University of Windsor

Scholarship at UWindsor

Electronic Theses and Dissertations

Theses, Dissertations, and Major Papers

2005

Hemispheric asymmetries for accessing the phonological representation of single printed words.

Christopher H. Domen
University of Windsor

Follow this and additional works at: https://scholar.uwindsor.ca/etd

Recommended Citation

Domen, Christopher H., "Hemispheric asymmetries for accessing the phonological representation of single printed words." (2005). *Electronic Theses and Dissertations*. 2283.
https://scholar.uwindsor.ca/etd/2283

HEMISPHERIC ASYMMETRIES FOR ACCESSING THE PHONOLOGICAL REPRESENTATION OF SINGLE PRINTED WORDS

By

Christopher H. Domen

A Thesis
Submitted to the Faculty of Graduate Studies and Research
Through the Department of Psychology
In Partial Fulfillment of the Requirements for
the degree of Master of Arts at the
University of Windsor

Windsor, Ontario, Canada

2005

© 2005 Christopher H. Domen

Canada

1032609

ABSTRACT

The differential abilities of the cerebral hemispheres to access the phonological representation of printed words was investigated using a visual half-field paradigm in which participants performed a lexical decision task for target words primed by semantic associates (e.g., TOAD-FROG), homophones of words semantically associated to target words (e.g., TOWED-FROG), and unrelated control words (e.g., FINK-FROG, PLASM-FROG). At a short stimulus onset asynchrony (165ms), significant priming was obtained for both semantic and homophonic associates regardless of visual field of presentation, although the effects were much less robust for the left visual field/right hemisphere. Thus, both hemispheres seem to initially have access to the semantic and phonological representations of printed words, but with the degree of activation being less in the right hemisphere. These results replicate those of previous studies indicating that both hemispheres initially have access to the phonological representations of printed words and are discussed in terms of the model of the hemispheres proposed by Chiarello (2003).

Acknowledgements

First, and foremost, I would like to thank my advisor, Lori Buchanan. I couldn't have completed this body of work without her knowledge, expertise and, perhaps most importantly, her support. Also, I would like to thank each of my committee members: Pierre Boulos, Stephen Hibbard and Keith Taylor. I appreciate your willingness to donate your time and delve into a new domain of research. Your comments and suggestions enabled me to think more critically about my research and greatly improved the quality of my work. To Karey, thank you for your support throughout. I apologize for all the times I was stressed and irritable. I love you. Thank you to all of my fellow graduate students for your support. Annette, thank you for helping me develop the idea for this thesis. Kevin, thanks for the non-words. To Ruth Ann Atchley, thank you for piquing my interest in psycholinguistics. Merritt, thank you for your support. You will always be like a brother to me. Jean and Phillip, thank you for your support. I am lucky to have you in my life. Bonnie, thank you for being Mom number two. Last, but not least, thank you Mom and Dad. I could not have accomplished this without you. Thank you for always showing me unconditional love and support.

TABLE OF CONTENTS

Chapter I

Introduction

Nineteenth century neurologists investigating the correlation between left hemisphere (LH) brain injury and language disorders initially established the importance of the LH for language comprehension and production (Beeman & Chiarello, 1998a). Since that time, linguistic functions have been thought of as uniquely lateralized to the LH, but it is now becoming increasingly clear that the right hemisphere (RH) mediates some linguistic processing. For example, prosody (i.e., fluctuations in melody or tone conveying grammatical differences in speech), discourse comprehension (i.e., the ability to mentally connect a series of disparate sentences that describe a sequence of events into a coherent whole), appreciation of figurative language (i.e., metaphors and idioms), and word meaning judgements can be impaired following RH injury (Chiarello, 2003). Thus, in contrast to the historical view of language lateralization, the modern view holds that although the LH is linguistically superior to the RH (Zaidel, 1990), the RH also contributes to linguistic performance, possibly in a complementary manner (Beeman & Chiarello, 1998a). The aim of this study is to contribute to our understanding of how the LH and RH complement each other, and more specifically to address the question of whether the hemispheres have differential access to the phonological (i.e. sound) representation of printed words.

Mechanisms for Accessing Meaning From Print

It seems clear that both the LH and RH are able to comprehend printed words (Chiarello, Hasbrooke, & Maxfield, 1999). The debate now centers on the mechanism, or mechanisms, by which the two hemispheres access semantic information (i.e., meaning)

in the mental lexicon (i.e., the mental dictionary). The lexical and sublexical routes are the two major mechanisms postulated thus far. The lexical, or direct, route takes advantage of the orthographic representation (i.e., letter identities) of words to access meaning. This is accomplished through either the visual recognition of the physical characteristics of the whole word (Smith, 1971), or through some undefined graphemic code (Evett & Humphreys, 1981). The sublexical, or assembled, route uses the phonological (i.e., linguistic sound patterns) representation of a word in order to access the appropriate lexical entry. The phonological representation of a word is yielded through a process of first parsing a word into its component graphemes, and then converting those graphemes into their phonemic equivalents. This conversion process operates on a set of explicit grapheme-phoneme-correspondence rules (Pinker, 1991, 1999) that most individuals know as the "sounding out" of a printed word. Although the predominant opinion is that the "...RH cannot evoke the sound image of a word from the orthographic representation" (Zaidel & Peters, 1981, p.218), a careful examination of the literature does not support such a conclusion.

<div align="center">Data from Commisurotomy Patients</div>

The conclusion that the RH does not have access to the phonological representation of printed words receives the most support from linguistic data produced by commisurotomy patients. These patients have had the interhemispheric fibre tracts (i.e., the corpus callosum and anterior commissure) that connect and transmit information between the LH and RH surgically cut. As a consequence of this surgery, researchers can evaluate the differential contributions of the two hemispheres more or less independently. For many linguistic studies this is done by taking advantage of the anatomical organization of the visual system whereby visual information presented to one visual

field, in the case of a complete commisurotomy, can be assumed to be processed by only

the hemisphere contralateral to the visual field of stimulus presentation (i.e., the spatial

location to the right or left of where an individual is fixating; for review see Chiarello,

2003).

The findings from commisurotomy patients most relevant to the present study are

that such patients are unable to match a word presented to the left visual field (LVF)/RH

to a rhyming word or picture (Baynes, Wessinger, Fendrich, & Gazzaniga, 1995; Sidtis,

Volpe, Wilson, Rayport, & Gazzaniga, 1981; Zaidel & Peters, 1981). Although these

results are compelling evidence against the presence of phonological processing in the

RH, a truly convincing demonstration of a similar lack of phonological processing in the

RH of intact individuals would strengthen that claim. Such evidence might be that

performance on rhyme decision tasks is enhanced for words presented to the right visual

field (RVF)/LH as compared to the LVF/RH (Chiarello et al., 1999).[1]

Data from Rhyme Decision Experiments done with Neurologically Intact Individuals

Although the two hemispheres are not isolated from each other in neurologically

intact individuals, when processing is initiated by either the RH or LH, asymmetries in

task performance reflective of the processing capabilities of each individual hemisphere

may be observed. For rhyme decision tasks, some results do indicate enhanced

performance for words presented to the LH, but these results are not as conclusive as is

generally purported (Chiarello, Hasbrooke, & Maxfield, 1999). Both Rayman and Zaidel

(1991) and Banich and Karol (1992) found a LH advantage for rhyme decisions when the

---

[1] For the purposes of the present discussion, although the relationship is not exact, stimuli being presented to the RVF will henceforth be referred to as being presented to the LH and stimuli being presented to the LVF will henceforth be referred to as being presented to the RH.

initial word was presented centrally and the subsequent word (i.e., the word to be judged) was presented laterally along with an unrelated distracter word simultaneously presented in the opposite visual field. In a condition in which the unrelated distracter was not presented, however, neither Rayman and Zaidel (1991) or Banich and Karol (1992) found a hemispheric advantage. The former findings are suggestive of a RH without access to phonology, but the latter findings suggest that this claim must be tempered. According to Chiarello et al. (1999), if the phonological processing necessary for the successful completion of the rhyme judgment task was done solely in the LH, then a LH advantage would have been obtained because the words to be judged presented to the RH would have been put at a disadvantage due to the need for callosal relay. The results obtained by Hunter and Liederman (1991) mirror those of Raman and Zaidel (1991) and Banich and Karol (1992).

Hunter and Liederman (1991) had participants perform a lateralized rhyme judgment task under single and dual task conditions. In a dual task paradigm, a task of interest, in this case rhyme decisions, is paired with a secondary task that is assumed to tap the process of interest, in this case verbal processing. For Hunter and Liederman (1991), the secondary task was one of verbal memory in which participants were asked to remember six words. This task was hypothesized to overload the processing capabilities of the verbally dominant LH, and contrasts in performance on primary task between that condition and one without the secondary task would reveal LH contributions in the form of reduced LH advantage in the secondary task condition. The data supported this hypothesis: under single task conditions a typical LH advantage was obtained, but under the dual task condition no asymmetries were found. These results are consistent with the findings of Rayman and Zaidel (1991) and Banich and Karol (1992), in that the secondary

task selectively disrupted the phonological processing of the LH, thus indicating that the RH did not rely on the LH to perform any of the phonological processing required for rhyme judgements, as LH and RH performance was equal under dual task conditions. Taken together, the results of Rayman and Zaidel (1991), Banich and Karol (1992), and Hunter and Liederman (1991) suggest that the RH's phonological processing capabilities are not equivalent to the LH, as hemispheric asymmetries favouring the LH are obtained on tasks that require more demanding phonological processing, but that the RH does have limited access to phonology (Chiarello et al., 1999).

Data from Phonological Priming Experiments done with Neurologically Intact

Individuals

Although the above evidence supports a LH advantage for phonological processing and corresponding phonological insensitivity in RH, this strong position requires consideration of all types of phonological sensitivity. It is important to note the difference between the explicit phonological awareness required of rhyming matches and the passive activation of phonological information that simply gets accrued during exposure to visually presented words. In other words, the RH's relative inability to perform rhyme judgement tasks does not necessarily imply a complete inability to derive phonological information from print (Chiarello et al., 1999). Evidence of the RH's ability to process other types of linguistic information has been much more readily obtained using implicit measures of processing (i.e., those that do not require overt decisions) rather than explicit measures (for review see Beeman & Chiarello, 1998b) and this is true even of phonological processing (Chiarello et al., 1999), although in this the findings are somewhat divergent.

Unlike explicit tasks such as rhyme judgments, tasks of implicit phonological awareness require a manipulation of phonological variables without overt demands that they be processed. One ideal manipulation is the use of phonological primes in tasks that otherwise keep processing requirements equal (Stone & Van Orden, 1993). Relatively few studies have used phonological priming (i.e., an implicit measure) with visual half-field paradigms to study the differential abilities of the hemispheres to access phonological information. Chiarello (1985) examined priming between centrally presented word primes and laterally presented target words that were orthographically dissimilar rhymes (e.g., JUICE-MOOSE) in a lexical decision task (LD; i.e., participants are asked to judge whether a target letter string is a word). Chiarello (1985) obtained significant priming (i.e., facilitated LD times for phonologically related versus non-rhyming prime-target pairs) for the LH alone in a condition in which the proportion of related prime-target pairs was low. When the relatedness proportion was high, however, significant priming was obtained for both the LH and RH. Such a result is problematic for researchers holding the strong position that the RH is insensitive to phonological information.

Two studies have investigated another form of implicit phonological processing, this via the influence of unattended distracter items on phonologically related target items in terms of single word processing, in visual half-field paradigms. Underwood, Rusted, and Thwaites (1983) conducted a LD experiment in which target words were presented centrally, while homophones of words semantically related to the target words (e.g., RUBBISH-WAIST) were simultaneously presented to either the LH or RH. Participants were instructed to decide whether the centrally presented target was a word or not, and ignore the laterally presented distracter items. LD times were attenuated regardless of the

visual field in which the homophonic distracter items were presented. Underwood et al. (1983) thus concluded that both the LH and RH have access to phonological information. Chiarello et al. (1999) presented two letter strings simultaneously to either the LH or RH, one vertically and one horizontally so that each pair shared an interior letter. Participants were instructed to either name the horizontal letter string and ignore the vertical letter string or vice versa. Chiarello et al. (1999) manipulated the phonological similarity of both word-nonword pairs (e.g., PRIZE-PRIPE) and word-word pairs (e.g., CALF-LAUGH) and observed facilitation for naming of words by phonologically related distracter items regardless of visual field. Thus the results of Chiarello et al. (1999) are in line with those of Underwood et al. (1983) and the high relatedness proportion condition of Chiarello (1985), in that evidence for bilateral access to phonology was found.

In contrast to Chiarello et al. (1999), Chiarello, (1985), and Underwood et al. (1983), Lavidor and Ellis (2003) found no evidence for RH phonological processing. In a visual half-field LD experiment, target words were presented laterally, subsequent to the central presentation of homophones of the target words that were either orthographically similar (e.g., LEAK-LEEK) or dissimilar (WITCH-WHICH). For the LH, significant facilitation of LD times was observed regardless of orthographic similarity. For the RH, however, significant facilitation of LD times was observed only for the condition in which the homophones were orthographically similar.

Chiarello's (1985) results may be explained via strategic processes, as facilitative phonological priming occurred for both the LH and RH in the high relatedness condition while there was no such effect in RH in the low relatedness condition. Under conditions subsuming automatic processing, facilitative priming effects are thought to arise due to the automatic spread of activation through associative connections in the mental lexicon.

In other words, the activation of a concept in the mental lexicon via a prime results in the residual activation of associated concepts. Thus, when a target related to the prime is presented, it is in a preactivated state and easier to subsequently access. Under conditions allowing for controlled processing, expectancy processes may be used. In other words, participants may use the prime to explicitly generate candidates for the subsequent target. Two factors influence the extent to which expectancy factors are used: stimulus onset asynchrony (SOA; i.e., the time elapsed between the onset of the prime and the onset of the target) and relatedness proportion of prime target pairs. The greater the SOA (i.e., greater than 400ms) and relatedness proportion (i.e., greater than .33), the more likely controlled processes are going to occur (for review see McNamara & Holbrook, 2003). Chiarello's (1985) results are consistent with a view of the hemispheres in which only the LH's lexicon is organized so that phonologically related concepts are interconnected, as automatic phonological priming only occurred in the LH condition and not the RH condition. The RH may have access to the phonological representation of words, but Chiarello's (1985) results are more in line with the interpretation that, under conditions allowing for controlled processing, RH phonological priming was obtained because of callosal relay. In other words, although the RH was unable to perform the phonological computations required of it by the phonological priming task, priming in the RH was obtained because of LH processing. Despite the time taken for the interhemispheric transfer of the stimuli from the RH to the LH, the LH was given sufficient time and indication as to the subsequent target that it completed the LD in a timely manner.

Although the findings of Chiarello (1985) and Lavidor and Ellis (2003) are consistent with the viewpoint that the RH does not have automatic access to phonology, the results of both Chiarello et al. (1999) and Underwood et al. (1983) provide evidence

to the contrary. Lavidor and Ellis (2003) note, however, that the temporal sequences of their own study and that of Chiarello (1985) differ markedly from that of both Chiarello et al. (1999) and Underwood et al. (1983). Chiarello et al. (1999) and Underwood et al. (1983) both used tasks in which a phonologically related distracter was presented simultaneously with the target word. Chiarello (1985) and Lavidor and Ellis (2003), on the other hand, used an SOA of approximately 500 ms. Thus, Lavidor and Ellis (2003) suggest that phonological information may initially be available to the RH but rapidly decays. The purpose of the present experiment was to test this hypothesis by examining phonological priming effects at a short SOA under conditions requiring automatic processing for printed words in the LH and RH.

Goal and Hypotheses of the Present Study

Goal

The goal of the present study was to investigate whether the RH has access to phonological information early on in the time course of processing printed words. In order to investigate hemispheric differences in phonological priming at a short SOA (165 ms), we conducted a visual half-field LD experiment in which target words (e.g., FROG) were primed by semantic associates (e.g., TOAD), homophones of the semantic associates (e.g., TOWED), unrelated semantic associate controls (e.g., FINK), or unrelated controls for the homophones of the semantic associates (e.g., PLASM)[2]. Both the semantic associates and homophonic associates (i.e., homophones of the semantic associates) chosen for this study have been shown to act as effective primes in studies using central visual field presentation (Lukatela & Turvey, 1994). Priming by

---

[2] For simplicity, henceforth, one stimulus prime-target pair is used to represent the set of stimuli to which it belongs.

homophonic associates is assumed to be the result of phonologically mediated activation of the semantic associate of the target.

Hypotheses

Given the goal and research design of the present study, the following predictions may be made:

1. The omnibus repeated measures analysis of variance (ANOVA) will include the variables: hemisphere of stimulus presentation (LH, RH) and prime type (TOAD-FROG, TOWED-FROG, FINK-FROG, PLASM-FROG). Given that a LH advantage for processing of words is one of the more robust and consistent findings in the literature concerning hemispheric asymmetries (Chiarello, 2003), we predict that target words presented to the LH will be responded to faster and more accurately than target words presented to the RH. This would be reflected as a main effect of hemisphere of stimulus presentation in the omnibus ANOVA.

2. Both semantic and homophonic associates have previously been shown to be effective primes in central visual field tasks (i.e., faster and more accurate responses to TOAD-FROG than FINK-FROG, and TOWED-FROG than PLASM-FROG), indicative of the activation of both semantic and phonological information across the hemispheres. This activation would be reflected partially through a main effect of prime type in the omnibus ANOVA. However, planned comparisons comparing only TOAD-FROG and FINK-FROG, and TOWED-FROG and PLASM-FROG will have to be conducted in order to determine what is truly driving the effect in the omnibus

ANOVA, as priming by only semantic associates or homophonic associates could cause the main effect to be significant.

3.   Regarding priming by semantic associates, access to word meaning is bilateral (for review see Chiarello, 2003). Thus, we predicted that priming would occur for the semantic associates (i.e., faster and more accurate responses to TOAD-FROG than FINK-FROG) regardless of hemisphere of stimulus presentation. If access to phonological information is also bilateral, then priming will also occur for the homophonic associates (i.e., faster and more accurate responses to TOWED-FROG than PLASM-FROG) regardless of hemisphere of stimulus presentation. As such, the pattern of priming across the hemispheres would be the same for semantic and homophonic associates, with both semantic priming and priming by the homophonic associates occurring bilaterally. Thus, no interaction in the omnibus ANOVA would be predicted. In contrast, if the RH is unable to access phonological information, then no priming will occur in the RH for the homophonic associates (i.e., no difference in speed or accuracy of responses to TOWED-FROG and PLASM-FROG). As such, the pattern of priming across the hemispheres would be different for semantic and homophonic associates, as semantic priming would occur bilaterally and priming by the homophonic associates would only occur in the LH. Thus, an interaction in the omnibus ANOVA would be predicted.

4.   As stated previously, additional ANOVAs will be conducted in order to examine priming by semantic and homophonic associates separately. For these planned comparisons the ANOVA concerning priming by semantic associates will include hemisphere of stimulus presentation (LH, RH) and

prime type (TOAD-FROG, FINK-FROG), and the ANOVA concerning

priming by homophonic associates will include hemisphere of stimulus

presentation (LH, RH) and prime type (TOWED-FROG, PLASM-FROG).

For both of the planned comparisons, if a significant main effect of prime type

is found that favors the associate conditions rather than the control conditions

(i.e., faster and more accurate responses to TOAD-FROG/TOWED-FROG

than FINK-FROG/PLASM-FROG), then priming has been obtained that is

reflective of access to either semantic or phonological information,

respectively. Also, if as predicted, both hemispheres have access to both types

of information early on in the processing of print, then no interactions are

expected. However, if the RH does not have access to phonological

information, then an interaction in the ANOVA concerning priming by

homophonic associates would be expected.

Chapter II

Method

Participants

Participants were students at the University of Windsor. Participants with an excessive error rate for the experimental trials (> 30%) were removed from the final analysis, as they were likely performing at chance levels. Of 66 participants, 26 were removed from the final analyses due to excessive error rates. Of the 40 participants included in the final analysis, 16 were males and 24 were females. All participants were right-handed native speakers of English with normal or corrected to normal vision and no history of neurological trauma.

Materials

All critical stimuli were taken from Lukatela and Turvey (1994) and consisted of 320 prime-target pairs (see Appendix A). The prime-target pairs combined each of 80 target words with four distinct primes, each corresponding to an experimental condition. For each foursome of primes, one was associatively related to the target word (e.g., TOAD as the prime for the target FROG), one was a homophone of the word associatively related to the target word (e.g., TOWED as the prime for the target FROG), one word served as an unrelated, length-matched control for the associatively related member of the yoked homophones (e.g., FINK as the prime for the target FROG), and one word served as an unrelated, length-matched control for the non-associatively related member of the yoked homophones (e.g., PLASM as the prime for the target FROG). In relation to its corresponding homophone, each control word had no letters in common (in rare cases just one letter, but in a different position), was the same length, was

approximately of the same word frequency, and was not a prominent associate of the corresponding target word.

In addition to the above critical stimuli, 320 non-critical prime-target pairs were presented. Forty such pairs were associatively related words taken from the University of South Florida free association norms (e.g., HAIR as the prime for the target COMB; see Appendix B; Nelson, McEvoy, & Schreiber, 1998), 40 non-related word pairs (e.g., ORANGE as the prime for the target DOG; see Appendix C), and 240 word-nonword pairs (e.g., CAT as the prime for the target FRIP; see Appendix D). All nonwords were orthographically regular and pronounceable.

Design

In this LD task participants were asked to decide whether a letter string (i.e., the target) displayed on the computer screen in the participant's LVF/RH or RVF/LH was a real English word. Each participant saw a total of 400 target items, each of which was preceded by another item for which no response was required (i.e., the prime). Prime and target items are as described above. Each participant saw all 320 non-critical prime-target pairs, with the nonwords serving as the target for all word-nonword pairs. For each participant, the 80 critical prime-target pairs that were seen was determined through random assignment to one of eight conditions. The eight conditions were determined by crossing all permutations of the two factors in this experiment: visual field of stimulus presentation/hemisphere of stimulus presentation (i.e., LVF/RH & RVF/LH) and prime type of the critical prime-target pairs (i.e., TOAD-FROG, TOWED-FROG, FINK-FROG, PLASM-FROG), such that each subject saw a critical target word only once and so that each of the critical target words was presented to half the subjects in the LVF/RH and half in the RVF/LH (e.g., condition 1: TOAD-FROG presented in the LVF/RH, condition 2:

TOWED-FROG presented in the LVF/RH, condition 3: FINK-FROG presented in the

LVF/RH, condition 4: PLASM-FROG presented in the LVF/RH, condition 5: TOAD-

FROG presented in the RVF/LH, condition 6: TOWED-FROG presented in the RVF/LH,

condition 7: FINK-FROG presented in the RVF/LH, condition 8: PLASM-FROG

presented in the RVF/LH). Consequently, 8 lists were created with 10 critical stimuli

pairs per condition in each list.

A 50-item practice list was also created. The construction of the practice list

mirrored the construction of the experimental lists.

Apparatus and Procedure

A Pentium III PC running Direct RT was used to present the stimuli and collect

reaction time (RT) and accuracy data. The stimuli were white, seen against a black

background, presented in a 24-point bold font. For each trial, a fixation point (+) was

presented in the center of the screen. The fixation point was present for the duration of

each trial. After an initial 1000 ms period during which only the fixation point was

present, the prime was presented to either the RVF/LH or LVF/RH for 150 ms. The

participants' heads were placed in a chin-rest 152cm from the monitor so that the visual

angle from the central fixation point to the innermost edge of each word was 2.25°.

Limiting the presentation time of the stimulus and manipulating the visual angle ensured

that the stimuli were presented laterally and that the participants were not able to foveate

toward the stimuli (Chiarello, 1985). Following the prime, only the fixation point was

present for 15 ms, so that the total stimulus onset asynchrony (SOA) was 165 ms. This

short SOA, in combination with the fact only 20% of the prime-target pairs were

associatively related per list for each of the conditions, ensured automatic processing of

the stimuli by the participants (McNamara & Holbrook, 2003). The target word was then presented to either the RVF/LH or LVF/RH for 175 ms. Following the presentation of the target word, a mask (e.g., #####) was displayed bilaterally until the participant responded. The subsequent trial began immediately after the response. For the critical trials, all primes were be presented in the same visual field as the targets. For the non-critical trials, half of the primes were presented in the same visual field as the targets and half were presented in the opposite visual field. Thus, the location of the prime did not provide a clue as to the subsequent location of the corresponding target. Prime-target pairs in each list were presented in random order.

Participants were asked to make a determination as to whether the target was a word or nonword. Responses were made via a button response made on a keyboard. Participants were instructed to make their response as quickly and accurately as possible. Participants were told that they should ignore the prime and not respond to it. The experimenter emphasized the importance of focusing on the fixation cross throughout the duration of trial. Each experimental session began with the practice list. The practice list was administered in two parts. After half of the practice trials were administered the experimenter provided the participant with feedback concerning accuracy.

Chapter III

Results

Presentation and background effects

Initially, the independent variables gender and list were analyzed to determine whether they had significant effects on performance or interaction with hemisphere of stimulus presentation. Using the dependent variables RT and percentage of correct responses, repeated measures analyses of variance (ANOVAs) were conducted and revealed that neither gender nor list had significant effects or interaction with the other variables (Fs < 2.5). Therefore, the data from all 40 participants performing above chance levels were grouped.

Reaction Time Analyses

Repeated measures ANOVAs were performed both by participants (F_1) and by items (F_2). For each participant, RT responses three standard deviations from the mean RT for the critical trials were labeled as outliers and not analyzed. Also, only RTs for correct trials were included.

Omnibus Repeated Measures Analyses of Variance

Regarding the omnibus ANOVAs, for the participants' analysis, hemisphere of stimulus presentation (LH, RH) and prime type (TOAD-FROG, TOWED-FROG, FINK-FROG, PLASM-FROG) were within-subjects factors. For the items' analysis, hemisphere of stimulus presentation and prime type were within-subjects factors and list was a between-subjects factor. As predicted, performance to LH targets (mean = 597.15 ms) was significantly faster than to RH targets (mean = 616.56 ms) [F_1 (1, 39) = 5.78, p<.05, partial η^2 = .13; F_2 (1, 71) = 3.797, p < .05, partial η^2 = .05], reflecting and reconfirming that the LH's language processor is more efficient than that of the RH.

Prime type was significant for participants [F_1 (3, 117) = 2.84, p < .05, partial η^2 = .07], but not for items [F_2 (3, 213) < 2.00], indicating that effective priming occurred, but not which levels of the prime type variable were effective primes. The interaction between hemisphere of stimulus presentation and prime type was not significant [F_1 (3, 117) < 1.00; F_2 (1, 72) < 1.00], indicating that whatever priming effects occurred were the same in both the LH and RH.

Planned Comparisons

In order to further investigate the effect of prime type, additional repeated measures ANOVAs were conducted. The data relevant to these planned comparisons are summarized in Table 1 and 2 and Figure 1 and 2. Regarding priming by semantic associates, for the participant's analysis, hemisphere of stimulus presentation (LH, RH) and prime type (TOAD-FROG, FINK-FROG) were within-subjects factors. For the items' analysis, hemisphere of stimulus presentation and prime type were within-subjects factors and list was a between-subjects factor. Surprisingly, a main effect was not found for hemisphere of stimulus presentation [F_1 (1, 40) < 2.50; F_2 (1, 72) < 1.00], indicating that the hemispheres were equal in their ability to respond to targets included in these ANOVAs. A main effect of prime type was not found for participants [F_1 (1, 40) < 4.00] but was for items [F_2 (1, 72) = 4.03, p < .05, partial η^2 = .05], but hemisphere of stimulus presentation did not interact with prime type [F_1 (1, 40) < 1.00; F_2 (1, 72) < 1.00]. Thus, these results indicate bilateral priming by semantic associates (i.e., facilitated LD RTs to TOAD-FROG versus FINK-FROG) as no interaction was found between prime type and hemisphere of stimulus presentation. The conclusion that the semantic associates were effective primes must be tempered, though, as no main effect of prime type was found in the participants' analysis, but a significant priming effect was obtained for items and the

participants' analysis did indicate a trend toward significance (p = .06). Regarding

priming by homophonic associates, for the participant's analysis, hemisphere of stimulus

presentation and prime type (TOWED-FROG, PLASM-FROG) were within-subjects

factors. For the items' analysis, hemisphere of stimulus presentation and prime type were

within-subjects factors and list was a between-subjects factor. A main effect of

hemisphere of stimulus presentation was found [F_1 (1, 40) = 5.28, p < .05, partial η^2 = .12;

F_2 (1, 72) = 6.75, p < .05, partial η^2 = .08], indicative of the LH being a more efficient

language processor. A main effect of prime type was found for participants [F_1 (1, 40) =

5.51, p < .05, partial η^2 = .11] but not items [F_2 (1, 72) < 1.00], but hemisphere of

stimulus presentation did not interact with prime type [F_1 (1, 40) < 1.00; F_2 (1, 72) <

1.00]. Thus, as with the semantic associates, no interaction was found, which indicated

that the homophonic associates were effective primes (i.e., facilitated LD RTs to

TOWED-FROG versus PLASM-FROG) for both the LH and RH.

Tests of Simple Effects

Although hemisphere of stimulus presentation interacted with neither semantic

associates nor homophonic associates, tests of simple effects were conducted because

priming appeared to be asymmetrical. For the LH, performance to TOAD-FROG (mean =

584.89 ms) was significantly faster than performance to FINK-FROG (mean = 612.05

ms) for participants [F_1 (1, 39) = 9.31, p < .01, partial η^2 = .19] but not for items [F_2 (1,72)

< 3.00], and performance to TOWED-FROG (mean = 582.14 ms) was significantly faster

than performance to PLASM-FROG (mean = 609.50 ms) for participants [F_1 (1, 39) =

8.80, p < .01, partial η^2 = .19] but not for items [F_2 (1, 72) < 1.50]. For the RH,

performance to TOAD-FROG (mean = 607.21 ms) was not significantly faster than

performance to FINK-FROG (mean = 616.04 ms) [F_1 (1, 39) < 1.00; F_2 (1, 72) < 1.00],

and performance to TOWED-FROG (mean = 613.01 ms) was not significantly faster than

performance to PLASM-FROG (mean = 629.99 ms) [F_1 (1, 39) < 1.00; F_2 (1, 72) < 1.00].

Thus, in contrast to the planned comparisons, the obtained results from the tests of simple

effects indicate that TOAD-FROG (i.e., semantic associates) and TOWED-FROG

(homophonic associates) were effective primes for the LH but not for the RH.

<div align="center">*Accuracy Analyses*</div>

Omnibus Repeated Measures Analyses of Variance

The same ANOVAs were conducted for the accuracy analyses as were conducted

for the RT analyses. Regarding the omnibus ANOVAs, the results were replicate of the

RT analyses. Performance to LH targets (mean = 86.06% correct) was significantly

better than to RH targets (mean = 82.69% correct) for participants [F_1 (1, 39) = 3.91, p <

.05, partial η^2 = .09] but not for items [F_2 (1, 71) < 4.00]. Prime type was significant for

participants [F_1 (3, 117) = 4.79, p < .01, partial η^2 = .11], but not for items [F_2 (3,213) <

1.00]. The interaction between hemisphere of stimulus presentation and prime type was

not significant [F_1 (3, 117) < 1.00; F_2 (3, 213) < 1.00).

Planned Comparisons

The data relevant to the planned comparisons are summarized in Table 1 and

Figure 3. Regarding priming by semantic associates, main effects of hemisphere of

stimulus presentation and prime type, as well as the interaction between the two variables,

were not significant (all Fs < 2.00). This is not surprising as accuracy data routinely fails

to show the same effects in visual half-field studies as the RT data (e.g., Lavidor & Ellis,

2003). However, for the homophonic associates the accuracy data was replicate of the

RT data, as a main effect of hemisphere of stimulus presentation was found for

participants [F_1 (1, 40) = 3.50, partial η^2 = .07] but not for items [F_2 (1, 72) < 2.00], a

main effect of prime type was found for participants [F_1 (1, 40) = 13.54, p < .01, partial η^2 = .25] but not for items [F_2 (1, 72) < 2.50], and hemisphere of stimulus presentation did not interact with prime type [F_1 (1, 40) < 1.00; F_2 (1, 72) < 1.00].

Chapter IV

Discussion

Findings of the Present Study

In this LD experiment, homophones (e.g., TOAD, TOWED) and non-related

controls (e.g., FINK, PLASM) were used as primes for target words (e.g., FROG) that

were semantic associates of one of the homophone pair members (e.g., TOAD-FROG).

Both primes and targets were presented laterally, separated by an SOA of 165 ms. The

omnibus ANOVAs revealed the two expected main effects: hemisphere of stimulus

presentation, with targets presented to the LH being responded to faster than targets

presented to the RH, and prime type. In order to further investigate the effect of

hemisphere of stimulus presentation on prime type planned comparisons were conducted.

The ANOVAs concerning semantic associates and the ANOVAs concerning homophonic

associates revealed only simple main effects and no interaction of prime type and

hemisphere of stimulus presentation. However, using a less conservative (i.e., simple

effects) statistical approach, priming for semantic associates and homophonic associates

was found only for the LH.

The findings for stimuli presented to the LH are as hypothesized. Regarding

priming by semantic associates, our findings replicate those of Chiarello, Liu, Shears,

Quan, and Kacinik (2003), in that reliable priming was found at a relatively short SOA

(i.e., facilitated LD RTs to TOAD-FROG versus FINK-FROG). Our results for the

homophonic associates mirror those of the semantic associates, as reliable priming was

found (i.e., facilitated LD RTs to TOWED-FROG versus PLASM-FROG). Thus, it

seems clear that there is both phonological and semantic activation in the LH early on in the time course of processing visually presented words.

The findings for the stimuli presented in the RH are less easily interpreted. However, with regard to semantic associates, our findings again replicate those of Chiarello et al. (2003). Specifically, the planned comparison indicates priming by the semantic associates (i.e., facilitated LD RTs to TOAD-FROG versus FINK-FROG) for both hemispheres, as only a main effect of prime-target relationship was found and no interaction was obtained between hemisphere of stimulus presentation and prime type. However, using a more direct and less conservative statistical approach, priming by the semantic associates did not approach statistical significance (i.e., equal LD RTs to TOAD-FROG and FINK-FROG), implying a lack of semantic sensitivity in the RH at 165 ms. In order to interpret these seemingly divergent results Chiarello et al. (2003) compared the statistical power of their study to that of similar visual half-field semantic priming studies.

Chiarello et al. (2003) greatly exceeded the statistical power needed to detect priming asymmetries (i.e., an interaction between prime type and hemisphere of stimulus presentation), as their sample included 44 participants. For their power analysis, Chiarello et al. (2003) used statistics from a visual half-field LD semantic priming experiment using an SOA of 165 ms conducted by Koivisto (1997) to estimate the population effect size (Cohen's f) for the two-way interaction between hemisphere of stimulus presentation and prime type. Following the procedures of Kirk (1995), Chiarello et al. (2003) found that the population effect size for the two-way interaction was .59 and would require only 12 participants to detect an effect of such magnitude with a level of power equal to or greater than .80. As such, their sample of 44 participants allowed them

to detect even a very modest effect. In fact, Chiarello et al.'s (2003) review of the literature indicated that previous experiments obtaining reliable interactions between prime type and hemisphere of presentation included an average of only 29 participants. Also, the range of RT standard deviations (78-160 ms) in previous studies was similar to their own. Thus, although it is not unequivocal evidence, given that Chiarello et al. (2003) failed to obtain an interaction between hemisphere of stimulus presentation and prime type at a 150 ms SOA, they concluded that the most parsimonious explanation for their results was that priming by semantic associates occurred (i.e., facilitated LD RTs to TOAD-FROG versus FINK-FROG) in the RH at 150 ms.

As our results concerning priming by semantic associates at an SOA of 165 ms replicate those of Chiarello et al. (2003) at a similar SOA of 150 ms, we can assume their line of reasoning to interpret our results. Similar to Chiarello et al. (2003), our study greatly exceeded the statistical power needed to detect an interaction between hemisphere of stimulus presentation and prime type, as our sample contained 40 participants. Also, just as with Chiarello et al. (2003), the range of RT standard deviations for our study coincided with previous similar studies. Thus, we also conclude that the most parsimonious interpretation of our results is that priming by semantic associates occurred (i.e., facilitated LD RTs to TOAD-FROG versus FINK-FROG) in the RH at 165 ms. Therefore, in the RH, semantic activation seems to occur early on in the time course of processing visually presented words, although this activation is not as strong as in the LH.

As the pattern of results for the homophonic associates are replicate of the semantic associates, it seems reasonable to use the same line of reasoning to interpret the homophonic associate priming results as the semantic associate priming results for the RH. Given that no previous study has examined priming by homophones of semantic

associates in the visual half-field methodology at a relatively short SOA, it is hard to estimate the population effect size for the two-way interaction. It seems reasonable, however, to use the population effect size calculated by Chiarello et al. (2003) for the two-way interaction involving priming by semantic associates for three reasons: (1) the pattern of results in this study for homophonic associate priming are the same as the pattern of results for semantic associate priming, (2) even if the interaction between hemisphere of stimulus presentation and prime type is more modest for priming by homophonic associates than semantic associates the size of our sample should allow us to detect it, and (3) the priming effects in our study are actually more robust for the homophonic associates than the semantic associates. Making this assumption, we can conclude that our study did not lack the statistical power to have obtained asymmetrical priming effects. Thus, although our results are not unequivocal, the most parsimonious interpretation of our results is that RH priming by homophonic associates occurred (i.e., facilitated LD RTs to TOWED-FROG versus PLASM-FROG) at 165 ms, indicating that in the RH phonological activation seems to occur early on in the course of processing visually presented words, although this activation is weaker than in the LH.

Two potentially problematic findings emerge for the interpretation of our results. First, the planned comparison examining priming by semantic associates revealed no effect of hemisphere of stimulus presentation. This is problematic as a LH advantage is one of the more robust and consistent findings in the literature concerning hemispheric differences in word recognition (Chiarello, 2003). This finding could indicate a failure in the methodology of our study. Perhaps all of the prime-target pairs included in the analyses were viewed by participants centrally as opposed to in either the LH or RH

initially. This seems implausible, however, as main effects of hemisphere of stimulus presentation were found in both the omnibus ANOVAs and in the planned comparisons concerning priming by the phonological associates. Therefore, it is unlikely that the visual half-field methodology failed only for this one condition.

The second problematic finding is that there appeared to be a hemispheric asymmetry for the control conditions, with no difference between the semantic associate and homophonic associate controls in the LH but with a large difference between them in the RH. This observation was confirmed by a test of simple effects which found that participants were much more accurate in their responses to targets preceded by primes in the semantic associate control condition than to primes in the homophonic associate control condition in the RH [F_1 (1, 39) = 5.03, p < .05]. This difference could be attributable to a greater activation of the primes in the homophonic control condition than of the primes in the semantic control condition, which may have caused an inhibition in the subsequent activation of the non-related target words. The primes in the semantic associate control condition had a word frequency (mean = 61.06; Kucera & Francis, 1967) less than that of the primes in the homophonic associate control condition (mean = 112.08). It has previously been demonstrated that high frequency words are recognized more quickly and with better accuracy than low frequency words. The word frequency effect is hypothesized to result from the brain being better able to access the engrams representing high frequency in the lexicon because it has more experience identifying the visual characteristics of high frequency words (Whitney, 1997). Processing of words via the lexical route, which takes advantage of the orthographic (i.e., visual) representations of words, is thus subject to word characteristics such as frequency. In contrast, words processed via the sublexical route, which is driven by GPC rules that operate at the

sublexical level, are hypothesized not to be subject to such word level effects (Coltheart, Curtis, Atkins, & Haller, 1993). Previous studies have found that the RH is more sensitive to the orthographic representations of words than the LH (e.g., Chiarello, 1985; Lavidor & Ellis, 2002; Lavidor & Ellis, 2003). It then seems likely that the difference in the controls present in the RH are the consequence of some interaction between word frequency and a heightened sensitivity to word level characteristics in the RH. Thus, in the RH, it is possible that activation in the lexicon of primes in the homophonic associate control condition was greater than that of the primes in the semantic associate control condition because of the disparity in word frequency between the control conditions. The consequence of which was that the primes in the homophonic associate control condition caused some sort of inhibition in the activation of the non-related target words, resulting in poorer performance. The lower frequency primes in the semantic associate control condition caused less or no inhibition in activation of their respective target words, resulting in better performance.

This difference in the primes for the semantic and homophonic associate control conditions is problematic as it may indicate that the small priming effect found in the RH is simply the result of inhibition of target words by prime words in the homophonic associate control condition, as opposed to actual priming of targets by homophonic associates. However, if the primes of each control condition had equal word frequencies, there is no reason to suspect that the results for the homophonic associate control condition would be different from the semantic associate control condition, and an interaction between hemisphere of stimulus presentation and prime type is not observed when comparing the homophonic associate condition to semantic associate control condition.

The hemispheric asymmetry for the control conditions does explain, however, why the priming effects for the semantic associates were less robust than the homophonic associates. There probably would be a smaller priming effect if the primes in the homophonic associate control condition had an equal word frequency to the primes in the semantic associate control condition. This smaller priming effect is evident when comparing the homophonic associate condition to the semantic associate control condition.

Directions for Future Research

In summary, the results favor a view in which both the LH and RH have access to both the semantic and phonological representations of words early on in the processing of visually presented words, with the caveat that the RH does so less robustly. Chiarello (2003) argues that perhaps the LH language processor very rapidly abstracts from the superficial physical letter identities of printed words (i.e., the orthographic representation) to the deepest and richest levels of language encodings (i.e., semantic and phonological representations). The RH, on the other hand, is argued to maintain and perhaps amplify the more shallow or superficial word forms (i.e., the orthographic representation) of printed words. Also, the operations of the RH are argued to be attenuated as compared to the LH. The current findings are in line with this theory. Semantic and phonological priming was found bilaterally at a short SOA, but less robustly in the RH than in the LH, indicating that words in the LH did achieve deeper and more meaningful word encodings more rapidly. However, finding phonological priming in the RH at this short SOA may prove to be problematic for this differential view of the hemispheres.

The hypothesis of most interest in this study was that phonological priming would be found at a short SOA. The previous data supporting this hypothesis indicate

immediate and simultaneous activation of phonology bilaterally (Chiarello et al., 1999; Underwood et al., 1983). This raises the question of whether phonological activation in the RH peaks prior to 165 ms, a relatively short amount of processing time, as the data may suggest, or whether it peaks subsequently to 165 ms, as Chiarello's (2003) view of the hemispheres would suggest. Therefore, future studies should replicate the findings of the current study and extend them by further investigating the time course of phonological activation in the hemispheres.

References

Banich, M. T., & Karol, D. L. (1992). The sum of the parts does not equal the whole: Evidence from bihemispheric processing. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 763-784.

Baynes, K., Wessinger, C. M., Fendrich, R., & Gazzaniga, M. S. (1995). The emergence of the capacity to name left visual field stimuli in a callosotomy patient: Implications for functional plasticity. *Neuropsychologia, 33,* 1225-1242.

Beeman, M. J., & Chiarello, C. (1998a). Complementary right- and left-hemisphere language comprehension. *Current Directions in Psychological Science, 7,* 2-8.

Beeman, M. J., & Chiarello, C. (1998b). Concluding remarks: Getting the whole story right. In M. Beeman and C. Chiarello (Eds.), *Right hemisphere language comprehension: Perspectives from cognitive neuroscience* (pp. 377-390). Mahwah, NJ: Lawrence Erlbaum Associates.

Chiarello, C. (1985). Hemisphere dynamics in lexical access: Automatic and controlled processing. *Brain and Language, 26,* 146-172.

Chiarello, C. (2003). Mind, brain, and language: Multidisciplinary perspectives. In M. T. Banich & M. Mack (Eds.), *Parallel systems for processing language: Hemispheric complementarity in the normal brain* (pp. 229-247). Mahwah, NJ: Lawrence Erlbaum Associates.

Chiarello, C., Hasbrooke, R., & Maxfield, L. (1999). Orthographic and phonological facilitation from unattended words: Evidence for bilateral processing. *Laterality, 4,* 97-125.

Chiarello, C., Liu S., Shears, C., Quan, N., & Kacinik, N. (2003). Priming of strong

    semantic relations in the left and right visual fields: a time-course investigation.

    Neuropsychologia, 41, 721-732.

Coltheart, M., Curtis, B., Atkins, P., Haller, M. (1993). Models of reading aloud: Dual-

    route and parallel-distributed-processing approaches. *Psychological Review, 100*,

    589-608.

Evett, L. J. & Humphreys, G. W. (1981). The use of abstract graphemic information in

    lexical access. *Quarterly Journal of Experimental Psychology: Human*

    Experimental Psychology, 33A, 325-350.

Hunter, N., & Liederman, J. (1991). Right hemisphere participation in reading. *Brain and*

    Language, 41, 475-491.

Kirk, R. E. (1995). Experimental design: procedures for the behavioural sciences. Pacific

    Grove, CA: Brooks & Cole.

Koivisto, M. (1997). Time course of semantic activation in the cerebral hemispheres.

    Neuropsychologia, 35, 497-504.

Kucera, H., & Francis, W. N. (1967). *Computational analysis of present-day American*

    English. Providence, RI: Brown University Press.

Lavidor, M., & Ellis, A. W. (2002). Orthographic neighbourhood effects in the right but

    not in the left cerebral hemisphere. *Brain and Language, 80*, 45-62.

Lavidor, M., & Ellis, A. W. (2003). Orthographic and phonological priming in the two

    cerebral hemispheres. *Laterality, 8,* 201-223.

Lukatela, G., & Turvey, M. T. (1994). Visual lexical access is initially phonologically: 1.

    Evidence from associative priming by words, homophones, and

    pseudohomophones. *Journal of Experimental Psychology: General, 123,* 107-128.

McNamara, T. P., & Holbrook, J. B. (2003). Semantic memory and priming. In I. B.

Weiner (Ed.), *Handbook of Psychology: Vol 4* (pp.447-474). New York: Wiley.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of Florida word

association, rhyme, and word fragment norms.

http://www.ucf.edu/FreeAssociation.

Pinker, S. (1991). Rules of language. *Science, 253,* 530-535.

Pinker, S. (1999). *Words and rules: The ingredients of language.* New York: Basic Books

Inc.

Rayman, J., & Zaidel, E. (1991). Rhyming and the right hemisphere. *Brain and*

Language, 40, 89-105.

Sidtis, J. J., Volpe, B. T., Wilson, D. H., Rayport, M., & Gazzaniga, M. C. (1981).

Variability in right hemisphere language function after callosal section: Evidence

for a continuum of generative capacity. *Journal of Neuroscience, 1,* 323-331.

Smith, F. (1971). *Understanding reading: A psycholinguistic analysis of reading and*

learning to read. New York: Holt, Rinehart, and Winston.

Stone, G. O., & Van Orden, G. C. (1993). Strategic control of processing in word

recognition. *Journal of Experimental Psychology: Human Perception and*

Performance, 19, 744-774.

Underwood, G., Rusted, J., & Thwaites, S. (1983). Parafoveal words are effective in both

hemifields: Preattentive processing of semantic and phonological codes,

Perception, 12, 213-221.

Whitney, P. (1997). *The psychology of language.* Boston, MA: Houghton Mifflin

Company

Zaidel, E. (1990). Language function in the two hemispheres following complete cerebral

commissurotomy and hemispherectomy. In F. Boller & J. Grafman (Eds.),

Handbook of Neuropsychology: Vol 4 (pp. 115-150). Amsterdam: Elsevier.

Zaidel, E., & Peters, A. M. (1981). Phonological encoding and ideographic reading by the

disconnected right hemisphere: Two case studies. *Brain and Language, 14,* 205-

234.

Appendix A
Critical Prime-Target Pairs

Target	Semantic Associate	Homophonic Associate	Semantic Associate Control	Homophonic Associate Control
AIRCRAFT	PLANE	PLAIN	DOUBT	SORRY
ARMOR	KNIGHT	NIGHT	FASTER	ASKED
ASHES	URN	EARN	BIB	CLUE
BEEF	STEAK	STAKE	MERGE	LUNGS
BIRD	HAWK	HOCK	RIPE	YORE
BOAT	SAIL	SALE	BUTT	BOND
BROOM	WITCH	WHICH	ASSET	THERE
BROWN	BEAR	BARE	SPOT	FLED
BUCKET	PAIL	PALE	FUSS	BUSY
BURDEN	LOAD	LODE	MAMA	FESS
BUTTER	BREAD	BRED	SMOKE	PALS
BUY	SELL	CELL	VICE	JULY
CAR	BRAKE	BREAK	COLON	FIXED
CAT	PAWS	PAUSE	FLOC	SCREW
CLAM	MUSSEL	MUSCLE	OATNUT	WEAPON
CLIMB	LADDER	LATTER	POLISH	MOVING
CLOTHES	WEAR	WHERE	BOMB	AFTER
COAL	MINER	MINOR	POLKA	AVOID
COFFEE	TEA	TEE	FOG	HUM
COPPER	STEEL	STEAL	PRIME	BROWS
DAUGHTER	SON	SUN	PAY	HIT
DEER	DOE	DOUGH	HAW	SLICE
DIAMOND	RING	WRING	HERO	TACIT
DOG	FLEA	FLEE	MUGS	STUNK
DRUMS	BEAT	BEET	JURY	ORGY
DRY	BARREN	BARON	TRUSTS	NECKS
EGG	YOLK	YOKE	PUFF	RUNG
EYES	SIGHT	SITE	COVER	GROW
FENCE	GATE	GAIT	FOOL	SLUM
FISH	BAIT	BATE	SWAP	PUBS
FLOOD	TIDE	TIED	CALF	CORN
FROG	TOAD	TOWED	FINK	PLASM
GIRLS	GUYS	GUISE	CROP	PROPS
GLUE	PASTE	PACED	ELBOW	ELBOW
GOD	PRAY	PREY	BITS	STUD
GOLD	MEDAL	MEDDLE	TORSO	PAJAMA
HAY	BALE	BAIL	SPIN	FOLD
HIGHWAY	ROUTE	ROOT	SKILL	FLUX
HIPS	WAIST	WASTE	VIOLA	URGED
HOST	GUEST	GUESSED	FIFTH	OMINOUS
HOTEL	SUITE	SWEET	CHARM	DRAWN
KING	THRONE	THROWN	COMPLY	VISUAL
LANE	ROAD	RODE	BOOK	INCH

LETTER	MAIL	MALE	COOK	PUSH
MONEY	LOOT	LUTE	SAWS	MOAN
MORNING	DEW	DUE	LAG	TRY
MOUNTAIN	PEAK	PEEK	RAGE	PLUM
OATS	CEREAL	SERIAL	SHIFTS	TYPING
OCEAN	SEA	SEE	OIL	OWN
OYSTER	PEARL	PURL	JOKES	FOWL
PADDLE	OAR	ORE	MEW	LAX
PENNY	CENT	SCENT	WALL	POKER
PRIEST	NUN	NONE	EEL	WISH
RABBIT	HARE	HAIR	LOWN	MEET
RIDER	HORSE	HOARSE	LIVED	CHILLY
SAND	BEACH	BEECH	DROVE	STAIN
SHEEP	HERD	HEARD	PALM	STUDY
SHOP	MALL	MAUL	DOOM	SOOT
SKY	BLUE	BLEW	FALL	TROT
SMELL	NOSE	KNOWS	TEXT	VISUAL
SNOW	SLEIGH	SLAY	ORNATE	OZON
SOCKS	FEET	FEAT	WORD	CLIP
STEP	STAIR	STARE	MOURN	HONEY
STICK	POLE	POLL	WING	DUSK
STORY	TALE	TAIL	SINK	ZERO
STREET	MAIN	MANE	ARMS	COUD
STRONG	WEAK	WEEK	CURT	HALF
THORN	ROSE	ROWS	LAWS	TAXI
TIRED	BORED	BOARD	PAILS	CLOSE
TRAFFIC	SIGN	SINE	LORD	USER
TRAVEL	WAY	WEIGH	TOO	MUSED
TREE	FIR	FUR	PAL	EGO
TRUCK	TOW	TOE	ALE	SPY
TULIP	FLOWER	FLOUR	ADULTS	KNELT
UMBRELLA	RAIN	REIN	DUST	OPUS
WATER	CREEK	CREAK	UPSET	OHMIC
WAVE	SURF	SERF	TENS	WOLD
WEATHER	VANE	VEIN	BROS	STAR
WINDOW	PANE	PAIN	TICK	LOSS
WRONG	RIGHT	WRITE	AGAIN	SCENE

Appendix B
Non-critical Related Prime-Target Pairs

Prime	Target
ADVICE	HELP
AGAINST	FOR
ALBUM	RECORD
ALONE	LONELY
ANNUAL	YEARLY
BALCONY	LEDGE
BEETLE	BUG
BEING	HUMAN
BELOW	ABOVE
BETTER	WORSE
BETWEEN	MIDDLE
BINDER	FOLDER
BIRTH	DEATH
BRACES	TEETH
BUYER	SELLER
DASH	RUN
DEFROST	THAW
DESK	CHAIR
DIAL	PHONE
DIME	NICKEL
DIZZY	FAINT
DRIP	DROP
DUST	DIRT
ENTER	EXIT
EXIT	ENTER
FABLE	STORY
FACULTY	STAFF
FAST	SLOW
FRILL	LACE
MAD	ANGRY
MARKER	PEN
MINUS	PLUS
NEPHEW	NIECE
ORANGE	JUICE
PARKWAY	CARS
PATTERN	SEW
PIECE	PIE
RASH	ITCH
REMAIN	STAY
RETAIN	KEEP

Appendix C
Non-Critical Non-Related Prime-Target Pairs

Prime	Target
ABOVE	ALIVE
ACORN	RED
ADJOURN	COURT
ARTS	BAKE
BALLOT	HAY
BANG	MILK
BENEATH	BAG
BICYCLE	LAST
BUMBLE	SMOOTH
DEBATE	FOUND
DEMON	NEVER
DENIAL	HOLY
DESIGN	WARM
DESTROY	GAME
DOUBT	RABBIT
DULL	LAVA
EMPEROR	ASSUME
FABRIC	SLAVE
FANTASY	DEEP
FIGHT	APPLE
FIVE	CIRCLE
FLOOR	CRAB
FORGIVE	HEN
FRAUD	LATER
FRENCH	BIRD
FURTHER	ACTOR
LABEL	POT
LEARN	TWICE
LOTS	GROUP
MALE	BLUE
MELODY	EVEN
MILDEW	WINE
ORGAN	STAPLE
OZONE	WEIRD
PIECES	TOP
PORK	TAPE
RACKET	FATHER
REACH	CAKE
ROBE	CLAY
RUNG	COLOR

Appendix D
Non-Critical Word-Nonword Prime-Target Pairs

Prime	Target	Prime	Target	Prime	Target
NICE	LARIAC	BAKER	FLICYS	CRAFTS	PAPAT
BEHIND	HLID	MAGGOT	LEITY	TEACH	PALUCES
UGLY	DERIKED	DINER	GOTF	GRAB	RORSTS
SHOP	OUTINY	BLOT	STREATS	TAG	HITYING
LATE	BELAPED	BUBBLE	BENK	LITTLE	TEINE
HANG	WAZEN	ANIMAL	EXCRATE	FIST	SCART
PENCIL	RUBUS	DEFEAT	CANCORD	LEAVE	CIRDIAL
DISH	SCIUNS	MARCH	ENJOK	FEAR	GRUSTS
VISION	ROUGEL	ARMS	NAIVEFY	BATH	GUSSETN
DINNER	BLINFLY	ABUSE	CASUCK	CREATE	TACKL
PICK	CRAKL	BOOT	PORKAS	CLOTH	SAWERS
HANDS	DOCED	MAMMAL	SNOFF	UNDER	VINA
THIRST	CEPLAY	PLENTY	CHIZEL	DREAM	CATOLOG
MOUSE	PASACE	LINK	SQUARUD	DEVIL	CORLIER
FRAME	FATAR	MIDDLE	SUEJ	GUN	FABMIC
OFFICE	WABD	LONELY	WANKB	VOTE	BIETA
BRICK	DEMOKE	LAUNCH	ATHID	BELOW	RRUDGE
FAT	XHAWED	DRUM	POICHED	TILE	RARLY
REASON	DRORED	BROKE	MORDER	TENNIS	REDOLE
WEAVE	RENUL	PIMPLE	KICKOPF	PUZZLE	MURMERS
SCARED	DISCE	BRAN	PROSTOS	FORGET	DIGMA
BACON	PISTRO	DANCER	PHARTER	AWAY	HORNAT
ATTACK	ASSOSS	DOOR	LISAED	TREE	CHOICOS
PART	ORANBE	FLESH	ALGERIU	FEMALE	IODIGES
CATS	ISSUEL	FOOL	PLACINS	PIANO	BIBBIES
WAIT	PRIVILG	OYSTER	PADDLU	KILL	SHARHER
BRA	BOMPS	LEASE	BANDJ	LAYER	SIER
DESERT	MANKER	FRESH	ENWRAGS	BORING	BREISES
READ	KRAVES	BACON	GOOSIER	FAKE	CEBELS
CHURCH	CERING	EXTRA	DIRMS	LADDER	FLOUP
PRIEST	NTERNA	DAYS	ROUVES	ARGUE	UNNAMOD
TRICK	ISRAELU	NORTH	TPAVAIL	PIG	OHERPAY
STONE	DROOM	MELLOW	TRIPLUX	MOLD	GREYESB
VIOLIN	IRVOLVE	LAWN	BLAWES	RIDE	DOULER
CALM	BABBY	BRIDE	TINGID	REFUSE	ZENEGAL
TRADE	RUFFINS	AXON	BONNISY	KING	EITCHES
GREAT	ABID	BEEF	ARSOG	BEE	FRIGGED
SAME	TOTR	FLAP	COOZANT	FRIES	RORELY
BIT	ZEETHE	LAWS	MACKERS	SONG	TLEMENT
NOT	SMEAREJ	RELY	TORRAIN	SIX	EGOISJ
ENDING	JARRIGG	LOVING	NAPTION	NEAR	SUML
ASLEEP	APERES	DELIGHT	BOMMA	TALE	AUCRION
MAJOR	FHAT	DEMAND	AMLE	BRUSH	MECRO
ORANGE	OETPUTS	BECAUSE	AZEROID	TEAR	BKINS
PROPER	REVARES	AFRAID	LIVOS	BRAVE	DERIXE

COP	CAMPUR	ADMIRE	TOUE	YOURS	NOMADOC
GROSS	SKAZER	FUR	AROUSU	WASH	DEBABS
SICK	ACACIOS	MANNER	TOUGHLR	HUG	COOKIO
FOOT	REFUGIS	PYRAMID	BASTEL	SHIRT	JABOBS
ARTIST	CHRU	ARGUE	PALFREV	FRANCE	PEERLY
NOW	UTILETY	PIG	ABSESS	AREA	MEMING
FENCE	LABEAL	LATE	ABEW	PLACE	ZAILORS
CODE	BOREL	BROAD	REFEND	WRONG	WUNDOW
GUARD	TERROB	EASTER	ONFOLD	WONDER	ANVELUS
RELAX	CURETES	BROTHER	EMBERN	SHY	SUNHAE
LEARN	OATCACE	NINE	XOLAR	LARGE	EAFT
JOGGER	HEOVES	LASTING	FACTISH	NEPHEW	SIFARIS
MARRY	COORTED	NAILS	SOEPING	SNEEZE	EXUDEJ
AWAKE	CORRALY	PLUG	PAGA	PEANUT	DUCAC
TROPHY	NILA	DEADLY	BODDY	CUP	WAIGHTS
TIME	LEORY	BUTCHER	PPRE	WRITER	WORDP
POTATO	TOMICAL	MARSH	NRONE	RULE	POPLUR
SIMPLE	IGEPT	EIGHT	LESSENG	APE	CERN
RICE	LINGED	ABDUCT	WHEA	SEX	OXIDEF
LOT	EBROAD	POT	LUDE	LET	DATOVE
LOST	EPUITY	ALGEBRA	ICICCE	SPORT	LLUT
TWELVE	ZLOC	DUNGEON	DUSCERS	EYE	CRODSES
BEAT	VAIF	BEAUTY	INYONE	CANS	ELECTOD
DAWN	DESIGES	ANATOMY	PANC	DRUGS	OUTWIED
PICKET	ITIMIZE	NAIL	SHDOUD	NEEDLE	SNARDOM
INHALE	WNEEZE	LUMP	LREAKS	KISS	UNJOY
CABIN	GECTILE	RUSH	CREVIGE	BEAR	REPUZES
CHECK	BROGUI	BRUISE	TELID	DRAWER	FUMIS
NATURE	TRAYR	FIG	EYASHOT	LAUGH	PHORONS
LESS	EZECUP	ATLAS	BMELT	SYSTEM	SERB
DESK	OMEMED	DESERT	STAGEH	HAND	UNNEMPT
WIN	PREUN	BREAK	UNSPIRE	STACK	SSINKER
WINNER	WEEVILN	LOSS	MOASE	WATCH	GOSSUPS
HEAVY	SAWINR	DEVICE	VIOLETW	TIGHT	TOTIM
GHOST	WREAM	FLEET	CODLINV	LAW	BOSGED

Table 1
Mean RT (ms) and percentage of correct responses to targets as a function of hemisphere of stimulus presentation and prime type

Hemisphere	Prime Type	Semantic Associate	Homophonic Associate	Semantic Associate Control	Homophonic Associate Control
LH	Mean RT	584.90	582.14	612.05	609.50
	(SD)	109.47	106.72	118.70	123.69
	%error	12.50	10.25	15.25	17.75
RH	Mean RT	607.21	613.01	616.04	629.99
	(SD)	109.00	144.05	122.16	119.98
	%error	16.25	15.75	17.00	20.25

Table 2.
Priming effect (ms; associate RTs subtracted from control RTs) as a function of
hemisphere of stimulus presentation and prime type

Hemisphere	Prime Type	Semantic Associate	Homophonic Associate
LH	Mean RT	27.15	27.36
	(SD)	56.28	58.33
	%error	2.75	7.50
RH	Mean RT	8.83	16.99
	(SD)	90.45	122.58
	%error	0.75	4.50
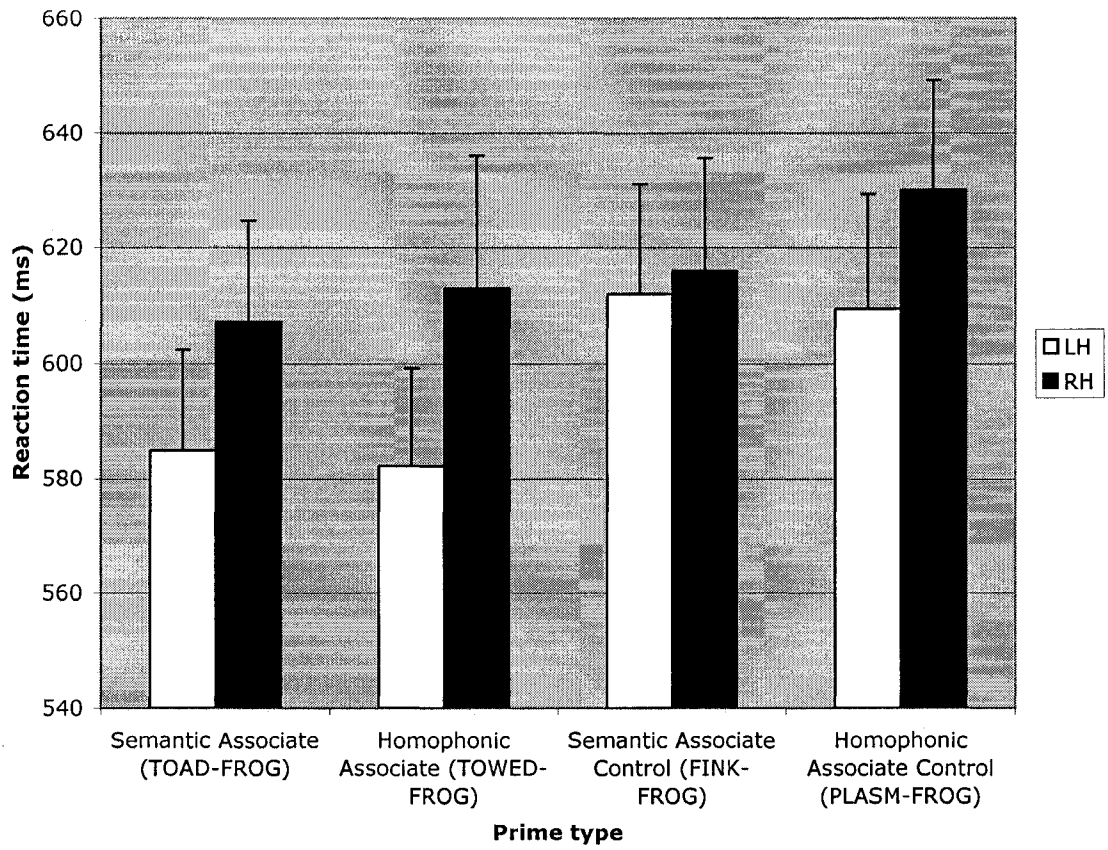
Figure 1. Reaction times to correct words as a function of hemisphere of stimulus presentation and prime type.
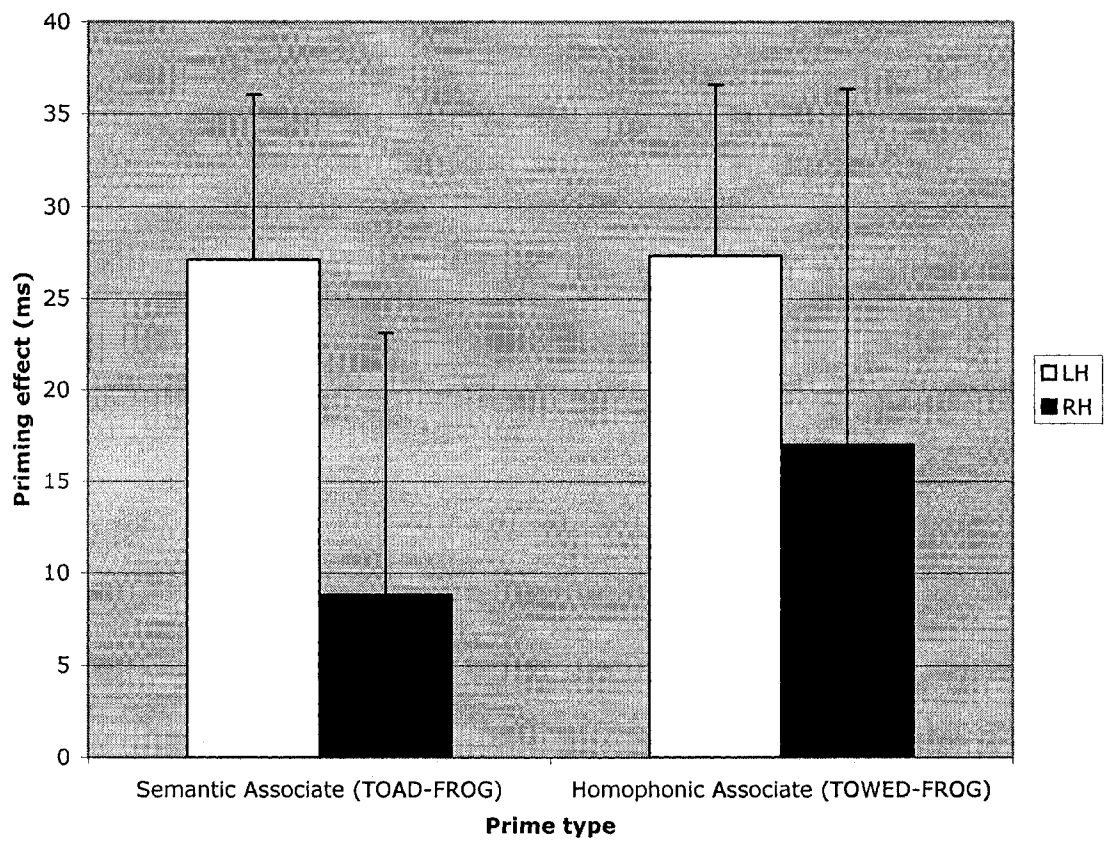
Figure 2. Priming effect (associate RTs subtracted from control RTs) as a function of
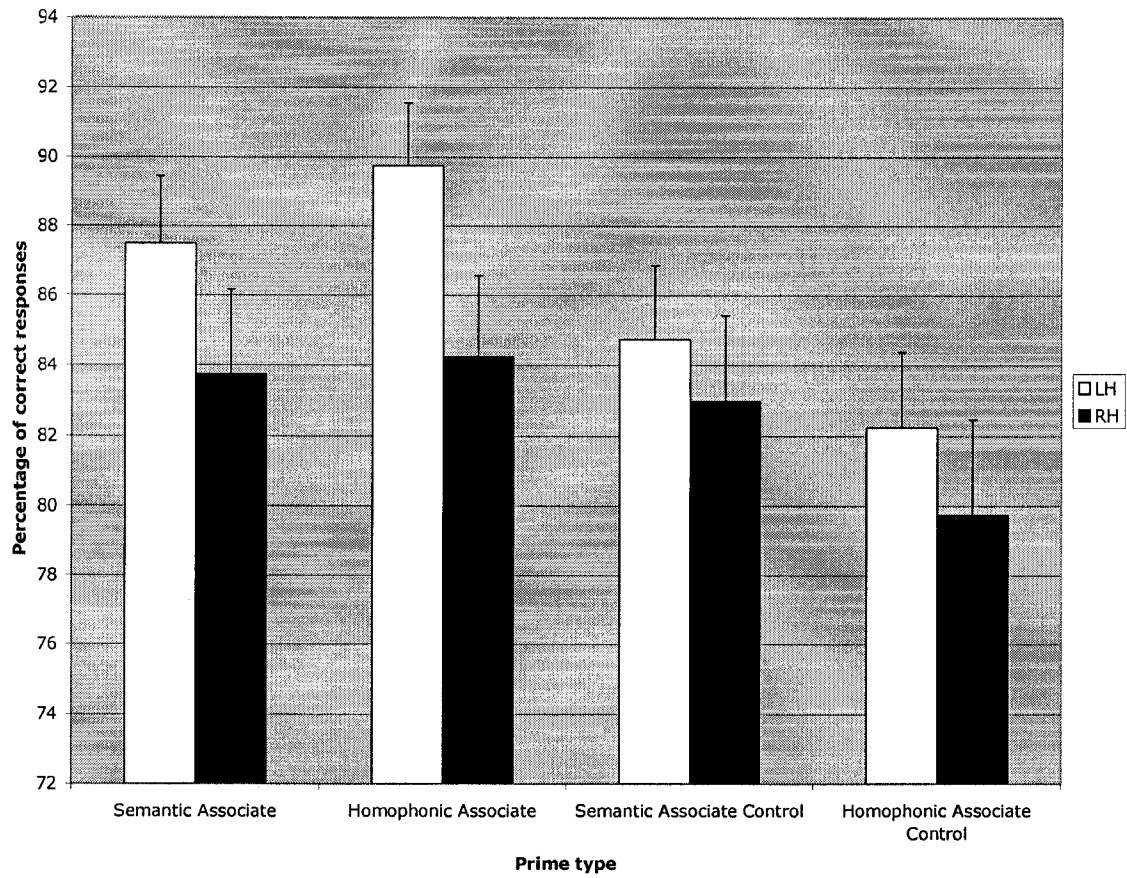
hemisphere of stimulus presentation and prime type.

Figure 3. Percentage of correct responses to words as a function of hemisphere of

stimulus presentation and prime-target relationship type.

Vita Auctoris

NAME: Christopher Hiroshi Domen

PLACE OF BIRTH: Wichita, Kansas

YEAR OF BIRTH: 1979

EDUCATION: Wichita High School East-International Baccalaureate Program, Wichita, Kansas
1994-1998

William Jewell College, Liberty, Missouri
1998-1999

The University of Kansas, Lawrence, Kansas
1999-2003 B.A.

University of Windsor, Windsor, Ontario
2003-2005 M.A.