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Naming and Inhibition in Aphasia

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by

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Dedication

This dissertation is dedicated to my husband, Ken, without whom I could never have accomplished my goals.

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ABSTRACT

Lexical retrieval models illustrate both activation and inhibition between concepts, words, and phonemes. When semantic activation spreads from one concept to its related concepts, inhibition is recruited so that competition between related concepts can be overcome and a target production achieved. Persons with aphasia often exhibit difficulty with producing the desired response, which could be the result of inadequate inhibitory processes to overcome response competition.

Inhibitory processing is typically measured using a negative priming task. Twenty participants with aphasia, twenty-five young participants, and twenty age-matched aphasia group controls were recruited for this study. Participants with aphasia completed a picture-naming task, two written lexical decision tasks, subtests of an aphasia assessment, and the negative priming lexical decision task. Control groups completed only the negative priming task. This task consisted of 4 blocks of 72 trials each in which target words were related associates (RA), related distractors (RD), or unrelated (UN), or pseudowords.

Results indicate that no groups showed predicted decreased reaction times to the RA condition. Instead of showing the fastest reaction times, the average RTs in the RA condition were between those in the RD and the UN conditions. Error rates were higher in the aphasia group, with significantly more errors for related conditions. In the young control group, significant negative priming was achieved. However, in the aphasia and aphasia-control groups, there was no significant negative priming. Multiple regression analysis determined that time post onset, age, education, type of fluency, and classification of anomia were not significant predictors of these results in the aphasia group.

It is argued that these results are not strategically induced secondary to expectancy or a semantic expectancy or a semantic-matching process. Using a prospective or a retrospective strategy would be useless since only a small portion of the prime-probe pairs are directly related. The results of the aphasia group and the aphasia-control group are similar to those found in the aging negative priming literature, but it is unclear if this should be interpreted as degraded inhibitory processes. Future studies to further explore negative priming in aphasia are discussed.

Chapter One

Introduction

Inhibitory processes can be conceptualized in different ways. In one way, one can think of inhibition as overtly withholding a response to keep from blurting out an answer in class or from reaching out to catch a sharp object. Another way to think about inhibition is as an automatic, unconscious process that prevents unpleasant memories from conscious recollection or assists one in focusing attention (Anderson, 1994). The retrieval of words and memories from long term memory is generally thought to be due to both activation of lexical information and inhibition of irrelevant information (Houghton & Tipper, 1994). To retrieve information, inhibition is necessary to keep non-relevant words and thoughts from intruding and causing interference for related items.

According to Anderson (1994), the presentation of a stimulus activates the semantic representation of that stimulus in long-term memory. Activation is considered to be an increase in the level of the resting state of that representation. When the stimulus is a lexical representation such as a word, the activation of that word spreads throughout a connected network such that all concepts related to that word are also activated according to how strongly the concepts are associated to the stimulus. This spreading activation (Collins & Loftus, 1975) to associated lexical representations is excitatory and facilitates retrieval of related concepts. To retrieve a word, it must be sufficiently activated so that a threshold value is obtained that is higher than the other related words or concepts. The highest activated word is then selected instead of the other possible responses.

If several related concepts are strongly activated (strongly related to the target representation) such that there is competition amongst them for the most highly activated, interference occurs. Interference is disruptive to processing because it can cause bottlenecks so that production is temporarily limited (Harnishfeger, 1995). When interference occurs, inhibition is recruited (Anderson, 1994). Inhibition reduces the level of activation of competing responses that may be irrelevant or inappropriate for the context. This competition amongst related lexical representations produces interference, which can be resolved by inhibitory mechanisms. If inhibitory mechanisms are slowed, intermittently active, overactive, or absent, the lexical representation that is produced may not always be the most highly activated. This could occur because unresolved interference between competitors may lead to selection of an incorrect word, the inability to retrieve a word, or intermittent target word retrieval.

Interactive Activation Models

There are many theories and models of lexical retrieval, the most popular of which are interactive activation models. According to McClelland and Rumelhart (1988), these models depict multilevel, interactive perceptual processing. In an interactive model, information is processed bidirectionally between levels in a network-like manner, not serially and sequentially. The flow of information is also continuous so that processing at each level is influenced by the other levels. Interactive activation models of naming (Bowles, 1994) can include inhibitory as well as excitatory connections between levels and the representations (nodes) within each level. To verbally produce a word, the semantic system accesses the relevant representation, activating all other associates of that word according to the connection strength of each associate to the target word. This is accomplished by spreading activation from stimulus to associates in a net-like manner. For example, the word "cat" has 3 associates (small set size)--dog, mouse, and kitten (Nelson, McEvoy, & Schreiber, 1998). Dog is considered to be the first associate because when cat is given as a cue, dog has the highest probability of being stated in a free-association task. Activation of cat, then would produce spreading activation to dog, mouse, and kitten. The number of associates of a cue is important because of a target set size effect. Nelson, McEvoy, Janczura, and Xu (1993) found that when using a cued recall paradigm, participants tested immediately after study of a list recalled more words with a small number of associates than words with a higher number of associates. Therefore, there is a greater chance in smaller activated set sizes that the desired target will be produced.

In addition to implicit activation of semantic associates, the phonemes of the target and its associates are also activated to varying degrees. Due to the possibly large number of lexical associates and phonemes activated above threshold, interference (competition) (Harnishfeger, 1995) may occur between the most highly activated nodes. This interference can be resolved by the recruitment of inhibition, which reduces the activation levels of competitors so that the target word will "win" the competition and be selected. In a person with brain damage, the lexical access system may become disrupted by altering the connection strengths, the threshold levels of activation, the spread of activation, or the recruitment of inhibition such that competition cannot be resolved. Access to the target semantic or phonological representation may be disrupted such that competing associate words or phonemes can have higher activation than the target representations, resulting in the production of inappropriate or unintended words or phonemes.

Models of picture naming (Bowles, 1994; Chilant, Costa, & Caramazza, 2002) propose interconnected layers of processing. Nodes of these layers represent semantic, phonological, and visual representations. An example of lexical retrieval in an interactive activation model is the expressive production of the word “cat” in response to a picture of a cat. This picture input activates the visuo-semantic features and the concept “cat”, along with the semantic associates of “cat”, such as “dog” and “mouse” in proportion to how strongly these presentations are associatively connected to the target word. For example, the representation for “dog” is more strongly associated to the cue “cat” than is the representation for “mouse”, so “dog” would be activated more strongly than “mouse”. This activation also spreads not only to the phonemes of the target word (/k/ /æ/ /t/), but also to the phonemes of its associates (/d/ /α/ /g/). The activated phonemes return activation back to the concept nodes to which they are connected. The lexical representation of “cat” also activates all phonological associates that begin with /k/ and inhibits the phonological associates that do not begin with /k/. With this large network of activated nodes, those representations reaching a threshold level of activation compete with each other for selection. Inhibition is important to resolve this interference, and is recruited both between and within nodes and layers to reduce the levels of activation of inappropriate lexical and phonological nodes. The lexical representation for “cat” will remain activated at high levels, but the activation levels of “dog” and “mouse” will be reduced from inhibition. The highly activated phonemes for “cat” send this activation back to the concept layer and also to the word output layer. The concept and phonemes for “cat”, having the highest activation, are selected for output and verbally produced.

Interactive activation models of lexical access become especially useful to describe production and comprehension errors in persons with aphasia. Aphasia is an acquired language disorder that can occur after a person has a stroke or a head injury affecting the language dominant cerebral hemisphere, typically the left hemisphere. Regardless of the type or severity of the aphasia, the most obvious language disturbance may be anomia, a difficulty producing item labels. This can be manifested in conversation, when confronted with naming an item, and/or may be intermittent such that the target is produced on one occasion but not the next. Errors during speech are generally present and can be of phonological, semantic, unrelated, or mixed origin (Gagnon & Martin, 2002).

Phonological errors (also known as formal errors) are substitutions of phonemes, such as “/h/ /æ/ /t/” instead of “/k/ /æ/ /t/”, while semantic errors substitute a word from the same category, such as “spoon” instead of “fork”. Unrelated errors show no obvious similarities (“glass” for “dog”), and mixed errors contain elements of both phonological and semantic influences (“hog” for “dog”).

Semantic production errors can be integrated into the paradigm of interactive activation models of lexical access. Assuming that the appropriate target lexical representation is activated when a picture or set of graphemes is viewed, activation should spread to the target’s semantic and phonological associates as well as boost the target’s activation above threshold. Subsequent interference should be resolved by inhibition so that the target word may be produced. However, if inhibitory mechanisms are absent (Fox, 1995; Mari-Beffa, Hayes, Machado, & Hindle, 2005), reduced (Hasher, Stoltzfus, Zacks, & Rypma, 1991), slowed (Prather, Zurif, Stern, & Rosen, 1992), or overactive, production errors may occur in the lexical retrieval of persons with aphasia. For example, when attempting to name a picture of a dog, a semantic error could be produced if the target representation of "dog" and its associates have been activated initially, but the inhibitory mechanism failed to reduce the activation of its associates. Instead, the activation of "dog" may have been reduced so that "cat", as a strongly connected associate, was selected. If inhibition is not absent but simply reduced or intermittent, the subsequent trial to produce "dog" may be successful. Slowed inhibitory processing may result in initial anomia, with the correct target word produced after an extended period of time. Inhibition in this instance may be intact, but may require extra time to operate (Prather et al., 1992). An overactive inhibitory mechanism may result in no response to the picture since interference cannot be resolved.

The assumption that activation is intact in persons with aphasia has been questioned. Poor performance on offline classification or categorization tasks lead to the theory that the semantic system in persons with aphasia may be disrupted, causing poor language production and comprehension (Goodglass & Baker, 1976; Kiran & Thompson, 2003; Wayland & Taplin, 1982; Whitehouse, Caramazza, & Zurif, 1978). If the semantic system is disrupted, it cannot be assumed that target words or associates are initially activated. To investigate these theories, implicit semantic processing studies have been conducted in persons with aphasia (Chenery, Ingram, & Murdoch, 1990; Milberg, Blumstein, & Dworetzky, 1988).

Semantic Activation and Aphasia

Implicit processing has been measured in persons with aphasia by the amount of positive priming (PP) observed using stimulus presentations that are semantically related. Positive priming is an example of excitation (facilitation) that occurs when a participant is exposed to a stimulus that is semantically related to a prior stimulus. This is reflected in a shorter response time to a stimulus when an initial (prime) presentation of a stimulus is followed immediately by another (probe) stimulus that is semantically related to the prime target. An example of this is the word “nurse” followed by the word “doctor”. The prime presentation activates its representation in long term memory, and activation spreads to its semantic and phonological associates. When a semantically related probe is presented, it has an advantage in activation level because it was previously activated as an associate of the prime word. The probe stimulus reaches threshold quickly, resulting in a faster response time than if the probe stimulus was not related to the prime stimulus.

There have been relatively few studies using PP in persons with aphasia (Baum, 1997; Chenery et al., 1990; Gerratt & Jones, 1987; Milberg & Blumstein, 1981; Ostrin & Tyler, 1993; Prather et al., 1992). Since the language system may be disrupted in persons with aphasia, typical experimental task modalities such as naming pictures or words or other language-based tasks are often inappropriate. A deficit in overt naming due to speech production difficulties would be very difficult to distinguish from difficulties in activation or inhibitory processing. With verbal production tasks very limited for this clinical population, implicit processing tasks may bypass the poor performance on explicit tasks and provide more information regarding the online or implicit language processing abilities of a person with aphasia.

Positive priming studies in persons with aphasia have generally utilized a lexical decision task (LDT) in visual (Del Toro, 2000; Gerratt & Jones, 1987; Milberg & Blumstein, 1981; Mimura, Goodglass, & Murdoch, 1996) and auditory (Blumstein, Milberg & Shrier, 1982, Chenery et al., 1990; Ostrin & Tyler, 1993) modalities. In a LDT, the participant judges if a presented letter string is a real word or pseudoword by pressing a button or verbally stating "yes" or "no". This binary decision task can provide evidence for access to intact lexical representations in persons who exhibit poor language comprehension and production. When utilized in a priming task, lexical decision (LD) can provide information regarding spreading activation and facilitation of semantic and phonological associates.

Lexical decision as a priming task involves the presentation of words and/or pseudowords in pairs. The prime letter string is presented first, followed shortly thereafter by a probe letter string. The prime and probe displays constitute one trial, and the relatedness of the letter strings is varied. Word pairs vary by semantic relatedness such that the prime and probe display may be semantically related, unrelated, neutral, or one or both presentations may be pseudowords. The participant generally responds only to the probe presentation and reaction time is the dependent variable. The reaction time to judge word/pseudoword is used to determine if semantic relatedness affects the time to judge lexicality of the letter strings. If the prime presentation is a word that is semantically related to the probe word presentation, PP occurs. The response to the probe word is faster because it has been activated as an associate of the prime word.

With the utilization of explicit categorization tasks, such as placing printed letter strings into word or pseudoword categories, previous research had proposed deficient semantic processing in persons with aphasia (Kiran & Thompson, 2003, Milberg & Blumstein, 1981). The hallmark study of automatic lexical activation in persons with aphasia was conducted by Milberg and Blumstein (1981). This visual LD experiment recruited six participants with Wernicke's aphasia, one with Conduction aphasia, five with Broca's aphasia and six control participants. The person with Conduction aphasia was included with the Broca's group for statistical analysis. Participants judged the lexicality of visual stimuli presented in pairs of related, unrelated, or pseudowords for each presentation. After this LD priming task, participants completed a semantic judgment task in which word stimuli were explicitly judged as related or unrelated. Across all conditions of the semantic priming task, both aphasia groups (Wernicke's and Broca's) exhibited longer reaction times than the control group, with the reaction times of the Wernicke's group as the most delayed. The most interesting finding was that the Wernicke's group's reaction times for semantically related words were similar to those of the control group such that related word pairs yielded decreased response times. Participants in the Broca's group, however, did not show a significant difference in reaction time latency for related versus unrelated and nonword stimuli. The authors concluded that while persons with aphasia exhibit difficulty with metalinguistic semantic judgment tasks, persons with Wernicke's aphasia appear to maintain intact automatic semantic organization. Persons with Broca's aphasia appeared to exhibit difficulty with the processing of semantic information which the authors could not explain. Based on this study, it would seem that automatic spreading activation is present in persons with Wernicke's aphasia but not in persons with Broca's aphasia. Only one other study, by the same authors, has found this semantic processing difficulty in persons with Broca's aphasia (Milberg, Blumstein, & Dworetzky, 1987).

Other studies of both visual and auditory lexical priming have found that persons with Broca's aphasia do exhibit automatic semantic processing as evidenced by shorter reaction time latencies to related words (Blumstein et al., 1982; Hagoort, 1997; Milberg et al., 1988; Mimura et al., 1996; Ostrin & Tyler, 1993) than to unrelated or pseudowords. Clearly, factors must be involved that determine successful versus unsuccessful priming.

According to Hagoort (1997), Milberg & Blumstein's (1981) initial study results were the product of the interstimulus interval (ISI) used between the prime and probe presentations. The Milberg and Blumstein (1981) study ISI was 2000 msec with a 4000 msec intertrial interval (ITI), which Hagoort believed to be so long that controlled and not automatic processing was exhibited. With twice as much time between trials as within trials, it could be possible that participants were aware that the stimuli were presented in pairs and could therefore employ conscious strategies for response. Additionally, in the Milberg and Blumstein (1981) study, one participant with Conduction aphasia was placed into the Broca's aphasia group. Individual results for the participants with aphasia were not discussed, so it is unknown if the addition of a person with fluent aphasia to a nonfluent group contributed significantly to the variance. The six control participants in this study were not strictly matched for age or education, nor were they adequately described. The mean age for control participants was 48, whereas the mean age for the aphasia group was 53.9 years, indicating that the control participants were generally younger. Finally, the related stimuli utilized in the Milberg and Blumstein study were all nouns that were either related by association or by category so that the type of relationship was not controlled.

Hagoort (1997) attempted to remedy these problems in his study by manipulating the ISI. Thirteen male and female participants with Broca's aphasia were approximately matched by age and education to sixteen elderly control participants. The mean age of the control participants in this study, 60 years, was older than the mean age for the aphasia group, 55 years. The LD stimuli in this study consisted of nouns, adjectives, and verbs with blocked ISI times of either 300 msec or 1400 msec. Participants responded only to the probe presentation instead of to each presentation as in Milberg and Blumsteins's (1981) study. At the 1400 ms ISI, all but one participant with aphasia exhibited faster reaction time latencies to related stimuli relative to unrelated stimuli. In the 300 msec ISI condition, all but one participant exhibited faster reaction time latencies in response to related versus unrelated stimuli. The participant who did not show priming in each ISI time condition was different for each condition. From this study the author concluded that persons with Broca's aphasia do exhibit automatic spreading activation as evidenced by PP, even at very short ISIs.

The time sequences utilized in other studies of PP in aphasia have varied greatly. The Blumstein et al. (1982) study presented auditory stimuli with an ISI of 500 msec and an 8000 msec ITI whereas the 1988 (Milberg et al.) study used a 500 msec ISI and 6000 msec ITI. Ostrin & Tyler's study (1993) of four participants with Broca's aphasia used a 250 msec ISI and 6000 msec ITI. A case study by Prather et al. (1992) hypothesized that spreading activation is present in persons with aphasia but slowed relative to normals. In the first experiment, the ISI varied between 500 msec, 800 msec, and 1500 msec, and between 800 msec, 1500 msec, and 1800 msec in the second experiment. The most detailed timing sequences were described in a case study of a person with severe nonfluent aphasia (Mimura et al., 1996). After a central fixation display for 2000 msec, the prime was presented for 500 msec with an ISI of 500 msec. Other studies (Chenery et al., 1990) provide only the cut-off criteria to be considered as a non-response. See Table 1 for a limited summary of relevant priming studies in persons with aphasia.

All of these studies demonstrated significant PP at all ISIs (not within each experiment). The most interesting studies are those in which the ISI was varied within the experiment because they provide a better range in which to find PP in persons with aphasia. In the Hagoort (1997) study, one participant in the 300 msec ISI experiment and one participant in the 1400 msec ISI experiment showed not positive but negative priming (NP). Instead of a faster reaction time when presented with related versus unrelated stimuli on the probe presentation, these individuals showed slower reaction times. It is unknown if the difference between the related and unrelated reaction times for these individuals were significantly different. Similarly, Prather et al. (1992) conducted a case study with a participant with non-fluent aphasia. Using a visual list priming paradigm, two experiments varied the ISI for this participant. In the first study, ISI varied from 500 msec to 1500 msec, while the second experiment utilized ISIs of 800 msec to 1800 msec. Only one ISI from both experiments (1500 msec) resulted in significant PP. The 1800 msec ISI resulted in nonsignificant NP. Therefore, to achieve PP in persons with aphasia, the ISI time range would appear to be anywhere from 300 msec to 1500 msec. It should be noted, however, that while the 300 msec ISI (Hagoort, 1997) resulted in PP, the participants responded only to the probe presentation. In the Prather et al.

(1992) study, the participant responded to each presentation, which would increase the ISI time depending on the response time. It is possible that a much longer ISI is needed in persons with aphasia when they are required to respond to each presented stimuli.

The stimuli utilized in each study are interesting to examine in light of the diagnoses of the participants with aphasia. For example, Hagoort (1997), Ostrin & Tyler (1993), and Prather et al. (1992) studied participants had non-fluent aphasia. The participants in Milberg et al. (1988), Chenery et al. (1990), Milberg & Blumstein (1981) and Blumstein et al. (1982) used mixed groups with different types and severities of aphasia. With the exception of Hagoort (1997), whose stimuli were 80 nouns, verbs and adjectives, the stimuli in these priming studies consisted only of nouns. Unfortunately, in the Hagoort study neither the proportion of each type of word stimulus nor the word list was provided, and the type of word stimulus was not analyzed. The use of only nouns may be of potential interest since some types of aphasia, such as Broca's, typically exhibit more difficulty producing and understanding verb stimuli. Persons with a Wernicke's type of aphasia typically exhibit more difficulty with noun production and comprehension. It is possible that the type of word stimulus may affect LD or the reaction time to judge the word depending on the participant's type of aphasia. This variable has not been analyzed, however, so it is unknown if the type of word stimuli affects the PP/LD paradigm.

Summary of Aphasia Priming

Relative to studies completed in the non-neurologically impaired literature, few priming studies have been completed with persons with aphasia. This is most likely due to the fact that neuropsychological studies tend to use language-intensive stimuli.

Positive priming experiments with persons with aphasia have generally yielded successful results although in some cases persons with Broca's type of aphasia have not demonstrated a significant reaction time difference between semantically related and unrelated conditions. The timing between the prime presentation and probe presentation has varied from 300 msec to 2000 msec, with the average ISI around 500 msec. The Prather et al. (1992) study, however, demonstrated that 500 msec may still be too short for priming to occur if spreading activation has been slowed. Additionally, nouns have largely been the preferred stimuli for the LDT. In general, persons with aphasia appear to maintain intact semantic network organization and activation at an automatic level.

Positive priming reflects an implicit mechanism by which information may be spread from an initial semantic representation in long term memory to its semantic and phonological associates. In the interactive activation framework, PP represents the excitatory pathway of a representation in a concept node to its phoneme nodes, its associated concepts, the associated concept phonemes, and back to the original representation. In PP, the facilitatory mechanism of the model is represented without any mention of the inhibitory processes that must be recruited to dampen the associate competitors. Spreading activation in persons with aphasia appears to be somewhat controversial given the results of Milberg and Blumstein (1981), Kiran and Thompson (2003), Hagoort (1997) and Ostrin and Tyler (1993). Since activation is only one part of lexical access, inhibitory processes of persons with aphasia should also be studied to provide more information about production errors. Inhibitory processes in an interactive activation network are measured by NP studies.

Negative Priming

Negative priming is a paradigm similar to that of PP with the exception that there are stimuli to be attended and stimuli to be ignored. In a PP experiment, the difference between the unrelated and related word conditions is positive since the related condition is faster than the unrelated condition. Negative priming means that the difference between the unrelated and the related condition is a negative number since the related condition is slower. Localization tasks, identity tasks, and semantic association tasks are the main types of stimuli utilized in these studies. Localization tasks are concerned with response to the spatial location of a stimulus, whereas identity tasks are concerned with the actual identity of the stimulus. Semantic associate tasks use related word pairs as stimuli. This paper will not elaborate on the literature of localization tasks since spatial abilities are not the purpose of this study.

Identity tasks generally show robust effects, and as such are utilized frequently in negative priming studies. Identity tasks have included geometric figure category (Yee, 1991), picture naming (Sullivan & Faust, 1993; Tipper, 1995), color naming (Little & Hartley, 2000), letter naming (Hasher et al., 1991) or lexical decision (Fuentes & Tudela, 1992). Identity tasks are concerned with the "identity" of the stimuli itself, such that the particular stimulus is de-selected. In these tasks, the same word or stimulus is used in consecutive trials. In this way, the stimulus that is inhibited on the prime trial becomes the target on the next trial. In contrast to this are the semantic association tasks in which the semantic concept is inhibited, so that its semantic associates are also affected. The priming examples in this paper will be limited to those at the semantic representation level of suppression. While identity priming shows robust effects, the inhibition of a word itself does not reveal information regarding that word's associates. Semantic associates NP is important to study because the potential interference between semantic associates may be linked to production of semantic errors in persons with aphasia.

The PP studies with persons with aphasia utilized lexical decision as the experimental task, and NP will be explained in terms of LD for direct comparison. As in the PP studies, the participant judges if the presented letter string is a word or not by using binary verbal or button-push choice. Stimuli are either real words or pseudowords. In the prime display, there are target letter strings and distractor letter strings. Two identical letter strings are located both above and below another string. The two identical strings are called flankers and/or distractors and the middle string is the target of the lexical decision. The participant is instructed to ignore the flanker strings and to make a judgment regarding the middle string. Another alternative is to display only one distractor letter string and one target string.

On the probe trial, one letter string is presented that may be related or unrelated (or a pseudoword) to the prime display's distractor letter string. If the probe string is related to the distractor string on the prime display, the reaction time to judge the probe display string should increase (Houghton & Tipper, 1994). In PP, a related probe display should elicit faster reaction times for response. In NP, however, the response to a related probe word is slowed, resulting in a negative difference between the related and unrelated conditions. This NP effect is theorized to be the result of intact inhibitory mechanisms. When told to ignore the distractor letter strings, the participant must inhibit the processing of those stimuli. If the probe display is then semantically related to the prime distractor letter string, inhibition of the prime distractor's associates must be overcome, leading to a slower reaction time before judgment. If inhibitory mechanisms are disrupted or slowed, relatedness of the prime distractors and probe presentation should not have a significant effect on reaction time to judge the probe target. The distractors in the prime display are presumed to have been processed instead of inhibited so that semantically related probe displays do not exhibit reaction time delays.

Support for the inhibitory account of NP comes from the selective inhibition theory of visual selective attention. According to Houghton & Tipper (1994), selective attention is necessary in daily life because there are an infinite number of stimuli in the environment that must be either attended to or ignored. Initially, all stimuli are attended to and facilitated, but then irrelevant stimuli are quickly suppressed so that further processing of the attended stimuli can proceed. In the NP paradigm, all stimuli on the prime display are initially attended to and analyzed in an automatic fashion. The participant then selectively attends to the target word, and the distractors words are suppressed.

Negative priming is thought to occur due to selective inhibition (Fox, 1995; Houghton & Tipper, 1994). Originally it was thought that the reaction time delay to a semantically related probe word occurred because these inhibited stimuli were actually deactivated (Neill, 1979). However, this theory did not account for the fact that sometimes PP occurs when probe displays contain no distractors (Moore, 1994). The current theory is that although the ignored distractor's representation has been suppressed, it has not been deactivated. Instead, its activation has been reduced below that of the target representation, but still above threshold (Houghton & Tipper, 1994). Inhibition of the distractor representation continues as long as the target representation remains selectively attended. Positive priming can occur on the probe display when the prime target representation is no longer selectively attended to since the related prime distractors are activated above threshold.

Negative priming and aging. Aging populations are one of the most extensively studied populations using a negative priming paradigm. Aging persons have been shown to show increased difficulty with selective attention and may attend to more irrelevant details than younger persons (Hamm & Hasher, 1990; Hartman & Hasher, 1990; McDowd & Oseas-Kreger, 1991; McDowd, Oseas-Kreger, & Filion, 1995). Since NP presumed to be a product of an intact selective attention mechanism, it makes sense to perform NP tasks with aging persons to determine if inhibitory processes contribute to this difficulty.

In a typical NP experiment, younger participants (ages are usually between 18-30 years) and older participants (ages are usually over 60 years) are given a task in which the dependent variable is reaction time. Although the older participants tend to be slower in a variety of tasks (Salthouse, 1985), this slowed overall RT is not experimentally important. Results of NP studies usually show that the younger participants exhibit significant NP whereas the older participants do not (Hasher, Stoltzfus, Zacks, & Rypma, 1991; McDowd & Oseas-Kreger, 1991; Tipper, 1991). This has led to the theory that older participants have "absent" or weakened inhibitory processes (Hasher et al., 1991). However, this theory is controversial in that some studies have found that older participants did exhibit NP (Gamboz, Russo, & Fox, 2000; Sullivan & Faust, 1993, Sullivan, Faust, & Balota, 1995). One study from each side of the debate will now be discussed in more detail.

Hasher et al. (1991) conducted two experiments in which younger and older participants named letters. Pairs of letters 6 mm apart were presented in which one letter was red and one was green. Half of the subjects named the red letter and half the green letter. In experiment 1, the response-to-stimulus interval (RSI) was 500 ms, while in experiment 2, it was 1200 ms. The RSI times were manipulated to determine if the older participants could exhibit NP at longer RSIs, since perhaps standard RSI did not allow enough time for build-up of inhibition. The authors found that for both experiments, the younger participants exhibited significant NP while the older participants did not.

Gamboz, Russo, and Fox (2000) conducted three similar letter-naming experiments in a NP paradigm. Their aim was to vary the difficulty of the target selection--easy or difficult. In the initial experiment, young and older participants were shown pairs of overlapping letters. In the easy selection condition, one letter was red while the distractor letter was green. In the difficult selection condition, the target letter was either in light red or light green while the distractor letter was in dark red or dark green (these colors were not intermixed so that light red appeared with dark red, and so on). These conditions were intermixed throughout the task.

In the second experiment, the easy and difficult conditions were presented in blocks, while the third experiment increased the distance between the distractor and the target for the easy condition. Results of all three experiments showed that both groups showed significant NP, with the older participants exhibiting a larger effect in the first experiment when the conditions were intermixed. Since negative findings in the majority of the aging literature conclude that older participants do not show NP and therefore must have deficient inhibitory processes, it appears that in a subset of studies, older participants can show NP. There may be variables involved that provide a better environment for NP to occur.

Variables in NP

There are many variables of concern that are thought to contribute to the presence or absence of the negative priming effect. Variables that have been examined include the emphasis on speed versus accuracy, spatial separation of target and distractors, the number of distractors on the prime display, the presence of probe trial distractors, the ISI between the prime and probe displays, and word frequency. Some variables have been indicated as good components for obtaining NP, while other studies have negated the findings of these studies. Studies analyzing or utilizing these variables will now be discussed.

Speed and accuracy studies. Since priming in general is concerned with an online reaction measure of some type of processing, it would seem that stressing the speed with which a participant responds to a stimulus is paramount to the experiment. In a judgment task such as LD, however, rapid responses may mean that the number of errors increases such that there is a speed/accuracy trade-off. High error rates on a task can indicate that the participant did not allow sufficient time for processing of the stimuli and can muddle the data. Researchers such as Neill and Westberry (1987) and Neumann and DeSchepper (1992) have manipulated speed and accuracy within participants to examine the extent to which these variables affect negative priming.

Neill and Westberry's (1987) study varied instructions for a Stroop task as either strict accuracy or lax accuracy. After the participant produced five errors, the strict accuracy condition displayed a visual cue instructing the participant to respond with greater caution. Participants producing fewer than five errors received visual cues to continue their manner of response. In the lax accuracy condition, speed was emphasized so that participants producing fewer than 8 errors received a visual cue to respond more quickly. The results showed that in the lax accuracy conditions, which emphasized speed over accuracy, nonsignificant positive priming occurred. However, there was significant NP in the strict accuracy conditions.

Similar speed/accuracy results were obtained by Neumann & DeSchepper (Experiment 2; 1992) using a letter naming task. This study was somewhat different in that it employed manual tasks and reaction time measures. Reaction time was manually recorded for a list of five orally named letters flanked by one to three partially overlapping distractors. The total time to name the five-letter set was divided by the number of displays for each set to achieve naming time per letter. For each set in the identical distractor condition, all target stimuli were the ignored distractors on the previous display.

According to Fox (1995), positive priming occurs in related, speed-emphasized conditions because all stimuli are initially activated and it takes time for inhibition to reduce the activation of the ignored stimuli. When participants respond quickly, facilitation occurs for related probe stimuli because all stimuli are still activated. When accuracy is stressed, a longer period of time elapses in which inhibitory mechanisms suppress the related ignored stimuli. The emphasis of accuracy above that of speed may therefore be a component necessary for observation of negative priming.

S*patial separation of target and distractor.* In addition to instructions regarding response emphasis, the spatial separation of the target stimuli from the distractor stimuli has also proven to be an important variable. Fox (1994) manipulated the spatial separation of a distractor letter from the target letter in prime displays so that target and distractor were equidistant from a fixation point and separated at center to near, medium, and far (.97, 1.7, and 2.6 respectively) degrees of visual angle. The separation of target and distractor in the probe displays was constant at .97 degrees of visual angle. A significant interference (compatible versus incompatible stimuli) effect for the prime display was shown for the near separation and medium separation conditions, but not for the far conditions. Interference slows reaction times on the prime trial in the face of distracting items, but negative priming is responsible for slowed reaction times on the probe trial, since inhibition takes time to develop. A significant negative priming effect for the probe display was revealed when the prime display target-distractor separation was near or medium, but not when the separation was far. Fuentes & Tudela (1992) showed similar results from their lexical decision task with foveally and parafoveally presented words. When the degree of target-distractor separation was large (4.3 degrees visual angle), positive priming occurred. However, smaller separation (2 degrees visual angle) resulted in a nonsignificant trend for negative priming. Tipper (1985), however, found significant negative priming with picture stimuli having target-distractor visual angles as high as 6.4 degrees. Yee's (1991) study using two word distractors for geometric shape targets in the prime display also found negative priming using a separation of 4.5 degrees of visual angle. These values would be similar to the "far" condition in the Fox (1994) study in which negative priming was not significant. It may be that other variables interact with target-distractor separation to contribute to negative priming such as ISI, type of stimuli, number of prime or probe distractors, or experimental task. Fox's (1994) study concludes that the closer distractor stimuli are to the target, the more interference occurs when trying to selectively attend to that target. The close distractors are stronger competitors for control of attentional processing and therefore require an increased amount of inhibition so that target activation becomes higher than that of the distractor. The studies finding negative priming in the presence of larger target-distractor visual angle separation may also loosely fall into this interpretation. Assuming that the stimuli are contextually novel, it may be that any distractor stimuli, no matter the proximity on the display to the target, can prove to draw attention away from the target stimuli. If all stimuli are initially activated, processing of the distractors may occur automatically in response to a novel event (Yee, 1991). Repeated exposure to a specific distractor stimulus may relegate it to "background noise" that is not consciously monitored (Houghton & Tipper, 1994). Further study is needed in the area of target-distractor proximity to define the mechanisms underlying the mixed results of these studies.

Distractors on prime and probe displays. The number of distractors on both the prime and probe displays has also met with mixed results. Using a geometric figure classification task with either one or two word distractors on the prime display, Yee (1991) found that significant negative priming occurred when two different distractor words flanked the figure. In the single word distractor condition, the ignored distractor randomly appeared either above or below the geometric figure. Negative priming did not occur for single word prime distractors. The probe task was a single word lexical decision of a semantically related or unrelated stimulus. In her second experiment, the prime display consisted of either two distractor words or one distractor word with a string of symbols in place of a second word. Again, the two word condition yielded negative priming when the single distractor condition did not. Yee posits that in the single distractor prime condition, perhaps the asymmetry of a blank where the other distractor would have been presented inadvertently drew attention to the distractor so that it was not ignored successfully. Since neither positive nor negative priming occurred, participants could have intermittently attended or ignored the single distractor resulting in an almost even effect of facilitation and inhibition.

Neumann & DeSchepper (1992), however, found the opposite results in their letter-naming task—NP decreased with an increasing number of distractors. This study is inconclusive, however, because the same number of distractors was used on both prime and probe displays. The results cannot differentiate effects from only the prime or only the probe displays. These authors attribute their results to a limited capacity inhibitory mechanism (Neill, Valdes, & Terry, 1995) that inhibits one item more easily than several items. The more items to be ignored, the weaker the inhibitory processes become for any one item.

The number of distractors on the probe display has also produced mixed results. Conflict on the probe trial has been shown to be both necessary (Lowe, 1979; Tipper & Cranston, 1985) and unnecessary (Neill & Westberry, 1987; Moore, 1994) for negative priming to occur. Studies utilizing a lexical decision task (Fox, 1994; Fuentes & Tudela, 1992; Yee, 1991), however, have shown negative priming effects with only the target word on the probe presentation. According to Fox (1995), the selective inhibition hypothesis could explain these conflicting results since the first representation to gain more activation is selected. It takes longer to respond to a recently ignored representation when conflicting distractors are present because inhibition slows the ignored representation's activation from becoming more activated than the probe's distractors, leading to negative priming. If there are no distractors on the probe display, the probe target could already be more activated than other representations so that no negative priming would be observed.

ISI between prime and probe displays. The final variable to explore is the interstimulus interval (ISI) between prime and probe displays. This has been described in the discussion regarding positive priming and aphasia and will be briefly revisited here. In the non-neurologically impaired population, ISI has been proposed as yet another critical factor necessary for production of negative priming. In Yee's (1991) study using lexical decision as the probe task, an ISI of 500 msec produced positive priming while increasing the ISI to 600 msec produced negative priming. Other researchers have found negative priming at ISIs of 20 msec (Neill & Westberry, 1987) and 500 msec (Neill & Valdes, 1992). Inhibition takes time to occur since all stimulus representations are initially attended to and activated before inhibition reduces the competing representations. It may be that the Neill & Westberry (1987) and Neill & Valdes (1992) studies manipulated other variables that contributed to negative priming and that the ISI itself was not the important variable. The priming studies in aphasia using a lexical decision task have shown that a range of 300 to 1500 msec (Hagoort, 1997; Prather, et al., 1992) produces positive priming. Therefore, it may be that inhibition is either delayed or disrupted in persons with aphasia and that ISIs longer than 1500 msec may be needed to produce negative priming.

It would appear that in order to attain negative priming, certain variables must be present. Examining the variables of speed versus accuracy, spatial separation of the target and distractor(s), number of distractors on prime and probe displays, and the ISI between the prime and probe displays may best set the stage to produce negative priming. The emphasis of accuracy over speed, a target-distractor separation of 2 or fewer degrees of visual angle, two prime display distractors, and an ISI of over 600 msec merges all of these variables into a study that has a higher probability of producing negative priming.

Other variables, such as word frequency, should also be taken into account. To achieve NP, it is best not to use words with too high of a frequency (P. Mari-Beffa, personal communication, March 3, 2006). Reaction time was regressed on word frequency, among other variables, in a study by Balota, Cortese, Sergeant-Marshall, Spieler, and Yap (2004). Using data from the English Lexicon Project (Balota, et al., 2002), the authors used hierarchical regression techniques to investigate predictive variance on over 2000 mono-syllabic words from a variety of participants, including young adult and aging populations. Results of studying word frequency in both naming and LDT showed that LDTs have more predictive power than naming tasks, and that frequency effects are stronger in LDT as opposed to naming tasks. Between the young adult and aging populations, the young adult group was more affected by objective frequency than subjective word frequency. The reverse was true for the older adults. It seems word frequency may be another important variable in LDTs.

Inhibition and Aphasia

Inhibition's role in the selective inhibition hypothesis is particularly important when applied to an aphasia population since several researchers have theorized that there are decreased attentional mechanisms in persons with aphasia (Erickson, Goldfinger, & LaPointe, 1996; Glosser & Goodglass, 1990; Murray, Holland, & Beeson, 1997). The PP studies in aphasia discussed previously were all oriented towards facilitation with no direct reference to inhibition. One study has directly examined interference mechanisms in persons with aphasia. Weiner, Connor, and Obler (2004) employed a modified Stroop task with five male participants having moderate-to-severe Wernicke's aphasia. Twelve male and female participants acted as non-neurological controls. The task involved the presentation of congruent, incongruent, or neutral number stimuli. In the congruent condition, a single series of number stimuli ranging from numbers one to four was presented in the same quantity as the Arabic number (333 = three threes). In the incongruent condition, the number of stimuli did not match the number presented (44 = two fours), whereas the neutral condition consisted of one to four x's (XXX = three x's). Instead of a yes/no response system, participants responded by pressing one of four buttons to specify the quantity of stimuli. The participants with aphasia responded significantly slower to stimuli than did the control group, although the compatible and neutral conditions were not significantly different between the groups. The difference between the neutral and incongruent conditions, the interference effect, was significantly larger in the aphasia groups than in the control group. A significant negative correlation was found between the score on the Token test and the error percentage interference effect from the Stroop-like task. From these results the authors conclude that persons with Wernicke's aphasia demonstrate impaired inhibitory mechanisms and as such cannot effectively ignore the conflicting stimuli. The negative correlation was interpreted to mean that impaired inhibitory processes may be related to the poor auditory comprehension observed in this type of aphasia. According to Fox (1994), interference and inhibition result from independent mechanisms. While incongruent stimuli on a single display may produce interference, inhibition (as measured by NP) can only be observed in the subsequent display in which the current target is related to a previous distractor. Inhibition can produce decreased interference on subsequent trials, but a longer amount of time may be necessary to decrease interference in the same display in which inhibition is applied. Since this study did not employ a NP paradigm, it is unknown if inhibition is disrupted in this population. The only conclusion that may be drawn is that persons with Wernicke's aphasia are highly affected by situations in which interference is present and may require prolonged processing time. A binary response system may have reduced the possibly higher cognitive load for the persons with aphasia, decreasing the amount of interference or the reaction time required for response. On a final note, there were only five participants with aphasia, and perhaps the results would have been more informative if these participants were discussed individually since comprehension varied from moderate to severe difficulty.

A second study that indirectly contributes to the notion that persons with aphasia may have reduced inhibitory mechanisms was done by Bushell (1996). Using a LDT in an expectancy paradigm, Bushell conducted two experiments with eight participants with Broca's aphasia. The proportion of related items and the relationship between displays was varied. In the first experiment, the relatedness proportion varied from 20% to 80%, while the prime and probe stimuli were semantically related or unrelated. The results of this experiment for the high relatedness proportion showed that while the neurologically normal group demonstrated significant PP, the aphasia group showed significant opposite priming, resulting in a negative number. This will be referred to as opposite priming to avoid confusion with NP paradigms. In the second experiment, the relatedness proportion was again 20% and 80%, but the manner of prime and probe relation was changed to identity so that the same word appeared in both prime and probe for the related condition. The results of the second experiment for the high relatedness proportion showed that both the control group and the aphasia group exhibited PP regardless of proportion.

The author's explanation for the opposite priming for the aphasia group in the first experiment was that the spread of semantic activation was inhibited. Equating the opposite priming to inhibition, Bushell follows the "center-surround" theory proposed by Carr & Dagenbach (1990). This theory states that in circumstances in which to-be-retreived information is weakly activated, inhibition dampens the surrounding competitors so that the target may receive more activation. Bushell further interprets her data as a possible difficulty with retrieval of semantic information.

An alternate view of the results of Bushell's (1996) study is that in the high semantic relatedness proportion condition, the aphasia group experienced interference from activation of related associates. Perhaps this interference was not dampened by inhibition in the time allotted, producing the opposite priming effect when the related condition was subtracted from the unrelated condition. If persons with aphasia are unable to effectively recruit inhibition to resolve interference, errors of selection could be made.

One study that serves as a good model for achieving priming in a LDT was conducted by Mari-Beffa, Fuentes, Catena, & Houghton (2000). In this study, Mari-Beffa, et al. showed both NP and PP with young participants. This study explored deep versus shallow-processing in a LDT and a letter search task. For the purposes of the current study, only the LDT portion of the experiment will be discussed.

In the LDT, 288 trials of Spanish words/pseudowords were presented in triplets on both prime and probe displays. The center word was the LD target, while the vertically flanking words were the distractors. Word pair relationships were exemplars chosen from four categories, with an equal proportion of word/pseudoword. Word pair stimuli were divided into related associates (RA), related distractors (RD), and unrelated pairs (UN). This format is a useful guide for the current study since not only can NP be measured, but PP can act as a "control" to ensure that lexical processing is occurring.

An additional component of Mari-Beffa et al.'s (2000) study is that participants responded to both the prime and probe displays, which will be important to consider when a neurologically-impaired group is tested. The timing of the stimuli presentations, as previously mentioned, is also an important variable. After a 500 msec fixation cue, Mari-Beffa et al.'s (2000) participants saw the prime display, 150 msec blank screen, then the prime display. The prime display remained on the screen until a response was made, followed by 300 msec, then the probe display. ITI was self-paced with a space bar, with an additional 200 msec before the next trial. An auditory feedback system provided a beep during errors. Results of the study showed effects in the hypothesized direction, with the RA condition as the fastest reaction time (RT), the UN condition as the next fastest, and the RD as the slowest. With the success of this particular study's methodology and design, it seems reasonable to use this study as a guide for the current study. However, due to the nature of the current study and its participants, a few small changes have been made. These changes from the modeled Mari-Beffa et al. (2000) study will be discussed further in the methods section.

Summary and Conclusions

Interactive activation models provide a connectionist semantic and phonological network in which inhibitory as well as excitatory connections influence word production. The selective inhibition hypothesis states that initially all visual stimuli are activated, but because all of these stimuli compete for dominance, inhibitory processes are recruited to reduce the activation on non-target stimuli. In this manner, the activation of non-essential or non-target stimuli is reduced relative to the selected target so that further processing of the target can occur. Persons with aphasia have been found to have deficits in all types of attention allocation and processing.

Persons with aphasia frequently exhibit anomia and other naming errors as a result of damage to the neurological substrates underlying these connectionist networks. When a target word is encountered and activated, its semantic and phonological associates are also automatically activated according to the strength of association. If a person with aphasia has an inhibitory mechanism that is delayed, disrupted, absent, or overactive the activation of these associates may not be reduced as needed to produce the target word. As a result, naming errors may occur.

Studies exploring the semantic system in persons with aphasia utilizing priming in LDT have generally found that automatic semantic activation occurs. Positive priming has been found using related words in all types and severity of aphasia with varying interstimulus intervals (ISI) and intertrial intervals (ITI). These studies support the facilitatory portions of interactive activation models, but the inhibitory portions have yet to be explored in persons with aphasia.

Like the PP studies, the NP paradigm has also utilized LDT. In this case, however, a target word is flanked by distractors that are to be ignored. When the target word on the probe display is semantically related to the previously ignored distractor, reaction time to respond to the probe is delayed. Inhibition reduces the activation of the prime distractor and its associates so that a related probe target must overcome inhibition before response can occur. Different variables such as accuracy instructions, spatial separation of target and distractors, the number of distractors on prime and probe displays, and the ISI, have been shown to be important to the production of NP. The NP effect is expected in young, non-neurologically-impaired participants, and lack of a NP effect has been thought to indicate delayed or disrupted inhibitory mechanisms. While NP has not been explored in persons with aphasia, it has been used in other patient populations.

Given the performance of participants with aphasia in PP lexical decision tasks and the lack of information regarding the inhibitory capabilities of these participants, the following questions will be addressed in this study:

1) Will persons with aphasia have poor inhibitory processes as evidenced by lack of negative priming?
2) Will there be a difference between the aphasia group and the control groups on degree and direction of priming?
3) Will the number of a word's associates affect its reaction time?

Chapter Two

Methods

Participants

Twenty-three participants (18 men) with aphasia were recruited from the University of South Florida's Communication Sciences and Disorders Clinic in Tampa, Florida and from the Bay Pines Veterans Affairs Medical Center in St. Petersburg, Florida. Participation criteria included a single left hemisphere lesion resulting from a CVA, monolingual English speaker, right-handed, no other neurological disorders, and hearing and vision normal to corrected normal. Participants were also free from a history of mental illness or substance abuse per patient report or medical records, if available. Three of the male participants were dropped from the study. Two of these dropped participants were unable to complete at least one of the tasks. The other dropped participant was discovered to have had bilateral lesions. Of the twenty participants, eight were judged as fluent based upon conversation samples and subtests of the *Boston Diagnostic Aphasia Examination-3* (BDAE-3; Goodglass, Kaplan, & Barresi, 2001).

The age of the participants with aphasia ranged from 38-81 years (M = 60.4, SD = 10.98). Time post onset (TPO) ranged from 2 – 348 months (M = 72.7, SD= 86.03). Years of education ranged from 12-20 years (M = 14.55, SD = 2.98). All participants were judged to have mild to moderately severe comprehension deficits as determined by subtests of the BDAE-3 (discussed in the next section) and were physically able to press a button. Additionally, selection criteria included the achievement of at least 75% accuracy on two visual lexical decision subtests (#25 and #27) of the *Psycholinguistic Analysis of Language Processing in Aphasia* (PALPA; Kay, Lesser, & Coltheart, 1992). These subtests were necessary to determine if the participant could successfully judge words and pseudowords.

Twenty aphasia-control participants matched for age and education were also recruited from the same facilities—typically spouses of the participants with aphasia. Aphasia-control participants were monolingual English speakers with no reported neurological impairment, history of substance abuse or mental illness. Vision and hearing were normal to corrected normal. The ages of these participants ranged from 38- 80 years. Two-tailed independent t-tests revealed no significant age differences between the aphasia group (M = 60.45, SD = 10.98) and the control group (M = 61.8, SD = 12.24), t (38) = -.367, ns. Years of education ranged from 12-20 years (M = 14.80, SD = 3.98). The group with aphasia (M = 14.55, SD = 2.98) was again not significantly different from their controls (M =14.8, SD = 3.13), t = -.258, ns.

An additional younger control group of 25 participants was recruited from the university setting. The ages of these participants ranged from 18-34 years (M = 21.8, SD= 4.24), with an education range of 12-16 years (M = 14, SD= 1.22). A young control group was necessary because there is debate in the aging literature regarding differences in the presence or amount of NP exhibited between younger and older groups. While the young participants have frequently been found to exhibit NP effects, the older participant groups have demonstrated mixed results (for a review of these studies see Gamboz, Russo, and Fox, 2002, and Verhaeghen & Meersman, 1998). Since the participants with aphasia, and therefore their matched controls, were assumed to be older adults, it was necessary to have a younger group who would show the NP effect with the same stimuli. In this manner, if the younger group achieved NP, then the design and stimuli themselves could be ruled out as a contributor to the results of the other control groups. The young control group results will be provided in the results section.

Test Instruments and Materials

Subtests of the *Boston Diagnostic Aphasia Examination 3rd Edition Short Form* (BDAE: Goodglass, Kaplan, & Barresi, 2001) were administered to the participants with aphasia to determine aphasia type and severity. These subtests included auditory word comprehension, commands, complex ideational material, repetition of words and sentences, responsive naming, and oral word reading.

Black and white line drawings of objects from the International Picture Naming Project at the Center for Research in Language, University of California, San Diego (http://crl.ucsd.edu/~aszekely/ipnp/index.html) were shown on a computer for a naming task. Eighty-four nouns were presented with various numbers of associates (2-29). The number of connective associates was determined using the norms of Nelson, McEvoy, and Schreiber (1998). The number of associates was important to determine if words with a higher number of associates were more difficult to name. Words are listed in Appendix A.

Experimental Task

A NP lexical decision task was utilized that generally followed the format of Mari-Beffa, et al. (2000), with three exceptions as noted. Target and distractor letter strings were paired such that the prime distractor and the probe target were semantically related (RD), semantically unrelated (UN), or the prime and probe targets were semantically related (RA). Target and distractor letter strings were not semantically related within the same display.

Pseudowords were used in both prime and probe displays, but only as targets. Pseudowords were made by substituting one letter or transposing two letters of words presented within the experiment (for example, "street" became "streef"). A listing of pseudowords appears in Appendix B.

In the Mari-Beffa et al. (2000) study, the word pairs were related in that they were all exemplars from four categories. In the current study, targets for related conditions were the first associates of the prime target with high connection strengths (.2 or higher) taken from the free association norms of Nelson, McEvoy, & Schreiber (1998). Free association strengths between primes and probes are calculated based upon the probability of producing the associate when given the specific cue (prime). The strongest associates for each prime were utilized so that related words could not be randomized within each trial, but word pairs could be randomized within the experiment. This deviation from the modeled study was necessary to test the hypothesis that the number of related associates would affect reaction times and picture naming.

Mean printed word frequency for primes (Kucera & Francis, 1982) was 106 ppm with a SD of 2.82. While this is a high frequency mean, the younger control subjects were experiencing difficulty during the pilot study with traditional frequency ranges of 50-80 ppm (see Balota, Cortese, Sergent-Marshall, Spieler, & Yap (2004) for analysis of word frequency using LDT for younger and older adults).

Design and Procedure

The stimuli were presented on a color monitor laptop using SuperLab Pro 2.0.4 software. The screen display was black with white stimuli, with letter strings written in capital letters in Verdana font size 28. Participants were seated approximately 60 cm from the computer monitor. Unlike the Mari-Beffa et al. (2000) study, no feedback regarding lexical decision performance was given during the task since such feedback could affect subsequent motivation and performance on the task in the participants with aphasia.

Both prime and probe displays consisted of a central letter string flanked both above and below by distractor letter strings. The flanker letter strings (ignored distractors) were situated above the central letter string approximately .95 degrees visual angle from fixation (Fox, 1994; Mari-Beffa, Hayes, Machado, & Hindle, 2005, Miller, 1991).

A total of 288 trials were conducted, divided into 4 blocks of 72 trials. A total of 72 pairs of words were developed based upon the connectivity strength requirements listed above. These 72 word pairs were divided into 4 blocks of 18 pairs of words. These 18 word pairs for each block were then divided into 6 RD, 6 UN, and 6 RA word pairs within each block. In the RD condition, the flankers on the prime trials were related to the target on the probe trials. For the UN condition, six randomly selected word pairs were re-paired so that neither the distractors nor the targets on the prime or probe displays were related to each other. For the RA condition, prime targets were related to the probe targets. Fifty-four filler trials within each block were pseudoword trials in which the prime target, the probe target, or both were pseudowords. A large number of pseudoword trials was necessary so that the probability of the presented letter string being a word or pseudoword was 50 percent.

Each related word pair appeared only once within the experiment. However, to complete the requirement for flanker distractors for both prime and probe trials, it was necessary to use each word from 4-6 times throughout the experiment. It has been found that more robust NP occurs when experimental words are used more than one time (Mari-Beffa, Fuentes,Catena, & Houghton, 2000; Strayer & Grison, 1999).

A two-button response box (Cedrus Response Pad Model RB-530) was placed before the participants' dominant hand. The participants with aphasia typically used the left hand due to right hemiplegia, although they were allowed to use the "best" hand. One button was designated as the "word" button and the other button as the "nonword". Button designations were the same for all participants, and all participants were asked to use two fingers of the same hand, usually the thumb and pinkie fingers, to "toggle" between the buttons. While participants in the Mari-Beffa et al. (2002) study used one finger from each hand to judge words/pseudowords, the current procedure was chosen to make the control participants more like the participants with aphasia since one hand was usually the most functional for the aphasia group. Participants performed a lexical decision for both prime and probe displays (Milberg & Blumstein, 1981; Mari-Beffa et al., 2005) to decrease the response inhibition needed to withhold a response to the prime display.

Prior to initiation of the test trials, 15 practice trials were presented two times. The practice trials allowed feedback to be given to the participant if needed. Participants were instructed to stress accuracy over speed (Neill & Westbury, 1987; Neumann &

DeSchepper, 1992). Participants were told that the distractors were there to make the task more difficult, and to ignore these distractor letter strings and concentrate on the central target.

Each trial began with a fixation cross in the center of the screen for 500 msec, followed by a blank screen for 150 msec. The prime display was presented until the participant pressed either button. After a response, a blank screen was displayed for 300 msec. The probe display then appeared and remained until the participant responded. A trial consisted of one prime and probe display sequence. A new trial sequence began 1000 msec after the probe response. The response-to-stimulus-interval (RSI; the time between participant response to the prime and the onset of the probe) was 300 msec, so that the probe onset was 300 msec after the participant response to the prime. See Figure 1 for an illustration of the display sequences.

Time to complete the experimental task was approximately 35 minutes for the control participants and 2.5 hours for the participants with aphasia. The majority of this time for the participants with aphasia was spent with the non-negative priming task, which was completed in approximately 45 minutes. Short breaks were given between the four blocks of lexical decision tasks.

Chapter Three

Results

Reaction times before 400 ms and after 2000 ms were eliminated from the data to decrease the number of outliers. This accounted for the loss of approximately 5% of the data from the aphasia group and 3% of the data from the aphasia-control group. Only those trials in which both the prime and probe responses were correct were included in the analysis. Priming was calculated by subtracting the RA condition from the UN condition. Negative priming was calculated by subtracting the RD condition from the UN condition. Pseudowords are not further analyzed because they are not necessary to complete the NP calculations.

Reaction Time Data

Figure 2 contains the results for the young control group, the aphasia-control group, and the aphasia group. The mean RT to the probes for each group was calculated. The young control group was analyzed separately from the aphasia and aphasia-control groups because they were meant to be a NP control group, not a group of experimental interest per se. A two-tailed paired samples t-test revealed that the RD condition (M = 625.84, SD = 114.70) was significantly slower than the UN condition (614.60, SD = 110.10), $t(24) = -2.14$, $p < .05$. The RA condition (M = 617.32, SD = 120.26) was not significantly different from the UN condition, $t(24) = -.283$, ns. The younger control group exhibited NP, but not PP from the RA condition.

A two-tailed t-test revealed that the aphasia group SOAs (M = 1298.69, SD = 245.27) was not significantly different from its control group (M = 1089.36, SD = 180.52), t (158) = -6.14, ns. This indicates that both groups were similar in the amount of time it took them to respond to the word primes.

The aphasia and aphasia-control groups had error rates of 6% and 2% respectively. A 2 x 3 repeated measures was conducted with group (aphasia, aphasia-control) as the between subjects variable and condition (RD, UN, RA) as the within subjects variable. There was a main effect of group, F (1,38), MSe = 2.62, *p* <.05, such that the aphasia group made significantly more errors (M = 1.58, SD = 1.41) than the aphasia-control group (M = .68, SD = .87). There was also a significant effect of condition, F (2,76), MSe =.728, *p* < .02, such that for the aphasia group, the RD (M = 1.35, SD = 1.44) and RA (M = 1.22, SD = 1.21) conditions exhibited more errors than did the UN condition (M = .83, SD = 1.03). The condition by group interaction was non-significant. Effect sizes for all analyses were conducted using Bakeman's (2005) effect size calculations for repeated measures designs. An η^2 (for between-subjects calculations) of .02 is a small effect, .13 medium, and .26 a large effect. Generalized eta squared (for within-subjects calculations), η^2_G, for group was .13, while the condition effect size was .03. For the aphasia group, relatedness had a negative effect on the lexical decision task such that significantly more errors were exhibited when the prime and probe had some type of semantic relationship.

A 2 x 3 mixed ANOVA design with group (aphasia and aphasia-control) as the between subjects variable and word relatedness (related, unrelated, and pseudowords) as the within-subjects variable was calculated. Means of the medians of participant responses to probe displays are shown in Table 2.

There was a main effect of group, F (1,38), MSe = 110552, p <.05. The aphasia group (M = 936, SD = 215) produced longer reaction times than did the aphasia-control group (733, SD = 168). While there was no effect of condition, F (2,76), MSe = 2487.91 , p > .05, there was a significant interaction between group and condition, F (2,76), MSe = 2487.91, p = .05. Effect size calculations revealed that the group had a medium effect (.21), while the condition and interaction had a small effect size (.00). Post-hoc analysis using Tukey HSD revealed that the significance was largely due to the difference in the aphasia-control group between the UN and the RD conditions in which the UN condition was significantly slower than the RD condition. Figure 1 illustrates these group differences.

Additionally, the aphasia group was comprised of individuals with a fluent (8) or a non-fluent (12) aphasia. A weighted means of the medians mixed 2 x 3 ANOVA was performed with fluency (fluent, non-fluent) as the between-subjects variable and condition (RD, UN, RA) as the within-subjects variable. There was no main effect of group, F(1,18), MSe = 123732.43, p > .05, or of condition, F (2,36), MSe = 3206.59, p > .05, but there was a marginally significant interaction, F (2, 36), MSe = 3206.59, p = .08.

Due to this marginally significant effect, the participant designations into the fluency groups were re-evaluated. Two participants (one from each group) were difficult to initially classify. Both participants suffered from non-fluent aphasia for many years after their strokes. However, due to motivation and continual treatment, these individuals expressed fluent, but sometimes halting, speech and could belong to either category. If both participants were eliminated from the ANOVA, new results emerged. While the group and condition effects continued to be non-significant, the interaction became significant, F (2, 36), MSe = 2342.83, $p < .02$. An unequal samples post-hoc Tukey HSD was conducted, and revealed that although there were no group differences regarding the UN condition, there were differences in the RA and RD conditions. Fluent participants were significantly slower than the non-fluent participants for these conditions, with RD being the slowest condition and no differences between the UN and RA conditions. The non-fluent participants, on the other hand, were slowest in the UN condition, with no differences between the RA and RD conditions. Figure 3 illustrates these relationships more clearly.

Several regression analyses were performed to determine what, if any, of the variables may have contributed to the reaction times of the aphasia group. Time post-onset (TPO), age, and education were all regressed onto the RT for the RD, UN, and RA conditions. All variables were non-significant with R-squared values of .09, .07, and .06, respectively.

Number of Associates

Of additional interest in this experiment was the possible effect of the number of semantic associates on picture naming ability in the aphasia participants. The number of associates ranged from 4-29, with the naming ability measured as the number of errors per word. An error was any initial utterance that was not the picture's label. This regression was non-significant with an R-squared of .02.

It was found that 13 of the 20 aphasia participants demonstrated relatively good naming abilities (performance of 90% or higher on the picture naming task). A 2 x 3 mixed design ANOVA of weighted means of the medians was conducted. There was no effect of group, condition, or interaction of the two. The presence of anomia does not appear to be a major factor in the results of this experiment.

A different regression analysis was completed with 91 of the prime targets that were not followed by pseudowords. The number of related associates and printed word frequency was regressed on the mean RT for the aphasia group. Neither of these variables affected the RT for this group, with an R^2 of .02.

Chapter Four

Discussion

This study sought to examine the performances of a group of participants with aphasia and their matched control group on a NP lexical decision task. Given that NP is generally "absent" or nonsignificant in studies of older participants (Hasher, et al., 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Tipper, 1991), it was reasonable to assume that persons with aphasia may also exhibit poor performance on similar tasks. Connectionist models of lexical retrieval that include an inhibitory function (Bowles, 1994) may provide insight into the naming and word-retrieval deficits often observed in persons with aphasia. Therefore, lexical decision and naming tasks were chosen to examine both implicit and explicit lexical processes.

While it is not surprising that the participants with aphasia were slower to respond to stimuli and made more errors than the control group, the error patterns were unexpected. Both the control group and the aphasia group exhibited significantly more errors when the trials contained related pairs (related targets or distractor with related target) than when the word pairs were unrelated. It would seem almost as if the related words "surprised" participants, causing more mistakes in lexical judgment. This outcome will be discussed in more detail in the next section.

The main focus of the study was the difference in performances between the two groups. While the aphasia group produced slower RT than the aphasia-control group, there was no overall RT difference between the three conditions. Activation-based inhibition would predict that the RD condition would have slower RTs than the UR condition. Additionally, activation of automatic spreading activation should produce slower RTs in the UN condition than the RA condition. This was not evidenced by either group. While the aphasia group showed a trend towards this effect (RA fastest, UN slow, RD slowest), this trend was not significant. The aphasia-control group did show significantly slower RTs to the UN condition than the RD condition. Traditional NP literature with older participants would seem to fall in line with this result. When compared with young groups, older groups have shown either no difference between the UN and RD conditions or slower RTs to the UN than the RD condition (Hasher, et al., 1991, McDowd & Oseas-Kreger, 1991). But what about the RA condition? Prather et. al.'s (1992) results indicate that PP was not achieved with their participant until an SOA (the time from the onset of the prime to the onset of the probe) of 1500 msec, which approximates the 1428 msec probe response time of the aphasia group. While it does not reflect NP, the RA condition should have acted as a control so that PP would be observed in relation to the UN condition. This was not the pattern of results for any group, including the young control group. Possible reasons for these results will now be explored.

Strategic Versus Automatic Processing

It could be argued that the SOAs (1298.69 msec aphasia group and 1089.37 msec aphasia-control group; these numbers include the 300 msec RSI) was sufficiently long to engage strategic processing instead of automatic spreading activation. Automatic processing is generally presumed to operate at around 250 to 500 ms, so that it is possible that the longer SOAs could reflect strategic processing. However, the lack of significant positive priming for the RA condition leads to a discussion of the possibility of strategic processes.

While Posner and Snyder (1975) proposed a strategic prime-generated expectancy theory, Neely (1991) and Neely & Keefe (1989) have posited a strategic retrospective semantic-matching process. A prospective strategy seems unlikely in this study, given that the expectation of related targets was rarely met. If a prospective mechanism establishes an expectancy for relatedness in the probe trial, then the control participants should have produced PP for the RA condition when compared to the UN condition.

However, it is possible that the relatedness proportion of this experiment contributed to the unremarkable RTs to the RA condition. It has been shown in PP studies that the proportion of related targets to unrelated targets affects RT (Bushell, 1996; Den Heyer, 1985; Keefe & Neely, 1990). When the relatedness proportion is low, participants do not show a significant PP effect. However, Hutchison (2002) did showed PP with a related/unrelated ratio of .25. The relatedness proportion in the present study, if we consider all non-RA conditions including pseudowords, was .08. Could the low relatedness proportion of the RA condition have acted to “surprise” the participants to cause more errors and a decrease in RTs? Recall that the RD condition also produced significantly higher errors. Does this imply that the to-be-ignored distractors were not inhibited in this condition, so that the low relatedness proportion (.08) affected RTs independent of the priming paradigm?

Retrospective semantic-matching was also an unlikely contributor to the results of this study. It has been shown that in a continuous LDT (in which participants respond to both prime and probe displays), backwards semantic matching does not occur (Hutchison, 2002; McNamara & Altarriba, 1985) since a nonword can follow a word just as easily as another word. Prime-probe trials were organized such that although single words were repeated, related pair trials were shown only once and were first associates of the prime in only the forward progression.

Additional information that must be taken into account is that this study was modeled after the NP study of Mari-Beffa, et. al (2000), in which the participants showed the expected negative and PP effects between the RD, UN, and RA conditions. Even with the minor alterations from the modeled study, the younger controls in the current study should have exhibited results similar to those in the Mari-Beffa et al. study since the relatedness proportion in that study and in the current study were the same. It is possible that the stimuli or the changes made for the current study caused this difference in results. While this study was an unsuccessful replication of the work of Mari-Beffa, et al. (2002), it was important to model the study after a successful study using only word stimuli. The fact that the current study was unable to replicate the RA condition in the Mari-Beffa et al. study highlights the need for replication of previous studies in the negative priming literature to help further investigate this phenomenon.

Aphasia Subgroups

The interaction between the fluent and non-fluent aphasia groups after elimination of two difficult to classify participants is of interest. While there were no group differences for the UN condition, the fluent group was significantly slower than the non-fluent group for both the RA and RD conditions. The fluent participants showed the RD condition to be the slowest RT, while the non-fluent participants performed similarly to the aphasia-control group. If the RA condition is put aside in this instance, the participants with fluent aphasia exhibited the expected NP effect in that the RD condition was significantly slower than the UN condition (51 msec). This seems to imply that the participants with fluent aphasia were successfully able to inhibit the distractors in the RD condition, in direct contrast to the conclusions of Wiener, Connor, and Obler (2004) for Wernicke's participants. Were the participants with non-fluent aphasia sensitive to the same processes that lead to the aphasia-control group's results? Or does this imply, as does the aging literature, that inhibition in this sub-group was disrupted or ineffective? Participants with non-fluent aphasia have been reported to show PP automatic spreading activation (Hagoort, 1997; Ostrin & Tyler, 1993), so perhaps the activation spreads successfully, but inhibition is not quickly (Prather et al., 1992) or properly recruited to suppress associates related to the target. It should also be noted that 13 of the 20 aphasia participants were not relatively anomic. Perhaps anomia is the most important variable to study with this paradigm. This portion of the study bears further exploration in future studies.

The non-significant findings for the effects of printed word frequency and number of associates on RT does not necessarily mean that these variables did not contribute to the overall RT. Printed word frequency of the primes was controlled so that there was a mean frequency value with a small standard deviation. In regards to the possible effect of the number of associates on either naming or a LDT, the NP paradigm may not be the best method for measuring the possibility of this effect. However, a number of the participants in the aphasia group performed very well on the picture-naming task, such that they would not be described as anomic per se. Perhaps anomia, and not fluency, is the key factor.

Future Directions

The implications of this study and future studies on the treatment of aphasia is perhaps difficult to see at this point. However, if NP can be used to determine if inhibition is insufficient in persons with aphasia in a LDT, then treatment may be devised that addresses this insufficiency. If inhibition is addressed, will word-retrieval success increase? What other language processes may be affected by poor inhibition instead of or in addition to word-retrieval? The use of free-association norms and knowledge of the effects of word frequency and the number of associates in treatment may also be beneficial to word-retrieval in some way. Future studies would first and foremost utilize a negative priming design with identity stimuli. Identity priming shows robust effects since the prime distractor and probe target are the same word. If persons with aphasia can inhibit the distractor in this situation, then inhibitory processes can be more clearly identified. If identity negative priming fails to show inhibition, then the current study could be replicated with the removal of the related associates (RA) condition. Additional variables to manipulate include varying the RSI or SOA, encouragement or discouragement of strategic processing, and perhaps changing the nature of the LDT task to contrast shallow versus deep semantic processing.

The addition of the RA task in the current study may somehow influence the groups' performance on the negative priming tasks. Removal of the RA condition may allow for a more specific view of inhibitory processes. If results of a purely negative priming task showed similar results, then more specific conclusions may be drawn about inhibitory processing in aphasia.

The RSI in a new experiment also holds great potential for further clarification of online processing in persons with aphasia. The stimulus-onset-asynchrony (SOA; the time between the onset of the prime and the onset of the probe) of the current study was variable such that it was dependent upon the participant's response to the prior stimulus. Adding a fixed SOA of both short and longer durations (perhaps 500 msec, 1000 msec, and 1500 mec) may reveal more about the time needed for inhibition to occur in persons with aphasia, if it occurs at all. It would be interesting to discover a time at which persons with aphasia could exhibit negative priming.

Manipulations of the experimental procedures could encourage or discourage strategic processing, depending upon the goals of the study. It would be beneficial in some ways to examine solely automatic processing so that implicit connections may be probed. Alternatively, strategic processing could provide clues about failures to retrieve lexical information. Directions given to participants may assist in these processes by offering feedback to each response or by setting expectations for related words or other relationships between words.

Directions may also be useful to instruct the participants as to the level of word-processing. For example, word pairs may be judged using a shallow processing task. In this format, participants would be instructed to complete a letter search, count the number of letters, or other task that focuses the prime display not on the semantic level of the word but on some superficial aspect of the word. Deeper semantic processing could be achieved by requesting participants to judge words not on their lexicality but on some other semantic variable, such as living versus non-living. Manipulation of variables such as those mentioned may all provide more specific information regarding inhibitory processing in both aphasia-control and aphasia participants so that treatment studies can be devised.

Conclusions

This preliminary study explored picture naming and a lexical decision NP task between a group of participants with aphasia and their matched controls. The aphasia-control group exhibited faster RT overall than did the aphasia group, but neither group exhibited a NP or PP effect. Retrospective semantic matching was not likely the cause of this result, given the continuous LDT. It is unclear if prospective strategic processing contributed to the lack of PP for the RA condition since Mari-Beffa et. al. (2000) had both PP and NP in her study of young participants with the same relatedness proportion.

The fluent and non-fluent aphasia subgroups did show differences in that the fluent subgroup showed an NP effect, but the non-fluent subgroup performed more like the aphasia-controls. The mechanisms behind these performance differences are unclear and in need of further study. Regression analyses for the aphasia group exploring the possible effect of variables such as word frequency, TPO, age, education, and number of associates on RT were all nonsignificant. The possible contribution of the number of associates on naming and LD would perhaps be better assessed in a different paradigm in which distractors and relatedness are not experimental factors.

References

Anderson, M. C. (1994). Rethinking interference theory: Executive control and the mechanisms of forgetting. *Journal of Memory and Language, 49*, 415-445.

Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior Research Methods, 37* (3), 379-384.

Balota, D., Cortese, M., Sergent-Marshall, S., Spieler, D., & Yap, M. (2004). Visual word recognition of single-syllable words. *Journal of Experimental Psychology: General, 133*, 283-316.

Balota, D.A., Cortese, M.J., Hutchison, K.A., Neely, J.H., Nelson, D., Simpson, G.B., Treiman, R. (2002). The English Lexicon Project: A web-based repository of descriptive and behavioral measures for 40,481 English words and nonwords. http://elexicon.wustl.edu/, Washington University.

Blumstein, S. E., Milberg, W., & Shrier, R. (1982). Semantic processing in aphasia: Evidence from an auditory lexical decision task. *Brain and Language, 17*, 301-315.

Bowles, N. L. (1994). Age and rate of activation in semantic memory. *Psychology and Aging, 9* (3), 414-429.

Chenery, H. J., Ingram, J. C. L., & Murdoch, B. E. (1990). Automatic and volitional semantic processing in aphasia. *Brain and Language*, *38*, 215-232.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review, 85*, 407-428.

Den Heyer, K. (1985). On the nature of the proportion effect in semantic priming. *Acta Psychologica, 60*, 25-38.

Erickson, R. J., Goldfinger, S. D., & LaPointe, L. L. (1996). Auditory vigilance in aphasia individuals: Detecting nonlinguistic stimuli with full or divided attention. *Brain and Cognition, 30*, 244-253.

Fox, E. (1994). Interference and NP from ignored distractors: The role of selection difficulty. *Perception & Psychophysics, 56* (5), 565-574.

Fox, E. (1995). Negative priming from ignored distractors in visual selection: A review. *Psychonomic Bulletin and Review, 2* (2), 145-173.

Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar*. Boston : Houghton Mifflin.

Fuentes, L. J., & Tudela, P. (1992). Semantic processing of foveally and parafoveally presented words in a lexical decision task. *The Quarterly Journal of Experimental Psychology, 45A* (2), 299-322.

Goodglass, H., Kaplan, E., & Barresi, B. (2001). *Boston Diagnostic Aphasia Examination* (3rd ed.). Philadelphia: Lippincott Williams & Wilkins.

Gagnon, D. A., & Martin, N. (2002). Diagnosis, prognosis, and remediation of acquired naming disorders form a connectionist perspective. In R. Daniloff (Ed.), *Connectionist approaches to clinical problems in speech and language* (pp. 147-187). Mahway, NJ: Lawrence Erlbaum Associates.

Gerratt, B. R., & Jones, D. (1987). Aphasic performance on a lexical decision task: Multiple meanings and word frequency. *Brain and Language, 30*, 106-115.

Glosser, G., & Goodglass, H. (1990). Disorders in executive control functions among aphasic and other brain-damaged patients. *Neuropsychology, 12*, 485-501.

Goodglass, H., & Baker, E. (1976). Semantic field, naming, and auditory comprehension in aphasia. *Brain and Language, 3,* 359-374.

Hagoort, P. (1997). Semantic priming in Broca's aphasics at a short SOA: No support for an automatic access deficit. *Brain and Language, 56*, 287-300.

Hamm, V., & Hasher, L. (1992). Age and the availability of inferences. *Psychology and Aging, (7)* 1, 56-64.

Harnishfeger, K. K. (1995). Development of cognitive inhibition. In F. Dempster and C. Brainerd (Eds.), *Interference and Inhibition in Cognition* (pp. 176-204). San Diego, CA: Academic Press.

Hartman, M., & Hasher, L. (1991). Aging and suppression: Memory for previously relevant information. *Psychology and Aging*, (*6)* 4, 587-594.

Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition. *Journal of experimental psychology: Learning, memory, and cognition, 17* (1), 163-169.

Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenbach and T. Carr (Eds.), *Inhibitory Processes in Attention, Memory, and Language* (pp. 53-112). San Diego, CA: Academic Press.

Kane, M., Hasher, L., Stoltzfus, E., Zacks, R., & Connelly, S. (1994). Inhibitory attentional mechanisms and aging. *Psychology and Aging, 9*, 103-112.

Kay, J., Lesser, R., & Coltheart, M. (1992). *Psycholinguistic Assessments of Language Processing in Aphasia.* East Sussex, UK: Psychology Press.

Keefe, D., & Neely, J. (1990). Semantic priming in the pronunciation task: The role of prospective prime-generated expectancies. *Memory and Cognition, 18* (3), 289-298.

Kiran, S., & Thompson, C. K. (2003). The role of semantic complexity in treatment of naming deficits: Training semantic categories in fluent aphasia by controlling exemplar typicality. *Journal of Speech, Language, and Hearing Research, 46*, 608-622.

Little, D. M., & Hartley, A. A. (2000). Further evidence that negative priming in the stroop color-word task is equivalent in older and younger adults. *Psychology and Aging, 15* (1), 9-17.

Lowe, D. G. (1979). Strategies, context, and the mechanism of response inhibition. *Memory and Cognition, 7* (5), 382-389.

Mari-Beffa, P., Hayes, A. E., Machado, L., & Hindle, J. V. (2005). Lack of inhibition in Parkinson's disease: evidence from a lexical decision task. *Neuropsychologia, 43*, 638-646.

Mari-Beffa, P., Fuentes, L., Catena, A., & Houghton, G. (2000). Semantic priming in the prime task effect: Evidence of automatic semantic processing of distractors. *Memory and Cognition, 28* (4), 635-647.

McClelland, J. L., & Rumelhart, D. E. (1988). *Explorations in parallel distributed processing: A handbook of models, programs, and exercises*. Cambridge, MA: MIT Press.

McDowd, J., & Oseas-Kreger, D. (1991). Aging, inhibitory processes, and negative priming. *Journal of Gerontology: Psychology Sciences, 46*, 340-345.

McDowd, J., Oseas-Kreger, D., & Filion, D. (1995). Inhibitory processes in cognition and aging. In F. Dempster and C. Brainerd (Eds.), *Interference and Inhibition in Cognition* (pp. 363-400). San Diego, CA: Academic Press.

McNamara, T., & Altarrriba, J. (1985). Depth of spreading activation revisited: Semantic mediated priming occurs in lexical decision. *Journal of Memory and Language, 27*, 545-559.

Milberg, W., & Blumstein, S. E. (1981). Lexical decision and aphasia: evidence for semantic processing. *Brain and Language, 14*, 371-385.

Milberg, W., Blumstein, S. E., & Dworetzky, B. (1987). Processing of lexical ambiguities in aphasia. *Brain and Language, 31*, 138-150.

Milberg, W., Blumstein, S., & Dworetzky, B. (1988). Phonological processing and lexical access in aphasia. *Brain and Language, 34*, 279-293.

Mimura, M., Goodglass, H., & Milberg, W. (1996). Preserved semantic priming effect in aphasia. *Brain and Language, 54*, 434-446.

Moore, C. M. (1994). Negative priming depends on probe-trial conflict: Where has all the inhibition gone? *Perception & Psychophysics, 56* (2), 133-147.

Murray, L. L., Holland, A. L., & Beeson, P. M. (1997). Auditory processing in individuals with mild aphasia: A study of resource allocation. *Journal of Speech, Language, and Hearing Research, 40*, 792-809.

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner and & G. Humphreys

(Eds.), *Basic processes in reading: Visual word recognition* (pp. 264-336). Hillsdale, NJ: Erlbaum.

Neill, W. T. (1979). Switching attention within and between categories: Evidence for intracategory inhibition. *Memory and Cognition, 7* (4), 283-290.

Neill, W. T., & Valdes, L. A. (1992). Persistence of negative priming: Steady state or decay? *Journal of Experimental Psychology: Learning, Memory, & Cognition, 18*, 565-576.

Neill, W. T., Valdes, L. A., & Terry, K. M. (1995). Selective attention and the inhibitory control of cognition. In Frank N. Dempster and Charles J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 207-261). San Diego, CA: Academic Press.

Neill, W. T., & Westberry, R. L. (1987). Selective attention and the suppression of cognitive noise. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13* (2) 327-334.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/.

Neumann, E. & DeSchepper, B. G. (1992). An inhibition-based fan effect: Evidence for an active suppression mechanism in selective attention. *Canadian Journal of Psychology, 46*, 1-40.

Ostrin, R. K., & Tyler, L. K. (1993). Automatic access to lexical semantics in aphasia: Evidence from semantic and associative priming. *Brain and Language, 45*, 147-159.

Prather, P., Zurif, E., Stern, C., & Rosen, T. J. (1992). Slowed lexical access in nonfluent aphasia: A case study. *Brain and Language, 43*, 336-348.

Salthouse, T. A. (1982). Adult cognition: An experimental psychology of human aging. New York: Springer-Verlag.

Strayer, D., & Grison, S. (1999). Negative priming identity is contingent on stimulus repetition. *Journal of Experimental Psychology, 25* (1), 24-38.

Sullivan, M. P., & Faust, M. E. (1993). Evidence for identity inhibition during selective attention in old adults. *Psychology and Aging, 8* (4), 589-598.

Sullivan, M. P., Faust, M. E., & Balota, D. A. (1995). Identity negative priming in older adults and individuals with Dementia of Alzheimer's type. *Neuropsychology, 9*, 537-555.

Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *Quarterly Journal of Experimental Psychology, 37A*, 571-590.

Tipper, S. P. (1991). Less attentional selectivity as a result of declining inhibition in older adults. *Bulletin of the Psychonomic Society, 29,* 45-47.

Tipper, S. P., & Cranston, M. (1985). Selective attention and priming: Inhibitory and facilitatory effects of ignored primes. *Quarterly Journal of Experimental Psychology, 37A,* 591-611.

Tipper, S. P., Weaver, B., Cameron, S., Brehaut, J., & Bastedo, J. (1991). Inhibitory mechanisms of attention in identification and localization tasks: Time course and disruption. *Journal of Experimental Psychology: Learning, memory, & cognition, 17*, 681-692.

Wayland, S., & Taplin, J. E. (1982). Nonverbal categorization in fluent and nonfluent anomic aphasics. *Brain and Language, 16*, 87-108.

Whitehouse, P., Caramazza, A., & Zurif, E. (1978). Naming in aphasia: Interactivity effects of form and function. *Brain and Language, 6*, 63-74.

Wiener, D. A., Connor, L. T., & Obler, L. K. (2004). Inhibition and auditory comprehension in Wernicke's aphasia. *Aphasiology, 18*, 599-609.

Yee, P. L. (1991). Semantic inhibition of ignored words during a figure classification task. *The Quarterly Journal of Experimental Psychology, 43A* (1), 127-153.

Zingeser, L. B. & Berndt, R. S. (1990). Retrieval of nouns and verbs in agrammatism and anomia. *Brain and Language, 39*, 14-32. *Neuropychologia, 43,* 638-646.

Appendices

Appendix A: List of Words

head	sugar	steel	court	gate	tissue
snake	dishes	work	paper	soap	winter
author	effect	death	rubber	bait	piece
song	milk	cage	kitten	clean	knife
team	link	bread	earth	lion	eggs
stop	house	baby	child	summer	roof
wings	stone	plant	lake	animal	quart
white	love	bacon	black	member	city
rock	poet	shoe	card	copper	bike
band	beach	coach	tree	hate	fence
sign	red	race	judge	button	club
iron	fish	foot	shirt	phone	enemy
moon	life	book	money	green	needle
shower	game	thread	wood	dirt	morning
window	sweet	tunnel	water	tea	fork
speech	sand	fire	people	class	car
job	quiz	knob	picture	bird	town
color	grass	street	bank	writer	part
sun	king	neck	blood	knit	wash
chain	door	seed	school	head	people
mouth	plates	cause	bath	dark	loaf
wire	leaf	camera	lunch	world	thing

Appendix A: continued

truck	bite	alley	night	part	object
soil	queen	cycle	test	coffee	glass

Appendix B: List of Pseudowords

alles	aniral	bame	beke	birs	bith
bleck	bluc	bork	cank	caz	cemera
chuld	ciepe	coof	couse	dalk	deach
deats	der	dight	dinnel	disles	dreab
dreath	druck	emms	flass	forp	freen
gart	gite	glast	griend	gudje	haby
heaf	houfe	ilong	jat	jow	kalt
kilm	kirg	knire	kree	leopple	loag
loffee	lufe	lunnet	mard	mindow	mong
mool	nace	nacob	naich	neesle	nence
nink	nomey	noor	nowt	paber	poas
prant	prass	pugar	quan	quant	quez
rautho	rictupe	rebber	rinned	rosel	roloc
runch	sceel	scrool	shif	slean	smirt
snape	soit	soach	spoe	stome	streef
suf	sweech	tace	ticy	taib	tand
tawer	tassue	teffec	thear	thoum	keam
thung	tibe	vash	vead	vings	warld
wign	woog	yause	yock	vang	tourc
tast	knos	onemy	haber	triwer	smower

Table 1.

Summary of relevant lexical decision priming studies with aphasia participants by author, reaction time variables in msec, aphasia type, and stimulus modality.

Experiment Authors	Aphasia types	SOAs/ITIs (msec)	Modality
Ostrin & Tyler (1993)	4 non-fluent	250/6000	auditory
Chenery et al. (1990)	Low & high comprehenders	500/8000	auditory
Prather, et al. (1992)	1 non-fluent	Exp. 1 500, 800, 1500	visual
		Exp. 2 800, 1500, 1800	
Milberg & Blumstein (1981)	4 non-fluent, 7 fluent	2000/4000	visual
Blumstein et al. (1982)	11 non-fluent, 12 fluent	500/8000	auditory
Hagoort (1997)	13 non-fluent	Exp. 1 1400/3000	visual
	10 non-fluent	Exp. 2 300/1000	visual
Mimura et al. (1996)	1 non-fluent	Exp. 1 500/not specified	visual
Bushell (1996)	8 non-fluent	500/2000	visual

Table 2.

Means and standard deviations (in msec) of median reaction times for all groups to the probe display for all conditions.

	Condition			Priming Difference	
Group	RD	UN	RA	(UN-RD)	(UN-RA)
Young	626	615	618	-11*	-3
SD	73	72	80		
Aphasia controls	717	755	727	38*	28
SD	162	188	159		
Aphasia	950	933	924	-17	9
SD	228	189	235		

Note. RD=related distractor; UN=unrelated pairs; RA=related targets. * = $p < .05$.

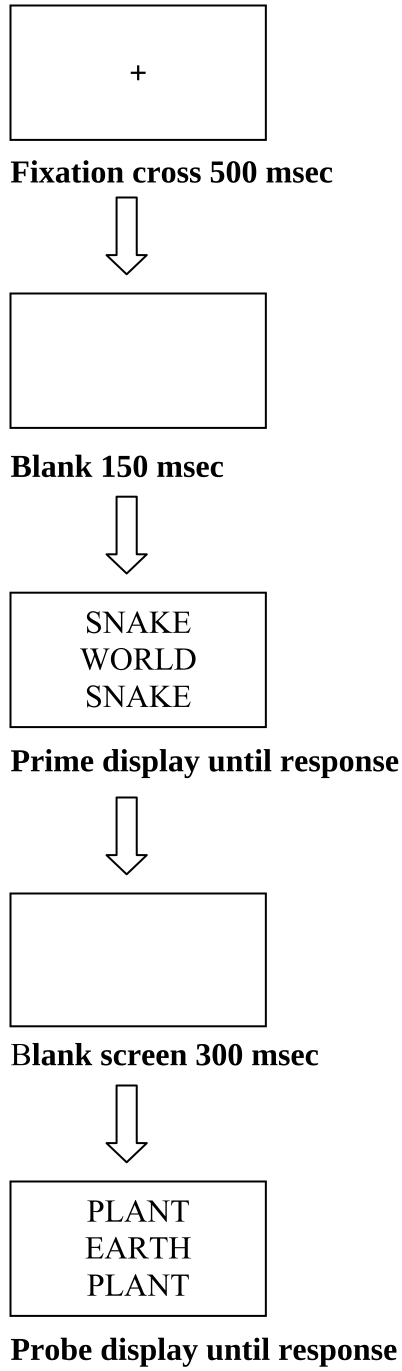

Figure 1. An example of the progression of computer screen displays for a related trial.

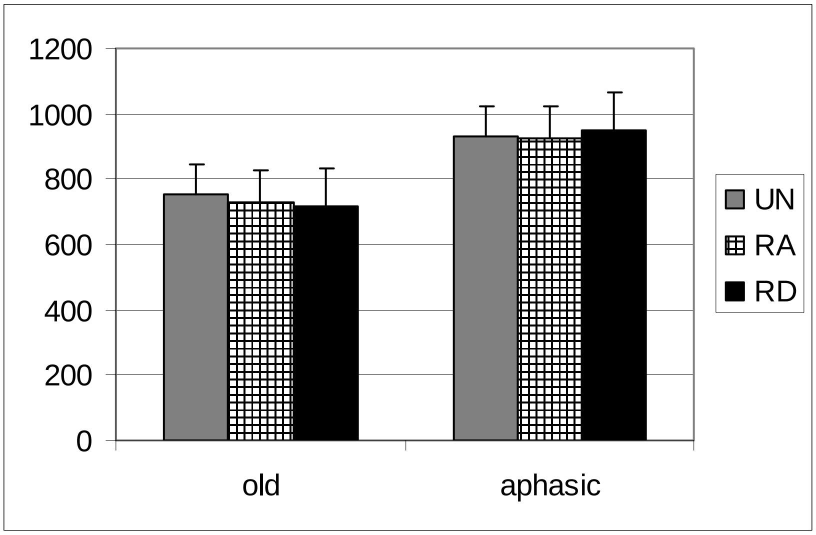

Figure 2. Means of median reaction times (in msec) for all groups. *Note*. RD = related distractor; UN = unrelated pairs; RA = related targets.

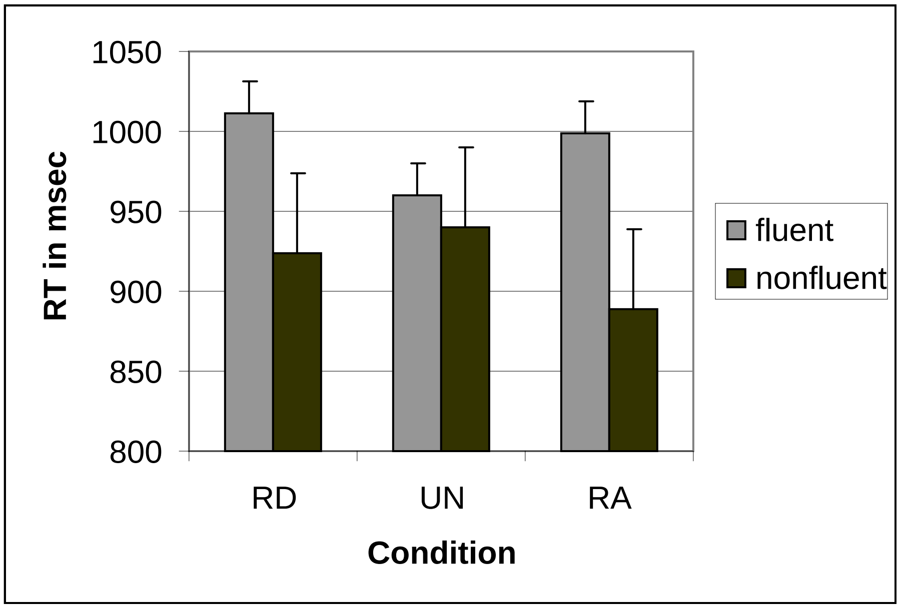

Figure 3. Means of median RT for fluent and non-fluent aphasias. Note. RD = related distractor; UN = unrelated pairs; RA = related targets.