

Laterality and Processing of Idiomatic Speech in a Normal Population

ACCEPTED

FACULTY OF GRADUATE STUDIES

by

Daniel Joseph Slick

DEAN

DATE

B.Sc., University of Alaska Anchorage, 1989

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of


MASTER OF SCIENCE


in the Department of Psychology

We accept this thesis as conforming
to the required standard:


Dr. Esther H. Strauss, Supervisor (Department of Psychology)


Dr. Roger E. Graves, Departmental Member (Department of Psychology)


Dr. Geraldine H. Van Gyn, Outside Member (Department of Physical Education)


Dr. Alison Preece, External Examiner (Department of Communication and Social Foundations)

© Daniel Joseph Slick, 1992
University of Victoria

All rights reserved. Thesis may not be reproduced in whole or in part, by
photocopying or other means, without the permission of the author.

Supervisor: Dr. Esther Strauss

ABSTRACT

Two experiments were conducted to examine lateralized processing of idiomatic and literal meanings of text. Priming with idiomatic phrases was followed by speeded semantic-decisions to laterally presented words. Three orthogonal categories of words were presented: (1.) *figuratively-related words* - semantically associated with the conventional idiomatic meaning of the priming phrases, (2.) *literally-related words* - semantically associated with a literal parse of the priming phrases, or (3.) *unrelated words* - no semantic association with the priming phrases. Subjects decided whether or not individual words reminded them of immediately preceding idiomatic phrases. Subjects in both experiments were able to reliably differentiate the word types, both during the semantic decision task and during a free-viewing post-test. Subjects could be divided into two “decisional criteria” groups by how they responded to literal targets. No VF asymmetries were found for reaction-time. Characteristics of the experimental design employed render interpretations of the lack of VF effects problematic, but the results do not rule out a hypothesized RH substrate for processing idiomatic language.

Examiners:



Dr. Esther H. Strauss, Supervisor (Department of Psychology)



Dr. Roger E. Graves, Departmental Member (Department of Psychology)



Dr. Geraldine H. Van Gyn, Outside Member (Department of Physical Education)



Dr. Alison Preece, External Examiner (Department Communication and Social Foundations)

Table Of Contents

Abstract	ii
List of Tables	iv
List of Figures	v
Acknowledgments	vi
Dedication	vii
Introduction	1
Experiment One	20
Subjects	20
Apparatus	20
Stimuli	21
Procedure	23
Results	24
Discussion	30
Experiment Two	31
Subjects	31
Procedure	31
Results	32
Discussion	38
Overall Analysis	45
Discussion	49
Concluding Remarks	52
Bibliography	55
Appendix A: Stimuli List	60
Appendix B: Prime-Target Rating Scale	62
Appendix C: Software	66
Appendix D: Consent Form	72
Appendix E: Subject Questionnaire	73

List of Tables

Table 1: Subject-Group Demographics	20
Table 2: Dependent Variables - Experiment 1	26
Table 3: Dependent Variables - Experiment 2	34
Table 4: Reaction-Time for Uncrossed Responses	35
Table 5: Mean Difference Scores & Laterality Indices	49

List of Figures

Figure 1: Uncrossed Response	18
Figure 2: Crossed Response	19
Figure 3: Experiment One -- Target Categorization	28
Figure 4: Experiment One -- Reaction-Time	29
Figure 5: Experiment Two -- Target Categorization	36
Figure 6: Experiment Two -- Reaction-Time	37

Acknowledgments

The author would like to thank:

Esther Strauss for providing advice, patience, and most of all, support and encouragement;

Roger Graves for providing thoughtful criticism and insight that added considerably to the merit of this project;

Chris Darby and **Tom Allen** for providing technical assistance with hardware and software employed in this project;

and **Wendy Foo** for helping collect data.

Dedication

This thesis is dedicated to **Lee, Jean, Brian, Glen, and Jody Slick**, and to **my friends**. Without your love and support, none of this would have been possible.

Introduction

From Broca's first published observations of severe language deficits associated with focal cortical lesions, to current research with the latest cognitive-neuroscience techniques, studies of the organization of primary language functions of the CNS (i.e., lexico-semantic representation and storage, orthographic, phonetic, and syntactic processing), have revealed in increasing detail the central role of the left cerebral-hemisphere (LH). In clear contrast, the weight of accumulated evidence on the role of the right hemisphere (RH) has supported conclusions such as those drawn by Moscovitch (1983, p. 57): "although the right hemisphere has some linguistic capacities that are not negligible, its contribution to normal language is minimal in those areas that are traditionally considered linguistic, such as syntax, phonology, and semantics." The last twenty-five years however, have been witness to a proliferation of studies specifically designed to delineate the cortical organization of considerably more subtle but no less important aspects of language production and comprehension. The findings of these neurolinguistic explorations have significantly transformed popular conceptions of the organization of language in the brain. The once considered "silent" hemisphere is now seen as an active and perhaps integral component in a variety of fundamental *paralinguistic* processes.

Paralinguistic processes include pragmatics (how language is employed as a tool), complex discourse functions (how abstract meaning is communicated), social and emotional functions, and verbal memory and metamemory. Examples of paralinguistic functions linked to the right hemisphere include appreciation of semantic relationships between individual words (Chiarello & Church, 1986), processing of prosody for affective content (Heilman, Scholes, & Watson, 1975; Ross & Mesulam, 1979) as well as for linguistic cues (Weintraub, Mesulam, & Kramer, 1981), inference generation (McDonald

& Wales, 1986; Brownell, Potter, & Bihrlé, 1986), identification of central themes in narratives (Hough, 1990), verbal reasoning and the detection of logical errors in sentences (Grossman & Haberman, 1986; Blonder, Bowers, & Heilman, 1991), use of semantic associations in verbal memory processes (Villardita, 1987), appreciation of humor (Wapner Hamby, & Gardner, 1981; Brownell, Michel, Powelson, Gardner, 1983; Bihrlé, Brownell, Powelson, & Gardner, 1986), appreciation of connotative meanings (Brownell, Potter, Michelow, & Gardner, 1984), and the comprehension of proverbs (Hier & Kaplan, 1980).

The comprehension of figurative speech is among the more complex paralinguistic functions currently associated with the right hemisphere. Several lines of research have provided evidence in support of a RH role in the comprehension of idioms. An idiom is any phrase with a conventional figurative meaning that cannot be derived from application of regular rules of logic and syntax to the ordered lexical identities of the individual constituent words. For example, the figurative meaning of the idiomatic phrase, *going out on a limb*, refers to risk taking rather than tree climbing.

Idioms may be ordered according to their linguistic properties; Gibbs, Nayak, and Cutting, (1989a) describe three useful criteria. Idioms may be categorized according to their level of *syntactic decomposability*, or ability to undergo syntactic transformations (i.e., to passive voice) and still maintain figurative meaning. Idioms may also be categorized according to their level of *semantic decomposability*, or the degree to which the meanings of their constituent words contribute independently to their overall figurative meanings. In semantically decomposable idioms, one or more of the constituent words is directly related (literally or metaphorically) to an element of the figurative meaning. Finally, idioms may be categorized by their level of *lexical flexibility*, or ability to maintain the same figurative meaning with different lexical constituents. A categorization criterion

alluded to, but not specified by Gibbs et al., involves context and literal interpretation. *Plausible* idioms (e.g., kick the bucket) may be figuratively or literally interpretable, depending on context, while *implausible* idioms (e.g., time flies), because of their logically or syntactically anomalous construction, cannot be literally interpreted under any conditions. The four categorization criteria are not orthogonal. For example, most, but not all semantically decomposable idioms are also syntactically decomposable, while the reverse is true for plausible idioms.

Because their figurative meanings are defined by convention rather than derived from literal parsing processes, idioms can logically be hypothesized to have direct connections to their figurative meanings, and perhaps, to be parsed in the same way as individual words. For direct access to figurative meaning to take place during parsing, an idiomatic phrase must somehow be recognized as a unitary lexical entity. Is normal lexico-syntactic processing of the constituent words of an idiomatic phrase a prerequisite for unitary recognition and direct access? Evidence from three psycholinguistic experiments suggests otherwise. Subjects in a study by Swinney and Cutler (1979) took *less* time to determine if idiomatic phrases were meaningful than taken for matched control phrases. The results were interpreted as inconsistent with predictions from models in which idiomatic interpretations are constructed after literal parsing has either failed or been completed. Glass (1982) demonstrated that figurative meanings of idioms are accessed equally as fast as literal interpretations are constructed. In addition, Glass used an interference task to demonstrate that *both* idiomatic and literal interpretations of idiomatic phrases are automatically available. Gibbs, et al. (1989b) found that subjects took less time to read both decomposable and non-decomposable idioms than matched control phrases. In sum, evidence from cognitive studies with normal subjects supports dual processing models in which idiomatic expressions are represented and parsed at a supra-segmental level, and

possibly even as unitary lexical items by one system, while at the same time a different system or process attempts to parse in accord with normal lexical-grammatical procedures. The existence of evidence for parallel processing is consistent with the possibility that distinct inter- or intra-hemispheric systems may exist for figurative and literal language processes.

Clinical studies have also provided evidence in support of separate processing systems ✓ for figurative and literal language, along with information about where such systems may be localized. Brownell, Simpson, Bihrie, Potter, and Gardner (1990) found that right-hemisphere damaged (RBD) non-aphasic patients performed worse than left-hemisphere damaged (LBD) aphasic patients on a task of grouping words by metaphoric association. / Winner and Gardner (1977) tested the ability of LBD aphasic patients, RBD patients, and controls to pick one of an array of four pictures as best matching a metaphoric or idiomatic phrase such as *it was such colorful music*, or *sometimes you have to give someone a hand*. Although both patient groups performed inferior to normal controls, RBD patients performed significantly worse than LBD patients at choosing appropriate pictorial representations of metaphors and idioms. An analysis of errors showed that RBD patients were much more likely to choose foils consistent with literal interpretations than either LBD patients or controls, who made few such mistakes. The pictures were arranged vertically to reduce the possibility of spurious results due to visual-field defects. Neither patient group chose pictures at chance level, indicating that deficits in basic visual-perceptual or visual-organizational processes were not influencing patient performance. In a similar study, Myers and Linebaugh (1981) also found a pattern of preference for literal interpretation in RBD subjects. Van Lanker and Kempler (1987) obtained a comparable hemispheric dissociation for the comprehension of idioms. Rather than focusing upon the right-hemisphere connection with figurative processing, Van Lanker and Kempler stress

the conventional, ingrained quality of idioms, which they classify as a type of *familiar phrase*, a rubric for any “over-learned, holistic expression...., including *inter alia*, social interaction formulae (e.g., greetings), expletives, over-learned lists and serials (e.g., days of the week), song lyrics, proverbs, and idioms" (p. 265). Observations of deficits in familiar phrase production and comprehension following RH damage and relative sparing of such functions in LBD aphasics led Van Lanker and Kempler to hypothesize the existence of a right hemisphere substrate for the processing of familiar phrases. They used a combined verbal-pictorial comprehension paradigm similar to that employed by Winner and Gardner (1977). Verbal stimuli consisted of literal and idiomatic phrases, and single words. Subjects included left-brain-damaged (aphasic), right-brain-damaged, and normal subjects. Results confirmed predictions of a group by task interaction. RBD subjects performed relatively well at comprehending single words and literal phrases, and poorly at comprehending common idiomatic phrases, while LBD subjects evidenced a reversed pattern of deficits.

In sum, there is reasonable evidence from studies with clinical populations to support the hypothesis of a right-hemisphere substrate for the system that processes figurative language, and in particular, idioms.

In an attempt to expand the inquiry into the role of the right hemisphere in comprehension of figurative speech, an exploratory study of semantic processing of idiomatic speech in a normal population was designed. In the study, priming was combined with lateralized visual-field presentation.

The priming phenomena has been extensively investigated in relation to a wide array of cognitive processes from basic perceptual processing to learning and memory. Its usefulness as a general experimental methodology is well documented (e.g., Anderson, 1985). The basic technique entails the sequential presentation of two stimuli. When

differences in performance between baseline (no priming) and primed conditions occur, processing of the initial stimulus or *prime* is assumed to affect processing of the subsequent stimulus or *target*. A methodology that has been extensively employed in studies of priming effects with verbal stimulus is tachistoscopic presentation. Simply put, a tachistoscope is any device which allows controlled duration (in millisecond precision) of visual stimuli display. With such devices, primes, targets, or both have been presented at durations from sub-threshold up to several minutes.

In studies where targets are briefly presented (i.e., for less than one second), typical measures of processing performance are response latency (reaction time) and accuracy; the signal-detection measures d' and β are less frequently reported. Regardless of dependent measures used, processing of briefly exposed linguistic targets is typically found to be affected by priming with related linguistic stimuli. The amount of facilitation or inhibition of target-processing has been shown to vary systematically as a function of processing task, conditions of stimuli presentation, and nature of relationship between target and prime. For example, Fowler, Wolford, Slade, and Tassinari (1981) demonstrated that sub-threshold priming with semantic associates conferred a 32 msec. advantage in a lexical-decision task.

A popular cognitive-theoretical framework for predicting and explaining the priming effect is *spread of activation*. Doshier and Rosedale (1989) provide a concise description of this concept:

...when a context element [prime] appears, the memory representation for that element is accessed or activated. Subsequently activation spreads to (linked) representations in memory. Those representations are then temporarily easier to access until residual activation decays below some useful level....The spreading activation model hypothesizes a representation consisting of nodes (concepts), some of which are linked (associated) to one another. When a person is shown a priming word or picture, the corresponding node is activated in memory.

Activation then spreads from this node along links to all connected concepts, which may activate other nodes. When a subsequent word or picture that is linked to the prime (either directly or indirectly) is seen, the corresponding and related concepts are still residually activated. This residual activation may allow earlier recognition, or it may facilitate selection among close competitors when a stimulus is ambiguous (p. 191).

Within the last decade, parallel distributed processing (PDP) and neural-network based models such as TRACE (McClelland & Elman, 1986) have increasingly supplanted spreading-activation models as popular analogs of lexical representation and storage. As in spreading-activation models, flow of finite amounts of excitation between multiply interconnected processing units is crucial to distributed models. However, distributed models forego representation by unitary nodes in favor of discrete patterns of activation across multiple units (or cells). A three-dimensional distributed network model of the lexicon (e.g., Stone & Van Orden, 1989) utilizes spatially separate, but richly interconnected areas of the network for representation of various dimensions of lexicon items (e.g., phonetic, semantic, etc.). For example, the referential dimension of words for concrete objects largely corresponds to patterns of activation in primary sensory networks akin to those occurring when in the presence of or in contact with the actual objects.

To the extent that any two words are related, they share overlapping representational patterns, or space in one or more dimensions. Thus, homophones such as *bee* and *be* share identical space in the phonological dimension, partially overlapping spaces in the orthographic dimension, and discontinuous spaces in the semantic dimension. Representational spaces associated with particular lexical items are not static; they are modified by experience and affected by top-down processes (e.g., the context in which the word is embedded). For example, the semantic space activated in association with perception of the word *cat* in the two phrases *my cat* and *your cat* may differ considerably.

According to spreading activation theories, priming results from excitation bleeding from node to node through associative connections. In contrast, priming effects in a spatial-network system result from coactivation through *direct* overlap or sharing of representational space within networks. In simple cases, the reduction in amount of stimulus input required for a target to reach recognition threshold should be proportional to the amount of overlap in representational space between target and prime, minus intervening interference effects or decay in activation. Thus, priming should reduce response times and increase accuracy if other processing demands can be controlled or accounted for. Because semantic dimensions of words are highly complex, larger portions of the neural network are probably utilized for their representation than are required for other dimensions. The semantic representation of abstract lexical items in particular may require high levels of coactivation in related lexical items. Therefore, lexical items that are closely semantically related are likely to share larger proportions of the network than words related only by surface characteristics such as orthography or phonetics, and thus should generally show larger priming effects.

Lateralized (divided visual-field) tachistoscopic presentation has been used for many years to study inter-cerebral differences in processing ability. The technique derives validity from the neuroanatomy of the visual system. "Nerve fibers from each of the nasal hemiretinae project to the visual cortex of the ipsilateral cerebral hemisphere, whereas the projections from the temporal hemiretinae are to the contralateral cerebral hemisphere. Thus, although each eye has projections to both hemispheres, information concerning LVF stimuli is projected to the visual cortex of the right cerebral hemisphere and information concerning RVF stimuli is projected to the left cerebral hemisphere" (Young, 1982, p. 12). Therefore, a RVF advantage for processing given types of information is generally accepted as corresponding to a left-hemisphere superiority. Additional validation of the

technique has come from studies such as carried out by Strauss, Wada, and Kosaka (1985) in which differences in performance between visual fields were found to corresponded to independent techniques (e.g., carotid Amytal test) for assessing lateralization of language function.

Many DVF studies have examined simple lateralized processing of single words. These studies typically measure accuracy and latency of word/non-word lexical-decisions or naming. In summarizing the results of such studies Beaumont (1982, p. 59 & 63) concluded that “the RVF superiority for words is the most stable effect to be observed with DVF presentations...[and the effect obtains]...across a broad range of stimulus types presented with a variety of experimental paradigms.” Thus the findings of DVF studies of single word processing are consistent with current conceptions of left-hemisphere dominance for basic language processes.

Studies combining semantic priming and lateralized presentation of single-word targets have demonstrated interactions between type of prime-target relationship and visual-field of presentation. These findings are typically interpreted as suggestive of differential hemispheric processing capacities. Chiarello (1985) reports on a series of six DVF experiments involving *automatic* and *controlled* priming. Automatic priming effects obtain when subjects have little or no conscious awareness of primes or are consciously unable to use them as an aid to processing targets. Examples of the paradigm include use of sub-threshold or pattern masked primes, very brief intervals between primes and targets, and inclusion of only a small proportion of related primes in the stimuli set (low probability). Controlled priming effects obtain when subjects are aware of primes and consciously make use of them when processing targets. Examples of the paradigm include provision of explicit instructions or explanations regarding stimuli, lengthy exposure of primes, and inclusion of a high proportion of related primes in the stimuli set (high

probability). Chiarello examined the effects on lexical decisions of semantic priming in the LVF and RVF under controlled (high probability) and automatic (low probability) conditions. Primes were presented to the same VF as targets. Under controlled conditions, semantic priming effects were observed for both visual-fields, but a significant RVF superiority was observed. Under automatic conditions, both VFs again demonstrated semantic priming, although an LVF superiority obtained. However, in a similar series of experiments employing automatic semantic priming, Abernethy and Coney (1990) failed to replicate the LVF superiority. Instead, an opposite trend of a RVF advantage for lexical decisions when targets and primes were both presented in the RVF was found. When order of prime-target presentation was either LVF-RVF or RVF-LVF, a smaller priming effect obtained. No priming effect was observed for LVF-LVF presentations. Chiarello, Burgess, Richards, and Pollock (1990), have also done a follow up study. Using an automatic priming paradigm, they demonstrated equal LVF and RVF semantic priming for closely related prime-target pairs (e.g., doctor-nurse), and a LVF advantage for more distantly related pairs (e.g., deer-pony). Gagnon, Joannette, Goulet, and Cardu (1989) had RBD and matched normal subjects engage in both automatic and controlled, semantically primed lexical decision tasks, and a non-tachistoscopic semantic-judgment task. They found that "RBD subjects showed intact automatic and controlled priming, but impaired performance on the semantic judgment task" (p. 2). Rodel, Cook, Regard, and Landis (1989) conducted two experiments using simultaneously presented, frequency matched noun pairs (one centered and one lateralized). The noun pairs were independently rated as being either closely or distantly semantically related. Subjects judged semantic similarity (similar or dissimilar). A visual-field by word-categorization interaction was found. Semantically close pairs were more often categorized as semantically similar in the RVF and dissimilar in the LVF, while there was small trend

toward the reverse for semantically distant pairs. In a second experiment, a set of randomly chosen, frequency-matched nouns was paired in all possible combinations. Subjects performed the same task as in the first experiment, and in addition, completed a post-hoc rating of each word pair on a four-point scale of semantic distance. When performance in each VF was compared to the post-hoc measure, an interaction again obtained. Word pairs rated as having distant or no semantic relation were categorized as semantically similar more often for LVF presentations, while the opposite pattern obtained for RVF presentations.

The results from these studies, while not entirely consistent, do support the hypothesis that the right hemisphere has some capacity to process semantic relations between lexical items. However, the relationships apprehended in the RH are apparently of a qualitatively different kind than those apprehended in the LH. While associations generated in the LH tend to be more concrete and direct, those in the RH tend to be abstract and even literally opaque. This dissociation in patterns of linguistic performance bears upon the previously discussed hypothesis of a RH substrate for idiom comprehension, because the association of literally unrelated lexical items is the one of the fundamental characteristics of figurative language.

Like all experimental methodologies, lateralized presentation techniques are not without limitations which affect both design parameters and interpretation of data. Lateralized presentation requires the eyes of the subject to be fixated on a location central to stimulus offset. A variety of techniques have been developed to promote or ensure fixation. It is first necessary to provide a visual marker at the point of fixation which subjects can focus on. Of course, merely providing a fixation point and instructions does not guarantee that subjects will properly fixate. Highly sophisticated video and infrared tracking systems have been developed to accurately monitor eye movement. These

systems can passively record and verify fixation or actively control stimulus display. When such equipment is unavailable, indirect methods have demonstrated sufficient validity. Simply randomizing the stimuli sequence with respect to visual-field of presentation effectively inhibits expectancy-based lateral scanning. The inclusion of *catch-trials* (McKeever & Van Eyes, 1986), in which presentations of stimuli at the fixation point are randomly inserted in lieu of lateralized stimuli, is also effective at enhancing subject fixation, particularly when accurate reporting is stressed. In addition, accuracy of responses to catch-trials provides a useful estimate of fixation consistency which may be used as criteria for validating fixation on a subject by subject basis.

The appearance of stimuli outside of foveal vision (i.e., the fixation point) engenders *express saccades*, a foveal reorientation reflex. To insure lateralized stimulus presentations, exposure durations must not exceed the time required to bring the fovea to bear on targets. Studies on the time-course of saccades have established a conservative upper limit of 150 milliseconds for lateralized presentations in normals (Young, 1982; Hardyck, Dronkers, Chiarello, & Simpson, 1985; Mckeever, 1986).

After fixation-control methods and display-time durations have been decided upon, the next design parameter to set is eccentricity of stimulus presentation. Although some animal species have bilateral projections from regions adjacent to foveal midline, no definitive evidence exists concerning the possibility of similar neural structures in humans. However, unihemispheric projection is considered insured if stimuli are laterally offset by at least 1.5° of visual angle from point of fixation (Mckeever, 1986).

When choosing stimuli, it is essential to be familiar with target characteristics other than those of interest which may nonetheless affect processing performance. Several studies have demonstrated that in lexical decision tasks, response latency decreases and accuracy increases as a linear function of log-transformed frequency of occurrence of

targets (Howes & Solomon, 1951, Howes, 1957, Forster & Chambers, 1973). This effect has been reliably demonstrated for languages other than English (Segui, Mehler, Frauenfelder, & Morton, 1982). Many current tachistoscopic studies in which frequency is not a variable of interest attempt to control for such effects by equating stimuli on an item by item or group basis.

Targets length has been shown to interact with visual field in producing effects on processing performance. Specifically, response latency to words, but not non-words in lexical decision tasks has been found to increase as a function of the number of *characters* in the target for LVF presentations, while character length had no effect on reaction-times to RVF presentations (Young & Elis, 1985, Elis, Young, & Anderson, 1988; Bub & Lewine, 1988; Bruyer & Janlin, 1989). In the above studies, the effect of character-length was demonstrated to be independent of target width (as measured in visual angle), which had no effect on performance in either visual field. It is generally easier and more preferable to control for the possibility of frequency and length effects through planned selection of stimuli rather than using post-hoc statistical procedures to partial them out.

Subject performance may be most variable during initial trials of tachistoscopic presentations. If initial high variability is unrelated to independent variables, then treatment effects may be obscured. Unfortunately, there is considerable conflict to be found in data concerning relationships between performance asymmetries and effects of practice, stimuli repetition, and set size. Two reviews within the last decade have found the aggregate data to be essentially equivocal (Beaumont, 1982; McKeever, 1985). However, in a recent, carefully controlled study, Brysbaert and D'Ydewalle (1990) found reasonable overall test-retest correlations (≥ 0.65) with a variety of laterality indices derived from single-word recognition measures, but poor correlations between initial trials and overall subject performance. They ascribed the low correlations primarily to task

adjustment and practice effects, and recommend presentations of large numbers of stimuli in multiple sets to obtain optimum reliability of effects.

The remaining design issue to consider is mode of response. A variety of choices are available, but all fall into one of three basic categories: verbal, unimanual, and bimanual. Studies using verbal response for reaction-time employ some type of device for registering and recording latency of voice onset. Responses may also be recorded for an analysis of accuracy or choice.

When manual response is incorporated into the design, issues of crossed/uncrossed responding must be resolved. Cortico-spinal efferents to skeletal muscles are almost entirely contralateral. Therefore, manual response is controlled by the contralateral hemisphere. Crossed responses are defined in terms of the hand used for response and the hemisphere which either initially receives lateralized input, or is superior for processing it. For example, when response hand is ipsilateral to the hemisphere which receives the information, response is *crossed with respect to input*. In the same way, when response hand is ipsilateral to the hemisphere which is superior for processing the information, response is *crossed with respect to processing* (admittedly, what is crossed or uncrossed with respect to processing is still largely speculative). The term "crossed" implies that information must travel from one hemisphere to another in order for a response to occur. The information that is transferred may be the final results of processing (e.g., a go/no-go command) or partially processed stimuli. For crossed responses, the required for interhemispheric information transfer will be reflected in reaction time penalties. In addition, when information passes from one hemisphere to another, penalties in reaction-time and accuracy may result from signal-degradation or inefficient processing in the non-dominant hemisphere. It is even possible to have a doubly crossed response, in which the hemisphere controlling the response hand initially receives the information, but is not

capable of processing it. The information would then have to be sent laterally for processing, and the command for response sent back before the subject could act.

Arbitrary stipulation of manual response parameters may result in confounds which hinder interpretation of the data.

Unimanual response requires the subject to press one or more buttons, or move a lever or joystick with one hand. To control for crossing effects, hand use may be counterbalanced between or within subjects. When bimanual response is employed, assignment of hand to response choice may also be counterbalanced between or within subjects. In bimanual paradigms, it is also possible to obtain all crossed or uncrossed responses (with respect to the hemisphere receiving information) by using continuously variable assignment of hand to response choice. For example, one can direct subjects to always use the hand ipsilateral to stimulus display to indicate responses. In this way, the hemisphere that initially receives the information is always in direct control of responses (see figures 1 & 2).

The final issue involved in lateralized presentation studies does not concern design, but bears instead on interpretation of results. The primary visual cortices are interconnected primarily through the splenial fibers of the corpus callosum. The cortical area with richest callosal interconnections appears to correspond to a strip of retina approximately 2° - 3° wide on either side of the vertical midline (Young, 1982). The nature of interhemispheric transmission is as yet poorly understood. While direct interhemispheric connections between visual cortices almost certainly have a role in basic visual processes such as depth perception, the extent of transmission of higher order visual information is unknown. Beyond primary visual cortex, interhemispheric transmission of more extensively processed visual information from association cortex in temporal, parietal, and frontal lobes is quite likely. Again, the nature of such transmissions is largely unknown. Our lack

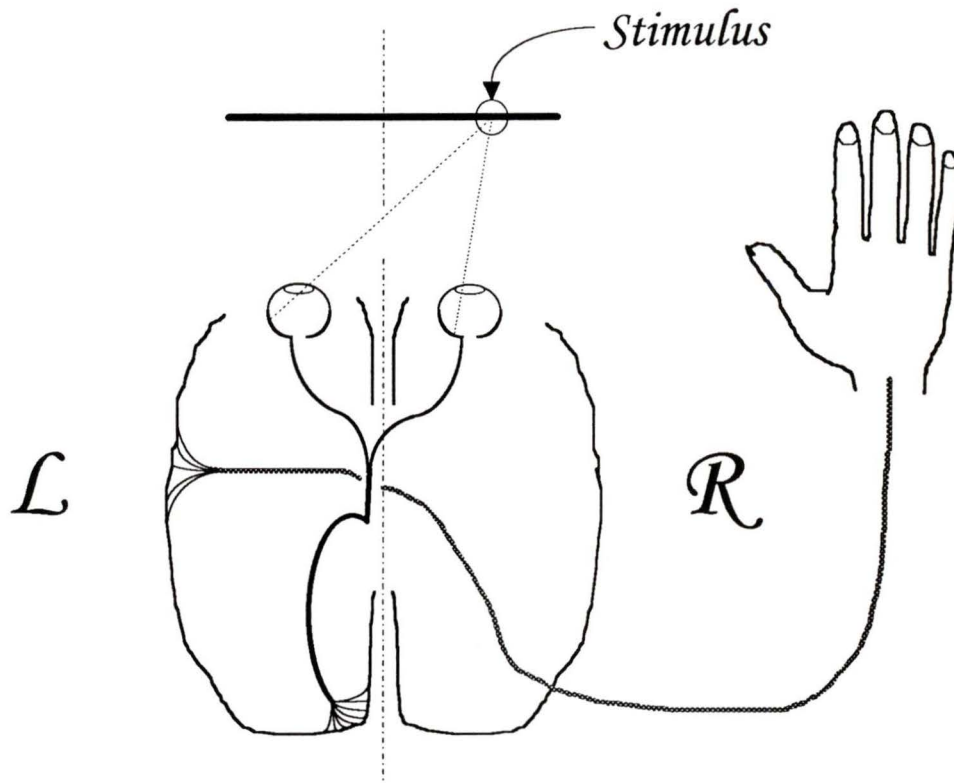
of understanding regarding interhemispheric communication and cooperative processing should inspire caution about attributing differences in performance following lateralized presentation to differential hemispheric abilities. However, when stimulus, display, and response parameters have been properly stipulated, obtained differences in processing time or accuracy are generally assumed to reflect the native abilities of each hemisphere and/or interhemispheric transfer processes rather than results of joint-hemispheric processing efforts.

Assuming that the lexicon is realized in some type of associative or spatial network (leaving aside the very large question of how such networks are realized in physiological structures and processes), then data from multiple sources converges on the hypothesis that the representations of idiomatic phrases are localized in part to the right hemisphere and/or require its intact function for normal activation. If figurative meanings of idioms are a parsed by the right-hemisphere and literal meanings by the left-hemisphere, then performance may dissociate on a lateralized task which promotes both types of processing.

Two experiments were carried out in an attempt to answer the above questions. The paradigm employed controlled priming with idiomatic phrases and a divided-visual-field, speeded semantic decision task (i.e., subjects were required to quickly decide if briefly presented lateralized words reminded them of preceding idioms). Three types of words were presented: figuratively-related, literally-related, and unrelated. Based upon results from other studies, three major predictions were made: (1) subjects would categorize figuratively and literally-related words as reminding them of primes more often than unrelated words, (2) general priming effects would be observed for figuratively and literally-related words in relation to unrelated words (i.e., the former would be responded to faster than the latter), and (3) for figuratively-related targets, the putative RH figurative processing substrate would evidence itself through an attenuation of the

typically observed RVF-LH advantage (i.e., subjects would show a RVF reaction-time advantage for literally-related and unrelated targets, but not for figuratively-related targets).

Anterior - Frontal

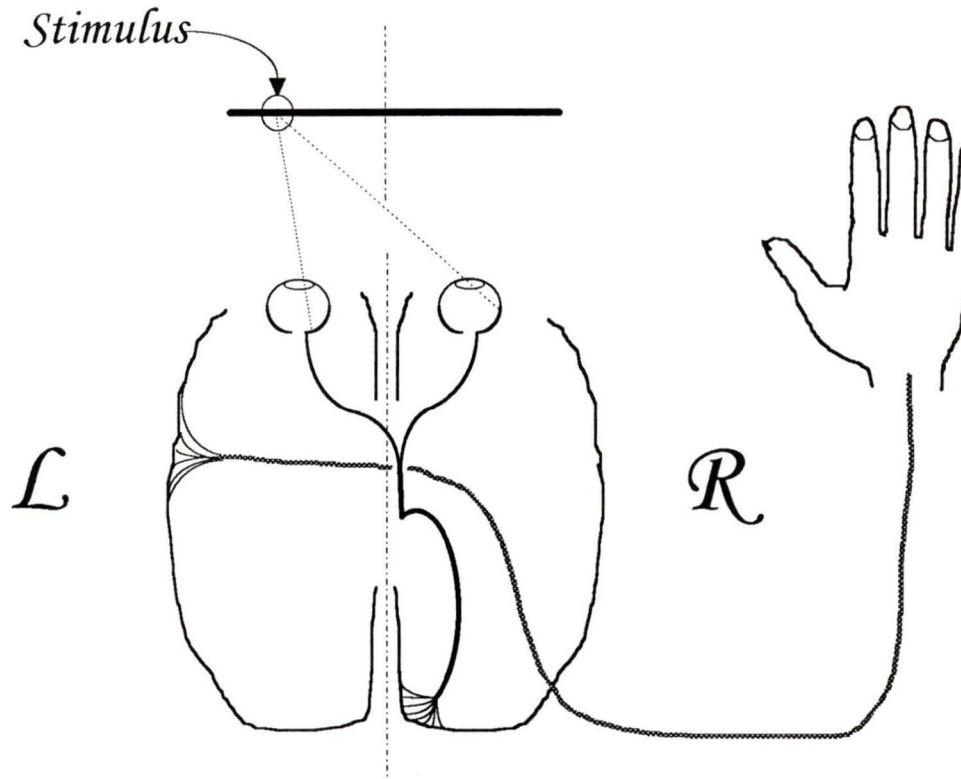


Posterior - Occipital

Figure 1:

Uncrossed response with respect to the hemisphere receiving the information. In this case, the stimulus is presented in the right visual field and thus falls upon the left hemiretina of each eye, which in turn project to the left occipital cortex. The subject responds with the right hand, which is also controlled by the left hemisphere. If the stimulus can be processed within the left hemisphere, no commissural transmission is required for initiation of response.

Anterior - Frontal



Posterior - Occipital

Figure 2:

Crossed response with respect to the hemisphere receiving the information. In this case, the stimulus is presented in the left visual field and thus falls upon the right hemiretina of each eye, which in turn project to the right occipital cortex. The subject responds with the right hand, which is controlled by the left hemisphere. Regardless of whether or not the stimulus can be processed within the right hemisphere, commissural transmission is required for initiation of response.

Experiment One

Controlled semantic priming was paired with a speeded semantic decision task to gather reaction-time and word-categorization data.

Subjects

Twenty two adult males were recruited from graduate and undergraduate psychology courses at the University of Victoria. All reported exclusive use of the right hand for writing. Most undergraduate subjects participated in return for credit in an introductory psychology course. Subjects completed a questionnaire providing data on incidence of sinistrality in immediate family, personal history of CNS trauma or disorder, and mental illness. No subjects reported significant CNS trauma, disorder, or mental illness. All subjects reported normal or corrected to normal vision. Group means and standard-deviations for subject demographic data are provided in Table 1.

Table 1. Experimental Subject-Group Demographics

	sex	n	age*	yrs. of education**
Experiment 1	male	19	25.5 (6.2)	17.0 (2.9)
Experiment 2	female	19	20.3 (3.2)	13.6 (0.8)

* difference between groups significant at $p < .005$

** difference between groups significant at $p < .001$

Apparatus

Gerbrands model G1166-S electromagnetic shutters controlled by a Gerbrands model G1176 controller were mounted to two Kodak model B2 slide projectors. Shutter timing was controlled by a Gerbrands 300 Series millisecond timer. Slide-advance was controlled by a Gerbrands model G1180 Slide Changer. An IBM PC was linked to the apparatus and used software developed for the project (see appendix C) to record word-categorization

and response latency. Timing of response latency began from the onset of lateralized word presentation, and was terminated by depression of either of two electromagnetic buttons (taken from a computer keyboard) mounted to the left and right armrests of a chair. The projectors were arranged vertically and set 67 cm. behind a 30 x 30cm. rear-projection screen. The low-output lamp setting on the projectors was used along with neutral gray density filters (0.6) to reduce glare and flash effects. The fixation point was mounted directly to the screen. It consisted of a 1mm. black dot circumscribed by four solid black triangles (vertices pointing inward) offset 1cm. vertically and horizontally. The distance between the chair and screen was adjusted so that each subject's eyes were approximately 85 cm. from the fixation point.

Stimuli

All stimulus slides were equal-focal-length photo-reproductions of laser-printed text. The original text was printed in black ink on white paper in lower case 14 pt. proportional Times-Roman bold font. Thirty common idiomatic phrases of 2 to 7 words in length served as primes (avg. length in words = 3.7, sd = 1.0). Priming phrases were presented horizontally centered immediately below the fixation point.

In order to distinguish between priming associated with figurative meaning and that associated with literal meaning, three mutually exclusive word groups were created: (1) *figuratively-related words* -- semantically related to the figurative meaning of their primes, (2) *literally-related words* -- unrelated semantically to the figurative meaning of their primes, *but* semantically related to one of the principal constituent words in their primes, and (3) *unrelated words* -- semantically unrelated to their primes. Inclusion of a group of unrelated words was necessary for establishing baseline (unprimed) performance. One unique figuratively-related word and literally-related word was paired with each prime, plus an unrelated word, producing 30 unique prime-word sets (see Appendix A).

For example, for the prime phrase "kick the bucket," the figurative word is *die*, the literal word is *can*, and the unrelated word is *how*. The number of characters in all words were kept as low as possible to help control for length effects (avg. length in characters = 4.43, $sd = 0.72$). All words in an individual prime's set were of identical length. Unique unrelated words were not chosen for each prime. Instead, four unrelated words were chosen, equal in length (3, 4, 5, or 6 characters) to related words and unrelated figuratively or literally to any of the primes. Equating frequency of word sets for each prime proved to be impractical. However, average word log-frequency (Francis & Kucera, 1982) was equated overall between figurative and literal words. Mean log-frequency of unrelated words (weighted for repeated exposure) was significantly greater (by approximately double) than the mean frequencies of the other two word-types. Words were presented at approximately 2.7° of visual angle off center at the same vertical position as the fixation point. Total horizontal visual angle subtended by words ranged from 2.7° to 4.0° , depending on number of characters. A central stimulus "*" was also presented at the fixation point along with each word.

Presentation of words were completely counterbalanced across visual fields. Thus, subjects viewed each idiomatic prime six times (once for each word for both VFs) while each set of words was seen twice (once in each VF). The total number of trials was therefore $30(\text{idioms}) * 3(\text{words}) * 2(\text{visual fields}) = 180$. Order of presentation was pseudo-randomized, with the following sequential stipulations: no more than three words consecutively to either visual field; no more than three words of a given type in a row; no more than two consecutive presentations of the same prime. The stimuli were divided into five groups of 36 trials. Two catch trials were inserted in pseudo-random locations within each group, bringing the total trials per group to 38 trials and the overall total to 190

trials. To reduce variability related to adjustment to task, the final (5th) set of stimulus slides was also shown as an initial practice session.

The sequence of stimulus presentation went as follows: prime phrase visible for 2.5 seconds; 2.5 second blank-screen fixation interval; word or catch-trial presented for 150 msec.; 5 second blank-screen interval before the next prime appeared on screen.

Approximately three minutes was given for subjects to relax between sets.

Procedure

Informed consent was obtained from all subjects. The apparatus was briefly explained, and instructions given for subjects to read each priming phrase to themselves as it appeared on the screen, and then to focus on the fixation point when the phrase disappeared. Subjects were told to keep the phrase in mind as they focused on the fixation-point and to decide as quickly as possible whether the laterally-presented word “reminds you of something about the phrase that came just before.” No further elaboration of decision-making criteria was provided. Half of the subjects were instructed to use the index finger of the left hand to indicate that the word reminded them of the prime and the index finger of the right hand to indicate otherwise; the other half of the subjects used reversed hand order. Subjects were told that both speed and accuracy of response were important, but that rapid response was most important. Subjects were instructed to respond to every trial, even if they had to guess. The existence and purpose of catch trials was made clear to subjects. They were informed that numbers would occasionally appear at the fixation-point rather than the usual off-center words, and that in these cases the number was to be verbally reported. Subjects were warned that if they were not fixating properly, they would miss the catch-trials. After the practice session, subjects with more than five reaction times above the 1500 msec. cutoff were asked to

respond faster during the following groups of trials. Subjects were not informed that the first group was a practice set.

Following the t-scope presentations, subjects were administered a form for assessing correspondence in meaning of primes and related words. The form contained a list of all primes, along with the figuratively and literally-related words of each (see appendix B). Five-point rating scales were provided for each word. Subjects were instructed to rate how closely the meaning of each word matched the meaning of the associated idiomatic phrase, and to take their best guess if unsure about meanings of any particular phrases or words. Definitions of words or idioms were not provided on the occasions when subjects requested help.

Results

Data from the initial (practice) exposure of the final stimulus set was not used in any statistical analysis. No subjects were excluded for failing to meet catch-trial report accuracy criteria (11 out of 12 correct). Response latencies greater than 1500 msec. were counted as missing data. Subjects were excluded for having excessive proportions of missing data (less than ten valid reaction-times per condition). Two subjects were excluded on that basis. Subjects were also excluded if they did not rate figuratively-related words closer in meaning to respective idioms than literally-related words (by at least an average of 1.5 points on the 5-point scale). One subject failed this criterion. The remaining 19 subjects were missing an average of 9% of their data to long reaction-times. Mean ratings of semantic congruency between primes and figuratively-related words was 4.79 ($sd = 0.26$). Mean ratings for literally-related words was 1.59 ($sd = .65$). The difference in ratings was significant at $p < .001$ [$t(1,18) = 20.35$].

Initial analysis of reaction-time data revealed the presence of positively skewed distributions resulting from the presence of small numbers of long-reaction-time outliers

(in excess of +3 *sd*). Such outliers are clearly not reflective of typical task performance, and may be interpreted as instances of concentration lapses or some other form of uncontrolled interference. Positively skewed distributions of raw-data are often obtained when reaction-time is the dependent variable, and were expected. Reaction-time (RT) data were therefore submitted to a planned log-transformation procedure to reduce bias in measures of central tendency. The analysis collapsed dependent variables across words and visual fields. Mean log-transformed RTs were calculated for each subject for each of the six conditions (3 word types * 2 VFs) and entered as data for the group statistical analyses reported. To facilitate interpretation, all graphs and tables report inverse logs of mean log-RTs.

The other dependent variable entered into statistical analysis was word-categorization (WC) - defined as the ratio of *positive* (word reminds subject of prime) responses to total number of valid responses. Observed WC ratios could therefore range from 0.0 (all valid responses were *negative* for a given condition) to 1.0 (all valid responses were *positive*). WC ratios were calculated for each of the six conditions for each subject and entered as cell data for the group statistical analyses.

For the following analysis, please refer to cell means and standard-deviations presented in Table 2. Homogeneity of covariance for both dependent variables was sufficient for application of ANOVA (All Greenhouse-Geisser Epsilons $\geq .73$). Therefore, reaction-time and word-categorization were submitted to separate two-way repeated-measures ANOVAs. In both cases, within-subjects variables were visual-field (2 levels) and word-type (3 levels). In cases of significant main effects of VF and word-type, preplanned univariate pair-wise comparisons within word-type or VF were carried out.

The overall main effect of VF on reaction-time was significant at the $p < .05$ level [$F(1, 18) = 5.51$]. Counter to predictions, univariate pair-wise comparisons of VF

asymmetries within word types revealed that only the average 27 msec. RVF advantage for figuratively-related words was significant [$F(4.69) = , p < .05$]. No VF asymmetry was observed for literal or unrelated words.

Table 2. Mean Values of Dependent Variables*: Experiment 1.

		Word Type			
		Figurative	Literal	Control	Combined
RT	LVF	831 (132)	888 (159)	813 (158)	844 (136)
	RVF	804 (144)	873 (158)	795 (164)	824 (133)
	Combined	818 (135)	881 (154)	804 (159)	834 (133)
WC	LVF	.77 (.15)	.50 (.31)	.09 (.17)	.45 (.16)
	RVF	.81 (.17)	.56 (.34)	.07 (.10)	.48 (.14)
	Combined	.79 (.16)	.53 (.30)	.08 (.12)	.47 (.14)

* *sd* in parentheses

No main effect of visual-field was found for word-categorization. Overall, subjects' categorization of words within the LVF matched that within the RVF.

Tests of main effects of word-type revealed significant trends in both RT and WC. The main effect of word-type was significant for reaction time at the $p < .005$ level [$F(1, 18) = 11.56$]. Univariate pair-wise comparisons showed that subjects took 63 msec. longer to respond to literally-related words than to figuratively-related words [$F(1, 18) = 13.22, p < .005$], and 77 msec. longer to respond to literal than to unrelated words

[$F(1, 18) = 5.85, p < .05$]. Counter to predictions, subjects reaction times to figuratively-related and unrelated words did not differ.

For word-categorization, the main effect of word-type was significant at the $p < .001$ level [$F(1, 18) = 328.50$]. As predicted, univariate pair-wise comparisons showed that subjects associated figuratively-related words with their primes more often than literally-related words [$F = 12.85 p < .005$], which in turn were associated with primes more often than unrelated words [$F = 43.74 p < .001$]. Needless to say, figuratively-related words were also associated with primes more often than unrelated words [$F = 328.5 p < .001$].

No word-type by VF interaction was observed for reaction-time or word-categorization. Therefore, VF effects were stable across the different word types.

An examination of individual word-categorization data indicated that subjects tended to produce one of two types of profile. All subjects responded positively to most figuratively-related words and negatively to most unrelated words. However, individual subjects' responses to literally-related words were either typically positive or typically negative (see figure 3). To determine if word-categorization decision processes were related to reaction-times, subjects were divided into two "WC profile groups" based upon average WC ratios for literally-related words. Subjects whose mean literal WC ratio was above 0.5 were placed into the "figurative-and-literal" decision criterion group (i.e., overall, they responded positively to both figuratively and literally-related words), while those whose mean literal WC ratio was below 0.5 were placed into the "figurative-only" decision criterion group (i.e., overall, they responded positively to figuratively-related words and negatively to literally-related words). There were twelve and seven subjects respectively in the two groups. Subjects in the figurative-and-literal group responded positively to 72% of literally-related words, while those in the figurative-only group responded positively to only 20% of literally-related words. Unfortunately, the

significance of this difference cannot be ascertained because there is no appropriate post-hoc test for group differences on the same variable that has been used for defining mutually-exclusive group membership. None the less, the face-validity of dividing subjects by WC profiles is compelling.

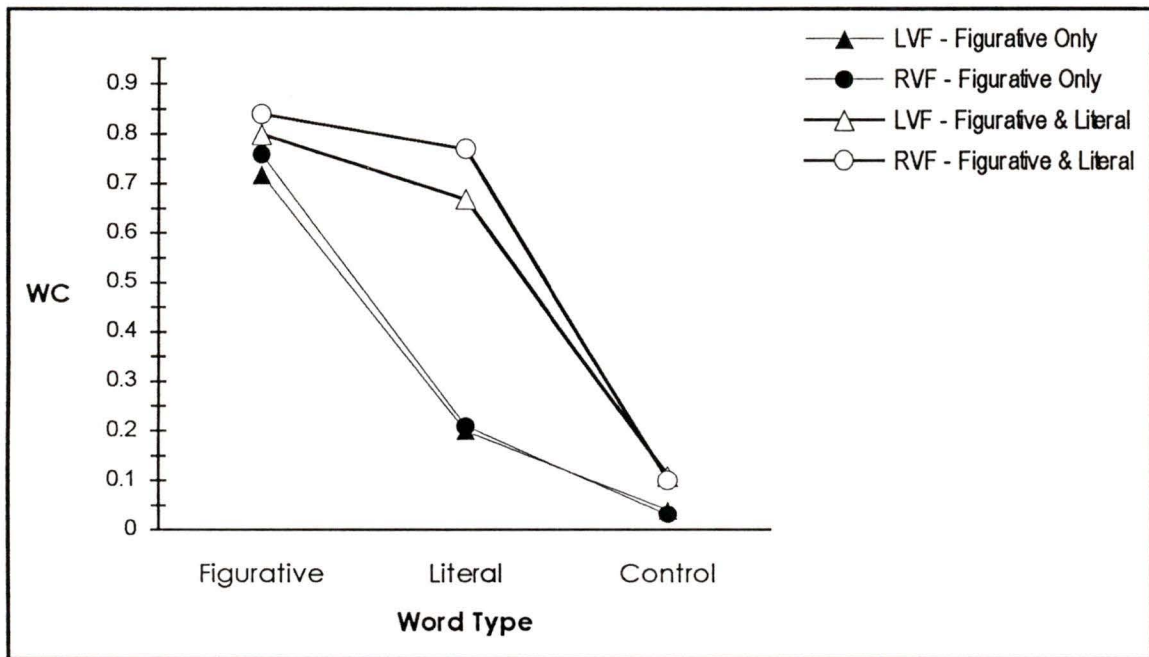


Figure 3. Experiment 1 -- word-categorization: n (Figurative & Literal) = 12; n (Figurative Only) = 7.

Reaction-time data were re-submitted to a repeated measures ANOVA with group membership (WC group) as a two-level between-subjects factor, visual field as a two-level within-subjects factor, and word-type as a two-level (idiomatically related and literally-related) within-subjects factor. Results of the test indicate that subjects who tended to respond positively to literally-related words show a complex differential pattern of VF asymmetry from those who tended to respond negatively to literally-related words (see figure 4).

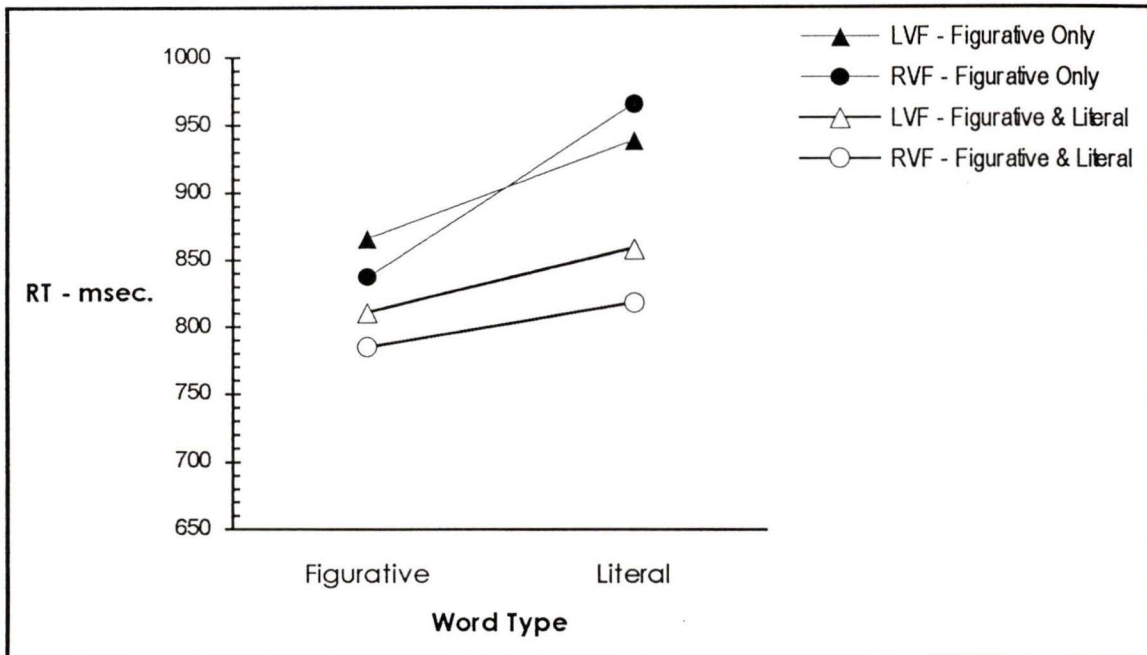


Figure 4. Experiment 1 -- reaction time: n (Figurative & Literal) = 12; n (Figurative Only) = 7.

The main effect of WC group was not significant. Therefore, when effects of VF and word type were taken into account *simultaneously*, the two groups did not differ. Both second order interactions of group (by word-type, and by VF) were also non-significant. In contrast to the initial analysis, the main effect of VF was also not significant. Thus, taking group differences into account attenuated the overall RVF advantage found previously. Additionally, the word-type by VF interaction was not significant. However, an interesting third-order interaction of group by word-type by VF was found [$F(1, 17) = 4.72, p < .05$]. Visual-field asymmetries in RT varied reliably only when both group membership and word type were considered together. Examination of figure 4 reveals that subjects who responded positively to both figuratively and literally-related words showed a consistent trend to LVF reaction-time advantage for both word types, while those who responded positively to figuratively-related words and negatively to

literally-related words showed a trend to LVF advantage for figuratively-related words, but an opposing trend to RVF advantage for literally-related words. The opposing VF effects for literally-related words shown by the two groups canceled each other out, thus reducing the F value of the overall test of the VF effect (given above), which compared means from each group pooled across figuratively and literally-related words.

As in the initial analysis, the main effect of word-type [$F(1, 17) = 17.51$] was significant at the $p < .001$ level. For both criteria groups, subjects took longer to respond to literal than to figuratively-related words.

Discussion

Because the stimulus set and response measures are identical in experiment one and experiment two, discussion of results from both experiments will follow experiment two.

While the first experiment was underway, a second one was begun. Changes in methodology used in experiment two were geared toward increasing the overall number of positive responses to literally-related words, and insuring that all positive responses were uncrossed. It was hoped that the changes would permit a comparison of only positive (uncrossed) responses to figuratively and literally-related words, providing more easily interpretable results.

Experiment Two

Initial analysis of procedures and early results from experiment one led to changes in design in experiment two. The changes were aimed at addressing the following two complementary issues: 1.) remedying design parameters that confounded possible effects of crossed and uncrossed responses with reaction time and word-categorization, and 2.) encouraging positive responses to literally-related words to reduce confounds of decision-type on comparisons of reaction-time between figuratively and literally-related words. Although attempts were made to obtain a subject group matching that used in experiment one, male subjects proved difficult to enlist and females were therefore enlisted as well. Eventually, too few males participated to derive reliable data. Therefore, only data from females will be considered for experiment two. Except for changes noted, all methods were identical to those used in experiment one.

Subjects

Twenty-six females were recruited from graduate and undergraduate psychology courses at the University of Victoria. Most undergraduate subjects participated in return for credit in an introductory psychology course. All subjects reported exclusive use of the right handed for writing. Demographic data are provided in Table 1.

Procedure

The directions for response criteria were modified. Subjects were told to decide as quickly as possible whether the laterally-presented word reminded them of “*anything* (rather than *something*) about the phrase that came just before.” As in experiment one, no further elaboration of response criteria was given. However, the word *anything* was clearly stressed. Response procedures were also modified. Subjects were instructed to press the key on the same side as the word flashed on screen if it reminded them of the

preceding phrase, and the button on the opposite side to indicate that the word did not remind them of the phrase. This change in response procedure results in all positive responses being uncrossed (in terms of the hemisphere originally receiving the stimulus) and all negative responses being crossed. It was hoped that sufficient numbers of positive responses would be obtained for figuratively and literally-related words for a condition-wise comparison of positive response averages.

Results

No subjects were excluded for failing to meet catch-trial report accuracy criteria (11 out of 12 correct). Four subjects were excluded for having excessive proportions of missing data (less than ten valid reaction-times per condition). Two subjects were excluded for not rating figuratively-related words closer in meaning to respective idioms than literally-related words (by at least an average of 1.5 points on the 5-point scale). The remaining 19 subjects averaged 8% missing data. Mean ratings of semantic congruency of meaning between primes and figuratively-related words was 4.80 (sd = 0.18). Mean ratings for literally-related words was 1.77 (sd = .72). The difference in ratings was significant at $p < .001$ [$t(1, 18) = 16.91$]

The same data transformations and statistical methods used in experiment one were applied to the data from experiment two. Results were generally congruent with those obtained in experiment one. For the following analyses, please refer to Table 3. Observed homogeneity of covariance for both dependent variables was sufficient for application of ANOVA (All Greenhouse-Geisser Epsilons $\geq .68$). Therefore, reaction-time and word-categorization were each submitted to a two-way repeated-measures ANOVA. In both cases, within-subjects variables were visual-field (2 levels) and word-type (3 levels). In cases of significant main effects of VF and word-type, preplanned comparisons within word-type or VF were carried out.

For the following analysis, please refer to cell means presented in Table 3. The main effect of visual field was significant for reaction-time at the $p < .001$ level [$F(1, 18) = 17.61$]. Counter to predictions, univariate pair-wise comparisons revealed that only the average 64 msec. RVF advantage for figuratively-related words was significant [$F(1, 18) = 22.45$, $p < .001$]. No VF asymmetry in reaction-time was observed for literally-related words or unrelated words.

Unlike experiment one, the main effect of VF was also significant for word-categorization [$F(1, 18) = 15.98$, $p < .001$]. Univariate pair-wise comparisons showed that figuratively-related words were responded to positively 13% more often when shown in the RVF [$F(1, 18) = 14.35$, $p < .001$], and that literally-related words received 9% more positive responses from the RVF [$F(1, 18) = 19.8$, $p < .001$]. Categorization of unrelated words did not differ between visual-fields.

For reaction-time, the main effect of word-type was significant at the $p < .005$ level [$F(1, 18) = 11.44$]. Univariate pair-wise comparisons revealed that subjects responded an average of 72 msec. faster to figuratively than to literally-related words [$F(1, 18) = 38.95$, $p < .001$]. Consistent with predictions, subjects responded an average of 43 msec. faster to figuratively than to unrelated words [$F(1, 18) = 4.52$, $p < .05$]. Overall, subject's reaction times to literally-related words and unrelated words did not differ significantly.

The main effect of word-type on word-categorization was also significant [$F(1, 18) = 359.75$, $p < .001$]. Just as in experiment one, the predicted pattern obtained; subjects associated figuratively-related words with their primes more often than literally-related words [$F(1, 18) = 11.97$, $p < .005$] or controls [$F(1, 18) = 359.74$, $p < .001$]. Literally-related words were also associated with primes more often than unrelated words [$F = 37.83$, $p < .001$].

Table 3. Dependent Variables: Experiment 2.*

		Word Type			
		Figurative	Literal	Control	Combined
RT	LVF	773 (147)	831 (154)	793 (167)	799 (146)
	RVF	709 (145)	794 (147)	775 (173)	759 (145)
	Combined	741 (143)	813 (142)	784 (168)	779 (144)
WC	LVF	.76 (.15)	.50 (.34)	.06 (.08)	.45 (.14)
	RVF	.89 (.06)	.59 (.38)	.09 (.15)	.53 (.15)
	Combined	.84 (.09)	.54 (.36)	.08 (.10)	.49 (.13)

* *sd* in parentheses

The interaction between visual-field and word-type was significant for both reaction-time [$F(1, 18) = 4.44, p < .05$] and word-categorization [$F(1, 18) = 16.81, p < .001$]. That is, the RVF reaction-time advantage was largest for figuratively-related words and got progressively smaller for literal and then unrelated words. In the same fashion, the VF asymmetry for word-categorization (more positive responses to RVF words) is largest for figuratively-related words and gets progressively smaller for literal and then unrelated words.

Preplanned comparisons were next carried out between means of uncrossed (positive) responses. Subjects with less than ten valid uncrossed reaction times for each cell were dropped from the analysis. Data from the 12 remaining subjects was entered. Mean log-RTs were recalculated, and submitted to a two-way repeated measures ANOVA. Within-subjects factors were VF (2 levels) and word-type (2 levels: figuratively-related & literally-related). Means and standard deviations of the cell values are presented in table 4.

In cases of significant main effects, preplanned tests of within word-type or within VF effects were carried out.

Table 4. Reaction-Time for Uncrossed Responses*

	Figurative	Literal	Combined
LVF	783 (91)	842 (102)	813 (88)
RVF	719 (111)	775 (120)	747 (107)
Combined	751 (93)	809 (103)	780 (92)

* *sd* in parentheses

Subjects showed an overall average 66 msec. RVF advantage [$F(1, 11) = 11.64$, $p < .005$]. Univariate tests ($dfs = 1, 11$) of VF asymmetry within word types demonstrated that both the 64 msec. RVF advantage for figuratively-related words and the 67 msec. RVF advantage for literally-related words were significant [$F = 7.74$, $p < .05$, & $F = 7.51$, $p < .05$, respectively].

Overall, subjects showed an average 58 msec. advantage for figuratively over literally-related words [$F(1, 11) = 8.87$, $p < .05$]. Univariate tests for between word-type differences within visual fields found both the 59 msec. and the 56 msec. advantage of figuratively-related words in the LVF and RVF to be significant [$F(1, 11) = 6.47$, $p < .05$, & $F(1, 11) = 5.13$, $p < .05$, respectively]. The VF by word-type interaction was not significant.

Despite the change in instructions the subjects could again be clearly divided into subgroups based upon a literal WC of less than or greater than 0.5 (see figure 5). As in experiment one, reaction-time data were re-submitted to a repeated measures ANOVA with group membership as a two-level between-subjects factor, visual field as a two-level

within-subjects factor, and word-type as a two-level (figurative and literal) within-subjects factor (see figure 6).

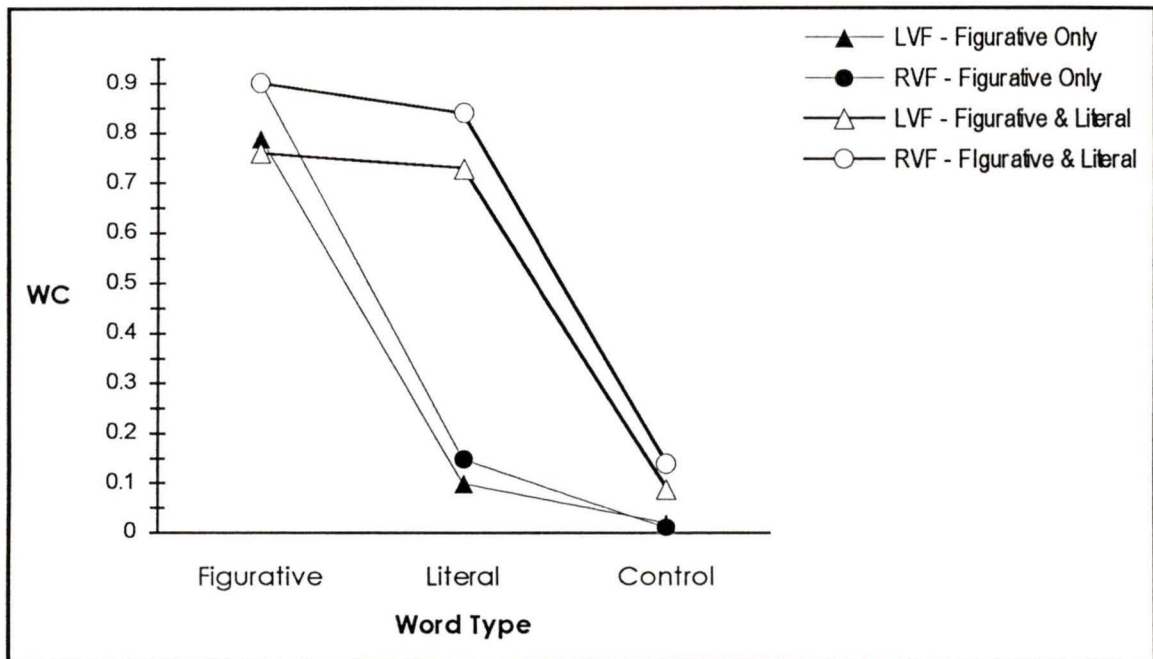


Figure 5. Experiment 2 -- word-categorization: n (Figurative & Literal) = 12; n (Figurative Only) = 7.

Subjects in the figurative-and-literal group responded positively to 79% of literally-related words, while those in the figurative-only group responded positively to only 13% of literally-related words. As in experiment one, reaction-times from subjects who tended to respond positively to literally-related words show differential patterns of VF asymmetry than those from subjects who tended to respond negatively to literally-related words. However, group by visual-field effects were more pronounced than in experiment one.

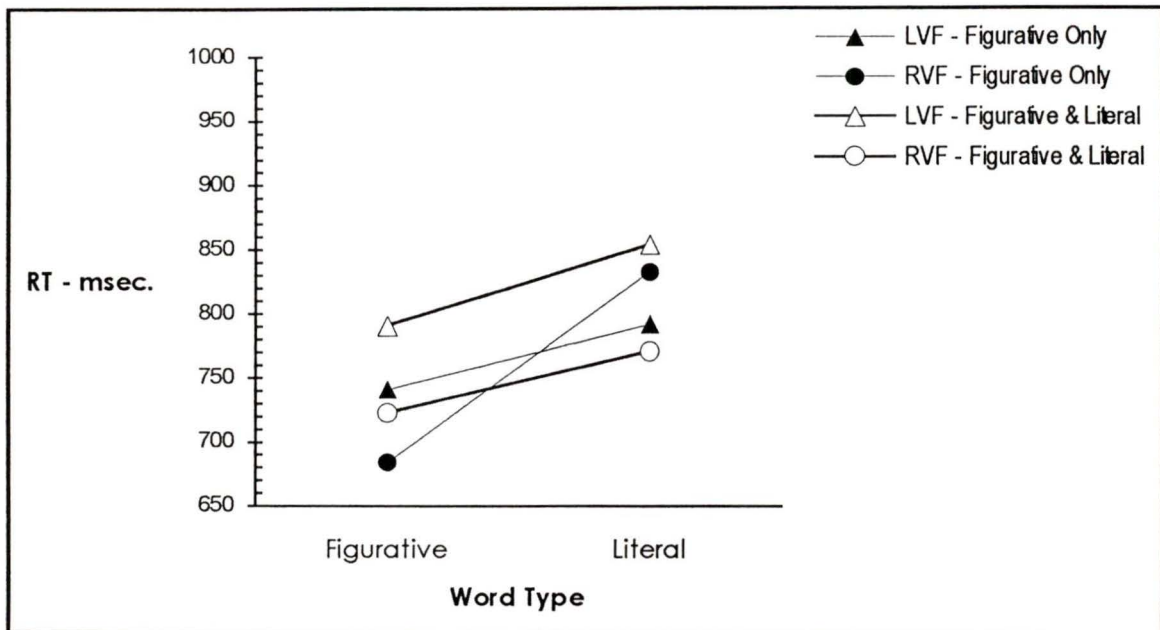


Figure 6. Experiment 2 -- reaction time: n (Figurative & Literal) = 12; n (Figurative Only) = 7.

Like experiment one, the main effect of WC group was not significant. Again, when main effects of VF and word-type were taken into account *simultaneously*, the two groups did not differ. Unlike experiment one, however, a significant group by VF interaction was found [$F(1, 17) = 7.31, p < .05$]. The figurative-and-literal group obtained a larger overall RVF advantage (averaged across both word types) than the figurative-only group. The group by word-type interaction also approached significance [$F(1, 17) = 4.11, p < .06$], indicating that when collapsed across visual-fields, the average RTs obtained by the two groups had some tendency to diverge across the two word types (the figurative-only group tended to show a larger RT advantage for figuratively-related words). In another notable contrast with experiment one, taking group differences into account did not significantly attenuate the overall RVF superiority found in the initial analysis [$F(1, 17) = 11.16, p < .005$].

The most salient congruency between results from experiment one and two is the significant group by word-type by VF interaction [$F(1, 17) = 5.98, p < .05$]. Again, between VF differences were dependent upon both group membership and word-type. Examination of figure 6 reveals a pattern of asymmetry largely congruent with that obtained in the previous experiment. Subjects who responded positively to both figuratively and literally-related words showed a consistent trend to RVF superiority for reaction-time, while those who responded positively to figuratively-related words and negatively to literally-related words showed a trend to LVF superiority for figuratively-related words, but an opposing trend to RVF superiority for literally-related words. As in experiment one, the opposing VF effects for literally-related words shown by the two groups tended to canceled each other out. However, the LVF advantage for figuratively-related words for both groups was larger than that found in experiment one -- large enough to result in an overall VF effect not found previously.

The main effect of word-type remained significant at the $p < .001$ level [$F(1, 17) = 49.77$]. Again, subjects took less time to respond to figuratively than literally-related words.

Discussion

Results from the word-phrase rating task validate the composition of the stimulus set. While subjects perceived semantic congruity between idioms and their figuratively-related words, literally-related words were viewed as semantically distant, demonstrating that the figurative meanings of the idioms were readily available and differentially associated to words during free viewing.

One of the objectives of the experiments was to determine whether subjects' patterns of word-categorization would vary by VF and word-type when decisions were speeded

and external criteria were vague. Therefore, subjects in the study were not instructed to use specific criteria regarding figurative/literal relationships between primes and words.

As expected, subjects responded differently to the three word types. Overall, when asked to respond according to whether or not words reminded them of primes, subjects responded positively to 82% of figuratively-related words, 54% of literally-related words, and only 8% of unrelated words. Clearly, this non-random pattern of response demonstrates that subjects understood the task, and were able to access the lexical identities of most of the words.

Although subjects generally accepted figuratively-related words and rejected unrelated words, two opposing trends were readily apparent within the general pattern of response to literally-related words. Evidently, subjects employed one of two criteria for responding to words. One group of the subjects responded positively to both figuratively and literally associated words, while the remainder responded positively only to figuratively associated words. This can be seen by the fact that subjects' average WC scores for literally-related words were well above the overall mean (45%), or well below it. Specifically, subjects whose average WC ratio scores were above the overall mean responded positively to 74% of literally-related words, while those whose scores were below the overall mean responded positively to only 17% of literally-related words. The exact nature of the criteria used, and whether they were consciously or unconsciously employed is difficult to ascertain. However, subjective reports and informal memory testing suggest that subjects failed to consciously perceive the identity of most words. As an interesting side note, only three subjects reported seeing the central stimulus present on every regular trial.

Effects of visual field on word-categorization were mixed. Although there was a slight trend toward more positive responses in the RVF, no significant asymmetry was obtained for any of the word types in experiment one. In experiment two, figuratively and literally-

related words obtained more positive responses when presented in the RVF. Given the hypothesized RH substrate for figurative speech, the finding that figuratively-related words were more often associated with primes when presented in the RVF was not expected. However, such a result does not necessarily rule out a RH role. It may very well be that the use of long intervals for prime study resulted in diffuse activation and bilateral priming. If such was the case, a left hemisphere superiority for parsing single words could account for less false negatives to figuratively and literally-related words (i.e., more positive responses to words presented to the RVF).

The main hypothesis being tested by the experiment is whether a VF by word-type interaction would obtain. Specifically, it was considered possible that the putative right-hemisphere capacity for comprehending idiomatic language might be evidenced by a reduction in the typical RVF reaction-time advantage for word recognition if priming through figurative association with idioms was employed. Surprisingly, just the opposite trend was found. In both experiments, RVF (left hemisphere) advantages were observed for figuratively-related words; no visual-fields asymmetry obtained for literal or unrelated words.

Like the unexpected asymmetry for word-categorization, the RVF advantage for figuratively-related words can be explained in terms of experimental design parameters. Again, the use of controlled priming may have worked against obtaining a RH effect. Regardless of a possible right-hemisphere superiority for processing idiomatic phrases, the amount of time provided for studying primes undoubtedly allowed bilateral priming as the figurative meaning of the idiom became available to both hemispheres. Given that the right-hemisphere is generally not as efficient at parsing single words, bilateral semantic priming should favor the left-hemisphere. It is also possible that the normal RH hemisphere simply has little facility for comprehending idiomatic language. Given the

weight of previously discussed clinical and experimental evidence, the first of the above alternative explanations seems more plausible.

The lack of asymmetry for reaction-time to literally-related words is likely related to word categorization processes. Examination of the data from both experiments reveals that subjects who typically responded positively to literally-related words evidenced a trend toward a RVF advantage for literally-related words, while an opposite trend was evidenced by subjects who typically responded negatively. Statistically, the opposing trends of the two groups served to cancel each other out, resulting in the observed non-significant overall effect of VF for literally-related words. In addition, most subjects in the figurative-and-literal groups made some negative responses to literally-related words, and the opposite is true for subjects in the figurative-only groups. Therefore, it is likely that the cell means in the analysis may have been more clearly differentiable (although still acting in opposition to cancel out an overall VF effect) had they been derived from RTs for only positive or negative responses.

Were decisional processes the crucial factor underlying the lack of asymmetry for literally-related words? Two findings indicate that they were. First, the group by VF by word-type interaction was significant for both experiments. Thus, although neither the RVF advantage for positive responses to literally-related words, nor the LVF advantage for negative responses were significant by themselves, the difference between the two trends was. Second, the analysis in experiment two of uncrossed (positive only) responses also supports the hypothesis that decisional processes interact with VF asymmetry for literally-related words. When only positive responses were examined, a RVF advantage was found for *both* literal and figuratively-related words. Therefore, the inclusion of negative responses is the probable cause of the reduced significance of the RVF advantage for literally-related words observed for subjects in the figurative-and-literal groups.

How might decisional processes affect asymmetry? The answer may lie in an interaction between priming interference and hemispheric differences in lexical organization. Priming interference occurs when priming effects work in opposition to response criteria. If, for example, congruence with figurative meaning is used as the sole criteria for accepting or rejecting words, then priming effects that predispose toward a positive response to literally-related words must be inhibited in favor of a response consistent with exclusionary criteria. Therefore, subjects using such a criteria may experience priming interference and evidence RT penalties for literally-related words. By the same logic, subjects who accept both figuratively and literally-related words as valid will not experience interference between priming effects and response criteria. In such cases, there should be no RT penalty for literally-related words. Now add the possibility that the two hemispheres are differentially receptive to semantic priming. If the left hemisphere contains representational networks where overlap in semantic dimensions is largely based upon literal congruency, then literally-related words presented in the RVF should show priming interference effects (i.e., RT penalties) for negative responses. If, in contrast, the right hemisphere contains representational networks in which overlap in the semantic dimension is based upon figurative associations, then there should be no interference effects (i.e., RT penalties) for negative responses to literally-related words projected in the LVF. The end result is a reduction or reversal in VF asymmetry when exclusionary criteria are applied to literally-related words. In a statistical test, this would be revealed by a third-order interaction between categorization criteria (as defined by WC group membership), word-type (literal vs. figurative), and visual field. Just such an interaction was found in both experiments.

Unfortunately, there are many unknowns concerning response criteria with the current data set. There is no way to know exactly what criteria individual subjects employed

(beyond the purposefully vague general instructions to respond positively to words that reminded them of the preceding primes), whether they varied their criteria during the experiment, or even how difficult it was to consciously employ a given criteria. A follow-up study in which subjects are randomly assigned to different groups and given specific and explicit categorization criteria would better illuminate many of the processes involved.

Outside of providing baseline data, responses to unrelated words were not of major interest in the study. As to the lack of asymmetry observed with unrelated words, there is evidence that frequent repetitions of stimuli result in reduced asymmetries in reaction-time. For example, Sullivan and Mckeever (1985) found that the RVF reaction time superiority for word naming decreased with the number of stimulus repetitions. It is certainly a possibility that such an effect obtained here.

Before discussing reaction-time comparisons with unrelated words, two possible confounds must be addressed. It might be argued that making reaction-time comparisons with unrelated words is problematic because they a.) have higher average frequencies and b.) were repeated more often than literal or figuratively-related words. However, an examination of the above stimulus characteristics revealed that they likely played only a minor role in between word-type differences in RT.

For all words in the stimulus set, log-frequency was found to have a very low overall correlation with reaction-time ($r = -.06$ in experiment one and $r = -.09$ in experiment two). It is therefore unlikely that this variable accounted for more than a trivial portion of the variance in reaction times. If the second potential confound, stimulus repetition, was a factor, then one would expect reaction times to decline with number of repetitions. The two unrelated words with high numbers of repetitions (22 & 30 times per subject), obtained small negative correlations between RT and serial position [$r = -.30$, & $r = -.28$ respectively in experiment one, and $r = -.24$, & $r = -.21$ respectively in experiment two].

However, when reaction times to all words were regressed against serial position, a slight overall decline across trials [$r = -.26$ in experiment one, $r = -.22$ in experiment two] was observed, indicating the presence of a general practice effect. For literally-related words only, the correlation between RT and serial position was comparable [$r = -.22$ in experiment one, $r = -.18$ in experiment two]. Logically, the general practice effect, which applies to all words, accounts for some portion of the already small correlation between serial position and RT found for repeatedly exposed unrelated words. Overall then, while effects of frequency and repetition served to slightly lower RT for unrelated words, they appear insufficiently powerful in and of themselves to explain any findings of large differences between word types.

General effects of priming on RT proved to be less robust than anticipated. Given that effects of frequency and repetition are minimal, which turned out to be the case, the pattern of reaction-time across word types was expected to bear out an advantage of figuratively-related words over both literal and unrelated words. Responses to literally-related words were expected to be at least equally as fast as those to unrelated words, if not faster. Although figuratively-related words obtained the predicted RT advantage over literally-related words in both experiments, they only obtained an RT advantage over unrelated words in experiment two. Unrelated words were responded to equally as fast as literally-related words in experiment two, and obtained an RT advantage over literally-related words in experiment one. These findings were only partially congruent with expectations.

Priming effects are the most likely source of the RT advantage of figuratively over literally-related words. The controlled priming design focused subjects' attention on the idiomatic phrases, which were, as demonstrated by the word-phrase ratings, clearly recognized as conventional figures of speech. No non-idiomatic primes were presented.

Furthermore, some of the idioms used were implausible (i.e., not literally interpretable), further decreasing the likelihood that subjects attended overtly to literal elements of the primes. With subjects concentrating upon the figurative meanings of primes, corresponding figurative representations were more highly activated than the representations of the literal representations of constituent words. Priming effects (i.e., RT advantage) should therefore be larger and more consistent for figuratively than literally-related words. An examination of uncrossed responses, in particular, supports the advantage of figurative priming over literal priming. For that analysis, cell means were derived entirely from positive responses, so confounds from decisional effects of “ruling out” are not applicable.

Why did figuratively-related words only obtain a reaction-time advantage over unrelated words in experiment two, while showing no advantage over unrelated words in experiment one? And why were literally-related words disadvantaged compared to controls in experiment two but not experiment one? Priming effects and decisional processes alone can not account for the observed patterns of reaction-time. The finding is certainly difficult to explain in terms of any of the variables that differentiate the two groups (age, sex, education, & response instructions), and there is little else to speculate from either in the literature or in the data. Without further study, the anomalies will remain unresolved.

Outside of the between-word-type differences noted above, the general findings of experiments one and two are similar enough to prompt the question of whether or not the overall performance of subjects in experiment one was distinguishable from the performance of subjects in experiment two. Therefore an analysis of the pooled data was carried out.

Combined Analysis

Although the subject populations and methods differed between experiments one and two, the stimulus set and response measures were identical. It was therefore possible to determine if overall performance of subjects differed between experiment's one and two. Visual inspection of the data from experiments one and two led to the suspicion that at least the performances of the two groups on the word-categorization measure were likely equivalent. In order to test this assumption, along with the possibility that the two groups might differ on the reaction time measure, the following between-groups analysis was conducted.

Reaction-time and word-categorization data from both experiments was pooled. Both reaction-time and word-categorization exhibited sufficient homogeneity of covariance (Greenhouse-Geisser Epsilons $\geq .72$ & $\geq .70$, respectively) to be entered into separate repeated measures ANOVAs. For both analyses, experimental group (one & two) was a 2 level between-subjects variable. Within subjects factors were visual field (2 levels) and word-type (3 levels).

For both reaction-time and word-categorization, the main effect of experimental group was not significant. Nor were any second- or third-order interactions between experimental group, visual-field or word-type observed for either dependent variable. Therefore, the overall performance of subjects in experiment one was indistinguishable from the performance of subjects in experiment two.

An analysis of the pooled data set was also performed with dependent variables collapsed across subjects rather than across words as done previously. This analysis treated the thirty figurative and thirty literal words as samples. Reaction-time and word-categorization were each entered into a two-way repeated-measures ANOVA. Visual field was a 2 level within-words factor and word-type a 2 level (figurative & literal)

between-words factor. Because previous testing showed the experimental groups homogenous with respect to RT and WC group, the pooled data set was used.

The main effect of visual-field on RT was significant [$F(1, 58) = 5.84, p < .05$]. Subjects obtained a significant RVF advantage for figuratively-related words [$F(1, 29) = 4.34, p < .05$], but no asymmetry was found for literally-related words. The main effect of word-type was significant [$F(1, 58) = 13.44, p < .001$]. Figuratively-related words were responded to faster than unrelated words. The word-type by VF interaction was not significant.

The main effect of visual-field on WC was significant [$F(1, 58) = 54.73, p < .001$]. A significant trend was found for making more positive responses to both figuratively and literally-related words when shown in the RVF [$F(1, 29) = 15.47, p < .001, & F = 53.75, p < .001, respectively$]. The main effect of word-type was also significant [$F(1, 58) = 69.03, p < .001$]. Figuratively-related words received more positive responses than literally-related words. The word-type by VF interaction was not significant. The above findings are congruent with those obtained when the analysis of the pooled data set collapsed dependent variables across words.

As a final test of the VF effect, an analysis based upon pair-wise differences was carried out on the pooled data. In the analysis, LVF - RVF difference scores and indices were computed for all cases of valid responses to the same word from each VF. Subjects were dropped from the analysis if they had less than ten valid reaction-time pairs for each word-type. Five of the thirty-eight subjects were dropped for this reason. For the remaining subjects, a small amount RT data points were lost due to having only a valid reaction-time for only one VF for a given word.

Given a reasonable absolute effect-size (≥ 20 msec.), a significant positive value indicates a RVF-LH advantage, and a significant negative value indicates a LVF-RH

advantage. Average log-difference scores were calculated for each word type. For each subject, difference scores were log-transformed prior to averaging and the mean for each of the three word types calculated. Means and standard deviations of VF difference scores (inverse-log transformed) for all subjects are presented in Table 5.

Laterality indices were also calculated for each subject for the three word types. The laterality index was derived with the following formula:

$$\frac{\sum (n_{(L+)} - n_{(R+)})}{n_p} \quad \left| \quad \begin{array}{l} n_{(L+)} = \text{number of valid word pairs where LVF RT} > \text{RVF RT} \\ n_{(R+)} = \text{number of valid word pairs where RVF RT} > \text{LVF RT} \\ n_p = \text{total number of valid word pairs} \end{array} \right.$$

As can be seen from the formula, the laterality index indicates a tendency (or lack thereof) to faster reaction-times in one visual field, independent of the magnitudes of individual word pair asymmetries. An index score of +1 indicates that LVF reaction-times were longer than RVF reaction-times for all word pairs (a left hemisphere advantage), and an index of -1 indicates that the opposite pattern obtained. An index score of zero indicates no overall hemifield asymmetry. Index scores with an absolute value of less than .33 indicate that over one third of the observed word-pair asymmetries were in a direction opposite to that of majority responses. An absolute index value of $\geq .33$ was stipulated as the cutoff for significant effect-size. Group mean laterality indices represented in Table 5.

Table 5: Mean RT Difference Scores and Laterality Indices.*

	Figurative	Literal	Control
RT (msec.): LVF-RVF	5 (8)	0 (10)	1 (3)
Laterality Index	.20 (.22)	.03 (.30)	.07 (.17)

* *sd* in parentheses. The pooled data set was used. Subjects were dropped from analysis if they had less than ten valid LVF-RVF pairs per word-type. Data based upon scores from the remaining 33 subjects.

As can be seen from Table 5, none of the cell values passed the established criteria for significant effect size. The largest of the mean RT difference scores (5 msec.) clearly falls beneath the chosen criteria for significant effect size (20 msec.). In the same fashion, the largest of the laterality indices (.20 -- representing only 60/40 split in number of paired comparisons favoring the RVF) is not indicative of a significant VF bias. Therefore, no statistical tests were carried out on either of these variables.

Discussion

The pooled experimental-group analyses indicates either that differences in gender, age, education, and methodology in experiments one and two had little effect on reaction-time and response choice, or that any effects those variables did have canceled each other out. Demographic variables were not expected to be influential because common idioms were used and competency with colloquial speech in adults should not be highly correlated with education, age, or sex. Organization of language within the CNS is often speculated to differ by gender. However, gender has typically demonstrated inconsistent or, more often, insignificant associations with common measures obtained from DVF tasks employing linguistic stimuli (see reviews by Fairweather, 1982, & Hiscock, 1989). Such was the case in the current study.

It was hoped that changing instructions to stress the acceptability of any association between primes and words would discourage subjects from adopting an figurative-only criterion, thereby increase the overall level of positive responses to literally-related words, but this strategy clearly failed. Subjects in experiment two were just as easily separated into two groups based upon response criteria to literally-related words as they were in experiment one, and the proportions of subjects using the two criteria were the same in both experiments. Finally, the statistical tests showed that the word-categorization profiles of subjects from experiment one were indistinguishable from those of subjects in experiment two. In sum, subjects are apparently capable of perceiving figurative and literal dimensions of prime-word relationships and responding accordingly, but one must provide explicit instructions regarding figurative/literal response criteria if a particular WC profile is desired.

When pooled data was collapsed across subjects rather than words (providing an estimate of the same subjects performance on a different stimulus set as opposed to an estimate of different subjects performance on the same stimulus set) the results were entirely consistent with earlier analyses from experiments one and two. This reinforces all earlier conclusions regarding effects and interactions of word-type and visual-field.

The most striking finding from the pooled analysis is that no VF asymmetries were obtained with matched-pair between-visual-field RT-difference scores. Here, difference scores and laterality indices for all three word types were of insufficient effect size to be considered significant. This result is not anomalous with respect to literal and unrelated words, where findings of symmetry of reaction-times are consistent with all previous analyses. The disappearance of the RVF advantage for figuratively-related words however, is a conspicuous incongruity. Examining only matched pairs eliminated some data points which contributed to LVF and RVF cell means in earlier analyses. That is,

subjects responded to some words within the 1500 msec. limit when shown to one VF, but not the other. In fact, five of thirty-eight subjects were lost due to insufficient numbers of paired data points. Large mean difference scores were observed when the data from the unreliable subjects was examined. For the remaining subjects, some amount of data was lost from incomplete pairs. The amount of data lost to incomplete pairs was minimal however. By examining the laterality indices however, one can see that, on the average, when complete pairs were compared, the number of reaction-time differences favoring the LVF nearly equaled the number favoring the RVF. Between-VF repetition effects can be ruled out as a confound because the order of word presentation was randomized so that half of the words appeared first in one VF and half first in the other. Needless to say, the fact that pair-wise laterality indices were inconsistent with an RT asymmetry for figuratively-related words is on its own quite convincing.

Concluding Remarks

This study demonstrated that normal subjects' knowledge of semantic relations between single words and idiomatic phrases is related to some aspects of their performance on a speeded semantic-decision task. Under both free-viewing and brief-exposure conditions, subjects demonstrated the ability to systematically categorize words as a function of their figurative or literal relationships to preceding idiomatic priming phrases. Indeed, subjects reliably differentiated the word types on the speeded categorization task even while reporting that most of the stimuli were not consciously recognized. When left to choose word-categorization criteria on their own, subjects tended to either accept words that were associated to the figurative and literal meanings of the idiomatic phrases, or accept only those words that were associated with figurative meanings. The inclusion of unrelated words in the speeded categorization task allowed subjects to demonstrate that they were readily able to reject words that bore no semantic relationship to the idiomatic phrases.

The use of uncrossed response instructions in the second experiment provided useful information. Despite the increased complexity of variable-valued response buttons, subjects had little difficulty with the task. The comparison of uncrossed positive responses provided by the paradigm proved helpful in interpreting the relationship of hemispheric and decisional processes to reaction-time. Therefore, when obtaining uncrossed responses is desirable, a similar methodology is recommended.

Data only partially confirmed the expected inter-word-type effects of priming on reaction-time. In both experiments, subjects showed the expected reaction-time advantage for figuratively-related words over literally-related words. Such a finding is in keeping with prior assumptions that lexical networks underlying figurative meaning would be more highly activated by the stimuli and methods employed than parallel networks underlying

literal meaning. However, the prediction of a general priming advantage for figuratively-related over unrelated words was only borne out in experiment two; subjects in experiment one responded to the two word types with equal speed. In addition, literally-related words showed an unexpected reaction-time *disadvantage* compared to unrelated words in experiment one. Possible confounds effecting comparisons with unrelated words (i.e., affects of decisional processes, frequency, and repetition) were shown to be small. An explanation for these findings could not be readily provided, and so awaits the results of further research.

Finally, what do the results of the study add to our understanding of cerebral lateralization and the organization of language? Despite the presence of some interesting findings, the results proved to be less than definitive. In terms of the hypothesized right hemisphere substrate for figurative language, the most interesting positive finding occurred when subjects were grouped by how they responded to literally-related words. Here, reaction-time data were shown to be consistent with a lateralized priming interference hypothesis. Such a hypothesis is predicated on the left hemisphere being organized to support literal language and the right hemisphere being organized to support figurative language. In contrast, the finding of a RVF-LH advantage for figuratively-related words is not, on the surface, consistent with the hypothesized RH role. However, the data can be explained in terms of controlled priming and bilateral activation conferring greater advantage to the LH, with its superior single-word recognition ability, rather than reflecting negatively on the possibility of a RH figurative lexicon. Still, this reasoning only explains the absence of a RH effect, and does little to directly support a RH substrate.

Most intriguing of all, the observed lack of asymmetry across all word types found in the LVF-RVF pairwise comparison does not support a unilateral RH substrate for figurative language. If between-VF pairwise repetition effects are controlled, then the

paired-differences and laterality indices derived from comparisons of reaction-times to identical words presented to each VF should provide the best estimate of a true laterality effect, if it exists. Outside of logical arguments, the case for accepting the pairwise measures as conservative estimators of asymmetry is fortified by the fact that neither one indicated the presence of VF asymmetries where earlier tests were also negative. Therefore, a cautious conclusion is that the RVF reaction-time advantage for figuratively-related words in earlier analyses is spurious. More significantly, the data are not directly consistent with the existence of a unilateral substrate for a figurative *or* literal lexicon.

Unfortunately, pairwise analyses are rarely reported (often because VF-wise counterbalancing of stimulus is done between rather than within subjects), so there is limited data with which to make a direct comparison. Perhaps some of the reported VF asymmetries may not have obtained had this method been used. It must also be added that the clinical studies reported have often relied on cross-modal matching of auditory-lexical to visual-pictorial stimuli for providing measures of comprehension. The current study employs only visual-lexical stimuli. It may certainly be the case that the different stimuli engage substantially different cerebral processing systems. In addition, while experimental cognitive studies using visual-lexical stimuli with normals have supported the hypothesis of parallel figurative and literal systems, such studies have provided no evidence regarding localization. In sum, the present findings, while not entirely consistent with predictions, do not rule out fundamental aspects of the hypothesized right-hemisphere, figurative language substrate. Only through further research can the full implications of the results from the current study be understood.

References

- Abernethy, M., & Coney, J. (1990). Semantic and phonemic priming in the cerebral hemispheres. *Neuropsychologia*, *28*, 933-945.
- Anderson, J. R. (1985). *Cognitive Psychology and its Implications* (2nd ed.). New York: Freeman
- Beaumont, J. G. (1982). Studies With Verbal Stimuli. In J. G. Beaumont (Ed.). *Divided Visual Field Studies of Cerebral Organization* (pp. 58-86). Toronto: Academic Press.
- Benowitz, L. I., Moya, K. L., & Levine, D. N. (1990). Impaired verbal reasoning and constructional apraxia in subjects with right hemisphere damage. *Neuropsychologia*, *28*, 231-241.
- Bihrlé, A. M., Brownell, H. H., Powelson, J. A., & Gardner, H. (1986). Comprehension of humorous and nonhumorous materials by left and right brain-damaged patients. *Brain and Cognition*, *5*, 399-411.
- Blonder, L. X., Bowers, D., & Heilman, K. H. Logical inferences following right hemisphere damage. Poster presented at the annual meeting of the International Neuropsychological Society, San Antonio, Texas, February, 1991.
- Boles, D. B. (1989). Word attributes and lateralization revisited: Implications for dual coding and discrete versus continuous processing. *Memory and Cognition*, *17*, 106-114.
- Brownell, H. H., Michel, D., Powelson, J., & Gardner, H. (1983). Surprise but not coherence: Sensitivity to verbal humor in right-hemisphere patients. *Brain and Language*, *18*, 20-27.
- Brownell H. H., Potter, H. H., Michelow, D., & Gardner, H. (1984). Sensitivity to lexical denotation and connotation in brain damaged patients: A double dissociation? *Brain and Language*, *22*, 253-265.
- Brownell, H., Potter, H., & Bihrlé, A. (1986). Inference deficits in right brain-damaged patients. *Brain and Language*, *27*, 310-321
- Brownell, H. H., Simpson, T. L., Bihrlé, A. M., Potter, H. H., & Gardner, H. (1990). Appreciation of metaphoric alternative word meanings by left and right brain-damaged patients. *Neuropsychologia*, *28*, 375-383.
- Bruyer, R., & Janlin, D. (1989). Lateral differences in lexical access: Word length vs. stimulus length. *Brain and Language*, *37*, 258-265.
- Brybaert, M., & D'Ydewalle, G. (1990a). Individual analysis of laterality data. *Neuropsychologia*, *28*, 901-916.
- Brybaert, M., & D'Ydewalle, G. (1990b). Tachistoscopic presentation of verbal stimuli for assessing cerebral dominance: Reliability data and some practical recommendations. *Neuropsychologia*, *28*, 443-455.
- Bub, D. N., & Lewine, J. (1988). Different modes of word recognition in the left and right visual fields. *Brain and Language*, *33*, 161-188.

- Cacciari, C., & Tabossi, P. (1988). The comprehension of idioms. Journal of Memory and Language, 27, 668-683.
- Chiarello, C. (1985). Hemisphere dynamics in lexical access: Automatic and controlled priming. Brain and Language, 26, 146-172.
- Chiarello, C., & Church, K. L. (1986). Lexical judgments after right- or left-hemisphere injury. Neuropsychologia, 24(5), 623-630.
- Chiarello, C., & Nuding, S. (1987). Visual field effects for processing content and function words. Neuropsychologia, 25(3), 539-548.
- Chiarello, C., Burgess, C., Richards, L., & Pollock, A. (1990). Semantic priming in the cerebral hemispheres: Some words do, some words don't ... sometimes, some places. Brain and Language, 38, 75-104.
- Crabtree, D. A., & Antrim, L. R. (1988). Guidelines for measuring reaction time. Perceptual and Motor Skills, 66, 363-370.
- Deloche, G., Seron, X., Scius, G., & Segui, J. (1987). Right hemisphere language processing: Lateral difference with imageable and nonimageable ambiguous words. Brain and Language, 30, 197-205.
- Dosher, B. A. & Rosedale, G. (1989). Integrated retrieval cues as a mechanism for priming in retrieval from memory. Journal of Experimental Psychology: General, 118(2), 191-211.
- Elgin, M. (1987). Interference and priming within and across visual fields in a lexical decision task. Neuropsychologia, 25, 613-624.
- Elis, A. W., Young, A. W., & Anderson, C. (1988). Modes of word recognition in the left and right cerebral hemispheres. Brain and Language, 35(2), 254-273.
- Eviatar, Z., Menn, L., & Zaidel, E. (1990). Concreteness: Nouns, verbs, and hemispheres. Cortex, 26, 611-624.
- Fairweather, H. (1982). Sex Differences. (pp. 148-194). In J. G. Beaumont (Ed.). Divided Visual Field Studies of Cerebral Organization. (pp. 58-86). Toronto: Academic Press.
- Forster, K. I., & Chambers, S. M. (1973). Lexical access and naming time. Journal of Verbal Learning and Verbal Behavior, (12), 627-635.
- Fowler, C. A., Wolford, G., Slade, R., & Tassinari, L. (1981). Lexical access with and without awareness. Journal of Experimental Psychology: General, 110, 341-362.
- Francis, W. N., & Kucera, H. (1982). Frequency Analysis of English Usage: Lexicon and Grammar. Houghton Mifflin: Boston.
- Gainotti, G., Caltagirone, C., & Miceli, G. (1983). (pp. 149-167). In E. Perecman (Ed.). Cognitive Processing in the Right Hemisphere. Toronto: Academic Press.

- Gagnon, J. Joannette, Y., Goulet, P., & Cardu, B. Active versus passive use of lexico-semantic knowledge in right-brain-damaged right-handers. Paper presented at the annual meeting of the International Neuropsychological Society, Vancouver, B.C., February, 1989.
- Gardner, H., Brownell, H. H., Wapner, W., & Michelow, D. (1983). (pp. 169-191). In E. Perecman (Ed.). Cognitive Processing in the Right Hemisphere. Toronto: Academic Press.
- Gibbs, R. W. Jr., Nayak, N. P., & Cutting, C. (1989a). How to kick the bucket and not decompose: Analyzability and idiom processing. Journal of Memory and Language, 28, 576-593.
- Gibbs, R. W. Jr., Nayak, N. P., & Cutting, C. (1989b). Speakers assumptions about the flexibility of idioms. Memory and Cognition, 17, 58-68.
- Glass, A. L. (1982) The comprehension of idioms. Journal of Psycholinguistic Research, 12, 429-442.
- Grossman, M., & Haberman, S. (1987). The detection of errors in sentences after right hemisphere brain damage. Neuropsychologia, 25(1B), 163-172
- Hardyck, C., Dronkers, N., Chiarello, C., & Simpson, G. V. (1985). The eyes have it: Exposure times and visual half-field experiments. Brain and Cognition, 4, 430-438.
- Heilman, K. M., Scholes, R. & Watson, R. T. (1975). Auditory affective agnosia: Disturbed comprehension of affective speech. Journal of Neurology, Neurosurgery, and Psychiatry, 38, 69-72.
- Heilman, K. M., Bowers, D., Speedie, L., & Coslett, H. (1983). The comprehension of emotional and non-emotional prosody. Neurology, 33, 241-259, suppl. 2.
- Hier, D. B., & Kaplan, J. (1980). Verbal comprehension deficits after right hemisphere damage. Applied Psycholinguistics, 1, 279-294.
- Hiscock, M., Hiscock, C. K., & Inch, R. Is there a sex difference in visual laterality? Poster presented at the annual meeting of the International Neuropsychological Society, San Antonio, Texas, February, 1991.
- Hough, M. S. (1990). Narrative comprehension in adults with right and left hemisphere brain damage: Theme and organization. Brain and Language, 38, 253-277.
- Howes, D. (1957) On the relationship between intelligibility and frequency of occurrence of English words. Journal of the Acoustic Society of America, 29, 296-305.
- Howes, D., & Solomon, R. L. (1951) Visual duration thresholds as a function of word probability. Journal of Experimental Psychology, 41, 401-410.
- Kaplan, J. A., Brownell, H. H., Jacobs, J. R., & Gardner, H. (1990). The effects of right hemisphere brain damage on the pragmatic interpretation of conversational remarks. Brain and Language, 38, 315-333.

- Kim, H., & Levine, S. (1991). Inferring patterns of hemispheric specialization for individual subjects from laterality data: A two-task criterion. Neuropsychologia, 29(1), 93-105.
- Levy, J., Wagner, N., & Luh, K. (1990). The previous visual field: Effects of lateralization and response accuracy on current performance. Neuropsychologia, 28, 1239-1249.
- McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. Cognitive Psychology, 18, 1-86.
- McDonald, S., & Wales, R. (1986). An investigation of the ability to process inference in language following right hemisphere brain damage. Brain and Language, 29, 68-80.
- McKeever, W. F. (1985). Tachistoscopic methods in neuropsychology. In H. J. Hannay (Ed.). Experimental Techniques in Human Neuropsychology. (pp. 167-211). New York: Oxford.
- McKeever, W. F., & van Eys, P. (1986). Evidence that fixation digits can contribute to visual field asymmetries in lateralized tachistoscopic tasks. Brain, & Cognition, 5, 443-451.
- Measso, G., & Zaidel, E. (1990). Effect of response programming on hemispheric differences in lexical decision. Neuropsychologia, 28, 635-646.
- Moscovitch, M. (1983). The linguistic and emotional functions of the normal right hemisphere. (pp. 57-82). In E. Perecman (Ed.). Cognitive Processing in the Right Hemisphere. Toronto: Academic Press.
- Moscovitch, M. (1986). Afferent and efferent models of visual perceptual asymmetries: Theoretical and empirical implications. Neuropsychologia, 24(1), 91-114.
- Myers, P. S., & Linebaugh, C. W. (1981). Comprehension of idiomatic expressions by right-hemisphere damaged adults. (pp. 254-261) In R. H. Brookshire (Ed.). Clinical Aphasiology: Conference Proceedings. Minneapolis: BRK.
- Nayak, N. P., & Gibbs, R. W. Jr. (1990). Conceptual knowledge in the interpretation of idioms. Journal of Experimental Psychology: General, 119(3), 315-330.
- Norusis, M. J. (1991). SPSS/PC+ V4.0 [Computer program]. Chicago: SPSS Inc.
- Rodel, M., Cook, N. D., Regard, M., & Landis, T. Hemispheric dissociation in judging semantic relations: Evidence for hemispheric complementarity? Poster presented at the annual meeting of the International Neuropsychological Society, Vancouver, B.C., February, 1989.
- Ross, E. D., & Mesulam, M. M. (1979) Dominant language functions of the right hemisphere? Prosody and emotional gesturing. Archives of Neurology, 36, 144-148.
- Segui, J., Mehler, J., Frauenfelder, U., & Morton, J. (1982) The word frequency effect and lexical access. Neuropsychologia, 20(6), 615-627.
- Shulman, H. G., & Davison T. C. (1977). Control properties of semantic coding in a lexical decision task. Journal of Verbal Learning and Verbal Behavior, 16, 91-98.
- Stone, G., & Van Orden, G. (1989). Are words represented by nodes? Memory and Cognition, 17, 511-524

- Strauss, E., Wada, J., & Kosaka, B. (1985). Visual laterality and cerebral speech dominance determined by the carotid amygdal test. Neuropsychologia, 23(4), 567-570.
- Sullivan, K. F., & McKeever, W. F. (1985). The roles of stimulus repetition and hemispheric activation in visual half-field asymmetries. Brain and Cognition, 4, 413-429.
- Swinney, D. A., & Cutler, A. (1979) The access and processing of idiomatic expressions. Journal of Verbal Learning and Verbal Behavior, 18, 523-534.
- Van Lancker, D., & Kempler, D. (1987). Comprehension of familiar phrases by left- but not right-hemisphere damaged patients. Brain and Language, 32, 265-277
- Villardita, C. (1987). Verbal memory and semantic clustering in right brain-damaged patients. Neuropsychologia, 25(1-B), 277-280
- Wapner, W., Hamby, S., & Gardner, H. (1981). The role of the right hemisphere in the apprehension of complex linguistic materials. Brain and Language, 14, 15-33.
- Weintraub, S., Mesulam, M. M., & Kramer, L. (1981). Disturbances in prosody: A right-hemisphere contribution to language. Archives of Neurology, 38, 742-744.
- Winner, E., & Gardner, H. (1977). The comprehension of metaphor in brain-damaged patients. Brain, 100, 717-729.
- Young, A. W. Methodological Theoretical Bases. (pp. 11-29). (1982). In J. G. Beaumont (Ed.). Divided Visual Field Studies of Cerebral Organization. (pp. 58-86). Toronto: Academic Press.
- Young, A. W., & Elis, A. W. (1985). Different methods of lexical access for words presented in the left and right visual hemifields. Brain and Language, 24, 326-358.

Appendix A: Stimuli List

	Prime	Idiomatic word	Literal word
1.	kick the bucket	die	can
2.	get the lead out	hurry	metal
3.	hit the road	leave	punch
4.	burn the midnight oil	work	fuel
5.	shoot the breeze	rap	gun
6.	off the hook	free	fish
7.	go out on a limb	risk	tree
8.	off your rocker	crazy	chair
9.	making good time	rapid	clock
10.	a thorn in my side	pest	rose
11.	hit the hay	sleep	straw
12.	hold your horses	stop	ride
13.	totally tongue tied	mute	knot
14.	second hand	used	palm
15.	broken hearted	grief	blood
16.	a real eye sore	ugly	pain
17.	fly off the handle	rage	hold
18.	bring home the bacon	cash	meat
19.	a square deal	fair	card
20.	bite the bullet	endure	nibble
21.	get the show on the road	begin	drive
22.	on the run	elude	track
23.	the coast is clear	safe	tide
24.	turning over a new leaf	change	branch

25.	nose to the grindstone	toil	face
26.	cat got your tongue	quiet	taste
27.	giving them a piece of your mind	scold	brain
28.	a wild goose chase	vain	duck
29.	jump the gun	eager	rifle
30.	give me a hand	help	fist

Unrelated words:

how
term
front
beyond

Appendix B: Prime-Word Rating Scale

1. <u>kick the bucket</u>								
1.	die	(not similar)	1	2	3	4	5	(very similar)
2.	can	(not similar)	1	2	3	4	5	(very similar)
2. <u>get the lead out</u>								
1.	hurry	(not similar)	1	2	3	4	5	(very similar)
2.	metal	(not similar)	1	2	3	4	5	(very similar)
3. <u>hit the road</u>								
1.	leave	(not similar)	1	2	3	4	5	(very similar)
2.	punch	(not similar)	1	2	3	4	5	(very similar)
4. <u>burn the midnight oil</u>								
1.	work	(not similar)	1	2	3	4	5	(very similar)
2.	fuel	(not similar)	1	2	3	4	5	(very similar)
5. <u>shoot the breeze</u>								
1.	rap	(not similar)	1	2	3	4	5	(very similar)
2.	gun	(not similar)	1	2	3	4	5	(very similar)
6. <u>off the hook</u>								
1.	free	(not similar)	1	2	3	4	5	(very similar)
2.	fish	(not similar)	1	2	3	4	5	(very similar)
7. <u>go out on a limb</u>								
1.	risk	(not similar)	1	2	3	4	5	(very similar)
2.	tree	(not similar)	1	2	3	4	5	(very similar)
8. <u>off your rocker</u>								
1.	crazy	(not similar)	1	2	3	4	5	(very similar)
2.	chair	(not similar)	1	2	3	4	5	(very similar)
9. <u>making good time</u>								
1.	rapid	(not similar)	1	2	3	4	5	(very similar)
2.	clock	(not similar)	1	2	3	4	5	(very similar)

10.	<u>a thorn in my side</u>								
1.	pest	(not similar)	1	2	3	4	5	(very similar)	
2.	rose	(not similar)	1	2	3	4	5	(very similar)	
11.	<u>hit the hay</u>								
1.	sleep	(not similar)	1	2	3	4	5	(very similar)	
2.	straw	(not similar)	1	2	3	4	5	(very similar)	
12.	<u>hold your horses</u>								
1.	stop	(not similar)	1	2	3	4	5	(very similar)	
2.	ride	(not similar)	1	2	3	4	5	(very similar)	
13.	<u>totally tongue tied</u>								
1.	mute	(not similar)	1	2	3	4	5	(very similar)	
2.	knot	(not similar)	1	2	3	4	5	(very similar)	
14.	<u>second hand</u>								
1.	used	(not similar)	1	2	3	4	5	(very similar)	
2.	palm	(not similar)	1	2	3	4	5	(very similar)	
15.	<u>broken hearted</u>								
1.	grief	(not similar)	1	2	3	4	5	(very similar)	
2.	blood	(not similar)	1	2	3	4	5	(very similar)	
16.	<u>a real eye sore</u>								
1.	ugly	(not similar)	1	2	3	4	5	(very similar)	
2.	pain	(not similar)	1	2	3	4	5	(very similar)	
17.	<u>fly off the handle</u>								
1.	rage	(not similar)	1	2	3	4	5	(very similar)	
2.	hold	(not similar)	1	2	3	4	5	(very similar)	
18.	<u>bring home the bacon</u>								
1.	cash	(not similar)	1	2	3	4	5	(very similar)	
2.	meat	(not similar)	1	2	3	4	5	(very similar)	
19.	<u>a square deal</u>								
1.	fair	(not similar)	1	2	3	4	5	(very similar)	
2.	card	(not similar)	1	2	3	4	5	(very similar)	

20. bite the bullet

- | | | | | | | | | |
|----|--------|---------------|---|---|---|---|---|----------------|
| 1. | endure | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | nibble | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

21. get the show on the road

- | | | | | | | | | |
|----|-------|---------------|---|---|---|---|---|----------------|
| 1. | begin | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | drive | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

22. on the run

- | | | | | | | | | |
|----|-------|---------------|---|---|---|---|---|----------------|
| 1. | elude | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | track | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

23. the coast is clear

- | | | | | | | | | |
|----|------|---------------|---|---|---|---|---|----------------|
| 1. | safe | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | tide | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

24. turning over a new leaf

- | | | | | | | | | |
|----|--------|---------------|---|---|---|---|---|----------------|
| 1. | change | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | branch | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

25. nose to the grindstone

- | | | | | | | | | |
|----|------|---------------|---|---|---|---|---|----------------|
| 1. | toil | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | face | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

26. cat got your tongue?

- | | | | | | | | | |
|----|-------|---------------|---|---|---|---|---|----------------|
| 1. | quiet | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | taste | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

27. giving them a piece of your mind

- | | | | | | | | | |
|----|-------|---------------|---|---|---|---|---|----------------|
| 1. | scold | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | brain | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

28. a wild goose chase

- | | | | | | | | | |
|----|------|---------------|---|---|---|---|---|----------------|
| 1. | vain | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | duck | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

29. jump the gun

- | | | | | | | | | |
|----|-------|---------------|---|---|---|---|---|----------------|
| 1. | eager | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | rifle | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

30. give me a hand

- | | | | | | | | | |
|----|------|---------------|---|---|---|---|---|----------------|
| 1. | help | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |
| 2. | fist | (not similar) | 1 | 2 | 3 | 4 | 5 | (very similar) |

Appendix C: Software

```

/*****
    Program EXP2.C
    Written by Tom Allen, modifications by Dan Slick
    Millisecond timing algorithm provided by Roger Graves
*****/

#include <stdio.h>
#include <conio.h>
#include <process.h>
#include <stdlib.h>
#include <stdarg.h>
#include <graph.h>
#include <dos.h>
#include <string.h>

#define TMRCNVRT(BiosTic,ResidualTic) \
    ( ( (double)(BiosTic) * 65536.0 + (double)(ResidualTic) ) * 0.000838095 )

extern void TMRSET (void);
extern void TMRREAD (unsigned long near *, unsigned int near *);
void GotoXY (int, int);
char Prompt (char *, char *);
void ABORT (char *, ...);
void Delay (double);

main()
{
    FILE *AnsFile, *DatFile;
    char AnsBuf[4], Ans[200], Pause[200], Hand[200], FileName[13];
    unsigned long BiosTic0, BiosTic1;
    unsigned int ResidualTic0, ResidualTic1;
    double T0, T1, RespTime, RespTimes[200];
    int NTrials, SubjectNo, TrialNo, Buttons, Correct[200];

    if ((AnsFile=fopen("EXP2.ANS","r")) == NULL)
        ABORT ("EXP2.ANS not found.\n");
    NTrials = 0;
    while (fgets(AnsBuf,4,AnsFile) != NULL) {
        NTrials ++;
        if (NTrials > 200)
            ABORT ("Too many (> 200) lines (EXP1.ANS).\n");
        if (strchr(AnsBuf,'\n') == NULL)
            ABORT ("Line Too Long (EXP1.ANS). Line %d.\n", NTrials);
        if (strchr("LR-",*AnsBuf) == NULL)
            ABORT ("Invalid Data (EXP1.ANS). Line %d.\n", NTrials);
        if ((Pause[NTrials-1]=strlen(AnsBuf) == 3) && AnsBuf[1] != '.')
            ABORT ("Invalid Data (EXP1.ANS). Line %d.\n", NTrials);
        Ans[NTrials-1] = *AnsBuf;
    }
    if (! feof(AnsFile))
        ABORT ("Disk Read-Error (EXP2.ANS). Line %d.\n", NTrials);
    fclose (AnsFile);

```

```

_clearscreen (_GCLEARSCREEN);
printf ("Enter Subject # ");
scanf ("%d",&SubjectNo);
if (!(1 <= SubjectNo && SubjectNo <= 99999999))
  ABORT ("Subject # must be between 1 and 99999999.\n");
printf ("\n");
printf ("Press 'P' to PAUSE at any time.\n");
printf ("      'A' to ABORT at any time.\n");
printf ("\n");
printf ("Press <RETURN> to start.\n");
if (toupper(getch()) == 'A')
  abort();

TMRSET ();
for (TrialNo=0; TrialNo < NTrials; TrialNo ++) {
  Delay (2000);
  while ((inp(0x201) & 0xD0) != 0xD0);
  while ((inp(0x201) & 0x10) == 0x10);
  printf("Trial # %3d\t", TrialNo+1);
  if (Ans[TrialNo] != '-') {
    TMRREAD (&BiosTic0, &ResidualTic0);
    T0 = TMRCNVRT (BiosTic0, ResidualTic1);
    while ((Buttons=inp(0x201) & 0xC0) == 0xC0) {
      TMRREAD (&BiosTic1, &ResidualTic1);
      T1 = TMRCNVRT (BiosTic1, ResidualTic1);
      if (T1 - T0 > 1501.0)
        break;
    }
    RespTime = T1 - T0;
    RespTimes[TrialNo] = (float) min (RespTime, 1501.0);
    if (RespTimes[TrialNo] == 1501.0) {
      Hand[TrialNo] = '-';
      Correct[TrialNo] = 0;
      printf("\t\t\t\t\t*****\n");
    } else {
      if ((Buttons & 0x80) == 0x00) {
        Hand[TrialNo] = 'L';
        if (Ans[TrialNo]=='L')
          { printf ("Left Hand\tRELATED \t%5.0f msec.\n", RespTime);
            Correct[TrialNo] = 1; }
        else
          { printf ("Left Hand\tUNRELATED\t%5.0f msec.\n", RespTime);
            Correct[TrialNo] = 0; }
      } else {
        Hand[TrialNo] = 'R';
        if (Ans[TrialNo]=='R')
          { printf ("Right Hand\tRELATED \t%5.0f msec.\n", RespTime);
            Correct[TrialNo] = 1; }
        else
          { printf ("Right Hand\tUNRELATED\t%5.0f msec.\n", RespTime);
            Correct[TrialNo] = 0; }
      }
    }
  }
} else {
  RespTimes[TrialNo] = 0;
  Hand[TrialNo] = '-';
  printf ("\t\t\t\t\t*** FT ***\n");
}
}

```

```

if (Pause[TrialNo]) {
    Prompt ("Press 'C' to continue.\n", "C");
} else {
    if (kbhit())
        switch (toupper(getch())) {
            case 'A':
                if (Prompt("\nSave Data? (Y/N) ", "YN") == 'Y')
                    goto SaveData;
                else
                    abort();
                break;
            case 'P':
                Prompt ("\nPress 'C' to continue >>> ", "C");
                printf ("\n");
                break;
            default:
                break;
        }
    }
}

SaveData:
printf("Saving Data ...\n");
*FileName = 'S';
itoa (SubjectNo,FileName+1,10);
strcat (FileName,".DAT");
if ((DatFile=fopen(FileName,"w")) == NULL)
    ABORT ("Unable to open EXP1.DAT.\n");
for (TrialNo=0; TrialNo < NTrials; TrialNo++) {
    fprintf(DatFile,"%4.0f %1d %c\n",RespTimes[TrialNo],Correct[TrialNo],
        Hand[TrialNo]);
}
fclose (DatFile);
exit(0);
}

void GotoXY (int Row, int Column)
{
    union REGS Regs;
    Regs.h.dl = Column;
    Regs.h.dh = Row;
    Regs.h.bh = 0;
    Regs.h.ah = 2;
    int86 (0x10, &Regs, &Regs);
}

char Prompt (Msg, ValidResp)
char *Msg, *ValidResp;
{
    char *RespP;
    printf(Msg);
    while ((RespP=strchr(ValidResp,toupper(getch())) == NULL);
    putchar (*RespP);
    return (*RespP);
}

```

```
void ABORT (Fmt, ...)
char *Fmt;
{
    va_list ArgPtr;
    va_start (ArgPtr, Fmt);
    vprintf (Fmt, ArgPtr);
    va_end (ArgPtr);
    abort();
}

void Delay (msec)
double msec;
{
    unsigned long BiosTic;
    unsigned int ResidualTic;
    double T0, T1;
    TMRREAD (&BiosTic, &ResidualTic);
    T0 = TMRCNVRT (BiosTic, ResidualTic);
    do {
        TMRREAD (&BiosTic, &ResidualTic);
        T1 = TMRCNVRT (BiosTic, ResidualTic);
    } while (T1-T0 < msec);
}
```

```

; =====
; Function gets current time in units of system tics
; =====
.MODEL    compact
.CODE
PUBLIC   _tmrread
_tmrread PROC
    push  bp
    mov   bp,sp
    push  si

    mov   ax,40h
    mov   es,ax           ; ES = BDA segment
    mov   si,6ch         ; SI = Offset of system timer counter location

    xor   al,al           ; ctrl byte 00h: latching, reading while counting
    cli
    out   43h,al         ; command to port 43h and
    mov   cx,word ptr es:[si] ; get BIOS timer counter
    mov   dx,word ptr es:[si+2] ; near by with intrpt disabled
    in   al,40h         ; read timer count channel 0
    xchg  ah,al
    in   al,40h
    sti

    xchg  al,ah

    test  ah,80h         ; if timer count < 10000000b
    jz   read_ok         ; no overflow problem exists

    cli
    mov   cx,word ptr es:[si] ; get BIOS timer counter again
    mov   dx,word ptr es:[si+2] ; for safety reasons
    sti

read_ok:
    not   ax             ; convert to "ascending" count
    mov   bx,[bp+4]     ; get pointer to BiosTic
    mov   [bx],cx       ; store timer count
    mov   [bx+2],dx     ; store timer count
    mov   bx,[bp+6]     ; get pointer to TimerTic
    mov   [bx],ax       ; store timer count

    pop   si
    pop   bp
    ret
_tmrread ENDP
END

```

```

; =====
; Function resets time counter
; =====
.MODEL    compact
.CODE
TIMER_0  equ    040h           ;8253 Counter 0 Port
TIMER_CTL equ    043h           ;8253 Control Port
TIMER_SET equ    00110100b      ;8253 Counter 0, set to Mode 2
PUBLIC  _tmrset
_tmrset  PROC
        mov     al,TIMER_SET
        out     TIMER_CTL,al    ;set Counter 0 to mode 2
        xor     al,al           ;zero AL register
        nop     ;8253 recovery time
        out     TIMER_0,al      ;set low order count byte to zero
        nop     ;8253 recovery time
        nop
        out     TIMER_0,al      ;set high order count byte to zero
        mov     cx,20000        ;loop to ensure
delay:   loop   delay           ;previous count ends
        ret
_tmrset  ENDP
        END

```

Appendix D: Consent Form

CONSENT TO PARTICIPATE IN A STUDY

I, _____, give my consent to participate in a study of *reaction time to visual presentations* carried out by Daniel J. Slick at the University of Victoria

I understand that none of the procedures involved in this study are of any known or speculative threat to my physical or psychological health and well being.

I understand that my participation in this study is entirely voluntary and uncompensated, and that I may terminate my involvement at any time without explanation or penalty.

I understand that my participation in this study is completely anonymous; the information collected in this study will not be associated with anything which could identify me, nor will permanent records of the fact that I participated be kept.

I understand that I may ask relevant questions about the study at any time before, during, or after my participation; that I will be debriefed following my participation; and that I am entitled to be informed of the final results of the study if I desire.

While serving voluntarily as a subject, I shall attempt to perform to the best of my ability.

signature _____ date _____

Appendix E: Subject Questionnaire

SN: _____ Sex: _____ D.O.B.: _____ Yrs. Ed.: _____ Hand: _____

1. Is any member of your immediate family (parents, brothers, sisters, or children) left-handed? YES NO

If yes, please list them: _____

2. Have you ever used your left hand as the primary hand for writing? YES NO

If yes, please describe: _____

3. Do you have any reading, writing, or learning disabilities such as dyslexia? YES NO

If yes, please describe: _____

4. Have you ever been diagnosed or treated for any neurological, psychological, or psychiatric disorder such as epilepsy or depression? YES NO

If yes, please describe: _____

5. Have you ever suffered an injury which resulted in loss of consciousness? YES NO

If yes, please describe: _____

6. Do you wear corrective glasses or contacts? YES NO

If yes, is your vision 20/20 with them on? YES NO

7. Is English your native (first learned) language? YES NO

If no, please list your native language: _____

8. Please list any languages other than English which you speak fluently: _____

9. Please list any medications you are currently taking: _____

CURRICULUM VITA

Slick, Daniel Joseph

EDUCATION

University of Alaska Anchorage 1984 - 1989

Degree: B.Sc. *Cum Luade*

GPA: 3.75

Major: Psychology

University of Victoria 1990 - present

Program: Clinical Psychology (Neuropsychology)

ACADEMIC AND PROFESSIONAL EXPERIENCE:

- 1989 TEACHING ASSISTANT - Introductory Neuropsychology,
Department of Psychology, University of Alaska Anchorage
- 1989 STUDENT INTERN - Department of Psychology, University of
Alaska Anchorage / Alaska Psychiatric Institute
- 1988-89 CERTIFIED COURT APPOINTED SPECIAL ADVOCATE -
State of Alaska, Office of Public Advocacy, Anchorage, Alaska
- 1988-89 MEMBER, FOSTER-CARE REVIEW BOARD - State of Alaska,
Office of Public Advocacy, Anchorage, Alaska
- 1988-89 MEMBER, PLANNING COMMITTEE - Behavioral Sciences
Conference of The North
- 1988 TEACHING ASSISTANT - Human Development, Department of
Psychology/Education, University of Alaska Anchorage
- 1987-88 LAB ASSISTANT / ANIMAL CARETAKER - Department of
Psychology, University of Alaska Anchorage

1987-88 HANDICAPPED TRAINER & SUPERVISOR - Alaska
Specialized Education and Training Services, Anchorage, Alaska

HONORS AND AWARDS:

1990 - present UNIVERSITY OF VICTORIA FELLOWSHIP HOLDER

1989 BEST UNDERGRADUATE PAPER - Behavioral Sciences
Conference of the North

1989 OFFICIAL COMMENDATION FOR WORK PERFORMED
AS A COURT APPOINTED SPECIAL ADVOCATE - Alaska
Court System, Anchorage Alaska

1988 BEST UNDERGRADUATE POSTER PRESENTATION -
Social and Behavioral Sciences Conference of the North

1988 SPECIAL RECOGNITION AWARD - Department of
Psychology, University of Alaska Anchorage

1988 SEAWOLF SCHOLARSHIP - UAA Chancellor's Award for
academic excellence.

1986-89 DEAN'S LIST - University of Alaska Anchorage

1986-89 NATIONAL DEAN'S LIST

PUBLICATIONS AND PRESENTATIONS:

Slick, D., & Craig, P. (1991). Neuropsychological assessment in public psychiatric hospitals: The changing state of the practice - 1979 to 1989. *Archives of Clinical Neuropsychology*, 6(1&2), 73-80.

- Slick, D., & Craig, P., Venator, T. (1989). *A Survey of Neuropsychological Practice in Publicly funded Psychiatric Hospitals*. Presented at the 1989 Western Psychological Association Annual Convention, Reno, Nevada.
- Venator, T., Slick, D., & Haley, M. (1989). *Naming Processes and the Relationships Between Names and Their Referents*. Presented at the 1989 Western Psychological Association Annual Convention, Reno, Nevada.
- Slick, D., Madigan, B. & Combes, K. (1988). *Does The Ability to Recognize Good Writing Predict Writing Skill?* Presented at the 1988 Western Psychological Association Annual Convention, San Francisco, California.
- Slick, D. & Combes, K. (1987). *Dichotic Listening with CV Pairs*. Presented at the 1987 Behavioral Sciences Conference of the North, Anchorage Alaska.
- Slick, D. (1986). *A Dichotic Listening Experiment*. Presented at the 1986 Behavioral Sciences Conference of the North, Anchorage Alaska.
-

PERSONAL:

Birth Date: November 20, 1962
Birth Place: Anchorage, Alaska
Citizenship: U.S.A.

PARTIAL COPYRIGHT LICENSE

I hereby grant the right to lend my thesis to users of the University of Victoria Library, and to make single copies only for such users or in response to a request from the Library of any other university, or similar institution, on its behalf or for one of its users. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by me or a member of the university designated by me. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Title of Thesis: *Laterality and Processing of Idiomatic Speech in a Normal Population*

Author



Daniel J. Slick

Date

9-30-92