

THE EFFECTS OF FEATURE TYPE ON SEMANTIC PRIMING OF PICTURE NAMING
IN NORMAL SPEAKERS

By

CHRISTINA MARIA DEL TORO

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To my family who has given me unending love, support, guidance and joy, this work is
dedicated to you

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TABLE OF CONTENTS

	<u>page</u>
ACKNOWLEDGMENTS.....	4
LIST OF TABLES.....	8
LIST OF FIGURES.....	10
LIST OF ABBREVIATIONS.....	11
ABSTRACT.....	12
CHAPTER	
1 INTRODUCTION.....	13
Semantic Memory.....	13
The Conceptual Structure Account.....	16
Evidence for the conceptual structure account.....	19
Limitations of the conceptual structure account.....	21
Confirming the CSA.....	23
Semantic Priming.....	24
Priming in Distributed Networks.....	25
Multiple Primes.....	26
Statement of the Problem.....	28
Research Questions and Hypotheses.....	28
2 METHODS.....	33
Data Collection.....	33
Design.....	33
Dependent variables.....	33
Independent variables.....	33
Trial structure.....	33
Timing.....	34
Task.....	34
Settings and Equipment.....	35
Stimuli.....	35
Semantic categories.....	35
Prime type.....	36
Participants.....	37
Inclusion criteria.....	38
Screening.....	38
Data Analysis.....	39
Transcription and Scoring.....	39
Data Trimming.....	39

Reliability	39
Statistical Analysis.....	40
3 RESULTS	44
Reliability	44
Research Question 1	44
Younger Adults.....	44
Older Adults.....	45
Research Question 2	45
Research Question 3	46
Research Question 4	47
Word Frequency Effects	47
4 DISCUSSION	63
Priming Effects from Related Features and Neutral Primes.....	63
The Effect of Feature Type	64
The Effect of Number of Features.....	68
The Effect of Timing on Multiple Feature Primes	69
The Effect of Word Frequency	71
Limitations.....	71
Implications for Anomia Treatment	72
Future Directions	73
Summary	74
APPENDIX	
A PRIME-TARGET STIMULI.....	76
B TARGET WORD FREQUENCY	79
LIST OF REFERENCES	80
BIOGRAPHICAL SKETCH.....	84

LIST OF TABLES

<u>Table</u>	<u>page</u>
1-1	The distribution and correlations of shared and distinctive features in living and nonliving things, according to the CSA. 31
1-2	Summary of Research Questions (RQ) and Predictions 32
2-1	Participant demographic information including age, years of education, gender and average (AVE) test scores with standard deviations (SD) for the Mini-Mental Status Exam (MMSE; Folstein, Folstein & McHugh, 1975), Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999), Pyramids and Palm Trees Test (P&P; Howard & Patterson, 1992), American National Adult Reading Test (ANART; Nelson, 1982), and estimated IQ based on ANART Scores (Grober & Sliwinski, 1991). 41
3-1	Raw mean SRT for younger adults for comparison of neutral, shared features, distinctive features, and combination of shared and distinctive features prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses. 49
3-2	Raw mean SRT for older adults from comparison of neutral, shared features, distinctive features, and combination of shared and distinctive features prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses. 50
3-3	Raw mean SRT from comparison of shared versus shared-shared prime conditions. There were no significant effects of prime condition. 51
3-4	Raw mean SRT from comparison of distinctive and distinctive-distinctive prime conditions. There were no significant effects of prime condition. 52
3-5	Raw mean SRT from comparison of 200msec and 600msec ISI for the prime conditions of neutral, shared features, distinctive features, and combination of shared and distinctive features. There were no significant effects of ISI. 53
3-6	Raw mean SRT from comparison of 200msec and 600msec ISI for the shared feature prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses. 54
3-7	Raw mean SRT from comparison of 200msec and 600msec ISI for the distinctive feature prime conditions. There were no significant effects of ISI. 55
A-1	Animal Stimuli..... 76
A-2	Tool Stimuli..... 77

A-3 Vehicle Stimuli 78

B-1 Taret Word Frequency..... 79

LIST OF FIGURES

<u>Figure</u>	<u>page</u>
2-1	Example of priming task trial structure displaying the shared-distinctive condition 42
2-2	Priming task trial structure for one complete trial displaying timings of each screen. All trials within one session are administered with an ISI of 200 or 600msec for the blank screens between primes and between the second prime and target picture. The target picture remains on the screen until the voice key is triggered by the participant's verbal response..... 43
3-1	Log-transformed mean SRT of young adult responses from comparison of neutral, shared, distinctive and combined prime conditions. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs. 56
3-2	Log-transformed mean SRT of older adult responses from comparison of neutral, shared, distinctive and combined prime conditions. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs. 1
3-3	Log-transformed mean SRT of older adult responses from comparison of shared and shared-shared prime conditions. There were no significant effects of prime condition..... 58
3-4	Log-transformed mean SRT of older adult responses from comparison of distinctive and distinctive-distinctive prime conditions. There were no significant effects of prime condition..... 59
3-5	Log-transformed mean SRT of older adult responses to all prime conditions (collapsed across shared, distinctive, combined, and neutral primes) at 200 ISI versus 600 ISI. There was no significant difference in SRT between ISI conditions. 60
3-6	Log-transformed mean SRT of older adult responses to shared primes (collapsed across shared and shared-shared) primes at 200 ISI versus 600 ISI. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs..... 61
3-7	Log-transformed mean SRT of older adult responses to distinctive primes (collapsed across distinctive and distinctive-distinctive) primes at 200 ISI versus 600 ISI. There was no significant difference in SRT between ISI conditions. 62

LIST OF ABBREVIATIONS

ANART	American National Adult Reading Test
CSA	Conceptual Structure Account
ISI	Inter-stimulus Interval
MMSE	Mini Mental Status Examination
msec	Milliseconds
P&P	Pyramids & Palm Trees
SEC	Seconds
SRT	Speech Reaction Time
TOWRE	Test of Word Reading Efficiency

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The aim of this study was to investigate the roles of shared and distinctive features on conceptual activation. A picture naming paradigm was employed to measure speech reaction time during feature-to-concept activation of animals, tools, and vehicles. Fifty-nine young adults and 47 older adults completed the priming task with an interstimulus-interval of 200msec and 600msec, in two different sessions. Results indicate that regardless of semantic category, distinctive feature primes resulted in the fastest reaction times compared to shared features, a combination of distinctive and shared features, and neutral primes. In general, manipulation of ISI did not produce changes in SRT. Overall, the results showed that as stated in the CSA, distinctive features have a privileged role in concept activation. However, the proposed differential roles of shared and distinctive features in living and nonliving things, was not confirmed. Additionally, the results indicate that in general, multiple feature primes do not require more time to activate a concept.

CHAPTER 1 INTRODUCTION

Semantic Memory

Semantic memory is our cumulative knowledge of things, people, places, and events and is considered one of the most critical aspects of human cognition (Hutchison, 2003). Many theories and models have been put forth to elucidate the structure of conceptual representations and how the representations are processed. One group of models, referred to here as semantic feature theories, is based on the assumption that concepts, or conceptual information, are instantiated in a distributed neural system comprised of smaller units. The smaller units represent semantic features or properties and are the lowest level of representation in semantic memory. Concepts emerge from overlapping patterns of activation across related feature units (Plaut, 1996). For example, the activation of the conceptual representation of *tree*, requires simultaneous activation of related feature units such as *branch*, *leaves*, *trunk*, *bark*, etc. Thus, a concept is not represented as a discrete unit, but instead emerges from activated features. This leads to distributed representations of concepts over unique patterns of activation (Plaut, 1996).

The relationship of conceptual feature units and their co-activation have been described by many researchers using varying terminology and specifications. However, despite such differences, it is generally agreed upon that the connections between conceptual representations are based on similarity and differences of features. Such connectivity has been described in terms of semantic neighborhoods (Mirman and Magnuson, 2008) and typicality effects (Rosh, 1975; Plaut, 1996).

Mirman and Magnuson (2008) propose that the structure of semantic memory is based on how close or distant conceptual representations are from one another in terms of semantic relatedness. If concepts are closely related, i.e. share overlapping features, such as *cow* and *bull*, they are considered to be 'near' neighbors. On the other hand, conceptual representations that share fewer overlapping features, such as *cow* and *tiger* are considered 'distant' neighbors. In this semantic neighborhood model, patterns of activation correspond to the distance between features based on similarity. Mirman and Magnuson have shown, in computational and behavioral experiments, that semantic processing is slowed by dense, near neighbors and speeded by far neighbors. These results are attributed to inhibitory effects from near neighbors and facilitative effects from distant neighbors. For example, when asked to name a picture of a *cow*, prior presentation of a far neighbor *tiger*, will be facilitative. Presentation of *tiger* will activate its features which will include a few shared features with *cow*; however, when *cow* is activated, the semantic system can inhibit the activation of *tiger* because there is little overlap of activation patterns for *tiger* and *cow*. Inhibiting the activation of *tiger* will not turn off a critical amount of features for *cow*. Conversely, prior presentation of a *bull* (a near neighbor) will be inhibitory when *cow* is presented. The presentation of *bull* will activate numerous features that are shared with *cow* but also features that are unique to *bull*. When *cow* is presented, the semantic system must activate its features which will overlap with the already activated features of *bull*. Additionally, the system must inhibit the features of *bull* which now do not match the activation pattern of *cow*. The greater number of shared features between *bull* and *cow* causes difficulties in inhibiting only *bull* and in turn, activation of *cow* is slowed.

Conceptual representations in semantic memory have also been purported to be connected through semantic typicality (Rosch, 1975). This view suggests semantic categories are built on a hierarchy of typicality, or how close each exemplar is to the prototype of that category. For example, *robin* is a typical member of the bird category, while *ostrich* is considered an atypical exemplar. The notion of typicality has been tested computationally (Plaut, 1996). The results of damaging and retraining the model revealed that generalization to untrained items was greater when the trained items were atypical members of a category. For example, training *ostrich*, resulted in generalization to untrained items such as *blue jay*, and *robin*; but training *blue jay* did not generalize to the untrained *penguin*. This suggests that activation of atypical exemplars activates features which are unique to that conceptual representation, as well as features which are common to most members of that category. On the other hand, activation of typical exemplars activates the features common to most members and not the unique features of the atypical members. Thus, if typical items are trained, the distinguishing features of atypical members will not be activated and access to them will not be improved.

Based on the theory that a concept is comprised of a distributed representation of features, and processed via simultaneous activation of those features, techniques for remediating word retrieval deficits have been developed. Two such treatments are semantic feature analysis (SFA; Boyle & Coehlo, 1995) and the complexity account of treatment efficacy (CATE; Thompson, Shapiro, Kiran, & Sobeck, 2003). In SFA treatment patients are asked specific question about the features of a pictured object and then asked to name the object; for example, while viewing a picture of an apple, the

patient is asked *where do you find it? What do you do with it?* The goal is to improve access to the concept (object to be named) by activation of the features. The CATE treatment is based on Plaut's (1996) computational model which investigated Rosch's (1976) typicality effect. As in SFA, the objective of CATE is to improve activation of a conceptual representation by activating the related features. The typicality effect is employed through the use of atypical (instead of typical) features of the concept to improve generalization to untrained items.

Although semantic treatments have had positive treatment effects, generalization to untrained items and maintenance effects long after therapy concludes can be improved (Nickels, 2002). Therefore, it is necessary to refine semantic feature treatments. One approach is to gain a better understanding about the relationship of the feature units on the activation of conceptual representations, so that this relationship can be exploited in word retrieval therapies. One theory that provides further specificity regarding feature types and their connections in the semantic system is called the Conceptual Structure Account (CSA; Tyler & Moss, 2001; Taylor et al., 2007).

The Conceptual Structure Account

The CSA, like other semantic feature theories (Mirman & Magnuson, 2008; Plaut, 1996), is based on the assumption that semantic memory is a distributed connectionist network comprised of units that represent semantic features and the processing of a concept is the result of overlapping patterns of activation across semantic feature units. CSA extends and adds further specificity to the above mentioned accounts of semantic memory through two essential points. First, the degree to which a feature is shared by different concepts varies and second, the frequency of co-occurrence of features varies. These two points will be described below and are summarized in Table 1-1.

In regards to the degree to which a feature is shared, the CSA identifies two types of features, shared and distinctive. The idea is that shared and distinctive features differentially activate conceptual representations. Shared features are defined as those features that are common to related concepts, while distinctive features are unique to each concept. That is, most living things share features of *eyes, ears, breathes, legs*; thus, these features are only indicative of category membership. Conversely, fewer living things have *stripes, trunk, mane, or an udder* making these distinctive features. Distinctive features belong to fewer concepts and provide more information about a specific concept.

An example given by Taylor and colleagues is *tiger*. To activate the concept of *tiger*, the shared features which define animals and, specifically cats, such as *four legs, teeth, and tail*, will be activated but, until *stripes* is activated, the concept of *tiger* will not be complete and therefore, not activated above other types of cats. Thus, shared features reflect category membership and are not helpful in identification, and distinctive features provide more information about a particular concept and are critical to identification.

The CSA goes on to stipulate that activation of only shared features will lead to activation of several concepts sharing those features (e.g., activation of *four legs, teeth, and tail* would activate animals in addition to *tiger*). Activation of a distinctive feature with shared features will highlight the target concept above its neighbors (e.g. activation of *stripes* and not *mane* will highlight *tiger* over *lion*). Thus, the distinctive feature is needed to fully activate the target concept (Taylor et al., 2007).

The second postulate of the CSA regarding semantic structure is the frequency of co-occurrence of features. The CSA proposes a Hebbian structure in which units that “fire together, wire together”; in other words, connection strengths are built through simultaneous activation (Munakata & Pfaffly, 2004). Thus, features that co-occur frequently have stronger connections than features which co-occur infrequently. For example, most things which *breathe* have *eyes* but not all things that *breathe* have *stripes*. In a Hebbian system, consequently, *breathe* and *eyes* will have a stronger connection than *breathe* and *stripes* and therefore, the activation of *breathe* is more likely to lead to the activation of *eyes* than *stripes*.

The frequency of feature co-occurrence, or correlation as referred to by Taylor et al., (2007), differs for living and nonliving things. In living things, shared features are highly correlated to each other (e.g. things which *breathe* typically have *eyes* and *ears*) while distinctive features, on the other hand, are weakly correlated to other features (e.g. most things with *eyes* and *ears* don't have *pouches*, *udders*, or *eight legs*). In the example of *tiger* given above, the features describing nearly all living things, *breathes*, *legs*, *hears*, *eyes*, *ears* are strongly correlated shared features while *stripes* is a distinctive feature that is weakly correlated with the other features of *tiger*. Nonliving things on the other hand, have distinctive features which are highly correlated (things that have a *blade* also *cut*) and fewer shared features with lower correlations (most *tools* have a *handle* but could be made of *wood*, *plastic*, or *metal*; be used for *hitting*, *cutting*, or *turning*). Thus, *knife* has the distinctive features of *blade* and *cuts* which are strongly correlated to each other as opposed to the shared features of *handle* and *metal* which

describe several tools but are weakly correlated with each other and the distinctive features of *blade* and *cuts*.

Evidence for the conceptual structure account

The claims of CSA have been supported by several studies (McRae, de Sa, and Seidenberg, 1997; McRae, Cree, Westmacott, and de Sa, 1999; Randall, Moss, Rodd, Greer, and Tyler, 2004) using neurologically healthy individuals. Study tasks have included feature generation, priming in a feature verification task, and priming with targets and primes that have correlated features.

The goal of feature generation studies is to understand more about the distribution of feature type in living and nonliving things. Participants are asked to list all the features they can think of for a given concept. From these lists, shared and distinctive values are calculated based on the number of occurrences of each feature for all concepts in the list. Distinctiveness, or the degree to which a feature is distinctive to one concept, is calculated in one of two ways: either by taking the inverse of the number of concepts for which a feature was produced or by identifying a cut-off a priori (e.g. distinctive features occur in only 1 or 2 concepts). Results of a feature generation study for living and nonliving things by Taylor and colleagues (2007) supported the proposed division of high and low correlations among shared and distinctive features in living and nonliving things. That is, living things had a greater number of highly correlated shared features compared to nonliving things; and, nonliving things had more highly correlated distinctive features than living things (Taylor et al., 2007).

McRae et al. (1997) have conducted two priming studies to investigate the effect of feature correlation. Priming studies are based on the principle that presentation of a word (prime) will facilitate recognition of a subsequent word (target) (Meyer,

Schvaneveldt, and Ruddy, 1974). McRae et al. used an online written word comprehension task in which participants viewed a prime concept followed by target features which were either weakly or strongly correlated to other features of the concept. Participants were required to answer questions about the semantic relatedness of the prime to the target, such as, *is it animate?* In this word comprehension task, reaction time to living things was faster compared to nonliving things when the correlations between prime and target were higher; thus, supporting the claims of the CSA that correlation of shared features is higher in living things than in nonliving things (McRae et al.).

In the second study by McRae et al. (2007) investigating the effect of feature correlation, participants viewed prime concepts and target features, such as *deer-is hunted*, and were asked if the features belonged to the concept. Reaction times decreased as the correlation of prime and target increased; conversely, reaction times increased as the correlation of prime and target decreased. The authors concluded that the simultaneous activation of correlated features leads to a faster initial rise in activation, allowing strongly correlated features to settle into a stable activation pattern faster than weakly correlated features (McRae et al., 1999).

Randall et al. (2004) used the results from McRae et al. (2007) to investigate if, in living things, distinctive features would indeed be activated more slowly than shared features due to the weaker correlation of distinctive features (when compared to a stronger correlation of distinctive features in nonliving things). This prediction was supported by their results from a timed feature verification task in which participants had to respond to the target within a set time limit (Randall et al). However, in an untimed

version of the task there was no such difference between distinctive features of living and nonliving things indicating that correlation strength of features affects only the initial rise time of activation and not the final level of activation when the network is in a stable state.

Limitations of the conceptual structure account

While the CSA provides a framework upon which testable hypotheses about the structure of semantic memory can be tested, two critical limitations remain: 1) the distribution of features in semantic categories and 2) the specificity of the semantic concepts to which the theory can be applied.

In regards to the distribution of features in semantic categories, the CSA proposes a distinction between living and nonliving things. As described earlier, there are more shared than distinctive features in living things and more distinctive than shared features in nonliving things. However, there are categories of living and nonliving things which violate this distinction. This is a fact acknowledged by the authors of the CSA. Vehicles, for example, although a nonliving category, are processed more like living things because they have many shared features (*wheels, engines, tires, doors, fuel, etc*) and fewer distinctive features (*wings, sail, etc.*) which are necessary to distinguish a plane from a car and a car from a truck (Taylor, Moss, Tyler, 2007).

This difference in the structure of features for vehicles is also supported by anatomical studies investigating the processing of different domains of concepts. In an fMRI study of the contribution of category and visual attributes to semantic knowledge in the fusiform gyrus, Wierenga et al., (2009) compared activation from naming pictures of animals, tools, and vehicles. To compare the contribution of visual attributes, the investigators varied the amount of visual information available by providing increasing

details to pictured images. At lower levels of spatial frequency only global form, which can be likened to shared features, was seen compared to local detail or distinctive information given as the spatial frequency information increased. Results indicated that animals required the least visual detail (distinctive features) while tools required the most and vehicles fell between the two (Wierenga, et al., 2009). These results align with the claims of the CSA that animals have many shared features so there is information available for identification from just shared features whereas tools have fewer shared features and need more local details or distinctive features for identification. Likewise, as predicted by the CSA, vehicles did not behave entirely like living or nonliving objects but instead required both global form and local details for identification (Wierenga et al., 2009).

Taylor and colleagues (2007) also point out that the features of fruits and vegetables are not distributed in the same manner as animals, though all three categories are considered living things. Fruits and vegetables have fewer distinctive features which have even lower correlations than animals. Thus, the distribution of shared and distinctive features and their weight for identifying objects cannot be solely attributed to a distinction of living and nonliving categories; within these categories, further distributional differences can be found. Taylor and colleagues (2007) posit that it is the internal structure of the properties of concepts which determines the relationship between shared and distinctive features, not just the category or domain to which the concepts belong. Therefore, investigation of the distribution of shared and distinctive features and their interaction in categories more specific than living or nonliving things may reflect the truer structure of the system.

The second limitation of the CSA, is the specificity of objects which must be used in order to account for the differential effects of shared and distinctive features. That is, the CSA provides experimental evidence that, with access to distinctive features alone, an animal will be identified more slowly due to fewer connections between features related to the concept. However, this point may not be entirely accurate. The specificity of the concept may influence the relationship of shared and distinctive features. For example, *meow* can be considered a distinctive feature of cats, which according to the CSA should activate the concept slower than a shared feature; but, *meow* would likely be able to activate the concept of cat on its own without other information. This issue has not been addressed by the authors of CSA. Their examples and stimuli from their studies appear to be specific objects or members of a category (e.g. tiger) and not general concepts or subcategories (e.g. cat). For example, Taylor and colleagues (2007) discussed the difference between a knife and a tiger, using stripes as the distinctive feature of tiger which would not apply to all cats. When presented alone, *stripes* would not have the same effect in eliciting *tiger* as *meow* would in eliciting *cat*. More information would be needed to activate *tiger* but *meow* could activate *cat* on its own. Until the authors address this issue investigations of the CSA are limited to employing specific items as stimuli and more critically the results of such studies can only be applied to specific exemplars of a category.

Confirming the CSA

The principles of the CSA may be applied to anomia treatments, such as SFA, by providing further insight into the nature of feature-to-concept activation. Such information could potentially improve treatment outcomes by specifying the type of stimuli that could be used in an experimental therapy program. However, the claims of

the CSA cannot be applied to these treatments without empirical evidence that the principles of the CSA can be used to affect lexical access in the manner used in aphasia therapy. Typical tasks employed in anomia treatments involve, object description, picture naming, or naming objects by description which engage feature-to-concept activations. In other words, when shown a picture of a hammer, individuals with aphasia are typically asked to “*tell me what you do with this?*”. However, CSA experiments, thus far, have only been tested using concept-to-concept activation (e.g. using *eagle* to prime *hawk*). In order for principles of the CSA to provide insight into rehabilitation of anomia, the principles must first be addressed in feature-to-concept activation. To date, no study has used features as the prime and concepts as the target. Since a priming paradigm will be used in this study, relevant semantic priming literature will be reviewed here.

Semantic Priming

Meyer, Schvaneveldt, and Ruddy (1974) first showed that presentation of a word (prime) will facilitate recognition of a subsequent word (target). Since then, priming effects have been shown to be stronger when the prime word and target word are related or share semantic information compared to a neutral or unrelated prime-target pair (Balota, & Paul 1996; Bueno & Frencke-Mestre, 2008; de Groot, 1984; McNamara, 2005; Moss, Ostrin, Tyler, & Marslen-Wilson, 1995; Neely, 1991; Seidenberg, Waters, Sanders, & Langer, 1984). Most commonly, primes and targets are concepts related or interacting in some manner. For example, *lake* may prime *ocean* because both are bodies of water. Such concept-concept pairs reliably produce priming effects given a semantic relationship and a semantic-based task (Hutchison, 2003).

Priming in Distributed Networks

Priming effects occur in distributed networks for two possible reasons. McNamara (2005) refers to the first as learning models. These models predict priming effects as a result of gradual learning by the network which leads to increased probability of producing the same response each time a specific input is recognized. Priming effects under this model occur over long lags of time as the system learns (McNamara, 2005). The second explanation of priming effects in distributed networks comes from the proximity models (Cree, McRae, & McNorgan, 1999; McRae, de Sa, & Seidenberg, 1997). These models suggest priming occurs because related words (primes and targets) are closer and more strongly connected than unrelated words. In priming, a target is processed after the processing of the prime; that is, a pattern is activated for the prime which in turn activates a pattern for the target. Thus, processing of the target is faster following processing of the prime when there are connections between the two patterns than when there are no connections between the patterns (McNamara, 2005).

The proximity model of priming in distributed networks particularly describes the process of priming between words which share features, because activating features for a prime will also activate features for the target. Consequently, when the target is processed, some of the features are already activated. Furthermore, the proximity model predicts that exposure to a feature, or set of features, will activate those features and connected features, thereby increasing the speed of reaching a stable pattern of activation for a subsequent concept (McNamara, 2005). Processing of *core*, *seeds*, *red* will activate these units and the units each is connected to (*stem*, *tree*, *worm*) so when the picture of *apple* is seen activation for the name is already in process, and thus, will more quickly achieve a stable pattern. The effect of multiple primes, as illustrated in the

above example is an empirical question which has been studied (Balota & Paul, 1996; Milberg, Blumstein, Giovanello, and Misiurski, 2003). However, these studies, described below, have not used semantic features as primes. Such a paradigm would provide further evidence that activation of features is the mechanism for concept activation. Furthermore, determining the type of feature and number of each feature type which most strongly primes concepts will provide a framework for devising rehabilitation approaches for semantic impairments.

Multiple Primes

The effect of multiple primes has been studied based on spreading activation theories which posit that activation of one unit (from one prime) will spread automatically to related and connected parts of the network (even areas not directly connected to the original node). Thus, activation of *lion* will spread to *stripes* through the connection of *tiger*. There are three possible influences from multiple primes: *additive*, *underadditive*, and *overadditive* (Balota & Paul, 1996). An additive influence occurs when the facilitation of multiple primes is equal to the sum of the facilitation of each prime presented individually. An underadditive influence is seen when the facilitation of multiple primes is less than the total facilitation of each prime individually. Lastly, overadditivity is when the facilitation from multiple primes is greater than the total facilitation from each prime individually (Balota & Paul, 1996). Balota and Paul (1996) investigated this effect using two sequential primes in a lexical decision task and in a speeded word naming task. Additionally, they manipulated duration of the first primes and degraded the target stimulus in separate conditions. All conditions resulted in additive priming. Thus, in their study, providing several primes in succession was no different than presenting each prime individually. However, the series of experiments

conducted by Balota & Paul (1996) used concept primes and concept targets.

Consequently, the effect of multiple features on priming a concept is not known and the effect of time on multiple feature primes is unknown.

Milberg, Blumstein, Giovanello, and Misiurski (2003) have conducted a multiple prime study using triplets in which the third word was the target of a lexical decision task. The interstimulus interval (ISI), or time between the offset of a prime and the onset of the next prime, was varied between 200msec and 600 msec. ISI was varied to determine at what time point an overadditive effect could be achieved. There were four types of triplets: definitionally related triplets (e.g. meal, morning, breakfast), triplets with a categorical prime and nonword (e.g. meal, foncern, breakfast), triplets with a nonword and featural prime (e.g. jarm, morning, breakfast), and triplets with two nonwords (e.g. jarm, foncern, breakfast). The authors concluded that the priming effect from the definitionally related triplets seen in the 200ms ISI condition was additive; that is, the same as adding the priming effects from each individual prime (categorical and nonword prime triplet + nonword and featural prime triplet). The priming effect from the definitionally related triplet in the 600ms ISI condition, however, was overadditive, or greater than the effect from each individual prime. Thus, the longer ISI provided time for the convergence of meaning of the multiple primes and, subsequently, the enhancement of the priming effect and semantic facilitation (Milberg et al., 2003).

Milberg and colleagues' (2003) work suggests that, given enough time, exposure to multiple related words can aid reaction to a target. Whether the priming at 200 msec ISI and 600 msec ISI is an automatic or controlled process is not discussed by Milberg et al. and was not the aim of the study. Moreover, while understanding if the potent

mechanism is automatic or controlled processing is important, it was not the primary focus of the current study. Instead, the aim was to determine if there is a benefit to presenting multiple features prior to naming a picture and timing may be an important factor in order to allow for consolidation of the meanings of each prime.

Statement of the Problem

The CSA appears to be a solid theory of semantic memory which suggests a unique structure based on shared and distinctive features. Shared features of living nouns are more abundant and more strongly correlated with other features, while distinctive features are more weakly correlated and fewer in number. Conversely, non-living nouns have more distinctive features which have strong correlations and fewer shared features with weaker correlations. The distribution of shared and distinctive features in living and nonliving concepts could be used to further specify the stimuli used in anomia treatments; however, it is unknown if shared and distinctive features can be used to activate concepts because previous studies have used concept-to-concept activation and not feature-to-concept activation. Thus, the aim of the current study was to test the roles of shared and distinctive features, as proposed by the CSA, in feature-to-concept activation. Additionally, there is evidence that more time is necessary to allow convergence of meanings from multiple primes which in turn leads to increased priming and semantic facilitation. To determine if time is a factor in activating different types of features, the current experiment was conducted at two inter-stimulus intervals.

Research Questions and Hypotheses

Table 1-2 summarizes the research questions and respective predictions. Specific Aim #1: According to the CSA, shared features will boost performance in naming living nouns due to more numerous connections to strongly correlated shared features.

Furthermore, distinctive features result in slower speech production time due to weaker correlations with other features. Conversely, for non-living nouns, distinctive features boost performance over shared features due to the stronger correlations and greater number of distinctive features; and shared features produce slower speech production time as a result of weak correlations to other features. The following null hypothesis was investigated: There is no significant difference in naming living and non-living nouns as measured by speech reaction time (SRT) when primed with shared or distinctive features or a combination thereof.

The research question is: Is there a significant difference in naming animals, tools, or vehicles as measured by SRT when primed with shared or distinctive features or a combination thereof compared to neutral primes? The prediction is: Based on the CSA, it was predicted in living things (animals and vehicles), that shared features would result in faster SRTs compared to distinctive features. For non-living nouns (tools), distinctive features were predicted to produce faster SRTs over shared features. For all domains of nouns, a combination of shared and distinctive features was predicted to result in the fastest SRTs.

Specific Aim #2: The CSA proposes different correlation strengths between shared and distinctive features for living and nonliving things. The strength of these correlations is largely based on the number of features for each concept, indicating that the more features, the stronger the correlations between them; and the stronger the correlations. Thus, activation of features or multiple features with strong correlations results in faster activation of the concept. The null hypothesis was: There is no

difference in SRT for naming living and non-living nouns between conditions varying number shared and distinctive features.

This hypothesis was addressed with two research questions: Does SRT for naming animals, tools, or vehicles change linearly as number of *shared* features changes from 1-2? Does SRT for naming animals, tools, or vehicles change linearly as number of *distinctive* features changes from 1-2? The prediction is: SRT following shared features will be faster for living nouns compared to non-living nouns; SRT following distinctive features will be faster for non-living nouns compared to living nouns.

Specific Aim #3: Using multiple features to prime conceptual activation requires the consolidation of the information from each prime. This consolidation may occur over longer time intervals than is required for one prime. The null hypothesis was: There is no difference in priming effects over time.

The research is: Is there a difference in priming effects over time when comparing an ISI of 200msec to an ISI of 600msec? The prediction is: Patterns of priming effects will be different over time. Specifically, an ISI of 200msec would have an additive influence and an ISI of 600msec would have an overadditive influence.

Table 1-1 The distribution and correlations of shared and distinctive features in living and nonliving things, according to the CSA.

	Living things	Non-living things
Shared features	High in number	Fewer in number
	High correlation (e.g. <i>things which breathe typically have eyes and ears</i>)	Weak correlation (e.g. <i>most tools have a handle but could be used for hitting, cutting or turning</i>)
Distinctive features	Fewer in number	High in number
	Weak correlation (e.g. <i>most things with eyes and ears do not have pouches, udders, or eight legs</i>)	High correlation (e.g. <i>things with blade also cut</i>)

Table 1-2. Summary of Research Questions (RQ) and Predictions

Specific Aims	Feature Type	Predictions for Living Things	Predictions for Nonliving Things
# 1 RQ: Is there a significant difference in naming animals, tools, or vehicles as measured by SRT when primed with shared or distinctive features or a combination there of compared to neutral primes?	Neutral, Shared, Distinctive, and Combination (shared & distinctive)	1. Combination of shared and distinctive features will lead to significantly faster SRT than shared or distinctive features alone 2. Shared features alone will lead to significantly faster SRT than distinctive features alone	1. Combination of shared and distinctive features will lead to significantly faster SRT compared to shared or distinctive features alone 2. Distinctive features alone will lead to significantly faster SRT than shared features alone
#2 RQ 1: Does SRT for naming animals, tools, or vehicles change linearly as number of <i>shared</i> features changes from 1-2?	One shared feature Two shared features	Two shared features will lead to significantly faster SRT	There will be no significant difference between one and two shared features in SRT
RQ2: Does SRT for naming animals, tools, or vehicles change linearly as number of <i>distinctive</i> features changes from 1-2?	One distinctive feature Two distinctive features	There will be no significant difference between one and two distinctive features in SRT	Two distinctive features will lead to significantly faster SRT
# 3 RQ: Is there a difference in priming effects over time when comparing an ISI of 200msec to an ISI of 600msec?	Prediction Patterns of priming effects will be different over time; namely, an ISI of 200msec would have an additive influence and an ISI of 600msec would have an overadditive influence.		

CHAPTER 2 METHODS

Data Collection

Design

A linear mixed effects model was employed to measure the effects of prime type (distinctive, shared, combination) and semantic category (animals, tools, vehicles) in two conditions (200 and 600 ISI) on speech reaction time during a picture naming task. The details of the experimental paradigm and data collection sessions are presented below.

Dependent variables

The dependent variable was SRTs for picture naming. SRTs were measured from the onset of the picture to the initiation of speech. Practice trials were administered to familiarize participants with the task and to minimize false starts. False starts and incorrect naming responses were excluded from analysis.

Independent variables

There were three independent variables. The first was combination of prime types which consisted of nine prime conditions (described below). The second independent variable was the semantic categories of target pictures (animals, tools, vehicles). The third independent variable was ISI (200msec vs. 600msec).

Trial structure

Trials consisted of two orthographic word primes and one picture target. All picture targets were concepts. Word primes were either semantic features or a neutral prime. The semantic feature primes were either a shared or distinctive feature (defined below) related to the target. The neutral prime was the word *blank*. The combination

and order of feature type and neutral primes were randomized across all trials while limiting each target to a single appearance per participant. Thus, in one trial a feature type was presented from 0-2 times. Figure 2-1 shows an example trial structure. The prime pair conditions were:

- Shared-shared
- Shared-neutral
- Neutral-shared
- Shared-distinctive
- Distinctive-shared
- Distinctive-distinctive
- Distinctive-neutral
- Neutral-distinctive
- Neutral-neutral

Timing

Each participant completed the experiment twice in two separate sessions in the same week, separated by no less than two days. The purpose of two test sessions was to compare the priming effects when ISI was manipulated. One administration presented the items with 200msec ISI and the other administration presented the items with 600msec ISI. The order of ISI over the two sessions was randomized. ISI was measured from the offset of a stimulus to the onset of the next stimulus. Figure 2-2 displays the trial structure with time intervals.

Each trial began with a fixation point of a (+) for 500 milliseconds. Two prime words appeared sequentially, each with duration of 200msec and an ISI of either 200 msec or 600 msec. Then a target picture appeared until the participant named the item aloud. The inter-trial interval was 3 seconds. The next trial began with a fixation point.

Task

Participants were given the following instructions: "You will see words and pictures. Just watch the words. When a picture appears, name it as fast as you can."

Participants completed 10 practice items followed by further instructions from the examiner if needed.

Settings and Equipment

All testing was conducted in a quiet room with participants seated at a comfortable distance from the computer screen. E-prime software (E-Prime version 2.0, Psychology Software Tools, Pittsburgh, PA) was used for stimulus presentation and collection of SRTs. Verbal responses were recorded by a C420 PP MicroMic head-mounted microphone connected to a Tube MP preamplifier which activated the voice key of a Serial Response Box interfaced with E-prime software. Reaction times were stored in by the E-prime software. Verbal responses were also recorded with a Marantz PMD671 digital recorder.

Stimuli

Semantic categories

Target items for this study were animals, tools, and vehicles. Targets can be found in appendix A. Additionally, a set of distracter items comprised two-thirds of the total items. These items were from several semantic categories with the exclusion of the three target categories (animals, tools, vehicles), in order to prevent participants from anticipating an animal, tool, or vehicle. Prime types for distracter items were the same as for target items. Distracter items were not analyzed.

Target pictures. Targets were presented as black and white line drawings. Pictures were collected from: the CRL International Picture-Naming Project (Bates et al., 2003), edupics.com, and Google Images. Target pictures were presented in the vertical and horizontal center of the screen.

Prime type

Neutral primes. The word *blank* was used as the neutral prime to compare to the effect of semantic feature primes. de Groot, Thomassen, and Hudson (1982) found using *blank* as a neutral prime did not result in a significant difference in reaction times to targets following *blank* versus meaningful primes.

Semantic feature primes. Semantic features were selected from the corpus of 541 living and nonliving things created by McRae, Cree, Seidenberg, & McNorgan (2005). This corpus was normed on over 700 neurologically-healthy participants. The features include nouns and verbs. McRae et al. categorized the types of features provided by the participants as: functional, visual-motor, visual form and surface, visual color, sound, taste, smell, tactile, encyclopedic, taxonomic. The data include concept production frequencies, which are the number of concepts in which each feature occurs. Semantic features can be found in the appendix listed by target and coded as shared (S) or distinctive (D).

The definition of shared and distinctive features is based on a modified version of the McRae et al. (2005) concept production frequency. Concept production frequency (CPF) is a measure from the McRae et al. database which is defined as the number of times the feature was produced in the entire corpus of items. Any feature with a CPF greater than two is considered shared and two or less is considered distinctive. However, the McRae et al. database calculates the CPF over all items in the database not items within semantic category. Because the hypotheses of the CSA regarding shared and distinctive features is based on categories, the CPF was re-calculated for this study to represent the number of times a feature was produced within semantic

category (animals, tools, vehicles). Shared and distinctive feature primes can be seen in appendix A.

As seen in appendix A, in order to construct the distinctive-distinctive and shared-shared prime conditions, each concept has two shared and two distinctive features. In constructing the shared-distinctive condition, only one pair of four possible pairings was chosen for each target. The most shared and most distinctive features were chosen. If the value for shared and distinctive was equal, then the decision was based on consensus from three outside raters asked to choose the most distinctive/shared feature of the two.

Stimuli were chosen from the McRae et al. (2005) database based on number of features and syllable length. Specifically, each target (pictured concepts to be named) had to have at least two distinctive and two shared features. Targets were controlled for syllable length, specifically one to four syllables, to minimize variance in speech motor programming.

Participants

Two groups of neurologically healthy individuals served as participants. Forty-seven individuals between the ages 50-80 comprised the older group. Fifty-nine University of Washington undergraduate students between the ages of 18-30 comprised the younger group. Neurologically healthy participants were chosen because feature-to-concept priming has not previously been employed in priming studies and the presence of priming effects should be established in a healthy brain before investigating effects in a pathologic population.

The older group is the population of interest in this study because this is the typical age range of stroke survivors and people with aphasia. The younger group was chosen

as a methodologic control group because the majority of previous research in semantic priming has been conducted on young adults; thus, it is an empirical question if priming effects from the current paradigm will be found in older adults. Demographic information can be found in Table 2-1.

Inclusion criteria

Participants were right-handed, monolingual, English speaking adults without a history of neurologic conditions or disease and/or developmental cognitive disorders as measured by participant report. Such disorders included, but were not limited to, dyslexia or alexia, phonologic impairments, memory impairments, language impairments, and vision impairments (excluding corrected vision).

Screening

Prior to data collection, each participant was administered the following tests in order to determine eligibility for participation:

Mini-Mental Status Exam (MMSE; Folstein, Folstein & McHugh, 1975) was administered to determine intact memory based on a minimum score of 27/30. No participants failed the MMSE.

Visual acuity screening was administered using a Snellen Eye Chart to ensure participants were able to perceive the stimuli based on minimum criteria of reading the stimuli for 30 feet from a distance of 20 feet. No participants failed the vision screening.

The following tests were administered to describe the participants' reading and semantic abilities:

The Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) was administered to describe the participants' abilities to read single words. This test was designed to measure the ability to sound out words and to read words as a whole unit (sight words).

The Pyramids and Palm Trees Test (P&P; Howard & Patterson, 1992) was used to describe participants' ability to access semantic information from picture stimuli.

Lastly, the American National Adult Reading Test (ANART; Nelson, 1982) was used to estimate intelligence quotient (IQ) in order to establish similar intelligence between the younger and older adults. IQ was calculated using the number of errors on the ANART and years of education as described by Grober & Sliwinski (1991). Average test scores can be found in Table 2-1.

Data Analysis

Transcription and Scoring

Digital audio-recordings of participant responses were transcribed and scored as correct or incorrect. Responses were scored correct when there was a single utterance of the name of the target picture. Responses were scored incorrect if they included verbal preparation output such as “um, huh” or self-corrections (ex. screw- no drill).

Data Trimming

Only correct responses were analyzed. This resulted in an exclusion of 8.8% of the responses (5304 total response, 468 excluded responses). Reaction times less than 200msec were excluded based on previous studies which have used this cutoff to minimize the inclusion of false triggering of the voice key (e.g. breathing, lip smacking, etc.). This resulted in an exclusion of 2.8% of the correct responses (4765 total responses, 133 responses).

Reliability

Five independent raters performed inter-rater reliability on 25% of each participant’s responses. Raters were trained to score items as correct or incorrect based on the original criteria explained above. Training took place in a one-hour session with the primary investigator. Raters demonstrated understanding of the criteria by completing reliability on a single participant’s responses. The reliability was

reviewed by the primary investigator and when determined to be accurately completed the training was complete.

Statistical Analysis

A linear mixed effects model was employed to measure the effects of prime type on SRT in each semantic category. The nine prime conditions described above were collapsed into six prime conditions by coding conditions which were only different by order of feature primes as the same conditions. This resulted in the following six prime conditions:

1. Shared-shared
2. Shared-neutral\ Neutral-shared
3. Shared-distinctive\Distinctive-shared
4. Distinctive-distinctive
5. Distinctive-neutral\Neutral-distinctive
6. Neutral-neutral

Distinct analyses were conducted for each group, and within categories (animals, tools, vehicles). Log-transformed data were used to reduce the effect of outliers. In all models, participants were included as a random factor and target frequency was included as a fixed factor. Frequency of targets was included as a fixed factor because frequency was not controlled for a priori, but the literature provides strong evidence that frequency interacts with priming. Frequency was entered into the models as a categorical variable, using criteria commonly seen in the literature (low frequency was less than ten per million, medium frequency between ten and twenty per million, high frequency over twenty per million. Frequency ratings were taken from Brysbaert and New (2009) and are displayed in appendix B. All analyses were conducted with Bonferroni correction for multiple comparisons.

Table 2-1 Participant demographic information including age, years of education, gender and average (AVE) test scores with standard deviations (SD) for the Mini-Mental Status Exam (MMSE; Folstein, Folstein & McHugh, 1975), Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999), Pyramids and Palm Trees Test (P&P; Howard & Patterson, 1992), American National Adult Reading Test (ANART; Nelson, 1982), and estimated IQ based on ANART Scores (Grober & Sliwinski, 1991).

		Age	Education	Gender Female (F) Male (M)	MMSE (raw score out of 30)	TOWER (standard score with a range of 35-165)	P&P (raw score out of 50)	ANART (raw score out of 50)	Estimated IQ based on ANART score
Young Adults	AVE (SD)	22 (2)	15 (2)	25 F 34 M	30 (1)	108 (11.6)	49 (1.79)	37 (6.5)	114.93 (8.0)
Older Adults	AVE (SD)	60 (7)	16 (2)	28 F 18 M	29 (1)	97 (18)	51 (1)	40 (8)	119.23 (7.8)

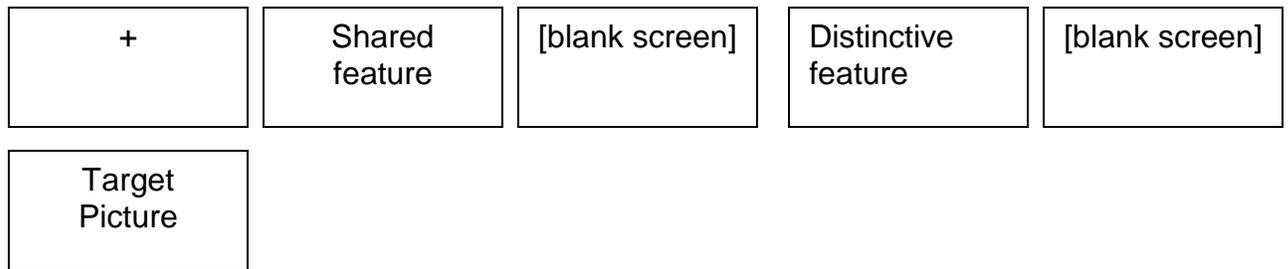


Figure 2-1. Example of priming task trial structure displaying the shared-distinctive condition

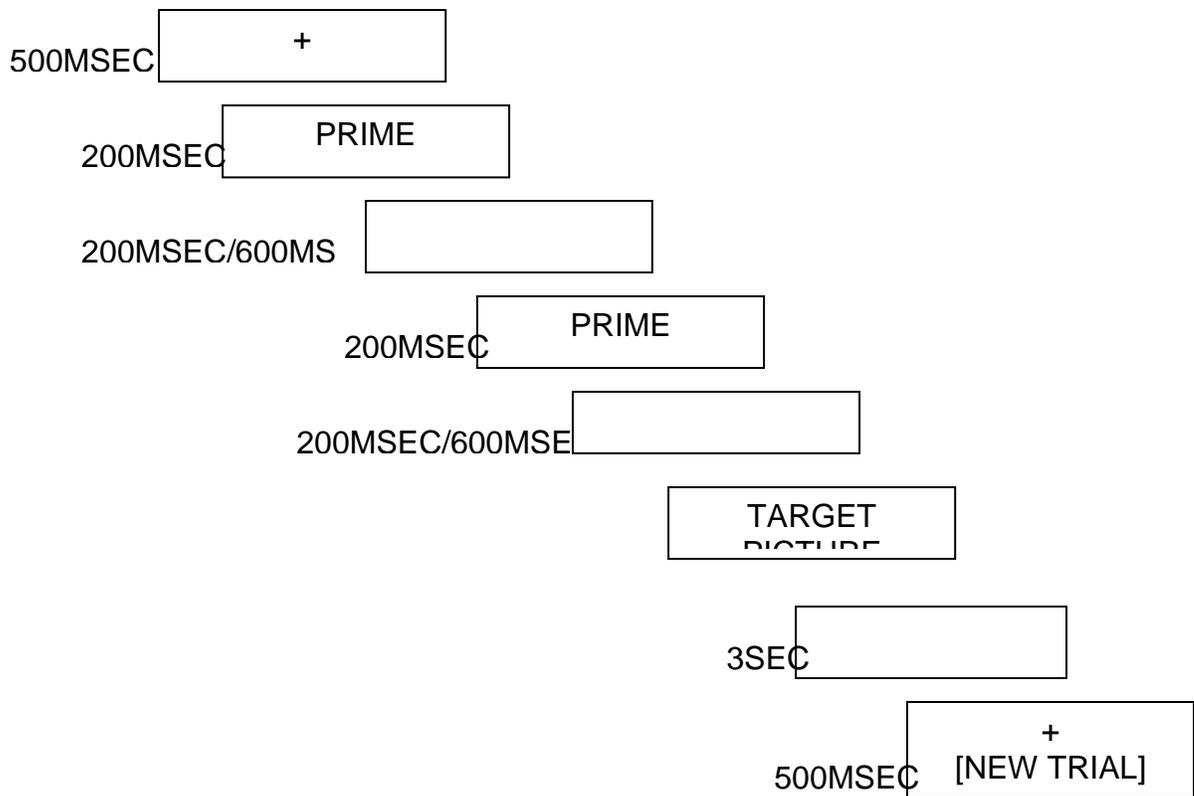


Figure 2-2. Priming task trial structure for one complete trial displaying timings of each screen. All trials within one session are administered with an ISI of 200 or 600msec for the blank screens between primes and between the second prime and target picture. The target picture remains on the screen until the voice key is triggered by the participant's verbal response.

CHAPTER 3 RESULTS

Reliability

Inter-rater reliability was performed on 25% of each participant's responses for each session. An Intra-class correlation was calculated. Inter-rater reliability was 96%.

Research Question 1

Is there a significant difference in naming animals, tools, or vehicles as measured by SRT when primed with shared or distinctive features or a combination there of compared to neutral primes? A linear mixed effects model was conducted for each category to determine the main effect of prime condition on SRT of picture naming. Each model included frequency and prime condition as fixed factors and participant as a random factor. Four prime conditions were entered into the model, shared (shared-blank, blank-shared, shared-shared), distinctive (distinctive-blank, blank-distinctive, distinctive-distinctive), combination (distinctive-shared, shared-distinctive), and neutral (blank-blank). Targets were coded for high, medium, or low frequency. Frequency effects are presented separately at the end of the results.

Younger Adults

Table 3-1 and Figure 3-1 display mean SRT and standard errors for each prime condition with each target semantic category (animals, tools, vehicles). The analysis of SRT of naming animals resulted in a main effect of prime condition $F(3, 874.86) = 6.26$, $p=.000$. Pairwise comparisons indicate distinctive primes resulted in significantly ($p<.05$) faster responses than the neutral primes and faster than the shared primes ($p=.001$). The main effect of prime condition on naming tools was not significant $F(3,$

861.85) = 2.34, $p > .05$. The main effect of prime condition on naming vehicles was not significant $F(3, 745.81) < 1$.

Older Adults

Table 3-2 and Figure 3-2 show mean SRT and standard error for each prime condition within the target semantic category (animals, tools, vehicles). The analysis of SRT of naming animals resulted in a main effect of prime condition that was significant, $F(3, 674.78) = 5.16$, $p < .05$. Pairwise comparisons revealed that reaction times to distinctive features were significantly faster ($p = .001$) than reaction times to shared features. The main effect of prime condition on naming tools was significant $F(3, 675.82) = 4.78$, $p < .05$. Pairwise comparisons indicate reaction times following distinctive features were significantly faster ($p < .05$) than responses to neutral primes, shared feature primes, and combination primes (distinctive-shared or shared-distinctive). The main effect of prime condition on naming vehicles was significant $F(3, 598.88) = 5.47$, $p < .01$. Pairwise comparisons revealed that reaction times following distinctive features were significantly ($p = .001$) faster than reaction times following shared features.

Results for research question one indicate similar priming patterns for the younger and older adults. Specifically, distinctive features have greater priming effects than shared thus, validating the use of this picture naming priming task with older adults. Given that older adults are the population of interest, only results from the older adult group will be presented and discussed for the remaining research questions.

Research Question 2

Does SRT for naming animals, tools, or vehicles change linearly as number of shared features changes from 1-2? A linear mixed effects model was conducted for each category to determine the main effect of prime condition on SRT of picture

naming. Each model included frequency and prime condition as fixed factors and participant as a random factor. Two prime conditions were entered into the model, shared (shared-blank, blank-shared) and shared-shared to compare the effects of the number of shared features.

Table 3-3 and Figure 3-3 display the mean SRT and standard error for the two prime conditions within each semantic category. The analysis of SRT of naming animals did not produce a significant main effect of prime condition, $F(1, 211.38) < 1$. Likewise, the main effect of prime condition was not significant for SRT of naming tools, $F(1, 220.24) < 1$ or vehicles, $F(1, 183.80) < 1$.

Research Question 3

Does SRT for naming animals, tools, or vehicles change linearly as number of distinctive features changes from 1-2? A linear mixed effects model was conducted for each category to determine the main effect of prime condition on SRT of picture naming. Each model included frequency and prime condition as fixed factors and participant as a random factor. Two prime conditions were entered into the model, distinctive (shared-blank, blank-shared) and distinctive-distinctive to compare the effects of the number of distinctive features.

Table 3-4 and Figure 3-4 display the mean and standard error of SRT for the two prime conditions within each target semantic category. The main effect of prime condition was not significant for SRT of animal picture naming, $F(1, 235.59) < 1$. Similarly, the main effect of prime condition was not significant for tools, $F(1, 226.62) < 1$, or vehicles, $F(1, 205.32) < 1$.

Research Question 4

Is there a difference in priming effects between 200 and 600msec ISI? The comparisons of priming conditions in research questions 1-3 were conducted with ISI as a fixed factor and participant as a random factor to determine the main effect of ISI on SRT of picture naming. Tables 3-5 through 3-7 and figures 3-5 through 3-7 display means SRTs with standard errors for comparisons of ISI.

Comparison of shared, distinctive, combination, and neutral primes did not produce significant effects of ISI for animals, $F(1, 663.65) = 1.704, p=.192$, tools $F(1, 663.60) < 1$, or vehicles, $F(1, 586.59) = 1.74, p=.188$. Comparisons of shared and shared-shared conditions produced a significant main effect of ISI for animals, $F(1, 197.55) = 4.89, p < .05$. Pairwise comparisons revealed that reaction times in the 600 ISI condition were significantly ($p < .05$) faster than reaction times in the 200 ISI condition. Responses to tools did not produce a significant main effect of ISI, $F(1, 208.60) = 1.44, p=.23$, neither did response to vehicles, $F(1, 179.82) < 1$. Likewise, comparisons of distinctive and distinctive-distinctive prime conditions did not result in significant main effects of ISI for animals, $F(1, 228.9) = 1.43, p=.23$; tools, $F(1, 222.70) < 1$; or vehicles, $F(1, 210.33) = 2.95, p=.09$.

Word Frequency Effects

When comparing SRTs from prime conditions of shared, distinctive, combined and neutral primes, only responses to animal targets revealed significant effects of frequency, $F(2, 665.90) = 6.43, p < .05$. Pairwise comparisons showed that reaction times to high frequency animals were faster than reaction times to medium frequency animals. Frequency did not have a significant effect on SRT for picture naming of tools $F(1, 666.76) < 1$, or vehicles $F(2, 589.10) = 2.09, p=.12$.

Comparison of SRTs of picture naming when primes were one shared feature and two shared features revealed no significant effects of frequency. The results from neither animals, $F(2, 194.88) = 2.87, p=.059$, tools, $F(1, 205.54) = 1.05, p=.307$, nor vehicles, $F(2, 179.22) < 1$ was significant. Analysis of frequency effects on SRT's following primes of one distinctive and two distinctive features, resulted in significant effects from only animal targets, $F(2, 230.88) = 4.18, p<.05$. Pairwise comparisons indicate reaction times to high frequency animals were significantly ($p<.05$) faster than reaction times to medium frequency animals. Frequency effects from neither tools, $F(1, 220.04) < 1$ nor vehicles, $F(2, 204.27) = 1.24, p=.293$ was significant.

Table 3-1. Raw mean SRT for younger adults for comparison of neutral, shared features, distinctive features, and combination of shared and distinctive features prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses.

Category	Prime Condition	Raw Mean SRT	Standard Error
Animals	Neutral	677.83	235.70
	Shared	695.18	541.28
	Distinctive*	637.81	308.88
	(Faster than neutral primes, $p < .05$ Faster than shared primes, $p = .001$)		
	Distinctive & Shared	665.34	331.52
Tools	Neutral	775.27	424.63
	Shared	783.72	483.57
	Distinctive	767.27	466.62
	Distinctive & Shared	768.28	354.28
Vehicles	Neutral	722.76	245.66
	Shared	687.80	259.64
	Distinctive	679.26	365.92
	Distinctive & Shared	715.57	304.34

Table 3-2. Raw mean SRT for older adults from comparison of neutral, shared features, distinctive features, and combination of shared and distinctive features prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses.

Category	Prime Condition	Raw Mean SRT	Standard Error
Animals	Neutral	661.38	207.21
	Shared	695.52	272.11
	Distinctive*	634.34	303.19
	(Faster than shared features, $p=.001$)		
	Distinctive & Shared	647.25	243.64
Tools	Neutral	769.70	303.69
	Shared	706.65	276.82
	Distinctive*	665.89	254.50
	(Faster than neutral primes, $p<.05$ Faster than shared features, $p<.05$ Faster than combined features, $p<.05$)		
	Distinctive & Shared	771.42	360.65
Vehicles	Neutral	701.04	236.43
	Shared	788.50	450.97
	Distinctive*	656.21	307.39
	(Faster than shared primes, $p=.001$)		
	Distinctive & Shared	656.18	227.95

Table 3-3. Raw mean SRT from comparison of shared versus shared-shared prime conditions. There were no significant effects of prime condition.

Category	Prime Condition	Raw Mean SRT	Standard Error
Animals	Shared	696.30	270.81
	Shared & Shared	694.25	275.83
Tools	Shared	713.52	304.50
	Shared & Shared	690.18	196.16
Vehicles	Shared	774.75	412.43
	Shared & Shared	810.19	507.90

Table 3-4. Raw mean SRT from comparison of distinctive and distinctive-distinctive prime conditions. There were no significant effects of prime condition.

Category	Prime Condition	Raw Mean SRT	Standard Error
Animals	Distinctive	625.89	289.44
	Distinctive & Distinctive	651.35	330.27
Tools	Distinctive	669.67	248.42
	Distinctive & Distinctive	658.38	267.60
Vehicles	Distinctive	671.48	325.08
	Distinctive & Distinctive	630.53	275.01

Table 3-5. Raw mean SRT from comparison of 200msec and 600msec ISI for the prime conditions of neutral, shared features, distinctive features, and combination of shared and distinctive features. There were no significant effects of ISI.

Category	ISI	Raw Mean SRT	Standard Error
Animals	200	679.62	294.65
	600	638.87	246.72
Tools	200	713.23	281.64
	600	715.41	311.25
Vehicles	200	711.60	330.48
	600	695.20	360.63

Table 3-6. Raw mean SRT from comparison of 200msec and 600msec ISI for the shared feature prime conditions. Asterisks indicate significant pairwise comparisons which are described in parentheses.

Category	ISI	Raw Mean SRT	Standard Error
Animals	200	740.33	303.57
	600*	653.85	232.88
	(Faster than 200ISI, $p < .05$)		
Tools	200	702.39	249.74
	600	711.18	304.03
Vehicles	200	799.11	464.01
	600	777.35	438.95

Table 3-7. Raw mean SRT from comparison of 200msec and 600msec ISI for the distinctive feature prime conditions. There were no significant effects of ISI.

Category	ISI	Raw Mean SRT	Standard Error
Animals	200	657.65	325.99
	600	609.32	275.77
Tools	200	654.86	210.44
	600	673.55	281.56
Vehicles	200	667.80	240.45
	600	642.39	372.62

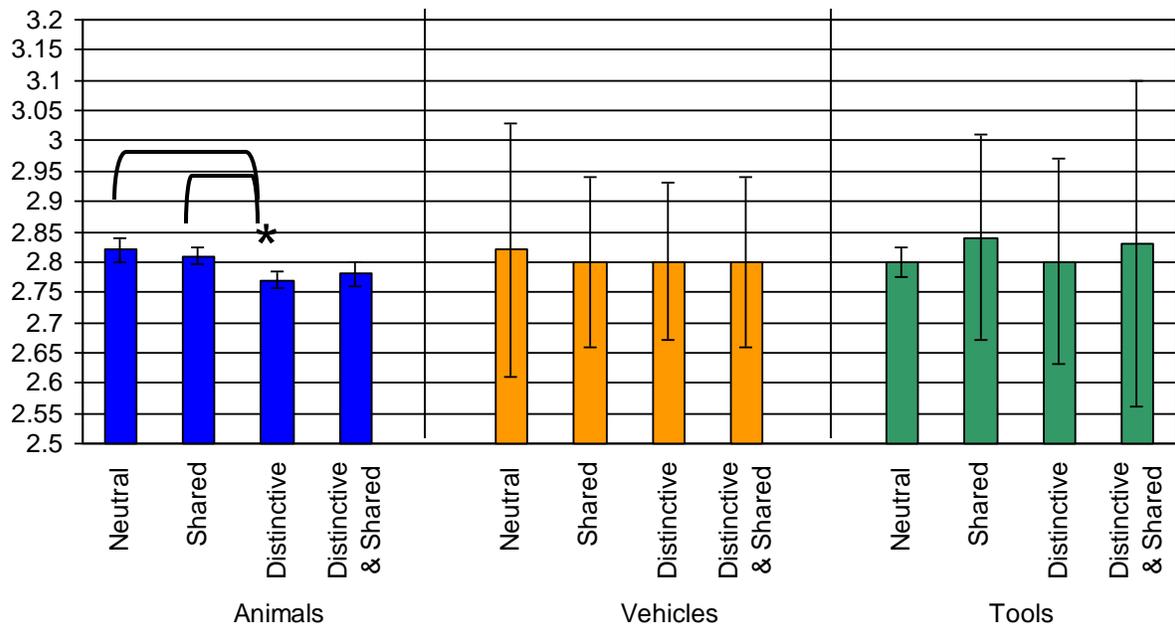


Figure 3-1. Log-transformed mean SRT of young adult responses from comparison of neutral, shared, distinctive and combined prime conditions. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs.

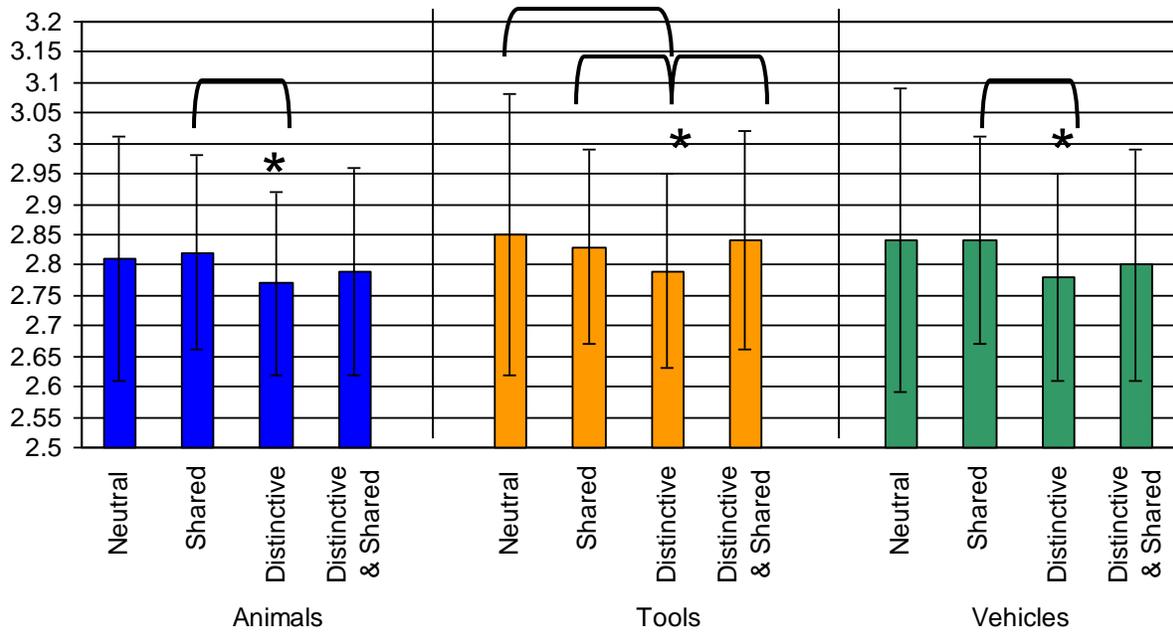


Figure 3-2. Log-transformed mean SRT of older adult responses from comparison of neutral, shared, distinctive and combined prime conditions. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs.

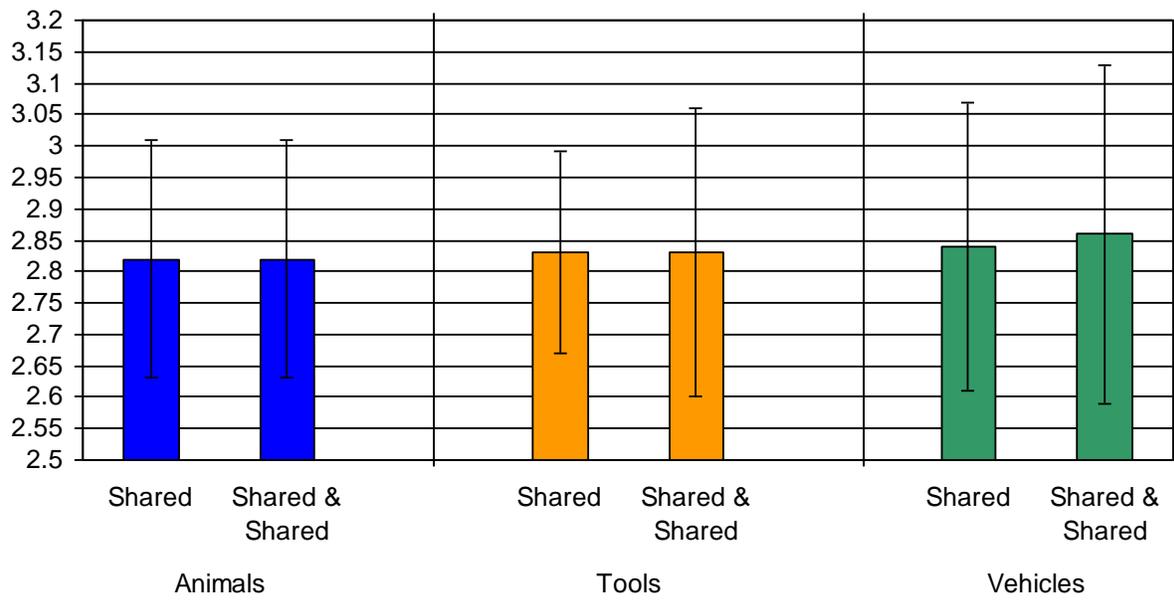


Figure 3-3. Log-transformed mean SRT of older adult responses from comparison of shared and shared-shared prime conditions. There were no significant effects of prime condition.

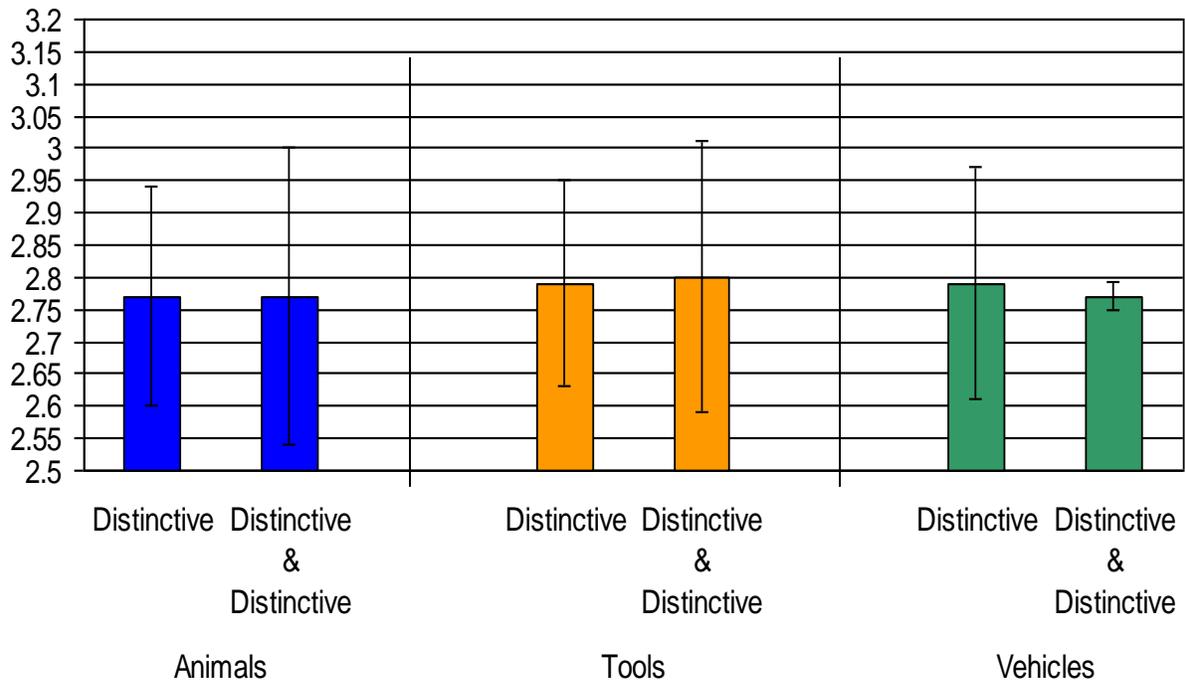


Figure 3-4. Log-transformed mean SRT of older adult responses from comparison of distinctive and distinctive-distinctive prime conditions. There were no significant effects of prime condition.

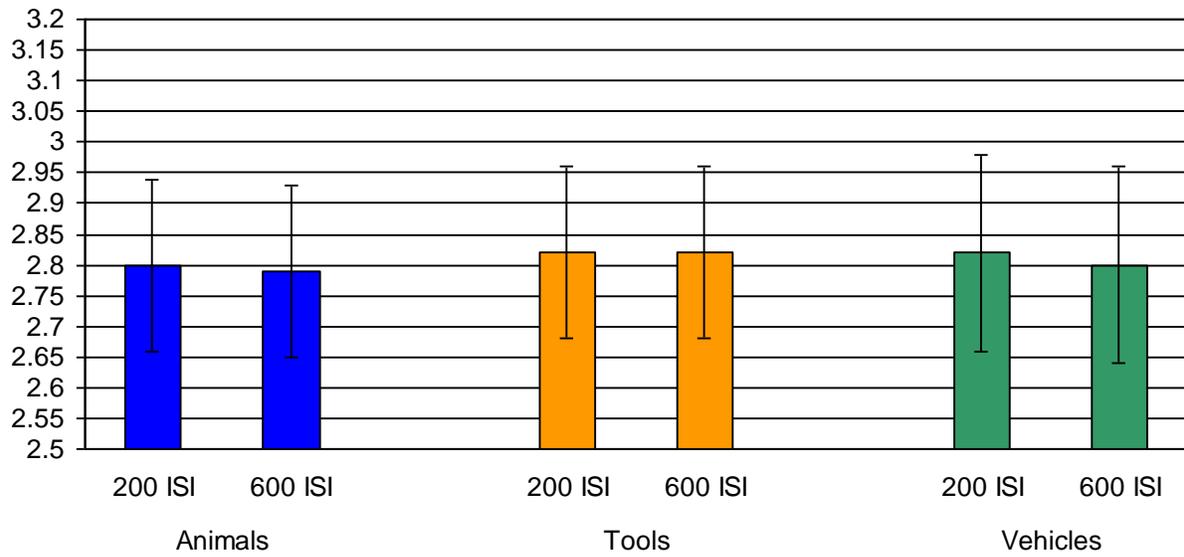


Figure 3-5. Log-transformed mean SRT of older adult responses to all prime conditions (collapsed across shared, distinctive, combined, and neutral primes) at 200 ISI versus 600 ISI. There was no significant difference in SRT between ISI conditions.

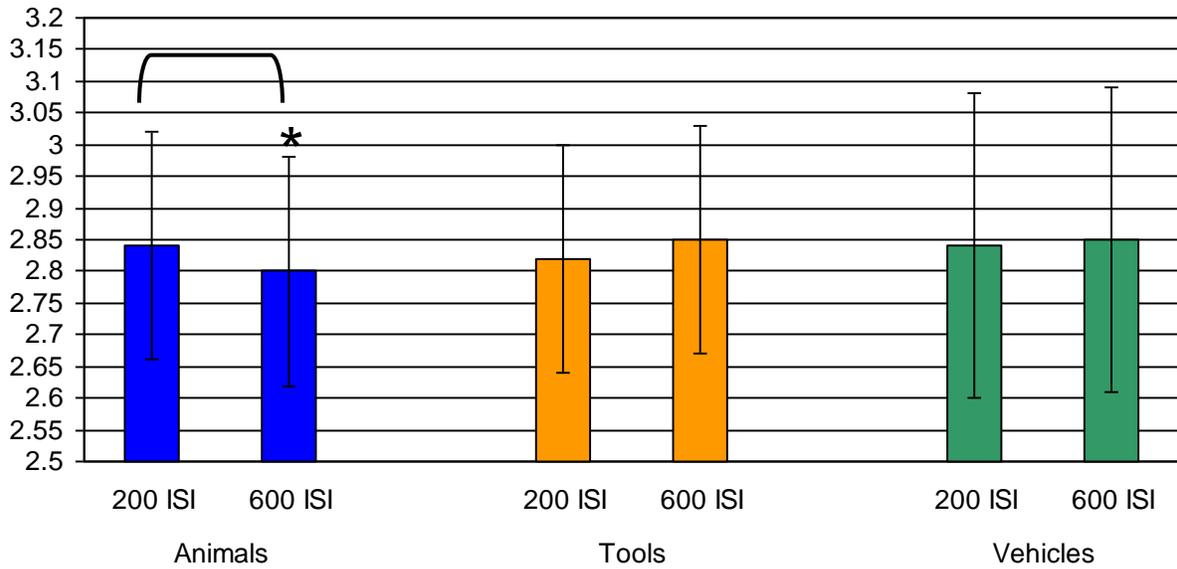


Figure 3-6. Log-transformed mean SRT of older adult responses to shared primes (collapsed across shared and shared-shared) primes at 200 ISI versus 600 ISI. Brackets indicate significant pairwise comparisons. Asterisks indicate the prime condition which produced significantly faster SRTs.

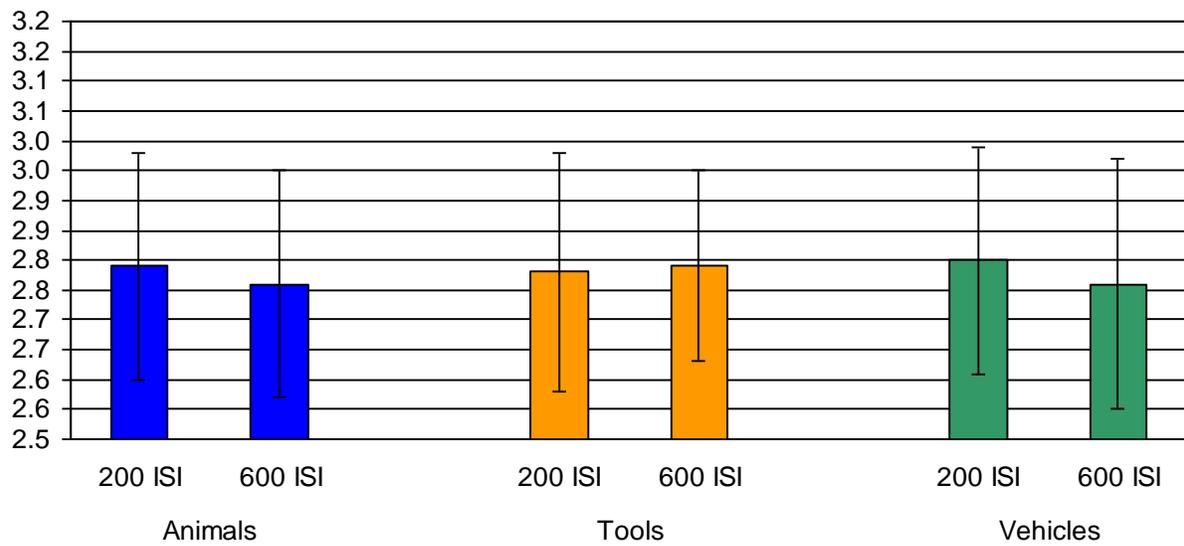


Figure 3-7. Log-transformed mean SRT of older adult responses to distinctive primes (collapsed across distinctive and distinctive-distinctive) primes at 200 ISI versus 600 ISI. There was no significant difference in SRT between ISI conditions.

CHAPTER 4 DISCUSSION

The purpose of this study was to investigate the roles of shared and distinctive features, as proposed by the CSA, in conceptual activation. The principles of the CSA could be used to further specify the stimuli used in anomia treatments however, it is unknown if shared and distinctive features can be used to activate concepts because previous studies have used concept-to-concept activation and not feature-to-concept activation, the route used in anomia treatments. Additionally, there is evidence that more time is necessary to allow convergence of meanings from multiple primes which in turn leads to increased priming and semantic facilitation. Thus, the current experiment was conducted at two inter-stimulus intervals.

Overall, the results showed that indeed, as stated in the CSA, distinctive features have a privileged role in concept activation. However, the proposed differential roles of shared and distinctive features in living and nonliving things, was not confirmed. Additionally, the results indicate that more time was not necessary to consolidate the information from two primes. The results are discussed below with respect to theoretical and clinical implications.

Priming Effects from Related Features and Neutral Primes

SRT was compared in priming conditions of related features (shared, distinctive, or combined) and neutral primes (*blank*) to establish the validity of feature-to-concept priming. Only the tools category revealed a significant difference in SRTs when primes were related compared to SRT's when the prime was the word *blank*. This is most likely due to the difference in frequency between tools and; animals and vehicles. As seen in appendix B, animals and vehicles had greater average frequencies (21.39 and 86.16,

respectively) than tools (5.96). Consequently, participants' greater exposure to animals and vehicles left little need for feature primes resulting in non-significant differences in SRT between feature primes and neutral primes. On the other hand, participants' reduced exposure to tools allowed the feature primes to boost concept activation. Most importantly, there were significant differences in the priming effects of the feature types for all semantic categories.

The Effect of Feature Type

The first analysis investigated the hypothesized difference between the roles of shared and distinctive features, in the representation of living and nonliving things, by measuring the difference in SRT for picture naming following primes of shared or distinctive features or a combination thereof. Based on the CSA (Tyler & Moss, 2001; Taylor et al., 2007), it was predicted that in living nouns (animals and vehicles), priming with shared features would result in shorter SRTs than priming with distinctive features, due to greater spread of activation from strongly correlated shared features and weaker correlation of distinctive features to other features. In the activation of non-living nouns (tools), distinctive features were predicted to boost performance over shared features due to the stronger correlations and greater number of distinctive features than shared features. For all domains of nouns, a combination of shared and distinctive features was predicted to be the optimal condition for performance because the semantic category is activated as well as a feature unique to that concept which will lead to identification of the concept from its category neighbors. Table 1-1 displays these predictions.

Overall, the predictions of the current study were not confirmed. Analysis of reaction times of animal, tools, and vehicle picture naming revealed that distinctive

feature primes consistently had a greater effect compared to shared feature or combination of shared and distinctive feature primes. Although, the CSA proposes that distinctive features play a critical role in concept activation, the level of information about a concept carried by distinctive features is proposed to be different in living and nonliving things. The CSA claims that because of weaker correlations between distinctive features and other features, distinctive features are less informative of living things than shared features with stronger correlations to other features; conversely, distinctive features of nonliving things are more informative and have stronger correlations to other features than shared features of nonliving things. Consequently, it was not surprising that in activation of tools, distinctive features produced the fastest SRTs. Although, the same result in living things was surprising it is not unique to this study. Cree, McNorgan and McRae (2006) reported identical results. They used two feature verification tasks, one with concept primes and feature targets and importantly one with feature primes and concept targets (as in the current study). Distinctive features consistently led to faster feature verification regardless of the conceptual classification as living or nonliving. Additionally, Cree et al. conducted a computer simulation similar to a feature verification task. The simulation showed that distinctive features activated the target concepts more strongly than did shared features. The findings of Cree et al. and the current study may be attributed to the high level of distinctiveness used in both studies.

The distinctive features used in this study, and those used by Cree et al. (2006) were not only distinctive but were unique to a single concept, thus exposure to this information alone (without a shared feature) could activate one concept only. For

example, the distinctive features of *quacks*, *cocoon*, or *udders* activate only the concepts of *duck*, *butterfly*, or *cow*, respectively. Likewise, the distinctive features of vehicles used in this study were also unique to each concept (e.g. *hovers-helicopter*, *mast-sailboat*, *caboose-train*) resulting in only one possible concept. Thus, it appears that when a feature is unique to a concept and not ambiguous, it will activate the concept without need of activating the category explicitly, through shared features. Furthermore, some of the shared features used in this study had very high concept production frequencies. As described in the methods, concept production frequency is the count of how many times the feature was listed in the norms by McRae et al. (2005). Shared features with high concept production frequencies may have provided minimal information on category membership. For example *large* was seen for animals as well as vehicles, consequently, *large* supplied minimal information regarding the target. In comparison, *metal*, a shared feature for tools, at the least indicated the target was a nonliving thing, thereby activating fewer semantic neighbors than *large* which could refer to a living or nonliving thing.

This raises an important issue which should be addressed in future studies investigating the CSA. It appears that the proposed distinction, between the roles of shared and distinctive features in living and nonliving things, is relative to the level of distinctiveness of the feature. A highly shared feature does little to activate the semantic category or neighborhood, of a living or nonliving thing. On the other hand, a highly distinctive feature, of a living or nonliving thing, can activate the concept directly; or, has stronger connections than proposed, to activate related features and lead to

activation of the concept. Further specifying the effects of different levels of shared and distinctive features is critical to the applicability of the CSA.

The most surprising finding was the lack of a significant difference in reaction times following, combined shared and distinctive feature primes, compared with distinctive feature primes alone, or shared feature primes. It was hypothesized that a combination of shared and distinctive features would result in the fastest SRT because the participant would have information on category membership and information unique to the target concept prior to seeing the target. The results however, suggest that shared features did little to activate the concept, whether presented alone or in combination with a distinctive feature.

One explanation is that, shared features activated large sets of semantic neighbors which could not be inhibited by the activation of the distinctive feature. In recent work, Mirman and Magnuson (2009) explain this effect at the featural level using the mechanisms of excitation and inhibition, as presented in the semantic neighborhood model. In the process of activating *lion*, shared features which also belong to *tiger* are activated (e.g. *predator, teeth, wilderness, and circus*), thus, *tiger* is partially activated. The activation of distinctive features of *lion* (*mane*) leads to inhibition of *tiger* while adding to the excitation of *lion*. In regards to the features of the current study, the shared feature prime of *four legs* would activate most animals to some degree. If the distinctive feature of *humps* has weak correlations to other features of *camel*, as suggested by the CSA, it may not provide enough additional activation to signal the system to inhibit all other four-legged animals while further exciting *camel*. Thus, the

distinctive feature of *hump*, seen without a shared feature, was just as effective in activating *camel*.

The Effect of Number of Features

The second analysis investigated the effects of multiple shared features on SRT of picture naming to determine if number of features had an effect on concept activation. The findings for animals, tools, and vehicles were identical; there was no difference in priming effects from one or two shared features, or from one or two distinctive features.

For living things (animals and vehicles), it was predicted that multiple shared features would increase priming because these features have strong connections with other features; as such, direct activation of several features should result in activation of several other features. However, it appears that this activation did not reach a measurable level. The prediction for nonliving things (tools) was that multiple shared features would not affect priming because these features have weak connections to other features. Results from analyses of research question one showed that shared features with or without a distinctive feature did not significantly prime picture naming for any category. Therefore, it is not surprising that increasing the number of shared features shows no difference. If *four-legged* activated animals the addition of *fur* does little to focus the activation within the semantic neighborhood of animals given so many four-legged animals have fur. The CSA model states that shared features reflect category membership only; these results suggest that multiple references to the category do not increase activation of that category.

In regards to the effects of multiple distinctive features, it was predicted that for activation of tools, increasing the number of distinctive features would increase priming because these features have strong connections to other features; thus, activating

several features would result in activation of several other features prior to viewing the target. On the other hand, for animals and vehicles it was predicted that increasing the number of distinctive features would not increase priming because these features have weak connections to other features. In the present paradigm, there was no significant difference in SRT when the primes were one or two distinctive features for animals, tools, or vehicles. Given the findings in research question one analyses that activation from distinctive features was greater than from shared features or a combination of shared and distinctive, it appears that multiple distinctive features are not necessary to activate a concept in any category. If the distinctive feature is unique to the concept, and therefore, will only activate one concept, additional distinctive features are not necessary to boost activation. The null effects of multiple features have interesting implications for anomia treatments which will be address in clinical implications below.

The Effect of Timing on Multiple Feature Primes

The comparison of priming effects at 200 and 600 ISI was motivated by the work of Milberg and colleagues (2003) who found overadditive priming effects at 600 ISI and additive effects at 200 ISI. Additive effects indicate the priming effect from two sequential primes is the same as adding the priming effect of each prime when presented individually; thus, there would be no significant difference in SRTs from conditions with one or two primes. Overadditive effects suggest the priming from two sequential primes is greater than adding the priming effects of each prime presented individually; therefore, there would be a significant difference in SRT from conditions with one or two primes. Additionally, multiple primes can result in underadditive effects which occur when the facilitation of multiple primes is less than the total facilitation of each prime individually. The current findings suggest multiple feature primes produce

underadditive effects, i.e. there is no benefit to presenting multiple feature primes. There is one exception to this finding. There were overadditive effects for naming animals when primed with only shared features. The implications of these results are discussed below.

In all prime conditions, except shared conditions, there was no difference in SRT when ISI was increased from 200msec to 600msec. This result is particularly interesting for the conditions containing a distinctive feature because in earlier analyses where ISI was collapsed, distinctive features produced the strongest priming effects. Consequently, it would seem plausible that this effect would increase over time. However, it appears that distinctive features do not need more time to activate the concept. As discussed earlier, this may be attributed to the high level of distinctiveness of the distinctive feature primes. If the distinctive primes of *periscope* and *underwater* can only activate *submarine*, then more time is not needed; i.e., there are not several concepts which could emerge from the activation patterns of *periscope* and *underwater* which would require time to reach a stable state. Consequently, the priming effects from such highly distinctive multiple primes do not change over time.

The one significant finding in analysis of ISI was in naming animals when primed with shared features; SRTs from the 600 ISI condition were faster than in the 200 ISI condition. Given that earlier analyses suggested the effects of shared features of any semantic category are not measurable in this task, this finding is surprising. The lack of priming effect from shared features in earlier analyses was partially attributed to the highly shared features used in this study (e.g. *large* or *metal* which both belong to many concepts). Again, the high shared value of the features may be implicated in the null

effects of ISI. Highly shared features (e.g. *legs* or *large*) may require more time to consolidate with other highly shared features (e.g. *fur* or *feathers*) because of the large semantic neighborhood each feature activates. When each feature is activated, related features are partially activated. Highly shared features will have many related features; consequently, a large semantic neighborhood is partially activated. Much of this neighborhood must be inhibited in the process of activating the target. Thus, with more time (600msec versus 200msec) the system is able to inhibit the features unrelated to the target and increase activation of the overlapping units from the shared primes.

The Effect of Word Frequency

In general, there was minimal influence of frequency on reaction times. Only SRTs to animal targets were affected by frequency, in the expected direction of faster reaction times following high frequency items. This effect was seen in analyses comparing the prime conditions of shared, distinctive, combined, and neutral; as well as analysis comparing shared and shared-shared prime conditions. The lack of frequency effect for vehicles and tools compared to animals is likely due to differences in category size. There are many more animals in semantic memory than vehicles and tools. Word frequency may play a larger role in semantic activation when there is larger semantic neighborhood and therefore, more competitors. However, there were no significant interactions between frequency and prime condition; therefore the significant priming effects are valid regardless of frequency differences.

Limitations

The comparison of only one and two features, may have limited the effects of combining feature types. A difference in priming may be seen with a greater number of features. Specifically, the effects of multiple shared features may be measurable when

comparing one shared feature to three or five shared features. Likewise the comparisons of one feature type to combined features are limited by having used only combinations of one shared and one distinctive. Comparing several shared and distinctive features, and even varying the number of each paired together (e.g. 1 shared, distinctive; 2 shared, 3 distinctive), could provide further insights into the level of information carried by each feature type.

With regards to the effects of multiple primes over time, the findings are limited to the use of 200msec and 600msec. As mentioned earlier, the aim of neither the Milberg et. al (2003) study nor the present work was the delineation of automatic and controlled processes. Certainly, the mechanisms of feature-to-concept activation, and the roles of shared and distinctive features would be further clarified by comparing the results from priming paradigms administered under controlled and automatic processes. However, the goal of the current study was to establish the validity of feature-to-concept activation and test the role of shared and distinctive features in such a paradigm.

Additionally, the current study did not employ a timed response. Randall et al. (2004) found slower activation from distinctive features of living things compared to distinctive features of nonliving things only when there was a response deadline. In an untimed version of the task there was no difference. Consequently, the differential roles of shared and distinctive features in living and nonliving things may be time dependent. The interaction of time and feature-to-concept activation is important for the clinical application of the CSA; however, more empirical evidence of an interaction is required.

Implications for Anomia Treatment

Two issues addressed in the current study have implications for anomia treatment: the use of multiple features for activation of a concept and the effects of shared and

distinctive features on concept activation. In regards to the former, the current study would suggest that asking a patient to name several features of a target concept or providing the patient with multiple features of a target is not the optimal condition for concept activation. In fact, the work of Mirman and Magnuson (2008) would further suggest that in the case of shared features, especially, multiple primes will lead to semantic competition. Consequently, semantic feature treatments may be improved in terms of treatment outcomes, if the number of semantic questions per target item were reduced.

The second issue regarding clinical treatments which the current findings can address is the feature type used in treatment. Clearly the current findings suggest that distinctive features have the greatest effects on feature-to-concept activation. The findings by Mirman and Magnuson (2008) regarding inhibitory effects of near neighbors and facilitative effects of distant neighbors, as well as the CATE approach (Thompson et. al, 2003), similarly suggest that distinctive features are more beneficial for feature-to-concept activation. Certainly, semantic feature treatments do include activation of distinctive features; however, a more explicit focus on these features may improve treatment outcomes.

Future Directions

The Conceptual Structure Account (Tyler & Moss, 2001; Taylor et al., 2007) is currently modeled in healthy adults and individuals demonstrating category-specific semantic deficits resulting from herpes-simplex encephalitis or other degenerative disease. Extending this theory to aphasia may add specificity to the claims of the CSA regarding the structure of the semantic system. Specifically, a comparison of individuals with aphasia and individuals with semantic dementia on a paradigm similar

to the current experiment may be useful in specifying effects of feature correlation on activation. Persons with a degrading semantic system may not be able to use feature correlations as well as someone with lexical-semantic access impairment. In addition, several question related to methodology remain. Answering these questions will further specify the claims of the CSA:

Are the results of this study different when there is a response deadline?

How do the roles of shared and distinctive features compare when used in automatic versus controlled processing?

Does order of prime type (shared-distinctive, distinctive-shared) affect SRT in a picture naming paradigm?

Do other psycholinguistic variables (number of phonemes, phonotactic probability, familiarity etc.) of the target items affect the difference in SRT between prime conditions?

Does manipulation of the concept production frequencies (i.e. manipulating the degree to which features are distinctive or shared) change the effect of the prime conditions on SRT?

Summary

In a series of analyses of speech reaction times following multiple feature primes during a picture naming task, the most consistent finding was greater priming after distinctive feature primes as compared to shared primes, distinctive and shared primes, or neutral primes. One of the most central hypotheses of the Conceptual Structure Account (Tyler & Moss, 2001; Taylor et al., 2007) is the unique and critical role of distinctive features in semantic space and conceptual activation. The current study supports this claim and validates it in verbal production, a language behavior not previously used in investigations of the CSA. The lack of support for the postulates of the CSA regarding differences in the distribution and correlations of shared and distinctive features in living and nonliving things, suggests further research is required to

elucidate these relationships. The unique contribution of the current work is the strong evidence that features prime concepts; suggesting, features can be used to activate the semantic network and indeed different feature types activate the network to varying degrees.

APPENDIX A
PRIME-TARGET STIMULI

Table A-1. Animal Stimuli

Concept	Feature	Feature Type	CPF
butterfly	pollinates	D	1
	cocoon	D	1
	flies	S	46
	small	S	121
camel	spits	D	1
	two humps	D	1
	legs	S	44
	large	S	106
chicken	clucks	D	1
	pecks	D	1
	wings	S	44
	edible	S	78
cow	udder	D	1
	produces milk	D	2
	four legs	S	49
	large	S	106
duck	quacks	D	1
	waddles	D	2
	feathers	S	38
	edible	S	78
elephant	trunk	D	1
	tusks	D	2
	four legs	S	49
	large	S	106
ostrich	large eggs	D	1
	buries head	D	1
	wings	S	44
	large	S	106
pig	squeals	D	1
	curly tail	D	1
	four legs	S	49
	edible	S	78
tiger	roars	D	2
	large teeth	D	2
	ferocious	D	2
	fur	S	22
	large	S	106

D indicates distinctive features, S indicates shared features. CPF is the concept production frequency.

Table A-2. Tool Stimuli

Concept	Feature	Feature Type	CPF
airplane	crashes	D	1
	engine	D	2
	large	S	106
	metal	S	133
bus	many seats	D	1
	fare	D	1
	transportation	S	33
	large	S	106
car	four doors	D	1
	steering wheel	D	1
	wheels	S	23
	transportation	S	33
motorcycle	two people	D	2
	helmet	D	2
	fast	S	33
	loud	S	34
canoe	paddles	D	1
	tips over	D	1
	wood	S	79
	long	S	81
helicopter	hovers	D	1
	propellers	D	2
	loud	S	34
	metal	S	133
sailboat	mast	D	1
	wind	D	2
	floats	S	7
	transportation	S	33
skateboard	board	D	1
	tricks	D	1
	wood	S	79
	long	S	81
submarine	periscope	D	1
	underwater	D	1
	large	S	106
	metal	S	133
train	caboose	D	1
	conductor	D	1
	fast	S	33
	transportation	S	33
unicycle	balance	D	1
	one wheel	D	2
	seat	S	7
	transportation	S	33

D indicates distinctive features, S indicates shared features. CPF is the concept production frequency.

Table A-3. Vehicle Stimuli

Concept	Feature	Feature Type	CPF
axe	metal blade	D	2
	chopping	D	2
	heavy	S	27
	handle	S	42
drill	bits	D	1
	makes holes	D	1
	electrical	S	22
	loud	S	34
hammer	hits nails	D	1
	metal head	D	2
	heavy	S	27
	handle	S	42
hoe	tilling soil	D	1
	metal bland	D	2
	handle	S	42
	long	S	81
rake	gardening	D	1
	prongs	D	2
	long	S	81
	metal	S	133
scissors	blades	D	1
	cuts	D	1
	sharp	S	18
	metal	S	133
screwdriver	tightens	D	1
	turns	D	2
	handle	S	42
	long	S	81
shovel	digging	D	1
	scooping	D	1
	handle	S	42
	metal	S	133
wrench	tightens bolts	D	1
	turns bolts	D	2
	heavy	S	27
	metal	S	133

D indicates distinctive features, S indicates shared features. CPF is the concept production frequency.

APPENDIX B
TARGET WORD FREQUENCY

Table B-1. Taret Word Frequency

Category	Target	Bryshaert and New (2009) Frequency (per million words)	Frequency Category
Animals			
	Butterfly	5.51	Low
	Camel	5.02	Low
	Chicken	61.73	High
	Cow	25.51	High
	Duck	24.76	High
	Elephant	11.37	Medium
	Ostrich	0.94	Low
	Pig	39.14	High
	Tiger	18.53	Medium
Average		21.39	
Tools			
	Axe	4.88	Low
	Drill	13.75	Medium
	Hammer	12.47	Medium
	Hoe	0.92	Low
	Rake	2.98	Low
	Scissors	6.69	Low
	Screwdriver	0.06	Low
	Shovel	6.84	Low
	Wrench	3.96	Low
Average		5.96	
Vehicles			
	Bus	74.18	High
	Canoe	3.57	Low
	Car	483.06	High
	Helicopter	15.80	Medium
	Motorcycle	8.92	Low
	Sailboat	1.61	Low
	Submarine	7.10	Low
	Train	95.06	High
Average		86.16	

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BIOGRAPHICAL SKETCH

Christina del Toro received her bachelor's and master's degrees in communication sciences and disorders from the University of Florida in 2004 and 2006, respectively. She received clinical training as a speech-language pathologist at the Malcom Randall Veterans Affairs Medical Center in Gainesville, FL. She has been involved in research at the VA Brain Rehabilitation Research Center since her undergraduate years. She has taught undergraduate and graduate level courses at the University of Florida and the University of Washington. She plans to continue research and teaching in speech-language pathology as an academician.