THE EFFECTS OF NAME AGREEMENT ON DUAL-TASK PICTURE NAMING

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The understanding of the relationship between attention and normal language processing can provide insight into the underpinnings of language disorders. Dual-task experiments can be used to understand the allocation of attention during different stages of word production. The central bottleneck model posits that while the central (response selection) stage of any cognitive task is being carried out, the same stage of any other task cannot be simultaneously carried out. The central bottleneck model permits the testing of specific hypotheses about the attentional requirements of particular elements of competing tasks. One purpose of the current study was to determine if the process of lemma selection can be said to require central attention. A secondary aim of this study was to determine whether name agreement is a variable that can be used to index lemma selection. A preliminary study was conducted to construct a set of pictures with high and low name agreement that were balanced on important confounding variables. The main experiment was a dual-task experiment involving tone identification and picture naming. Name agreement effects were examined in the dual-task experiment. The effects were investigated in relation to the central bottleneck model, word production models, and the semantic picture-word interference effect. Low name agreement due to multiple correct names was employed. Tone identification was the primary task, while picture naming was the secondary task. Average picture naming reaction times were significantly longer for low than for high name agreement condition across levels of stimulus onset asynchrony. The results are consistent with a locus of

the name agreement effect at the central, response selection stage of the central bottleneck model.

TABLE OF CONTENTS

LIST OF TABLES

PREFACE

The support which I received from several sources was invaluable to the completion of this thesis. I would like to first thank Dr. William Hula for all of the time and work that he has put forth in aiding me to succeed in completing this work. His efforts were above and beyond what I could have expected from a thesis co-director. My thesis committee offered their time and advice and stimulated my thinking about the issues relevant to my thesis. Their insight was vital to my understanding of this material. I would like to thank Dr. Michael Walsh Dickey, my thesis co-director, for the use of his laboratory space for data collection and also those working in his laboratory for accommodating my scheduling requests. The contributions of Casey Regula and Mary Sullivan in coding the data collected are also appreciated. Finally, the School of Health and Rehabilitation Sciences Research Development Fund supported the completion of this thesis financially for which I am grateful.

1.0 INTRODUCTION

Models of dual-task performance have increasingly been used to understand the stages of word production. A dual-task experiment requires that an individual completes two tasks simultaneously or in rapid succession. Several models have been proposed for use in identifying the stages and time course of task completion in dual-task experiments. The central bottleneck model is the model which is applied in this study. A picture-word interference (PWI) task has also been used to examine linguistic processing during picture naming (Damian & Martin, 1999; Dell'Acqua et al., 2007; Ferreira & Pashler, 2002; Hashimoto & Thompson, 2009; Schriefers, Meyer, & Levelt, 1990). In the PWI task, a picture is presented and the participant is asked to name it. A distractor word is also presented, but the participant is asked to ignore the word. It has been found that if the distractor word is a semantic coordinate of the picture name, interference results. This semantic interference effect has been hypothesized to arise as a result of increased competition between semantic representations, which is referred to here as lemma selection, during word production (Schriefers, Meyer, & Levelt, 1990). It has been suggested by some that resolving this interference does not require central attention (Dell’Acqua et al., 2007). Dell’Acqua and colleagues (2007) performed a dual-task study using tone identification and a PWI task and concluded that the locus of the picture-word interference effect was precentral.

The purpose of this study was to address the question of whether lemma selection requires central attention through the use of another variable, name agreement, which has been hypothesized to index lemma selection (LaGrone and Spieler, 2006; Vitkovitch & Tyrrell, 1995). Name agreement refers to the degree to which participants produce the same name for an object or picture stimulus (Lachman, 1973; Lachman, Shaffer, & Hennrikus, 1974; Vitkovitch & Tyrell, 1995). Several picture naming studies (Lachman, 1973; Lachman et al., 1974; LaGrone & Spieler, 2006; Vitkovitch & Tyrrell, 1995) have shown that picture naming latencies increase as name agreement decreases. Several types of low name agreement have been identified by Vitkovitch & Tyrrell (1995), including low name agreement due to multiple correct names. These authors proposed that this type of low name agreement occurred after visual recognition and was likely due to competition during lemma selection.

The specific aims of this study were examined through the use of a dual-task experiment involving tone identification and picture naming. The following questions were addressed in this study:

Specific Aim 1: Do name agreement and the PWI effect index the same stage of word production?

Specific Aim 2: Does resolving the effects of low name agreement due to multiple correct names require central attention?

2.0 BACKGROUND AND SIGNIFICANCE

2.1 BACKGROUND

2.1.1 Attention and Language

Determining the extent to which cognitive processing inherent to normal language use requires attentional resources can significantly affect our understanding of aphasia. One theory of attention proposes that there are pools of cognitive resources from which different cognitive processes can draw (Kahneman, 1973). The amount of attention necessary for different cognitive processes is thought to vary according to the task being performed. Language deficits in individuals with aphasia may arise from the inability to properly allocate attention to certain cognitive processes, in particular linguistic processes (McNeil, Odell, & Tseng, 1991).

2.1.2 Central Bottleneck Model

One way to investigate the use of resources by different cognitive processes is through the use of a dual-task paradigm. In a dual-task paradigm, the participant is asked to perform two tasks simultaneously or in rapid succession. Performing even moderately complex tasks simultaneously or in rapid succession has been shown to create dual-task interference (Pashler, 1994). The central bottleneck model has been used to understand dual-task performance. It suggests that some cognitive processes can be performed simultaneously, while others cannot (Ferreira & Pashler, 2002). According to this model, those processes that cannot occur in parallel require a cognitive resource or resources that are shared by all tasks or domains, which has been referred to as central attention (Johnston, McCann, & Remington, 1995). Three stages of cognitive processing are hypothesized: perception, response selection, and response production (Pashler, 1994). Perception and response production, also referred to as the precentral and postcentral stages respectively, do not require central attention under the central bottleneck model. On the other hand, the response selection, or central, stage of cognitive processing does require central attention. The use of central attention is "all-or-nothing" under the central bottleneck model (Tombu & Jolicoeur, 2002). In other words, while the response selection stage of one task is using central attention, the response selection stage of another task cannot begin until central processing of the first task is complete. It should be noted that a competing resource or capacity sharing model analogous to the central bottleneck model has been proposed (Navon & Miller, 2002; Tombu & Jolicoeur, 2003), and supported with empirical evidence (Tombu & Jolicoeur, 2002; 2005). Under the central capacity sharing model, the central stage operates by graded sharing of resource capacity, rather than by the serial, all-or-none operation. These two models make identical predictions for secondary-task reaction times, and thus, the distinction between them is irrelevant for the current study.

The psychological refractory period (PRP) paradigm is a type of dual-task paradigm that has been used to investigate the use of central attention by different cognitive processes (e.g., Dell'Acqua, Job, Peressotti, & Pascali, 2007; Ferreira & Pashler, 2002). In the PRP paradigm, presentation of the stimuli for a primary and a secondary task is separated by various stimulus onset asynchronies (SOAs). As SOA is shortened, the reaction time for the second task is typically lengthened, and this effect is referred to as the PRP effect (Pashler, 1994). According to the central bottleneck model, the PRP effect results from the fact that as SOA is shortened, the response selection stages of both tasks overlap increasingly. Thus, the response selection stage of the second task is increasingly delayed due to the central bottleneck, increasing Task 2 reaction times.

The manipulation of certain variables can affect the efficiency with which certain stages of a task are carried out (Ferreira & Pashler, 2002). The central bottleneck model predicts specific outcomes in the reaction times of PRP experiments as the lengths of different stages of a task are altered (Pashler, 1994). Depending upon which task and which stage of a task are manipulated, different outcomes are hypothesized. In PRP experiments, patterns of reaction times to Task 2 at short SOAs provide information about which stage of a task is affected by the manipulation of a particular variable (Dell'Acqua et al., 2007; Ferreira & Pashler, 2002; Pashler, 1994).

Reaction times for Task 2 at long SOAs are not typically affected by manipulations of Task 1 (Pashler, 1994). The central bottleneck model accounts for this by positing that at long SOAs the response selection stage of Task 1 is typically complete prior to the start of the response selection stage of Task 2, allowing Task 2 to be completed without delay. Therefore, only manipulations affecting Task 2 can affect its own reaction times at long SOAs. Manipulations to any particular stage will not be differentiable in this case.

Reaction times to Task 1 are typically not affected by manipulations of Task 2 (Pashler, 1994). Under the central bottleneck model, this occurs because the response selection stage of Task 1 always occurs before that of Task 2 and thus has access to central resources first. Thus, all stages of Task 1 are carried out without delay. Only manipulations affecting Task 1 itself can affect its own reaction times under the central bottleneck model.

If the response production, or postcentral, stage of Task 1 is prolonged at short SOAs, no effect on the reaction times to Task 2, other than the PRP effect, is predicted by the central bottleneck model (Pashler, 1994). In this case, the response selection stage of Task 1 is unaffected. Therefore, bottleneck effects do not occur, and only reaction times for Task 1 will be prolonged by the manipulation.

However, according to the central bottleneck model, at short SOAs if either the precentral or central stage of Task 1 is prolonged by manipulation of a variable, then reaction times of both tasks will be increased by the same amount (Pashler, 1994). The model posits that this occurs because the completion of the response selection, or central, stage of Task 1 is delayed by manipulation of the variable. The time at which the resources are freed from the bottleneck will be delayed, and consequently the response selection stage of Task 2 will also be delayed. Regardless of which stage is prolonged, the reaction times of Task 2 will be increased by the amount of time that Task 1 is prolonged.

A picture-word interference (PWI) task has been used to investigate linguistic processing during picture naming (Damian & Martin, 1999; Dell'Acqua et al., 2007; Ferreira & Pashler, 2002; Hashimoto & Thompson, 2009; Schriefers, Meyer, & Levelt, 1990). In the PWI task, a picture is presented and the participant is asked to name it. A distractor word is presented either before, after, or simultaneously with the picture. The participant is asked to ignore the word. It has been found that if the distractor word is a semantic coordinate of the picture name, a semantic interference effect arises, and the picture naming reaction time is delayed relative to an unrelated distractor condition. The locus of the semantic interference effect that arises in PWI tasks has been hypothesized to be a result of increased competition at the level of lemma selection during word production (Schriefers, Meyer, & Levelt, 1990).

While some have posited that competition between semantic representations, which is referred to here as lemma selection, does not require central attention (Dell'Acqua et al., 2007) others have suggested that it does (Ferreira & Pashler, 2002). In their 2002 study, Ferreira and Pashler performed a PRP experiment in which Task 1 was a PWI task, while Task 2 was a tone identification task. In Task 1, a word was presented either simultaneously with a picture or 100 ms after the picture was presented. The relatedness of the word to the picture was manipulated. Distractor words were either semantically related (belonging to the same semantic category), phonologically related (sharing at least the two initial phonemes of the picture name), or unrelated to the picture. A tone was then presented at varying SOAs (50, 150, or 900 ms) after the picture was presented. Ferreira and Pashler (2002) found that in the semantically related distractor word condition, reaction times to the tone identification task were increased by an amount of time comparable to that which Task 1 reaction times were increased. The authors interpreted these results as indicating that the PWI effect could be localized to the response selection/central stage and thus required central attention. However, we argue that there may be an alternate explanation for the pattern of results under the central bottleneck model. The locus of the picture-word interference could in fact be precentral, which would produce the same pattern of results. Ferreira & Pashler's (2002) experimental design was not sufficient to differentiate between the localization of the semantic interference created by the use of semantically related distractor words to either the central or precentral stages.

It is also possible to manipulate variables to affect the complexity of Task 2, resulting in a different set of interpretable reaction time patterns under the central bottleneck model

(Dell'Acqua et al., 2007; Pashler, 2004). At short SOAs, the PRP effect will again be present, with longer Task 2 reaction times overall at short SOAs versus long SOAs. However, the pattern of results in Task 2 reaction times is dependent upon which stage of Task 2 is manipulated. When a variable affecting the precentral or central stages of Task 2 is manipulated, differentiable patterns of results are predicted. If the central or postcentral stages of Task 2 are prolonged by manipulation of a particular variable, the model predicts that the reaction times in this condition will be longer than when Task 2 central or postcentral processing is unaffected (Dell'Acqua et al., 2007; Pashler, 2004). Also, this effect on Task 2 reaction time should not interact with SOA. The central bottleneck model predicts a null interaction between manipulations of Task 2 central or postcentral processing and SOA.

In contrast, the central bottleneck model predicts that manipulations of Task 2 precentral processing will interact with SOA. Specifically, if a variable increases the amount of processing time for the precentral stage of Task 2 at short SOAs, the model predicts that reaction times in both conditions (increased processing time for the precentral stage of Task 1 versus normal processing time) will be the same. This is interpreted under the central bottleneck model as being the result of the delay in processing of the (central) response selection stage in Task 2 while the response selection stage of Task 1 uses bottleneck resources. There is a period of time created between the completion of perceptual encoding and the start of response selection in Task 2. If the processing of the precentral stage of Task 2 is prolonged at short SOAs, it can be completed during this period of time without causing additional delay of the response selection stage.

Dell'Acqua and colleagues (2007) performed a study in which Task 1 required a manual response to a tone and Task 2 required a picture naming response. Half of the trials contained distractor words that belonged to the same semantic category as the picture name, while the other half contained unrelated distractor words. The results showed a PWI effect only at long SOAs indicating that the locus of the PWI effect may be prior to the response selection stage. According to the central bottleneck model, at short SOAs, the response selection stage of the picture naming task is delayed until the response selection stage of Task 1 is complete, creating a period of time between the perception stage and the response selection stage of the picture naming task. According to this account, the PWI effect does not manifest at short SOAs because the interference present in the related distractor condition is resolved during this delay period. At long SOAs, the delay between the perception and response selection stages does not exist. Thus, the picture naming reaction times increase as the interference is resolved. According to this pattern of results, Dell'Acqua and colleagues (2007) concluded that the locus of the picture-word interference effect was precentral, in contradiction to Ferreira & Pashler's (2002) interpretation of their own results.

2.1.3 Word Production Models

A generally accepted class of word production models is based on spreading activation among features or representations (Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Levelt, Roelofs, & Meyer, 1999). Such models propose that different stages, or levels, of word production exist (Dell, 1986; Dell et al., 1997; Levelt et al., 1999). At each level, pieces of information, or nodes, exist. These nodes are connected to each other within and between levels.

In models of lexical access, or word retrieval, the first stages are thought to be dominated by semantic processing while the later stages are dominated by phonological processing (Dell, 1986; Dell et al., 1997; Levelt et al., 1999). According to this class of models, during a picture naming task, word production begins with conceptual features, or lexical concepts, that are activated by a picture stimulus (Dell et al., 1997; Levelt et al., 1999). These conceptual features activate lemmas, which encode semantic and syntactic features of words (Dell et al., 1997; Levelt et al., 1999). Lemmas contain no phonological information. Activation then spreads to later stages including the phonological word form, or lexeme, level. The phonological word form contains whole-word features such as metrical sound properties and information necessary for morphological processes. According to Levelt and colleagues (1999), for example, the phonological word form can be thought of as a frame with open slots. The frame contains information about the metrical properties of a word, such as stress and prosody, as well as morphological information. Next, activation spreads to phonemes, which are segmental sound properties of the word that drive articulation. Thus, lexical retrieval for word production involves at least three stages: lemma selection, phonological word-form selection, and phoneme selection.

Although the models are similar in many aspects, they do diverge on some theoretical points. Dell and colleagues (Dell, 1986; Dell et al., 1997) propose a model that is both interactive and cascaded. Interactive refers to the fact that, in addition to the feedforward mechanism of spreading activation, connections between levels, or stages, are bidirectional and excitatory. This means that lower levels can feedback information to higher levels via these connections. For example, information at the phonological word form level can activate nodes at the lemma level through feedback connections. This is an important distinction between interactive and serial models, such as that of Levelt and colleagues (1999). They propose that connections between stages of word production are feedforward in nature only. Therefore, processes occurring in later stages do not affect activation of nodes in earlier levels. Once a selection process at a level is complete, activation at this level is complete and does not change.

In addition, Dell and colleagues (Dell, 1986; Dell et al., 1997) propose that activation is cascaded in his interactive model rather than discrete as in Levelt and colleagues' (1999) serial model. Under Dell and colleagues' (Dell, 1986; Dell et al., 1997) model, activation can spread to lower levels while processes are continuing at higher levels. In contrast, Levelt and colleagues (1999) propose that activation cannot spread to subsequent stages until processes are complete at earlier levels. This means that, for example, activation cannot spread to the phonological word form level until lemma selection is complete.

Another distinction between the two models is the way in which selection processes occur at each level. Under Dell and colleagues' (Dell, 1986; Dell et al., 1997) model, the node that receives the most activation at each level at the time of selection via connections within and between levels is selected. Under Levelt and colleagues' (1999) model, selection occurs through a binding-by-checking action. Binding-by-checking refers to the process in which, prior to selection at any level, it is "checked" whether the to-be-selected item at this level matches the representation selected at the previous level. For example, when a phoneme is activated, it is first compared to the previously selected phonological word form to ensure that the two are linked together within the network prior to its selection. Consider the PWI scenario in which the target name of a picture is "king" while the distractor word, "page," is presented (Levelt et al., 1999). If the initial phoneme /p/ is activated and then compared to the phonological word form <king>, no link would be found between the two and thus /p/ would not be selected, preventing the word "ping" from being produced. Conversely, if the initial phoneme /k/ is activated and compared to <king>, it would be selected and "binding" would occur between /k/ and <king>. This process would continue for the remaining phonemes of the word.

Support for Levelt and colleagues' (1999) model can be found in latency, or reaction time, studies. A study by Schriefers, Meyer, & Levelt (1990) has been cited by Levelt and colleagues (1999) as support for their discrete model. The study used a PWI paradigm. In Schriefers and colleagues' (1990) study the interfering stimuli were words that were presented auditorily. The words were presented at varying SOAs of 150 ms before the presentation of the picture, simultaneously with the picture, and 150 ms after the presentation of the picture. The words differed in their relationship to the picture names in each of the experiments. They were semantically related, phonologically related, or unrelated to the picture name. Participants were told to ignore the auditory stimuli and name the pictures. Picture naming reaction times from trials in which the picture was correctly named were the dependent variable. The results showed a semantic interference effect at the -150-ms SOA only, along with a phonological facilitation effect at both the 0-ms and 150-ms SOA. The authors interpreted this finding as supportive of a serial model in which feedback from later to earlier stages does not occur, because semantic processing was affected by related distractor words only early during word production while phonological processing was only affected at later SOAs, as would be predicted by such a model. Information processed at the later phonological stage (phonologically related distractor words) did not produce effects at earlier SOAs when earlier semantic processing is assumed to be occurring.

However, these sorts of data can be accommodated by a cascaded, interactive model as well. Damian & Martin (1999) presented auditory distractors in a PWI paradigm at -150, 0, and 150 ms. The distractors varied in their relatedness to the picture name. The relatedness condition included control (no distractor word), unrelated, phonological only, semantic only, and both semantic and phonological conditions. Like Schriefers and colleagues (1990), they found an earlier semantic interference effect with the semantic only distractors and a later phonological facilitation effect with the phonological only distractors. However, in the semantic and phonological condition, an interaction was found between SOA and distractor condition such that the semantic interference effect was attenuated at the -150-ms SOA and entirely eliminated at the 0-ms SOA. The effect at the 150-ms SOA was the only roughly additive effect yielding attenuated phonological facilitation. The authors interpreted these findings as support for interactivity between the stages of word production. They concluded that the presence of an interaction indicates that processing stages are not modular in relation to each other. They hypothesized that the influence of feedback from the lexeme level to the lemma level could explain the interaction found. At the -150-ms SOA condition, priming of the target lemma occurred through feedback from the phonological word form level and thus attenuated the effects of competition at the semantic-syntactic level. Similarly, at the 0-ms SOA, phonological facilitation effects completely eliminated semantic interference effects that were present in the semantic only condition. At the 150-ms SOA, semantic interference effects had decayed almost completely; therefore, the influence of feedback no longer had an effect on reaction times.

Empirical evidence for the support of interactive models like Dell and colleagues' (Dell, 1986; Dell et al., 1997) is most robust in speech error literature (Dell, 1986; Dell & Reich, 1981; Martin, 1996). The prevalence of mixed errors in normal speech shows that activity at the phonological level may affect activity at the semantic levels (Martin, 1996). However, Levelt and colleagues (Levelt, 1991; Levelt et al., 1999) claim that their model can explain this as well by means of a post-lexical self-monitoring mechanism that is not part of the word production mechanism itself. Such a mechanism is driven by selective attention and can be influenced by experimental tasks and instructions in such a manner that certain types of errors (i.e., mixed) may not be monitored as closely as others and thus are produced in higher proportion than others.

It should be noted that the interactivity proposed in Dell and colleagues' (Dell, 1986; Dell et al., 1997) model is local rather than global. This means that effects will be most robust at adjacent levels, and only minor, if any, effects will be present at more distant levels. For example, activity at the phonological word form level may activate nodes at the lemma level via feedback connections. However, activity at the phonological word form level will have little, if any, effects on activation at the conceptual level. For this reason, a stance on the distinction between interactive and discrete models will not be taken in this study as it is not essential to the main goals of the study.

It has been suggested (Caramazza & Miozzo, 1997) that the existence of a lemma level in word production models is unnecessary. Caramazza and Miozzo (1997) argue that there need not be a lemma level as based on their interpretation of Vigliocco, Antonini, & Garrett's (1997) findings as well as their own data that in "Tip of the Tongue" (TOT) states, people can retrieve gender as well as partial phonological information. They argue that the models discussed above predict that at any time, activation at the lemma level and thus available syntactic information (gender) should far exceed that available at the phonological levels. Even though Dell and colleagues' (Dell, 1986; Dell et al., 1997) cascaded models allow for some activation at later levels before selection has occurred at previous levels, this activation should not be enough to pass the threshold to allow a person to access specific phonological information. Caramazza and Miozzo (1997) found no correlation between access of gender and partial phonological information in their experiments or in Vigliocco and colleagues' (1997) data, which Caramazza and Miozzo (1997) interpret as being indicative of the independence of syntactic and phonological information in word production. In fact, participants could provide partial phonological information at a comparable rate as they could provide gender info in TOT states. Caramazza and Miozzo (1997) suggests that these findings are incompatible with a model containing separate lemma and lexeme levels as they claim that such models require a dependence of phonological information retrieval on retrieval of syntactic information, such as gender. Therefore, the authors propose an alternative model of word production that does not include a lemma level. Instead, they propose that there is a single, modality specific lexical level between the semantic and phonological levels. This single level has both syntactic and phonological connections, providing a model that would allow for comparable rates of activation of/access to syntactic and phonological information in TOT states.

Vigliocco and colleagues' (1997) study of the "Tip of the Tongue" phenomenon in Italian participants has also been cited as support for existence of the lemma level (Levelt et al., 1999). When experiencing the phenomenon, the participants could not say the word but were able to produce its meaning as well as its gender. The authors interpreted this as showing that syntactic features must be encoded at a level prior to phonological encoding. A case study of a patient with anomia by Badecker, Miozzo, & Zanuttini (1995) yielded a similar result that was interpreted in the same manner (Levelt et al., 1999). Other studies (Dell, 1986; Kempen & Huijbers, 1983) support the existence of a lemma level as well. In addition, verbal, or whole-word, paraphasias most often occur with words that are members of the same syntactic category (e.g., a noun is substituted for a noun) (Garrett,1980).

2.1.4 Name Agreement

Name agreement is a variable that has been hypothesized to manipulate competition at the level of lemma selection (LaGrone & Spieler, 2006). Name agreement refers to the degree to which participants produce the same name for an object or picture stimulus (Lachman, 1973; Lachman, Shaffer, & Hennrikus, 1974; Vitkovitch & Tyrell, 1995). In several picture naming studies by Lachman and colleagues (Lachman, 1973; Lachman et al., 1974), name agreement, or codability as they referred to it, affected reaction times independently of the variables of word frequency and age of acquisition. Pictures with high codability were those for which there was a high degree of consensus among participants in the names produced, while those with low codability had a low degree of consensus. Lachman and colleagues (Lachman, 1973; Lachman et al., 1974) used the measure of uncertainty to gauge the relative distribution and frequency of names produced for each picture by participants. Picture naming latencies increased as codability decreased and thus uncertainty increased. The authors attributed this effect to time-consuming processes involved in searching the lexicon.

LaGrone and Spieler (2006) manipulated word frequency and name agreement in a speeded picture naming task with both young and older adults. They hypothesized that pictures with low name agreement produce more competition for lemma selection, while pictures with high name agreement do not produce such competition. They based this hypothesis on the fact that previous studies have shown longer response times for pictures with low name agreement, but non-naming tasks, such as category judgment, have not shown effects of name agreement. A study by Vitkovitch and Tyrrell (1995) identified three different types of low name agreement. These types included low name agreement due to the use of expansions or abbreviations (e.g., *telephone* for *phone, phone* for *telephone*), pictures with multiple correct names (e.g., *sofa* for *couch*), and pictures frequently given incorrect names (e.g., *ant* for *spider*). Only name agreement due to the use of pictures with multiple correct names and those often given incorrect names created longer naming latencies. Using an object recognition task, the authors concluded that low name agreement due to the use of pictures often given incorrect names arises from interference at the structural recognition level, while interference associated with low name agreement due to the use of pictures with multiple correct names arises after visual recognition. Competition during lemma selection was proposed as a possible source of low-name-agreement effects due to multiple correct names.

2.2 SUMMARY AND STATEMENT OF PURPOSE

Both the low name agreement and PWI effects have been hypothesized to arise from competition at the level of lemma selection (Dell'Acqua et al., 2007; LaGrone & Spieler, 2006; Vitkovitch & Tyrrell, 1995). It has been proposed that the PWI effect has a precentral locus and does not require central attention in order to be resolved (Dell'Acqua et al., 2007). This conclusion has been drawn from the finding of an underadditive effect of PWI and SOA. The primary aim of the current study was to examine whether the effects of low name agreement (due to multiple correct names) can be localized to the pre-central or central stage of the central bottleneck model. The secondary purpose of this study is to determine whether the effects of low name agreement and the PWI effect do in fact arise at the same stage of word production (i.e., lemma selection). These conclusions are dependent upon whether the effect of low name agreement has a similar outcome to that of the PWI effect in a PRP study.

If the PWI effect and name agreement do, in fact, index the same stage of word production, we would expect the results of this study on name agreement to be consistent with Dell'Acqua and colleagues' (2007) findings of the PWI effect only at long SOAs. We predicted an interaction between SOA and name agreement such that there would be a significant name agreement effect at the long SOA and a smaller or absent name agreement effect at the short SOA. If this prediction was upheld, it would have been consistent with the view that name agreement and the semantic PWI effect affect the same stage of word production (i.e., lemma selection), and that this stage of lexical retrieval does not require central attention. If no interaction between SOA and name agreement were observed, this finding would indicate that name agreement and the semantic PWI affect different stages of word production. This outcome would also suggest that either lemma selection does in fact require central attention or that name agreement does not index lemma selection.

We expected a significant main effect of SOA such that naming latencies would be higher at the short SOA than the long SOA. We expected a significant main effect of name agreement on picture naming such that reaction times in the low name agreement condition would be higher than those in the high name agreement condition.

If the name agreement effect is underadditive with SOA and thus pre-central, it will be consistent with the hypotheses that (1) name agreement and semantic PWI affect the same stage(s) of lexical retrieval, and (2) this stage of lexical retrieval does not require central cognitive (attentional) processing resources that are limited in supply. This hypothesis and interpretation were based on Dell'Acqua and colleagues' (2007) finding that semantic PWI is underadditive with SOA. Within current models of word production, lemma selection would be a likely candidate for the locus of both of these effects. On the other hand, if the name agreement effect is additive with SOA, suggesting a central locus, it will imply that (1) name agreement and semantic PWI affect different stages of word production and (2) the name agreement effect necessarily occurs later in the processing stream than semantic PWI. This case would be most consistent with the following interpretation: Name agreement has its locus at lemma selection, which does require scarce central processing resources, while semantic PWI affects some earlier stage of lexical retrieval, perhaps related to interaction of competing conceptual semantic codes generated by the picture stimulus and distractor word (Dell'Acqua et al., 2007).

2.3 SIGNIFICANCE

Determining whether low name agreement affects the lemma selection stage of word production and whether resolving its effects requires central attention can affect our understanding of both normal and disordered language. Manipulating the variable of name agreement within a dual-task paradigm will produce a set of interpretable results under the central bottleneck model. By determining if a variable likely affects a stage of word production which requires central attention or not can increase our knowledge of the process of word production in language-impaired individuals. For example, it has been suggested that language deficits in individuals with aphasia may arise from the inability to properly allocate attention to linguistic processes (McNeil, Odell, & Tseng, 1991). Identifying which stages of word production require central attention can aid in determining which aspects of a linguistic task are most demanding cognitively and may create particular difficulty for these individuals. These findings may inform not only our understanding of word production in individuals with aphasia but also our approaches toward treatment.

3.0 PRELIMINARY EXPERIMENT

3.1 RATIONALE

The purpose of the preliminary study was to provide object recognition times, which would be used in concert with other previously published data (Szekely et al. 2003) to balance sets of pictures with high and low name agreement for confounding variables. In particular, since the current investigation was focused upon lemma selection, it was necessary to exclude low name agreement due to other factors that may affect earlier perceptual processing stages. Object recognition times can be used to gauge the influence of visual recognition of objects (Jescheniak & Levelt, 1994; Wingfield, 1968), which is associated with pre-central processing in the PRP paradigm and central bottleneck model.

3.2 RESEARCH DESIGN AND METHODS

3.2.1 Participants

The sample consisted of 12 subjects (5 males, 7 females). Eight were right-handed, two were left-handed, and one was ambidextrous by self report. In a previous study (Hula, 2007), this sample size was adequate to detect as statistically significant an 18-ms average effect of lexical frequency between sets of pictures with high and low frequency names (n = 144 pictures in each group). Participant exclusion criteria were a self-reported history of speech, language, or hearing impairment including stuttering, developmental or acquired apraxia of speech, or speech delay; autism or Asperger's syndrome; dyslexia or other learning disability; attention deficit disorder or attention deficit hyperactivity disorder; stroke or progressive neurological disease; head injury causing any loss of consciousness, post-traumatic amnesia, alteration of consciousness lasting longer than one minute, or any memory or other cognitive symptoms. Isolated articulation disorder was not an exclusionary criterion. All participants had English as their primary language and were between the ages of 18-29 (mean = 19.67, SD = 3.14), inclusive. All participants were students recruited from the University of Pittsburgh community. Eleven participants were recruited via the University of Pittsburgh's Psychology Research Participation website and reimbursed with class credit for their participation. One participant was recruited from the Communication Science and Disorders department and was paid $20 for participation.

3.2.2 Apparatus and Stimuli

The data were collected on a laptop PC using the E-Prime 2.0 software package (Schneider, Eschman, & Zuccolotto, 2002). Picture and word stimuli were taken from the University of California San Diego Center for Research in Language International Picture Naming Project (CRL-IPNP) online database of object pictures and associated normative data (Szekely et al., 2003; Szekely et al., 2004). Four hundred and seventy-eight stimulus pairs were presented. Half of those pairs were in the compatible condition and thus the word was the dominant name given for the picture in the CRL-IPNP database. The other half were picture-word pairs that did not include dominant or alternative names for the picture in the database, i.e., the incompatible condition. High name agreement pictures were those from the CRL-IPNP database that had ≥ 97% name agreement. Low name agreement pictures were those with name agreement ≤ 94%.

The set of 520 object picture stimuli from the CRL-IPNP database were reviewed for use in this study. Three hundred low name agreement items were rated independently by two judges as to whether or not each picture had low name agreement due to multiple correct names. The judges were the author and a thesis co-advisor. The judges considered the dominant name given for a picture in comparison with the alternative names given. They also considered how many times each alternative response was given. If the majority of response (tokens) for alternative names given was considered to be correct names for the picture, the item was to be judged as having low name agreement due to multiple correct names. Other sources of low name agreement included multiple incorrect names, names of part of the picture, elaborations, abbreviations, and plural-singular distinctions. If the alternative names given for an item included two or more responses for a given name due to any of these factors, they were not included in the study. Of the 300 low name agreement stimuli reviewed, the two judges rated 75 pictures as having low name agreement due to multiple correct names. One low name agreement picture was excluded, because it had a very low rated image agreement value (Szekeley et al. 2003). A third judge rated the remaining 74 pictures as to whether or not each picture had low name agreement due to multiple correct names. The third judge was a research assistant in the co-advisor’s laboratory. Sixteen of the 74 low name agreement pictures were excluded due to lack of agreement across all three judges, yielding a final set of 66 low name agreement pictures to be used in the compatible condition of the preliminary study. One hundred and seventy three were also chosen from the CRL-IPNP database to be used in the compatible condition, yielding a total of 239 picture-word pairs in the compatible condition. An equal number of picture-word stimuli were taken from the remainder of the items in the database for use in the incompatible condition, yielding a total of 478 picture stimuli.

3.2.3 Procedure

Each participant was shown a word and then a picture. They were asked to press a button indicating whether the picture matched the word previously presented or not. Object recognition reaction times were the primary dependent variable of interest and name agreement and picture-word compatibility were the independent variables.

All data for this experiment were collected in a single session lasting 30 minutes or less. Following the informed consent process, each participant completed a short questionnaire regarding their medical, speech, and language history in order to be considered for inclusion in the study. Participants who met the inclusion criteria were familiarized with the experimental procedure during a practice block of 18 trials using picture and word stimuli not included in the experimental task. They received feedback on their performance during these trials. Next, five blocks of two warm-up trials and 80 experimental trials were administered along with one block of two warm-up trials and 78 experimental trials, yielding a total of 478 experimental trials. At the beginning of each experimental trial, a fixation cross appeared in the middle of the screen. The participant pressed a button on the stimulus response box with the index finger of their non-dominant hand to start the trial. This caused the fixation cross to disappear and after a 200-ms delay, a text word appeared on the screen for 1000 ms. Two hundred ms following the offset of the word, the picture stimulus was presented. The participant indicated “Yes” if the picture was that of the previous word or “No” if it was not a picture of the word by pressing the button corresponding to their response on the serial response box. The index and middle fingers of the participant's dominant hand were used to respond. Participants were instructed to respond as quickly as possible without sacrificing accuracy. Responses and reaction times were recorded.

3.2.4 Design

The study was a within-subjects design. Each trial contained a combination of the following variables: name agreement (high, low) and compatibility (compatible, incompatible). The presentation order of stimuli was randomized with the single constraint that an equal number of compatible ("yes") and incompatible ("no") stimulus pairs were presented within each block of trials.

3.2.5 Analysis and Hypotheses

Because the purpose of this preliminary study was to provide object recognition times for use in balancing stimulus sets used in the main experiment, there were no hypotheses and the data were analyzed descriptively. Specifically, the reaction times for correct responses to the candidate stimuli were averaged across subjects for each picture, after excluding outliers according to the non-recursive procedure outlined by Van Selst & Jolicoeur (1994).

The average object recognition time across participants for each picture was calculated. This value was then used along with the average values of word frequency, word length, image agreement, and age of acquisition for each picture acquired from the CRL-IPNP database (Szekely et al., 2003; Sekely et al., 2004) to create a list of high name agreement pictures and a list of low name agreement pictures. The picture stimuli were divided into two groups based on name agreement and balanced on these variables, yielding two lists of 48 pictures each.

Random coefficient analysis (RCA) (Lorch, Jr. & Myers, 1990; Thompson, 2008) was then used to analyze the object recognition reaction time data for the picture stimuli (N = 96) included in the dual-task experiment. Unlike repeated-measures ANOVA based on aggregated data, RCA employs regression analysis in order to produce unbiased error term estimates. The strength of each experimental effect is estimated within each participant first. Then the hypothesis that these within subjects effects differ significantly from zero for the sample is tested. One-sample t-tests are used to test and report main effects and interaction. These tests are equivalent to correlated t-tests of the difference between conditions in RCA.

The dependent variable in this analysis was object recognition reaction time. The independent variables were name agreement, lexical frequency, image agreement, (subject) age of acquisition, and number of syllables (word length). Name agreement was indexed by the H statistic (Lachman, 1973). The H statistic is a measure of response agreement that considers the number of participants providing each alternative response. The number of participants in this case is based on the number involved in production of the CRL-IPNP database and associated norms (Szeleky et al., 2003; Szekely et al., 2004). Perfect name agreement is indicated by an H statistic value of zero, while higher values designate lower name agreement. The maximum H statistic value in this study's data set was 2.005 and the minimum was 0.

3.3 RESULTS

3.3.1 Object Recognition Times

The Appendix includes the lexical characteristics (Table 5) and the mean and log object recognition times collected for the pictures included in the final stimuli set (Table 6). Table 1 shows the results of independent samples t-tests between the lists of high and low name agreement stimuli on several relevant lexical and picture-stimulus variables. The assumption of equal variance was met for all balancing variables but not for name agreement. There were no significant differences found across the high and low name agreement stimuli for any of the balancing variables. All p-values for these variables were greater than 0.5. The lists differed significantly only in name agreement ($p < 0.001$). When stimuli were divided into four sublists based on name agreement and SOA condition (see "Main Experiment" description), and the analysis was repeated, again the sublists were homogeneous on the each of the balancing variables.

Table 2 shows the results of the RCA. Only subject age of acquisition had a significant effect on object recognition reaction times ($p < 0.05$). The effect of image agreement on object recognition reaction times approached significance ($p = 0.054$). However, name agreement, as measured by the H statistic, had no significant effect on object recognition reaction time.

Table 1. Results of two-tailed independent samples t-tests between the final balanced sets of high and low name agreement stimuli

Variable Name	t-value	df	p-value	Mean Difference	Standard Error	95% Confidence Interval	
						Lower Bound	Upper Bound
Name Agreement (%)	-12.484	94	0.000	-0.230	0.018	-0.267	-0.194
Name Agreement (H statistic)	15.034	94	0.000	0.889	0.059	0.772	1.007
Lexical Frequency	0.652	94	0.516	0.074	0.114	-0.151	0.299
Object Recognition Time (ms)	0.021	94	0.983	0.208	9.711	-19.073	19.489
Log Object Recognition Time (ms)	-0.235	94	0.814	-0.002	0.007	-0.016	0.012
Image Agreement	0.157	94	0.876	0.017	0.106	-0.194	0.227
Subject Age of Acquisition	0.334	94	0.739	0.068	0.203	-0.335	0.470
Object Age of Acquisition	-0.358	94	0.721	-0.063	0.174	-0.409	0.284
Number of Phonemes	-0.197	94	0.845	-0.063	0.318	-0.694	0.569
Number of Syllables	-0.282	94	0.779	-0.042	0.148	-0.335	0.252

Table 2. Results of the random coefficients analysis for the final picture stimuli set

Variable Name	t-value	df	p-value	Mean Difference	95% Confidence Interval	
					Lower Bound	Upper Bound
Name Agreement (H statistic)	0.712	11	0.491	6.506	-13.613	26.625
Lexical Frequency	0.174	11	0.865	2.594	-30.179	35.367
Image Agreement	-2.158	11	0.054	-19.753	-39.899	0.392
Subject Age of Acquisition	2.850	11	0.016	19.027	4.331	33.724
Number of Syllables	0.662	11	0.522	3.083	-7.168	13.333

3.4 DISCUSSION OF PRELIMINARY EXPERIMENT

The results of the preliminary experiment yielded a set of balanced stimuli for the main experiment. By balancing the lists of high and low name agreement pictures on the variables of word frequency, word length, image agreement, and age of acquisition, we can conclude that these variables will not contribute significantly to any observed effects of picture-stimuli in the main experiment. Thus, this increases the likelihood that any observed effects are due to name agreement.

4.0 MAIN EXPERIMENT

4.1 RATIONALE

The purpose the current study was to examine whether the effects of low name agreement can be localized to the pre-central or central stage of the central bottleneck model and to determine whether the effects of low name agreement and the PWI effect arise from competition at the level of lemma selection. These questions will be considered in the context of a PRP experiment involving tone identification and picture naming.

If an underadditive effect of name agreement and SOA is found, the results will be consistent with the hypotheses that (1) name agreement and semantic PWI affect the same stage(s) of word production, and (2) this stage of word production does not require central attention. In contrast, if the name agreement effect is additive with SOA, the results will suggest that (1) name agreement and semantic PWI affect different stages of word production and (2) the name agreement effect occurs after semantic PWI.

4.2 RESEARCH DESIGN AND METHODS

4.2.1 Participants

The sample size was 24 (6 male, 18 female). Twenty three were right-handed and one was left-handed by self report. A power analysis (D'Amico, Neilands, & Zambaro, 2001) was conducted to confirm that this sample size would yield a power of 0.80 to detect the interaction effect of primary interest. The analysis was performed using data from previous and ongoing studies similar to this one (Hula, 2007; Hula, unpublished data) to estimate effect sizes and correlations between conditions. Participants ranged in age from 18-21 (mean = 18.54, SD = 0.884), inclusive. Inclusion criteria were the same as for the preliminary experiment. All participants were recruited via the University of Pittsburgh's Psychology Research Participation website and reimbursed with class credit for their participation.

4.2.2 Apparatus and Stimuli

The data were collected on a laptop PC using the E-Prime 2.0 software package (Schneider, Eschman, & Zuccolotto, 2002) and a CRT monitor. Tone stimuli were presented via speakers at a clearly audible level that was constant across participants. Tones were either low (400 Hz), medium (1000 Hz), or high (2500 Hz) in pitch and each was presented for 250 ms. The short SOA was 100 ms while the long SOA was 988 ms. Picture stimuli were taken from the CRL-IPNP database (Szekely et al., 2003; Szekely et al., 2004). Based on the stimulus lists produced by the preliminary study, there were 48 low-name agreement and 48 high-name agreement pictures used. The high name agreement pictures had ≥ 94% name agreement according to the

CRL-IPNP database and associated normative data (Szekely et al., 2003; Szekely et al., 2004). Low name agreement pictures had agreement ≤ 92%. These criteria for name agreement were selected in order to create four balanced picture sets with dominant names that were matched on word frequency, word length, image agreement, age of acquisition, and object recognition time. The four lists were based on the four name agreement-SOA conditions in this study.

Tone reaction times were collected via button press, using the PST serial response box. Picture naming reaction times were collected via the response box's voice key.

4.2.3 Procedure

All data for this experiment were collected in a single session lasting approximately 30 minutes. Following the informed consent process, each participant completed a short questionnaire regarding their medical, speech, and language history in order to be considered for inclusion in the study. Participants who met the inclusion criteria were familiarized with the experimental procedure during practice blocks of 18 trials each for each task in isolation and for the dual-task, using picture stimuli not included in the experimental sets. They received feedback on their performance during a portion of these trials. Practice trials were also completed without feedback in order to expose participants to conditions most similar to the actual experimental procedure. Next, four blocks of experimental trials were administered. Each block consisted of 3 warm-up trials using pictures not contained in the experimental sets and 24 experimental trials. Each experimental trial began with a fixation sign at the center of the screen. The participant pressed a button on the response box with the index finger of their non-dominant hand to start each trial. The fixation sign disappeared and after a 500-ms pause a tone was played. A picture was presented 100 or 988 ms later, depending on the SOA condition. The picture remained on the screen until a voice key response was detected. Naming responses and voice key malfunctions were coded online by the author. The author coded responses for the picture naming task by entering a code into the laptop PC.

The naming response was coded as “correct” (1) if the target name for the picture was given. The target name was the name given most often for the picture in the CRL-IPNP database. The response was coded as “alternative” (2) if it was one of the names in the CRL-IPNP database that was listed as an alternative name and was considered as by the three judges to be an alternative correct name for the picture. The response was coded as “incorrect” (3) if it was any other name, included preceding interjections (“um, uh”) or words (articles, adjectives), incomplete, or disrupted (e.g., repetition of initial phonemes) in any way. It was coded as a “voice key error” (4) if the voice key was triggered by any mouth noise other than the initial phoneme of the response or if the voice key failed to trigger in response to a correct or alternative verbal response. It was coded as an “operator error” (5) if the voice key was triggered by the tone stimulus sound.

After the code was entered, a fixation sign appeared at the center of the screen. The participant pressed a button on the response box with their non-dominant hand to begin the next trial. Participants were instructed to always respond to the tone first by pressing a button on the serial response box and then to the picture by saying the name of the picture. Participants used the index, middle, and annular fingers of their dominant hand to respond to the tones. Participants were instructed to respond as quickly and accurately as possible to each task without sacrificing accuracy.

4.2.4 Design

The research questions were investigated in a PRP dual-task experiment involving tone identification and picture naming. Task 1 involved a manual response to a tone. Task 2 involved picture naming. Naming reaction time was the primary dependent variable of interest, and name agreement and SOA were the independent variables. Half of the picture stimuli had high name agreement, while the other half had low name agreement. The high name agreement pictures were distribution-matched to the low name agreement pictures on the variables of word frequency, word length, image agreement, age of acquisition, and object recognition time. There were two name agreement conditions. There was both a long and a short SOA condition yielding two SOA conditions.

The study was a within-subjects, repeated measures design. Each block contained an equal number of high and low name agreement pictures, and within each stimulus set, half of the pictures were presented at the short SOA and half were presented at the long SOA. Across subjects, each picture was presented in each SOA condition an equal number of times. Tones were counterbalanced within each block of stimuli.

4.2.5 Analysis and Hypotheses

Separate ANOVAs ($\alpha = 0.05$) for picture naming and tone identification error rates were performed, both with two repeated factors: name agreement (high, low), and SOA (100 ms, 988 ms). Error rates were also inspected to insure that no speed-accuracy trade-off has taken place.

RCA (Lorch, Jr. & Myers, 1990; Thompson, 2008) was used to analyze the reaction time data. In the RCA reported below, the independent variable of name agreement was indexed by the H statistic (Lachman, 1973).

Hypothesis 1: *There will not be a significant main effect of SOA on tone identification reaction time.*

Hypothesis 2: *There will not be a significant main effect of name agreement on tone identification reaction time.*

Hypothesis 3: *There will be a significant ($p < 0.05$) main effect of name agreement on picture naming reaction time such that reaction times will be longer for low name agreement words than for high name agreement words.*

Hypothesis 4: *There will be a significant ($p < 0.05$) main effect of SOA on picture naming reaction time such that reaction times will be longer for picture stimuli presented at the short SOA than those presented at the long SOA.*

Hypothesis 5: *There will be a significant ($p < 0.05$) name agreement by SOA interaction effect on picture naming reaction time such that the effect of name agreement will be large at the long SOA and small or absent at the short SOA.*

4.3 RESULTS

Point-to-point inter-rater reliability for coding of naming responses was 98.2%. Trials containing incorrect responses (9%), voice key errors (2%), incorrect response order (1%), operator error (0.2%), and RT outliers (4%) were excluded from analyses.

4.3.1 Error Rates

A speed-accuracy tradeoff was not suggested for either task in the examination of error rates by conditions, averaged across subjects. For the tone identification task, only the main effect for SOA was significant, $F(1, 23) = 5.598$, $MSe = 0.001$, $p = 0.027$, $ES = 0.196$, with more errors in the short SOA condition. Neither the main effect of name agreement, $F(1, 23) = 0.16$, $MSe = 0.002$, $p = 0.901$, $ES = 0.001$, nor the interaction, $F(1, 23) = 1.045$, $MSe = 0.001$, $p = 0.317$, $ES = 0.043$, was significant.

For the naming task, the main effect for name agreement was significant, $F(1, 23) = 426.600$, $MSe = 0.003$, $p < 0.001$, $ES = 0.949$, with more errors in the low name agreement condition. Neither the main effect of SOA, $F(1, 23) = 1.022$, $MSe = 0.005$, $p = 0.323$, $ES = 0.043$, nor the interaction, $F(1, 23) = 0.125$, $MSe = 0.005$, $p = 0.727$, $ES = 0.005$, was significant.

4.3.2 Reaction Times

The results for each hypothesis are presented below, beginning with the tone identification reaction times.

4.3.2.1 RT1: Tone Identification

Hypothesis 1: *There will not be a significant main effect of SOA on tone identification reaction time.* Contrary to the prediction, the main effect of SOA on tone identification reaction times was significant, SOA, $t(23) = 5.316$, SE difference = 15.37, $p < 0.001$, $\eta_p^2 = 0.54$. Tone identification reaction times were 82 ms slower on average in the short SOA condition than the long SOA condition.

Hypothesis 2: *There will not be a significant main effect of name agreement on tone identification reaction time.* The main effect of name agreement on tone identification reaction times was not significant, t (23) = -0.784, SE difference = 10.16, p = 0.441, $\eta_p^2 = 0.03$. The Name Agreement x SOA interaction was also not significant, t (23) = -0.368, SE difference = 17.14, p = 0.716, $\eta_p^2 = 0.01$.

4.3.2.2 RT2: Naming

Table 3 shows the average picture naming reaction times by SOA and name agreement. Table 4 shows the mean name agreement values (H statistic, percent name agreement) for the high and low name agreement picture stimuli.

Hypothesis 3: *There will be a significant ($p < 0.05$) main effect of name agreement on picture naming reaction time such that reaction times will be longer for low name agreement words than for high name agreement words.* The main effect for name agreement was significant, t (23) = 2.338, SE difference = 17.19, $p < 0.05$, $\eta_p^2 = 0.23$. A 1-unit decrease in name agreement (i.e., a 1-unit increase in the H statistic) was associated with a 40 ms increase in reaction time.

Hypothesis 4: *There will be a significant ($p < 0.05$) main effect of SOA on picture naming reaction time such that reaction times will be longer for picture stimuli presented at the short SOA than those presented at the long SOA.* The main effect for SOA was significant, t (23) = 11.835, SE difference = 27.71, $p < 0.001$, $\eta_p^2 = 0.85$. The average difference in reaction time between SOA conditions was 328 ms.

Hypothesis 5: *There will be a significant ($p < 0.05$) name agreement by SOA interaction effect on picture naming reaction time such that the effect of name agreement will be large at the long SOA and small or absent at the short SOA.* Contrary to the prediction, the Name Agreement x SOA interaction was not significant, $t(23) = -0.064$, SE difference = 27.04, $p = 0.949$, $\eta_p^2 = 0.02$. On average, the name agreement effect was 2 ms larger at the long SOA than the short SOA.

Table 3. Mean picture naming reaction times (ms) by SOA (ms) and name agreement

		SOA	
		100	*988*
Name Agreement	*Low*	1133	806
	High	1100	771

Table 4. Mean name agreement values for high and low name agreement picture stimuli

Name Agreement	*H statistic*	*Percent Name Agreement*
Low	0.92	0.77
High	0.08	0.99

4.3.2.2.1 Secondary Analyses

Secondary analyses were conducted in order to test whether additional potentially confounding variables could have accounted for the observed name agreement effect. The variables tested included subject age-of-acquisition, word (lemma) frequency, object recognition time, image agreement, and word length (in syllables). These variables were entered as predictors into the initial step of the RCA. It was also tested whether articulatory characteristics of the initial phonemes of target picture names could account for the observed name agreement effects. Place, manner, and voicing were coded as a series of 12 dummy variables (affricative, alveolar, bilabial, fricative, glottal, labiodental, liquid, nasal, palatal, stop, velar, and voiced) and entered as predictors in the RCA. The name agreement effect maintained significance and the SOA by name agreement effect remained non-significant in all cases.

5.0 DISCUSSION

The locus of the effect of name agreement was investigated using a PRP paradigm involving tone identification and picture naming. Pictures stimuli varied on level of name agreement. The results of the experiment yielded significant main effects for SOA and name agreement. The interaction was not significant. The overall pattern of results shows an additive effect of name agreement and SOA. Picture naming reaction times for low name agreement pictures were 33 ms longer than those for high name agreement pictures in the short SOA condition and 35 ms longer in the long SOA condition.

According to the central bottleneck model, the results indicate that resolving effects of low name agreement due to multiple correct names requires central attention. The additive effect found in the current study is distinct from the underadditive effect of PWI found by Dell'Acqua and colleagues (2007). This pattern of results is consistent with the hypotheses that (1) name agreement and semantic PWI affect different stages of word production and (2) the name agreement effect likely has its locus at lemma selection, while semantic PWI affects an earlier stage of lexical retrieval.

Considering the results of the current study in light of Dell’Acqua and colleagues’ (2007) findings indicates that name agreement and the PWI effect arise from different stages of word production. More specifically, the findings suggest that the effect of name agreement arises later in the processing stream than that of PWI. Whereas Dell’Acqua and colleagues (2007) found the effect of PWI to be underadditive with SOA using a PRP dual-task experiment, the current study yielded an additive effect of name agreement using the same method. As picture naming is a task of word production, it can be concluded that the name agreement and PWI effects arise from different stages of word production.

The findings of the present study could be interpreted as supportive of the views that name agreement indexes lemma selection and lemma selection thus requires central attention. Dell'Acqua and colleagues (2007) suggested that the results of their study are inconsistent with accounts of lexical competition as a cause of the PWI effect. They based this on the claim from previous research (Ferreira and Pashler, 2002) that lexical competition requires central attention in order to be resolved. They suggested instead that the PWI effect arises from a precentral conceptual stage of word production. They proposed that competing semantic codes interact early in processing, and this creates the PWI effect. It is conceivable that the single word production inherent to the PWI task may activate competing concepts prelinguistically. Competition between prelinguistic representations is a possible source of the PWI effect. According to this account, it would then be reasonable to propose that the additive effect found in the current study is consistent with lexical competition as a source of interference. As the lemma is the first properly lexical level in the models of word production discussed here, lemma selection could be the level at which competition arises when low name agreement exists.

Vitkovitch and Tyrrell's (1995) study involved three different types of low name agreement. The results demonstrated that only name agreement due to the use of pictures with multiple correct names and those often given incorrect names created longer naming latencies in comparison with matched high name agreement stimuli. In a subsequent object decision task, pictures often given incorrect names showed slowed recognition times in comparison with matched high name agreement stimuli, but those with multiple correct names did not. The authors concluded that these results suggest that the interference effect associated with low name agreement due to the use of pictures with multiple correct names arises after visual recognition. The authors proposed that such picture stimuli activate different conceptual representations and semantic descriptions. They suggested that this activation results in delayed semantic processing and the activation of different correct names for a picture that are only available at a lexical name retrieval stage. They identified this stage as lemma selection.

LaGrone and Spieler (2006) manipulated word frequency and name agreement in a speeded picture naming task with both young and older adults. There were longer reaction times in the low name agreement condition compared with the high name agreement condition for both groups. They hypothesized that the consistency with which semantic properties converge on one or more lemmas creates variation in the difficulty of lemma selection. They proposed that pictures with low name agreement produce more competition for lemma selection, while pictures with high name agreement do not produce such competition. The authors emphasized that previous studies have shown that non-naming tasks, such as size and category judgment, do not yield effects of name agreement. They interpreted this as evidence that the name agreement effect is specifically tied to lexical selection.

It should also be considered that the PWI effect may actually index lemma selection as has been suggested by previous literature (Schriefers, Meyer, & Levelt, 1990). Lemma selection would not require central attention in this case. It is possible that name agreement indexes another central (or postcentral) process. One possible process is phonological word form selection.

It could be argued that increasing the number of competing lemmas could cause interference in selecting the correct phonological word form, particularly within a cascaded model of word production, such as Dell and colleagues' model (Dell, 1986; Dell et al., 1997). They proposed an interactive, cascaded model of word production. Within their model, activation is bidirectional within and between word production levels. In addition, activation may spread to later levels of word production before processing at prior levels is complete. Under this model, it is possible that activation may spread to the phonological word form level while competition at the level of lemma selection is being resolved. This activation at the phonological word form level may then be the source of interference that arises in naming low name agreement pictures with multiple correct names. Resolving the effects of this interference may require central attention, while lemma selection does not.

It could also be the case that some picture stimuli with multiple correct names actually had the same lemma representation. For example, for the picture stimulus with the target name "couch", "sofa" was often produced as an alternative response. It could be argued that both of these names, in fact, activate the same semantic-syntactic representation. Competition at the phonological word form level rather than the lemma selection level could be the source of interference for such stimuli. However, other target and correct alternative names may be less likely to activate the same lemma (e.g., "wolf" and "dog" or "acorn" and "nut").

In order to further investigate the effects of these different types of picture stimuli on picture naming reaction time, separate analyses for each group could be performed. Target and correct alternative names for picture stimuli used in the dual-task experiment would first be rated by judges as likely having the same or different lemma representations. Separate RCA analyses would then be performed for each group. One would expect that results for the group with the same lemmas ("couch, sofa") would be similar to those found for name agreement in this study. One would expect an additive effect of this type of name agreement. Such an effect would be indicative of a central locus of the effect and could likely arise at the phonological word form level. Conversely, for the group rated as activating different lemmas, one would expect an underadditive effect. This result would suggest a precentral locus of the effect that could likely at the level of lemma selection.

Linguistic response monitoring is another potential source of interference. Levelt and colleagues (1999), for example, proposed a post-lexical self-monitoring mechanism. After a response is selected, such a mechanism monitors that the best response was, in fact, selected. The authors suggested that as individuals monitor representations during word production, encoding duration may be affected. Stimuli with multiple correct names may interfere with the efficiency with which the response monitoring process is carried out, creating the name agreement effect.

A final possibility is that the presence of multiple potential names for a stimulus has effects outside of the linguistic domain. Conflict resolution in this case may engage non-linguistic executive function. This could potentially bring word production to a halt while conflict is being resolved, creating the name agreement effect.

The particular source of interference behind low name agreement can be argued. However, this study offers evidence in support of the requirement of central attention to resolve it. This is significant as name agreement has been found to be a strong predictor in naming accuracy in individuals with aphasia (Laiacona, Luzzatti, Zonca, Guarnaschelli, & Capitani, 2004). Laiacona and colleagues (2004) employed a picture naming task in which pictures were varied by visual, lexical, and lexical-semantic attributes. It was found that name agreement demonstrated the most significant level of influence on naming accuracy of all attributes. If resolving name agreement effects requires central attention, this may explain its impact on naming in individuals with aphasia. These individuals may have difficulty allocating attention during linguistic and other cognitive tasks (McNeil, Odell, & Tseng, 1991). If attention allocation necessary to resolve the effects of low name agreement is, in fact, impaired in individuals with aphasia, deficits in naming objects with more than one correct name may be present.

Identifying the underlying cause of a deficit and its relationship to linguistic processing can inform our approaches for intervention with these individuals. For example, clinicians should be aware that low name agreement stimuli may be difficult for patients to name and may then be the target of training. This study showed that the presence of attention-demanding tasks may further decrease the efficiency with which low name agreement stimuli, particularly with multiple correct names, are named. The clinician may want to reduce or induce distracting tasks when utilizing low name agreement stimuli, depending on the goal of treatment. Also, the existence of more than one correct name for an item may be exploited during treatment. The clinician may want to train multiple correct names for low name agreement items in an attempt to facilitate naming.

6.0 CONCLUSIONS

This study identified a central locus of the effect of low name agreement due to multiple correct names under the central bottleneck model. The results showed an additive effect of name agreement with SOA in the context of a PRP paradigm. This finding is distinct from that of a previous study identifying a precentral locus for the semantic PWI effect in a similar PRP study (Dell'Acqua et al., 2007). The results indicate that resolving the effects of low name agreement is attention-demanding. Since previous work has indicated that resolving the PWI effect does not require central attention, it was concluded that the low name agreement and PWI effects affect different stages of word production. Both effects have been hypothesized to arise at the lemma level of word production. In light of the finding that different stages of word production may be indexed by each effect, it was concluded that name agreement most likely indexes lemma selection, while PWI occurs at an earlier stage of word production.

APPENDIX

Table 5 shows the lexical characteristics of the final picture stimuli set. Table 6 shows the mean and log object recognition times collected during the preliminary experiment for the pictures included in the final stimuli set. The final stimuli sets are the 48 high and 48 low name agreement pictures used in the dual-task experiment.

Table 5. Lexical characteristics of the final picture stimuli set

Target Picture Name	Name Agree. (%)	Name Agree. (H stat.)	Lexical Freq.	Image Agree.	Subj. Age of Acq.	Obj. Age of Acq.	No. of Phon.	No. of Syll.
acorn	0.830	0.703	0.97	5.15	5.77	3	5	2
alligator	0.900	0.606	1.13	5.90	5.16	2	7	4
anchor	1.000	0.057	1.18	6.55	6.58	3	4	2
ant	0.880	0.607	1.59	5.70	3.79	2	3	1
antlers	0.720	0.959	0.69	5.40	6.61	3	6	2
arm	0.837	0.658	2.42	5.50	3.08	1	3	1
ax	0.864	0.668	1.27	6.35	6.22	3	3	1
barbecue	0.898	0.494	0.11	6.15	6.04	3	8	3
bell	1.000	0.000	1.95	5.95	4.40	3	3	1
belt	1.000	0.029	1.67	5.80	4.83	2	4	1
bone	1.000	0.000	2.23	5.95	4.50	3	3	1
bowl	0.980	0.169	1.68	5.70	3.78	1	3	1
boy	0.900	0.661	2.80	5.80	3.04	1	2	1
bra	1.000	0.000	0.30	5.35	8.02	3	3	1
bucket	0.660	0.925	1.35	5.90	4.73	2	5	2
bug	0.440	2.005	1.47	5.25	6.06	1	3	1
button	1.000	0.000	1.61	5.95	4.39	1	4	2
cactus	1.000	0.057	1.03	5.20	6.22	3	6	2
cannon	1.000	0.111	1.27	5.95	6.75	3	5	2
canoe	0.617	0.986	1.57	5.75	6.18	3	4	2
carrot	1.000	0.000	1.23	6.05	4.09	1	5	2

Target Picture Name	Name Agree. (%)	Name Agree. (H stat.)	Lexical Freq.	Image Agree.	Subj. Age of Acq.	Obj. Age of Acq.	No. of Phon.	No. of Syll.
castle	1.000	0.000	1.72	5.45	5.16	3	4	2
cheese	1.000	0.235	1.57	5.55	4.00	1	3	1
chest	0.630	1.354	1.73	5.75	5.93	3	4	1
chimney	1.000	0.111	1.35	5.95	5.15	3	5	2
couch	0.740	0.928	1.10	6.45	5.40	1	3	1
cowboy	0.796	1.015	1.49	5.25	4.78	2	4	2
dinosaur	0.980	0.141	1.62	6.00	4.45	3	7	3
doctor	0.837	0.658	2.32	4.6	4.10	2	5	2
doll	0.860	0.842	1.50	5.35	3.24	1	3	1
drawer	1.000	0.000	1.45	5.90	4.82	1	4	2
dress	1.000	0.000	1.90	5.75	4.44	1	4	1
earring	0.588	1.636	0.70	2.85	5.58	3	5	2
egg	0.980	0.141	2.27	5.20	4.01	1	2	1
envelope	0.920	0.402	1.34	6.30	5.95	3	7	3
flag	1.000	0.000	1.58	5.75	4.63	2	4	1
flashlight	0.980	0.169	1.26	5.95	5.21	3	7	2
frog	1.000	0.000	1.96	6.05	4.04	1	4	1
ghost	1.000	0.000	1.66	6.00	4.35	3	4	1
gun	0.898	0.687	1.94	6.05	5.08	3	3	1
hat	0.667	1.046	2.00	5.15	5.10	1	3	1
jacket	0.917	0.519	1.57	5.60	4.30	1	5	2
knife	1.000	0.057	1.73	5.95	4.29	2	3	1

Target Picture Name	Name Agree. (%)	Name Agree. (H stat.)	Lexical Freq.	Image Agree.	Subj. Age of Acq.	Obj. Age of Acq.	No. of Phon.	No. of Syll.
ladybug	0.667	1.225	0.79	5.30	4.69	3	7	3
lamp	0.920	0.402	1.67	6.35	4.80	1	4	1
leopard	0.543	1.441	0.82	5.75	6.10	3	5	2
lizard	0.878	0.784	1.32	5.65	5.13	3	5	2
lock	1.000	0.029	1.48	5.95	5.25	3	3	1
log	0.740	1.269	1.79	5.75	5.08	3	3	1
mask	0.980	0.141	1.41	5.40	5.28	3	4	1
match	1.000	0.057	1.75	5.50	5.16	3	3	1
mirror	1.000	0.029	1.81	5.50	4.09	3	3	2
mountain	0.940	0.383	2.54	5.45	4.68	3	5	2
music	0.500	1.628	2.06	5.80	4.51	3	6	2
ostrich	0.800	1.085	0.86	5.80	6.71	3	6	2
package	0.940	0.423	1.58	5.55	6.14	3	5	2
pan	0.840	0.842	1.67	6.00	4.54	3	3	1
pants	0.896	0.592	1.32	5.95	3.67	1	5	1
parrot	0.792	0.765	1.02	5.65	5.47	3	5	2
peanut	1.000	0.137	1.35	5.85	4.43	3	5	2
pear	1.000	0.000	0.82	5.50	4.68	3	3	1
pillow	1.000	0.000	1.33	4.50	3.92	1	4	2
porcupine	0.979	0.224	0.82	5.65	6.41	3	9	3
puzzle	0.980	0.141	1.26	5.90	4.81	2	4	2
queen	1.000	0.029	1.87	5.95	4.76	3	4	1

Target Picture Name	Name Agree. (%)	Name Agree. (H stat.)	Lexical Freq.	Image Agree.	Subj. Age of Acq.	Obj. Age of Acq.	No. of Phon.	No. of Syll.
rabbit	0.837	0.658	1.99	6.65	4.01	3	5	2
rainbow	0.979	0.197	1.15	4.15	4.25	3	5	2
rake	0.980	0.141	0.78	5.85	5.26	3	3	1
ring	1.000	0.000	1.98	5.80	5.17	3	3	1
road	0.920	0.482	2.41	5.85	4.40	3	3	1
rose	0.755	0.816	2.11	5.75	5.11	3	3	1
saddle	1.000	0.029	1.41	5.45	6.29	3	4	2
sailor	0.900	0.606	1.71	5.15	5.97	3	4	2
scarf	0.980	0.141	0.98	5.15	6.05	2	5	1
seesaw	0.750	0.935	0.75	6.40	4.75	3	4	2
sheep	0.636	1.433	1.89	5.50	4.50	1	3	1
skateboard	1.000	0.000	0.54	5.85	6.91	3	8	2
soldier	0.688	1.849	2.12	5.65	6.25	3	5	2
stove	0.720	0.959	1.56	5.80	4.95	1	4	1
strawberry	1.000	0.029	1.02	5.55	4.04	2	8	3
stroller	0.841	0.912	0.31	6.00	4.88	1	6	2
suitcase	0.792	0.997	1.21	5.75	5.59	3	6	2
tape	0.796	0.928	1.73	6.40	6.72	2	3	1
teeth	0.792	0.765	2.18	5.90	3.61	3	3	1
tomato	0.980	0.141	1.39	5.80	4.42	3	6	3
trumpet	0.694	1.109	1.06	6.15	6.73	3	7	2
volcano	1.000	0.000	1.57	5.60	6.34	3	7	3

Target Picture Name	Name Agree. (%)	Name Agree. (H stat.)	Lexical Freq.	Image Agree.	Subj. Age of Acq.	Obj. Age of Acq.	No. of Phon.	No. of Syll.
walnut	0.617	1.208	0.89	5.20	6.25	3	6	2
watermelon	0.980	0.141	0.72	4.55	4.52	3	9	4
wheel	1.000	0.000	2.13	6.00	4.21	3	4	1
wig	0.940	0.327	0.89	5.85	7.01	3	3	1
window	1.000	0.000	2.43	6.00	4.08	1	5	2
wolf	0.560	1.510	1.88	5.60	5.27	2	4	1
woman	0.694	1.406	2.70	5.80	3.85	3	5	2
wood	0.551	1.793	2.42	4.80	4.37	3	3	1
zipper	1.000	0.057	0.54	5.50	4.53	1	4	2

Table 6. Mean and log object recognition times (ms) for the final picture stimuli set

Target Picture Name	Mean Object Recognition Time	Log Object Recognition Time
acorn	570.92	2.74
alligator	553.25	2.73
anchor	665.82	2.80
ant	541.83	2.72
antlers	576.25	2.74
arm	562.17	2.74
ax	604.75	2.76
barbecue	624.60	2.79
bell	554.58	2.73
belt	547.50	2.73
bone	541.83	2.72
bowl	535.09	2.71
boy	530.58	2.71
bra	521.60	2.71
bucket	568.92	2.74
bug	590.30	2.76
button	559.10	2.73
cactus	707.50	2.83
cannon	626.82	2.79
canoe	580.00	2.74
carrot	528.17	2.71

Target Picture Name	Mean Object Recognition Time	Log Object Recognition Time
castle	623.25	2.77
cheese	591.58	2.76
chest	688.11	2.82
chimney	573.92	2.75
couch	616.42	2.78
cowboy	553.00	2.74
dinosaur	526.08	2.71
doctor	524.09	2.69
doll	547.33	2.73
drawer	590.00	2.76
dress	539.25	2.72
earring	709.50	2.83
egg	596.00	2.76
envelope	532.00	2.72
flag	603.75	2.77
flashlight	596.17	2.75
frog	595.90	2.77
ghost	616.83	2.78
gun	515.73	2.70
hat	632.00	2.77
jacket	528.33	2.72
knife	531.25	2.70

Target Picture Name	Mean Object Recognition Time	Log Object Recognition Time
ladybug	675.08	2.80
lamp	532.58	2.72
leopard	589.18	2.75
lizard	543.33	2.72
lock	593.58	2.76
log	619.08	2.77
mask	551.42	2.72
match	594.91	2.75
mirror	633.17	2.80
mountain	575.42	2.75
music	590.18	2.76
ostrich	544.75	2.71
package	695.00	2.83
pan	566.20	2.74
pants	557.82	2.72
parrot	526.27	2.71
peanut	548.60	2.72
pear	560.75	2.74
pillow	582.58	2.75
porcupine	623.00	2.77
puzzle	575.25	2.75
queen	542.00	2.73

Target Picture Name	Mean Object Recognition Time	Log Object Recognition Time
rabbit	564.45	2.73
rainbow	575.44	2.75
rake	603.27	2.76
ring	577.50	2.75
road	690.83	2.82
rose	558.50	2.74
saddle	601.36	2.77
sailor	624.67	2.78
scarf	536.42	2.72
seesaw	594.08	2.76
sheep	621.91	2.78
skateboard	547.18	2.72
soldier	609.75	2.77
stove	582.00	2.74
strawberry	592.67	2.76
stroller	580.00	2.75
suitcase	552.83	2.72
tape	620.10	2.78
teeth	580.27	2.76
tomato	609.60	2.77
trumpet	670.67	2.81
volcano	670.36	2.81

Target Picture Name	Mean Object Recognition Time	Log Object Recognition Time
walnut	678.90	2.82
watermelon	609.89	2.77
wheel	540.80	2.73
wig	634.92	2.80
window	590.42	2.75
wolf	604.83	2.77
woman	470.75	2.66
wood	617.27	2.76
zipper	568.92	2.75

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