit, that is, without significant pause. It is not necessarily the number of words in a sentence. For example, one nonfluent patient said, "The cans [pause] are straight," two 2-word phrases.

For each of the three passages, find the three longest phrases. Then find the average of the their lengths. For example, one patient said, "There's a bad boy [4] ... knocked over eggs [3]. The woman is reaching for a cup or soup can [10]. Butcher [1] ... cut his finger [3]. Igloo with eskimos in front [5]." In this passage, the three longest phrases are 4, 10, and 5 words long, respectively. Their average is $4 + 10 + 5 = 19 \div 3 = 6.3$.

After calculating the average longest phrase length for each of the three passages, determine the best score (highest average). If no task has 3 or more phrases, use the 3 longest phrases across all 3 tasks to compute the average longest phrase length. The highest average longest phrase length is used in determining speech fluency.

When making the written transcript, record all clinician probes at the points at which they were used. Note that only neutral probes should be used.

PROFILES

Transfer raw scores from each subtest to the Scoring Worksheet (page 16). Look up the appropriate standard scores (and percentile ranks if desired) in the Norms Tables in the **ADP** *Manual.* Use the standard scores in computing all composite and profile scores, which may be plotted on the Score Summary on page 16. Information from the individual ADP subtests can be used in the following Profiles:

1. **Aphasia Severity Profile** (page 16)—Use Lexical Retrival Standard Score (based on Personal Information, Information Units from Fluency subtest, and Naming), Auditory Language Comprehension Standard Score, and Repetition Standard Score.
2. **Error Profiles** (page 14)—Use error information from Naming, Comprehension of Single Words, and Repetition.
3. **Classification Profile** (page 15)—Use Lexical Retrieval Standard Score (Personal Information, Information Units from Fluency subtest, and Naming), ADP Phrase Length Standard Score, Auditory Language Comprehension Standard Score, and Repetition Standard Score to determine if the patient displays a classifiable form of aphasia.
4. **Alternative Communication Profile** (page 16)—Use Writing Standard Score, Reading Standard Score, Elicited Gestures Standard Score, and Singing Standard Score.
5. **Behavioral Profile** (page 14)—As soon as testing is finished, complete the Behavioral Profile as instructed. Use observations made during administration of all subtests and information from conversation with the patient.

PERSONAL INFORMATION

After greeting the patient and making him or her comfortable, give the following instructions: *"I'd like to start out with some general information about you."*

3 = Immediately, Fully Correct
2 = Mostly Correct Immediately, Fully Correct with Prolonged Delay, or Self-Corrected
1 = Some Correct
0 = Fully Incorrect
N = No Response

Item/Response	Score					
1. *What is your full name?*	3	2	1	0	N	
2. *And what is your current address?*	3	2	1	0	N	
3. *How old are you now?*	3	2	1	0	N	
4. *Can you tell me your exact birthdate?*	3	2	1	0	N	
5. *And where were you born?*	3	2	1	0	N	
6. *What languages do you speak?*	3	2	1	0	N	
7. *What do [did] you do for a living?*	3	2	1	0	N	
8. *How many years of education did you have?*	3	2	1	0	N	
Column Totals						
Personal Information Score (Transfer to page 16, Scoring Worksheet.)	/24					

"Say, why don't I just let you fill in this form?" Hand the patient the Patient Information Form on page 5 of this Record Form and a black, medium-point felt-tipped pen. (Do not use a pencil.) **If the patient cannot write, ask him or her to complete the multiple-choice sections of the form by indicating choices.** This is a reading comprehension test. Do not read aloud to the patient. When the patient is done, take the form back and turn to page 6.

SCORING THE PATIENT INFORMATION SHEET (Facing Page)

The Patient Information Sheet is a brief test of functional writing and reading skills.

3 = Immediately, Fully Correct
2 = Mostly Correct Immediately, Fully Correct with Prolonged Delay, or Self-Corrected
1 = Some Correct
0 = Fully Incorrect
N = No Response

WRITING

Item/Response	Writing				
1. Name	3	2	1	0	N
2. Street	3	2	1	0	N
3. City	3	2	1	0	N
4. State	3	2	1	0	N
5. ZIP Code	3	2	1	0	N
6. Birth Date	3	2	1	0	N
7. Social Security Number	3	2	1	0	N
8. Telephone Number	3	2	1	0	N
9. Signature	3	2	1	0	N
10. Date	3	2	1	0	N
Column Totals					
Writing Score (Transfer to page 16, Scoring Worksheet.)	/30				

Hand Used for Writing: ____________

READING

Item	Reading				
1. Sex	3	2	1	0	N
2. Hand Preference	3	2	1	0	N
3. Age	3	2	1	0	N
4. Siblings	3	2	1	0	N
5. Education	3	2	1	0	N
6. Marital Status	3	2	1	0	N
7. Children	3	2	1	0	N
8. Veteran	3	2	1	0	N
9. Employment	3	2	1	0	N
10. Permission	3	2	1	0	N
Column Totals					
Reading Score (Transfer to page 16, Scoring Worksheet.)	/30				

PATIENT INFORMATION SHEET

NAME (Please Print) ____

ADDRESS ____
Street

______________ ______________ ______________
City State ZIP Code

BIRTH DATE ____________ SOC. SEC. NO. _____-____-______ TELEPHONE NO. (___)________

CHOOSE ONE IN EACH CATEGORY:

1. SEX: Male Female
2. ORIGINAL HAND PREFERENCE: Right Left Ambidextrous
3. AGE BRACKET: 20–29 30–39 40–49 50–59 60–69 70–79 80–89 90 or older
4. BROTHERS AND SISTERS: 0 1 2 3 4 5 6 7 8 9 ___
5. EDUCATION COMPLETED: Grammar School Junior High High School College Graduate School
6. MARITAL STATUS: Single Married Divorced Separated Widowed
7. CHILDREN: 0 1 2 3 4 5 6 7 8 9 ___
8. VETERAN OF ARMED SERVICES: Yes No
9. EMPLOYMENT STATUS: Employed Unemployed Retired Disabled

10. **Indicate the correct choice** so that the following statement reflects your wishes:

I give my permission — I do not give my permission — for tape recording my speech for evaluating my language skills.

SIGNATURE: ______________________________ TODAY'S DATE: ____________

5

FLUENCY

1. After the patient has filled out the Patient Information Form, say, *"Well, now that that's out of the way, I'm going to turn on the tape recorder"* (if permission for taping was granted). *"Now I'd like you to tell me exactly what happened to you."* Neutral probes such as *"And then what happened?"* or *"Can you tell me more?"* may be used. Use the grid below to record the patient's response *verbatim*. On each line write the words uttered without a significant pause or breath. Number each phrase and count the words in each.

Phrase Number	Phrase	Phrase Length

Average of 3 Longest Phrase Lengths: ☐

2. After asking the patient to describe what happened to him or her, continue to tape record. Present Card 1, The Grocery Store, and give the following instruction: *"I have a picture here. As you see, there's lots going on. Look it over and tell me about it."* If the patient leaves out some important details, use neutral probes such as"Any other details?" or *"What about here?"* (pointing to the butcher). Never use nonneutral probes such as, "What is the woman doing?"

Phrase Number	Phrase	Phrase Length

Average of 3 Longest Phrase Lengths: ☐

OTHER VARIABLES (Scored from Picture Description)

Total Number of Words: Count every word produced in response to the initial prompt. Also count responses to neutral probes. Do not count hesitation noises and interjections ("um," "er," "hmm") or fragments that are false starts on a word that is eventually produced ("bu, bu, butcher"). Do count fragments that seem to be broken-off words, along with incorrect words, repetitions, jargon words, irrelevant statements, digressions, frame statements ("Let's see, now..."), and comments ("This is a strange picture").

Total Number of Words: ________

Number of Correct Information Units: ________
(Transfer to page 16, Scoring Worksheet.)

Number of Correct Information Units: Count the number of new pieces of **correct** information about the picture given by the patient. If the patient repeats, count only the best mention of a particular element (e.g., "the eggs" rather than "the egg"). (A list of acceptable information units can be found in the **ADP** *Manual*.)

Number of Probes: Count the number of additional neutral probes used after the initial presentation of the item.

Number of Probes Used: ________

Index of Wordiness (Total Words Divided by Correct Information Units): ________

3. Say to the patient, *"That's fine. Now I want to test your memory a little. Do you remember President Kennedy? What can you tell me about him?"* Again, neutral probes such as "Can you tell me more?" may be used.

Phrase Number	Phrase	Phrase Length

Average of 3 Longest Phrase Lengths: [ ]

ADP Phrase Length: [ ]
(Transfer to page 16, Scoring Worksheet.)

When testing is complete, compare the averages of the 3 longest phrase lengths from the three samples transcribed on pages 6, 7, and 8. Find the highest average, called the **"ADP Phrase Length."** Transfer to the Scoring Worksheet (page 16); look up the standard score equivalent. Use that standard score in the Classification Profile. If no sample has at least three phrases, average across samples.

NAMING

Say to the patient, *"Here are some pictures that might be a little easier for you. What is this?"* Present cards 2-13. Do not cue the patient. Record any spontaneous use of correct representational gestures such as throwing the dart. If the patient gives a phrase instead of one word, say, *"Just give me one word."* Classify all errors and note delays. *Do NOT score gestures.*

3 = Immediately, Fully Correct	
2 = Mostly Correct Immediately, Fully Correct with Prolonged Delay, or Self-Corrected	
1 = Some Correct	
0 = Fully Incorrect	
G = Correct Representational Gesture	
N = No Response	

- ph Phonemic Paraphasia ("kack" for jack)
- sm Semantic Paraphasia ("clock" for watch)
- aug Augmentation ("sojie watch" for watch)
- pw Part Word ("noculars" for binoculars)
- cir Circumlocution/Description ("blow it" for whistle)
- ps Phonemic Error on Semantic Paraphasia ("miskroscope" for binoculars)
- neo Neologistic Paraphasia ("kargy" for whistle)
- urw Unrelated Real Words ("thunder time" for scissors)
- ste Stereotypy ("bukky, bukky" for wrench)
- per Perseveration (after naming scissors, "sistle" for whistle)
- o Other ("I know this one but I can't think of the word")
- un Unintelligible, nontranscribable
- vp Visual Perceptual ("trash cans" for binoculars)

Card	Item/Response	Score						Error Type												
2.	1. Watch	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
3.	2. Gun [pistol, revolver, firearm]	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
4.	3. Key	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	rel	ste	per	o	un	vp
5.	4. Dart	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
6.	5. Jack	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
7.	6. Scissors [shears]	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
8.	7. Whistle	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
9.	8. Tweezers	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
10.	9. Binoculars [field glasses]	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
11.	10. Wrench	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	rel	ste	per	o	un	vp
12.	11. Thermometer	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
13.	12. Typewriter	3	2	1	0	G	N	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
	Column Totals																			
	Naming Score (Transfer to page 16, Scoring Worksheet.)	/36						(Transfer to page 14, Error Profile.)												

AUDITORY LANGUAGE COMPREHENSION

This subtest contains three sections. Each item receives a score of 1 or 0. After giving all three sections, use the formula on the bottom of page 11 to sum the scores and find the Auditory Language Comprehension Score.

1 = Correct Response
0 = Incorrect Response
R = Repeated Stimulus
N = No Response

Following Commands

"Okay, now I want you to do some things without talking." If the patient asks, the command may be repeated one time without penalty, but it should be noted by marking the "R" in the response grid.

Item/Response	Score			
1. *Sit up straight.*	1	0	R	N
2. *Now, take a deep breath and relax.*	1	0	R	N
3. *Close your eyes. [Now open them.]*	1	0	R	N
4. *Look all around the room because I'm going to ask you to find something. Check it out. Now...*	1	0	R	N
5. *Where is the exit?*	1	0	R	N
6. *Let's do something different. Please make a fist.*	1	0	R	N
7. *Where is your heart?*	1	0	R	N
8. *Where is your elbow?*	1	0	R	N
Commands Subtotal				

Comprehension of Single Words

Use Cards 14–18 for this section. Begin by placing Card 14 in front of the patient and saying, *"Now for something new. Look carefully at these pictures and show me the [clock.] Now show me the [keys]."* Again, one immediate repetition upon request is permitted without penalty but should be noted in the "R" column.

ph Phonemically Related ("lock" for "clock")
sm Semantically Related ("lock" for "keys")
per Perseveration (incorrectly points to "lock" a second time)
o Other ("watch" for keys)

Card	Item/Response	Score				Errors			
14.	1. *Clock*	1	0	R	N	ph	sm	per	o
	2. *Keys*	1	0	R	N	ph	sm	per	o
15.	3. *Shower*	1	0	R	N	ph	sm	per	o
	4. *Tree*	1	0	R	N	ph	sm	per	o
16.	5. *Banjo*	1	0	R	N	ph	sm	per	o
	6. *Stool*	1	0	R	N	ph	sm	per	o
17.	7. *Candle*	1	0	R	N	ph	sm	per	o
	8. *Ladder*	1	0	R	N	ph	sm	per	o
18.	9. *Headphone*	1	0	R	N	ph	sm	per	o
	10. *Flashlight*	1	0	R	N	ph	sm	per	o
	Single Words Subtotal (Transfer error information to page 14, Error Profile.)								

Understanding Stories

These stories may be read only once, but the questions may be repeated one time without penalty if the patient asks you to repeat them. If the patient fails to answer clearly, instruct him or her to respond with either yes or no. Present all questions after each story. In order to receive credit, the patient must choose the correct answer (marked *) to both questions in each matched pair; that is, both question #1 and question #3 must be answered correctly to receive a score of 1. Present the questions for each story by reading down the left column and then down the right column; that is, read question #1, then #2, then #3, and finally #4.

A. *"Now let's do something different. This time I'm going to read you some stories and then ask you some questions about them. Listen carefully, because some of the questions are kind of tricky, and I'm only allowed to read the story once. Are you ready?"*

"My cousin's doctor recommended that she get some exercise and lose 25 pounds, so she decided to buy a stationary bike. She rode two miles a day, but she never reached her goal."

Question	Resp.		Question	Resp.		Items	Score		
1. *Did my cousin's doctor recommend that she put on a little weight?*	Y	N*	3. *Did my cousin's doctor recommend that she lose 25 pounds?*	Y*	N	1 & 3	1	0	N
2. *Did my cousin reach her goal?*	Y	N*	4. *Did my cousin lose 25 pounds?*	Y	N*	2 & 4	1	0	N
						Story A Subtotal			

B. *"Good. Here's another one. Listen carefully."*

"My friend Bobby is a professional singer. Last week her manager, Robin, was very concerned when Bobby had a sudden attack of laryngitis the day before a performance. Robin thought he would have to cancel the concert, but fortunately Bobby recovered."

Question	Resp.		Question	Resp.		Items	Score		
5. *Is my friend Bobby a woman?*	Y*	N	9. *Is my friend Bobby a man?*	Y	N*	5 & 9	1	0	N
6. *Did Bobby's manager think Bobby would be able to perform?*	Y	N*	10. *Did Bobby's manager think he would have to cancel her concert?*	Y*	N	6 & 10	1	0	N
7. *Did the concert go on as planned?*	Y*	N	11. *Was the concert cancelled?*	Y	N*	7 & 11	1	0	N
8. *Was Robin concerned last week because Bobby had appendicitis?*	Y	N*	12. *Was Robin concerned last week because Bobby had laryngitis?*	Y*	N	8 & 12	1	0	N
						Story B Subtotal			

C. *"Good. Here's the last one. Listen carefully, because it's kind of long."*

"My aunt Alberta, a professor who lives in Boston, has trouble getting to places on time, so her lectures often have to be rescheduled. Last week, she had to catch an 8:45 a.m. plane to Albuquerque for an afternoon lecture. Not surprisingly, to those of us who know her, her lecture was rescheduled for the following morning."

Question	Resp.		Question	Resp.		Items	Score		
13. *Is my aunt frequently late?*	Y*	N	17. *Is my aunt good about getting to places on time?*	Y	N*	13 & 17	1	0	N
14. *Was my aunt going to Alberta?*	Y	N*	18. *Was she going to Albuquerque?*	Y*	N	14 & 18	1	0	N
15. *Did she miss her scheduled plane?*	Y*	N	19. *Did she arrive at the airport on time?*	Y	N*	15 & 19	1	0	N
16. *Was she supposed to leave in the morning?*	Y*	N	20. *Was she scheduled to leave in the afternoon?*	Y	N*	16 & 20	1	0	N
						Story C Subtotal			

Commands Subtotal	/8	+	Single Words Subtotal	/10	+	Story A Subtotal	/2	+	Story B Subtotal	/4	+
Story C Subtotal	/4	=	Auditory Lang. Comp. Total Score	/28							

(Transfer to page 16, Scoring Worksheet.)

REPETITION

Say to the patient, *"Now, I want you to try to repeat some things after me. Do the best you can. Some of them are long. Can you say ... ?"* One immediate repetition upon request is permitted without penalty, but should be noted with an "R" on the response grid. Classify all errors.

3 = Immediately, Fully Correct
2 = Mostly Correct Immediately, Fully Correct with Prolonged Delay, or Self-Corrected
1 = Some Correct
0 = Fully Incorrect
R = Repeated Stimulus
N = No Response

- ph — Phonemic Paraphasia ("noney" for money)
- sm — Semantic Paraphasia ("children" for babies)
- aug — Augmentation ("hundreds" for hundred)
- pw — Part Word ("lidoscope" for kaleidoscope)
- pa — Paraphrase ("here she is" for Is she here?)
- pp — Partial Phrase ("three hundred dollars" for three hundred and twenty-one dollars)
- ps — Phonemic Error on Semantic Paraphasia ("dreiden" for babies)
- neo — Neologistic Paraphasia ("foriga" for tornado)
- urw — Unrelated Real Words ("dreams of fire" for Babies cry)
- ste — Stereotypy ("bukky, bukky" for pizza)
- per — Perseveration (after saying money, "mizza" for pizza)
- o — Other ("You've got to be kidding" for Chuck challenged Chick ...)
- un — Unintelligible, nontranscribable

Item/Response	Score						Error Type												
1. *Money*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
2. *Pizza*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
3. *I love you.*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
4. *Kaleidoscope*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
5. *Babies cry.*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
6. *Is she here?*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
7. *Three hundred and twenty-one dollars*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
8. *If they come, he will go.*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
9. *After you push the button, turn the knob.*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
10. *Happy hippopotamus*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
11. *A terrible tornado*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
12. *Chuck challenged Chick to a game of quoits.*	3	2	1	0	R	N	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
Column Totals																			
Repetition Score (Transfer to page 16, Scoring Worksheet.)	/36						(Transfer to page 14, Error Profile.)												

ELICITED GESTURES

Before beginning, tell the patient that you are going to ask him or her to pretend to do some things without talking. Then say, *"Show me how you would...."* Note that, when testing oral movements (Items 1 and 2), it is important to suppress any hand movements the patient might use as a form of self-cuing.

3 = Immediately, Fully Correct
2 = Mostly Correct Immediately, Fully Correct with Prolonged Delay, or Self-Corrected
1 = Some Correct
0 = Fully Incorrect
N = No Response

"Okay, now we're going to try some things without talking. Without talking, show me how you would ...:"

Item/Response	Score				
1. *Lick someone's ice cream cone.*	3	2	1	0	N
2. *Blow out a candle.*	3	2	1	0	N

"Now I want you to use your hand to show me some things. Remember, no talking. Show me how you ...:"

Item/Response	Score				
3. *Wave goodbye.*	3	2	1	0	N
4. *Saw a board in half.*	3	2	1	0	N

Use cards 19–21. Say, *"This is the last batch. This time I'm going to show you some pictures of*
Again, without talking, show me a gesture that would represent this object." Do not name the object for the patient.

Card	Item/Response	Score				
19.	5. Bugle.	3	2	1	0	N
20.	6. Can of paint and a stir stick.	3	2	1	0	N
21.	7. Piano.	3	2	1	0	N
	Column Totals					
	Elicited Gestures Score (Transfer to page 16, Scoring Worksheet.)	/21				

SINGING

This section assesses three aspects of singing: whether a patient can (1) initiate the song, (2) carry the tune, and (3) produce at least some of the words of the song. Score 3 points if the patient meets all three criteria, 2 points for two criteria, 1 point for one criterion, and 0 points for no criteria met. If the patient cannot initiate an appropriate song spontaneously, introduce the song(s) and ask him or her to continue. In this case, no score of 3 can be earned. Show the patient cards 22–25 and say, *"Look at this picture. Can you think of a song you might sing when someone is presented with this?"*

Card	Item/Response	Score				
22	1. Birthday cake. ("Happy Birthday to You.")	3	2	1	0	N
23.	2. Cradle. ("Rock-a-Bye-Baby" or other "baby" song.)	3	2	1	0	N
24./ 25.	3. National flag. ("Star-Spangled Banner," "O Canada," or other patriotic song.)	3	2	1	0	N
	Column Totals					
	Singing Score (Transfer to page 16, Scoring Worksheet.)	/9				

BEHAVIORAL PROFILE

Following the completion of the examination, complete the Behavioral Profile by marking the appropriate descriptive observations of the patient's behavior during the **ADP** exam. There will be **no basis for judgment** of some behaviors, and that should be so indicated. In order to prorate scores, at least 8 features must be rated.

Lethargic	1	Somewhat Lethargic	2	Alert	3	No Basis	
Confused	1	Somewhat Confused	2	Lucid	3	No Basis	
Disinhibited	1	Somewhat Disinhibited	2	Appropriate	3	No Basis	
Unconcerned	1	Somewhat Unconcerned	2	Concerned	3	No Basis	
Uncooperative	1	Somewhat Cooperative	2	Cooperative	3	No Basis	
Impulsive	1	Somewhat Impulsive	2	Deliberate	3	No Basis	
Emotionally Labile	1	Somewhat Labile	2	Emotionally Stable	3	No Basis	
Disagreeable	1	Somewhat Disagreeable	2	Pleasant	3	No Basis	
Self-Deprecating	1	Somewhat Self-Deprecating	2	Self-Confident	3	No Basis	
Discouraged	1	Somewhat Discouraged	2	Optimistic	3	No Basis	
Anxious	1	Somewhat Anxious	2	Relaxed	3	No Basis	
Unrealistic	1	Somewhat Unrealistic	2	Realistic	3	No Basis	
Suspicious	1	Somewhat Suspicious	2	Trusting	3	No Basis	
Verbose	1	Somewhat Verbose	2	Verbally Interactive	3	No Basis	

☐ (a) Total Points (Sum of col. 1 + Sum of col. 2 + Sum of col. 3)

☐ (b) Number of Features Rated (14 − Number of "No Basis" checked)

☐ Behavioral Profile Raw Score [(a) or Prorated Behavioral Profile Score (a) ÷ (b) × 14; see **ADP** *Manual*, Table 4.2]

ERROR PROFILES

For each error in each profile, record the total in the "Error Count" space at the top of the appropriate column. Find the row that displays the range containing each total and record the number of that row in the "Standardized Error Score" (SES) space at the bottom of the column.

Comprehension of Single Words

	Error Count			
	ph	sm	per	o
SES 1		1		
SES 2	1	2		
SES 3	2–4	3–6		
	Standardized Error Score			

Naming

	Communicative Error Count					Noncommunicative Error Count							Nonaphasic Error Count
	ph	sm	aug	pw	cir	ps	neo	urw	ste	per	o	un	vp
SES 1	1	1			1		1			1–2	1		
SES 2	2–4	2	1	1	2–3		2–3	1–2		3–6	2–4	1–2	1
SES 3	5–6	3–4	2	2–6	4–8	1	4–8	3–11	1–12	7–11	5–11	3–12	2–4
	Standardized Error Score					Standardized Error Score							SES

Repetition

	Communicative Error Count						Noncommunicative Error Count						
	ph	sm	aug	pw	pa	pp	ps	neo	urw	ste	per	o	un
SES 1	1			1	1	1					1		
SES 2	2–3	1	1		2	2–3		1–2	1–2		2–3	1–3	1–3
SES 3	4–9	2	2	2–3	3–4	4–5	1–2	3–7	3–5	1–12	4–12	4–12	4–12
	Standardized Error Score						Standardized Error Score						

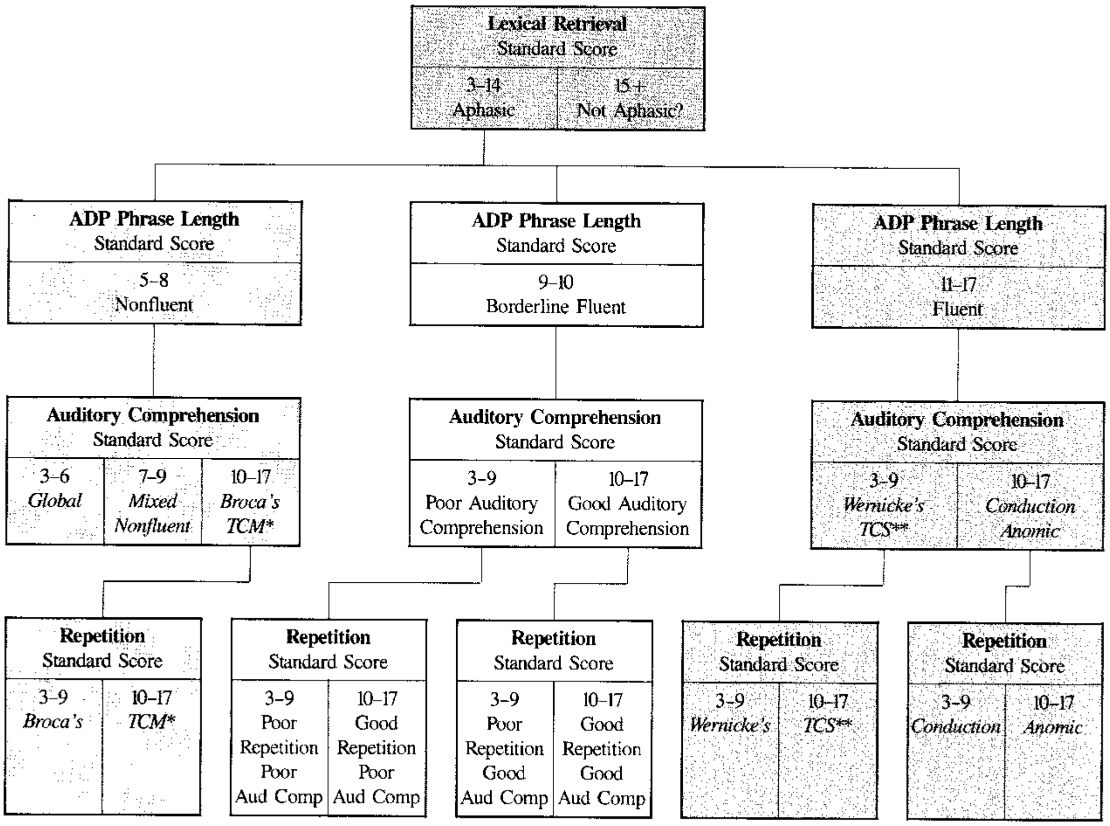
14

CLASSIFICATION PROFILE

Following the completion of the examination, complete the Classification Profile by marking the appropriate STANDARD SCORES, from the Scoring Worksheet on page 16. *Note:* DO NOT use raw scores.

Nonfluent types
Borderline fluent types
Fluent types

**TCM = Transcortical Motor*
***TCS = Transcortical Sensory*



SCORING WORKSHEET

	Subtest/Score (Norms Table 1)			Lexical Retrieval (Norms Table 2)			Aphasia Severity (Norms Table 3)			Alternative Communication (Norms Table 3)		
	Raw Score	SS	PR	Subtest Std. Score	Lex. Retriev. SS	Lex. Retriev. PR	Subtest Std. Score	Aphasia Sev. SS	Aphasia Sev. PR	Subtest Std. Score	Alt. Comm. SS	Alt. Comm. PR
Personal Information, p.3												
Writing, p.4												
Reading, p.4												
Information Units, p.7												
ADP Phrase Length, p.8												
Naming, p.9												
Auditory Comprehension, p.11							×2=					
Repetition, p.12							×1=					
Elicited Gestures, p.13												
Singing, p.13												
Behavioral Profile, p.14 (Norms Table 3)		SS	PR									
Lexical Retrieval				Sum	SS	PR	×2=					
Aphasia Severity							Sum	SS	PR			
Alternative Communication										Sum	SS	PR

SCORE SUMMARY

Plot subtest and composite STANDARD SCORES from the worksheet. To reflect confidence ranges, plot an interval of +1 SEM (upper limit) to −1 SEM (lower limit) for each standard score. Consider any two scores different if their confidence ranges do not overlap.

	Lexical Retrieval — Standard Scores			Aphasia Severity Profile — Standard Scores			Alternative Communication Profile — Standard Scores				Summary — Standard Scores		
	Personal Info.	Info. Units	Naming	Auditory Compre.	Repetition	Lexical Retrieval	Writing	Reading	Elicited Gestures	Singing	Aphasia Severity	Altern. Commun.	Behavioral Profile
SEM	.9	.9	.7	1.0	.6	.3	.7	.7	.9	1.2	1.0	.8	6.7
Upper Limit + points													
Lower Limit − points													

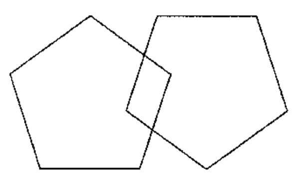
	Subtest scale	Summary scale
+2SD	17	
	16	130
	15	125
	14	120
+1SD	13	115
	12	110
	11	105
Mean	10	100
	9	95
	8	90
−1SD	7	85
	6	80
	5	75
−2SD	4	70
	3	
	2	

APPNEDIX E
THE MINI-MENTAL STATE EXAMINATION

The Mini-Mental State Exam

Patient________________________ Examiner ____________________ Date________

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials ________
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.



____ Total Score

ASSESS level of consciousness along a continuum ________
Alert Drowsy Stupor Coma

"MINI-MENTAL STATE." A PRACTICAL METHOD FOR GRADING THE COGNITIVE STATE OF PATIENTS FOR THE CLINICIAN. *Journal of Psychiatric Research*, 12(3): 189-198, 1975. Used by permission.

APPENDIX F
MIAMI VETERAN'S ADMINISTRATION MEDICAL CENTER COMMUNICATION SCREENER

COMMUNICATION SCREENING
MIAMI VETERANS ADMINISTRATION MEDICAL CENTER

Name: ____________________ S.S.# ____________________ Date: _________

Admission Date: _________ Ward: _______ Date of Birth: __________ Age: _____

Examiner: ______________________ Audiology/Speech Language Pathology

SIGNIFICANT MEDICAL HISTORY:

Stroke:	Yes: ____ No: ____	Head Injury:	Yes: _____ No: ______
Heart Attack	Yes: ____ No: ____	Dementia:	Yes: _____ No: ______

Other: ____

Medications: ____

COMMUNICATION HISTORY:

	Patient Identified	Staff Identified
Hearing Problem:	Yes __ No __	Yes __ No __
Speech Problem:	Yes __ No __	Yes __ No __
Voice Problem:	Yes __ No __	Yes __ No __
Language Problem:	Yes __ No __	Yes __ No __
Memory Problem:	Yes __ No __	Yes __ No __
Swallowing Problem:	Yes __ No __	Yes __ No __
Drooling:	Yes __ No __	Yes __ No __

History of Speech-Language and/or Hearing Intervention: _______________

Hearing Aid: ________ Dentures: ________ Glasses: ________________

OBSERVATION:

Socialization:	Appropriate: ___________	Withdrawn: ___________
Appearance:	Appropriate: ___________	Disheveled: ___________

Other: ____

HEARING SCREENING:

Otoscopic Exam: ____

Pure Tone Screening:

	500 Hz 35 dB	1000 Hz 30 dB	2000 Hz 30 dB	3000 Hz 50 dB
Right:	_____	_____	_____	_____
Left:	_____	_____	_____	_____

PASS/FAIL

VISION SCREENING:

B F M E P W Did not Respond: ___________ Refused: ____________
Visual Field Deficit: ______________ Other: _______________

PASS/FAIL

COMMUNICATION SCREENING:
DISCOURSE:
Mr. (Mrs., Ms.) __________, I'm here today to find out if you have any problems using or understanding words, but first, I'd like to get to know you a little bit.

1. Where were you born?
2. What kinds of things do you do here?
3. Did you have a big family?
   a. How many brothers and sisters do you have?
   b. Tell me about your wife.
   c. How many children do you have?

Failure = Any evidence of anomia, paraphasia, confabulation, circumlocution, rejection, and/or any error on personal biographic information. PASS/FAIL

PICTURE DESCRIPTION:

Look at this picture and tell me what's going on:

Need for repetition:	Yes ________	No ________
Need for prompting:	Yes ________	No ________
Need for cueing:	Yes ________	No ________

Vocabulary/Word finding:	Passed ____	Failed ____	Note _____
Grammar:	Passed ____	Failed ____	Note _____
Syntax:	Passed ____	Failed ____	Note _____
Articulation:	Passed ____	Failed ____	Note _____
Voice:	Passed ____	Failed ____	Note _____
Relevance:	Passed ____	Failed ____	Note _____

Example of Sentence: ____
____

Evidence of appropriate self correction:	Yes ______	No ______
Patient refused to complete verbal task:	Yes ______	No ______
Patient did not respond:	Yes ______	No ______

Failure = Any apparent disorder of phonatory, resonatory, articulation/oral-motor process and/or evidence of anomia, paraphasia, confabulation, circumlocution, or rejection. PASS/FAIL

GRAPHIC OUTPUT:

Now, I want you to write down what you just told me.

Alternate: If patient is unable to remember what he/she saw in the picture ask him/her to write down a sentence to dictation. "I'll tell you a sentence and you write it down. The family is having a picnic at the lake."

Hand Used:	Right _____	Left _____	
Legibility:	Passed ____	Failed____	Note ____

Spelling:	Passed ____	Failed____	Note ____
Vocabulary:	Passed ____	Failed____	Note ____
Grammar:	Passed ____	Failed____	Note ____
Syntax:	Passed ____	Failed____	Note ____
Evidence of self correction:		Yes ______	No ______
Refused to complete task:		Yes ______	No ______
Patient did not respond:		Yes ______	No ______

Failure = Any evidence of anomia, paraphasia, confabulation, circumlocution, rejection, visual perceptual errors, spelling errors, syntax errors, memory/recall errors. PASS/FAIL

ORAL READING:

Now, I want you to read this short story aloud.

* THE SUNFLOWER, A NATIVE OF NORTH AMERICA, IS A STRONG COARSE PLANT WITH ROUGH TOOTHED LEAVES AND FLOWERS. IT IS A QUICK GROWER IN LIGHT, DRY SOIL, AND MAY GROW FROM 3 TO 15 FEET IN HEIGHT. IT WAS GROWN BY THE INDIANS FOR FOOD.

Intelligibility:	Passed _______	Failed _______	Note _______
Word Pronunciation errors:	Passed _______	Failed _______	Note _______
Rate:	Passed _______	Failed _______	Note _______
Omissions:	Passed _______	Failed _______	Note _______
Additions:	Passed _______	Failed _______	Note _______
Patient refused to complete the reading task:		Yes ________	No _______
Patient did not respond:		Yes ________	No _______

Failure = 5/45 words PASS/FAIL

AUDITORY COMPREHENSION:

I'm going to read you a short story then ask you some questions. Ready?
*DOCTORS DO NOT KNOW WHAT CAUSES THE COMMON DISEASE KNOW AS THE COLD. COLDS ARE PROBABLY CAUSED BY A GERM, BUT IT HAS NEVER BEEN FOUND. THE WORST SEASON FOR COLDS IS FALL. TO AVOID GETTING A COLD YOU SHOULD EAT WELL, DRESS FOR THE WEATHER, AND KEEP OUT OF CROWDS WHEN YOU CAN.

1.	Do doctors know what causes a cold?	Yes	No
2.	Is Spring the worst time for colds?	Yes	No
3.	Are colds probably caused by germs?	Yes	No
4.	Is it wise to stay out of crowds to avoid a cold?	Yes	No
5.	Is it also best to dress for the weather to avoid a cold?	Yes	No

Patient refused to complete auditory comprehension task: Yes ______ No______
Patient did not respond: Yes ______ No ______
Failure = Errors on 2/5 questions PASS/FAIL

COMMENTS: ____

____

____

REFERRALS RECOMMENDED:	Audiology	Speech Pathology	Dysphagia
	Dental	Eye Clinic	Psychology
	EMS	ENT	RT
	Other: ______________________		

APPENDIX G: FIGURES G1-G6

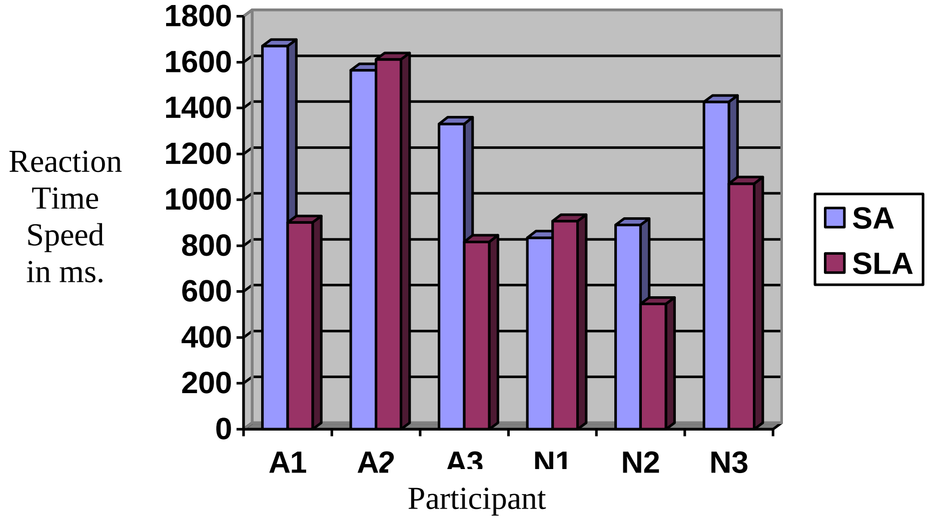


Figure G1
Individual Performance on SA versus SLA

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

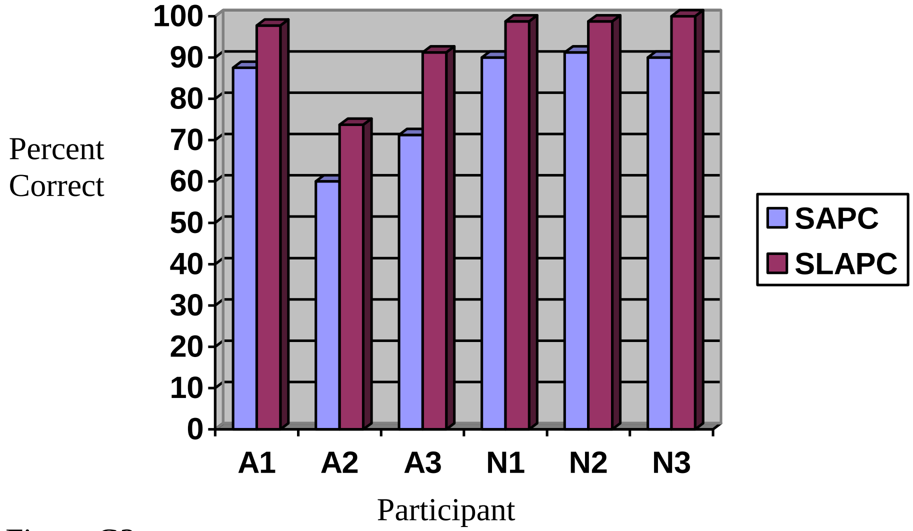


Figure G2
Individual Performance on SAPC versus SLAPC

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

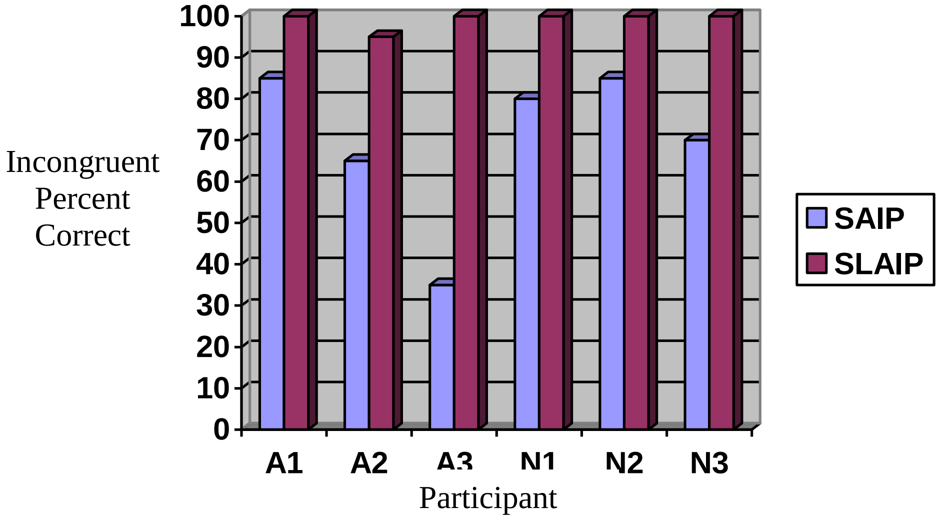


Figure G3
Individual Performance on SAIP versus SLAIP

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

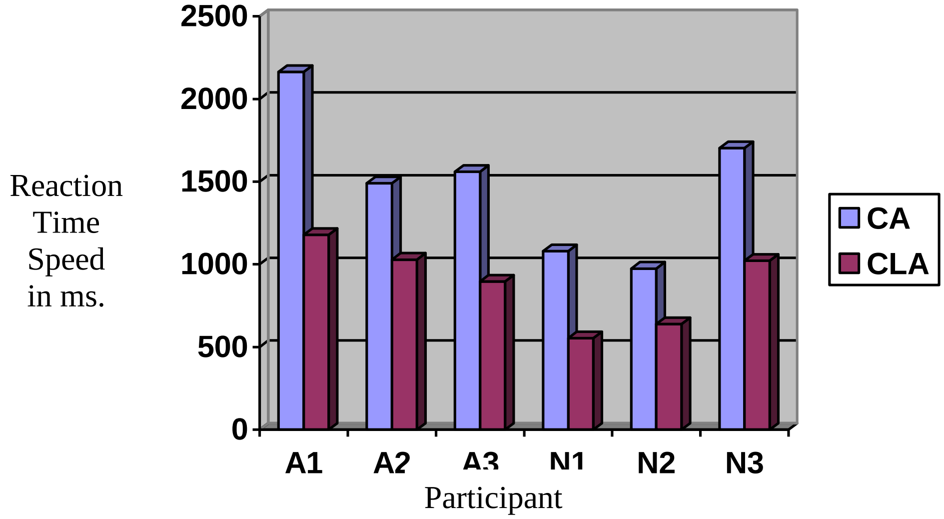


Figure G4
Individual Performance on CA versus CLA

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

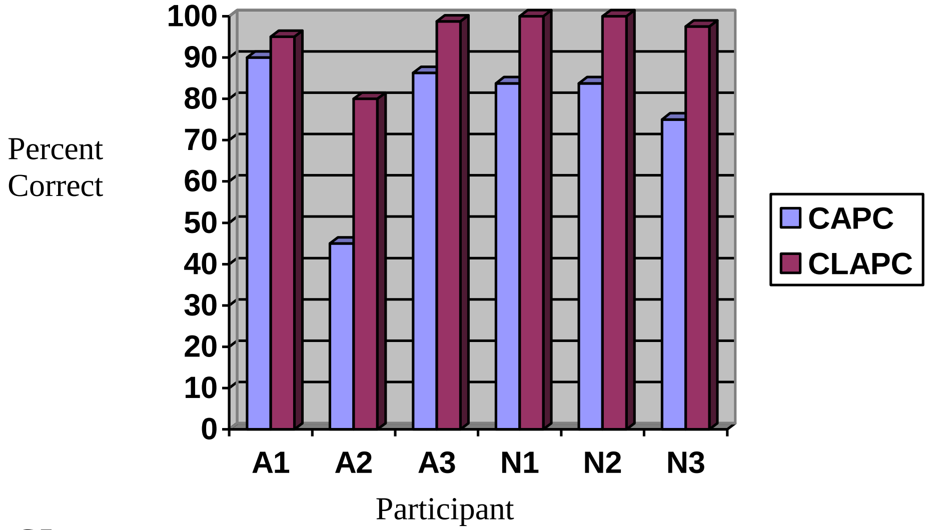


Figure G5
Individual Performance on CAPC versus CLAPC

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

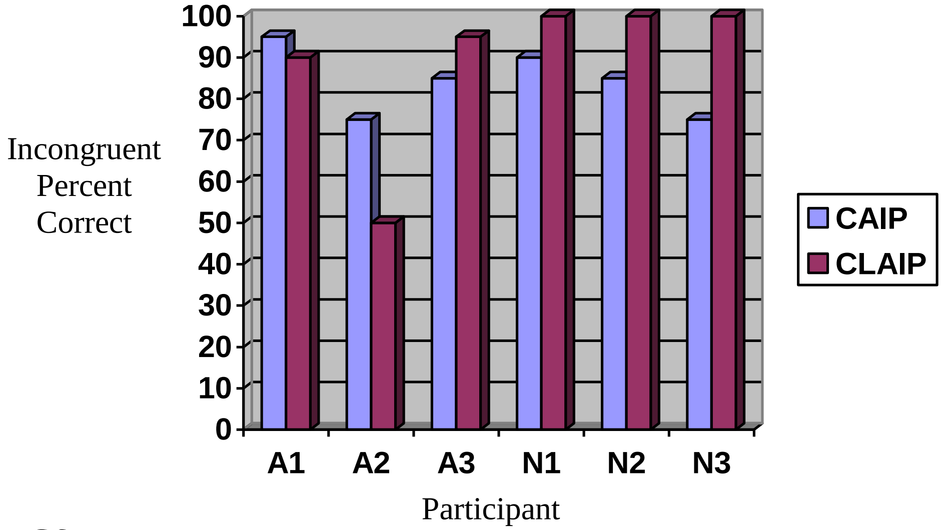


Figure G6
Individual Performance on CAIP versus CLAIP

A1-Individual with Aphasia 1
A2-Individual with Aphasia 2
A3- Individual with Aphasia 3
N1-Non-Neurologically Damaged Individual 1
N2-Non-Neurologically Damaged Individual 2
N3--Non-Neurologically Damaged Individual 3

VITA

Meghan Evelyn Collins was born in Baton Rouge, Louisiana, on July 2, 1982. She received her Bachelor of Arts degree in psychology from Hendrix College in May 2004. She continued her education at Louisiana State University for a Masters of Arts in Communication Disorders. While completing this thesis she began doctoral work in adult language disorders post stroke. Future plans include completing her doctoral work in speech language pathology and continuing to research nonverbal language abilities post stroke.