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WHAT DISTRACTING INFORMATION TELLS US ABOUT BILINGUAL SPEECH PLANNING: EVIDENCE FOR ASYMMETRIES IN BILINGUAL TRANSLATION

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by
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ABSTRACT

Previous research on bilingual speech production has exploited the presence of distractor stimuli to determine whether the two languages are activated. The primary question in this line of research is whether words that are not intended for production (“unintended words”) become activated and compete for selection with the target word to be spoken. A number of studies have shown the phonology of the distractor is available, suggesting that unintended words compete with intended words for production. However, there are fewer studies demonstrating that the semantic properties of the distractors are available. As it stands, the evidence on the effects of semantic and phonological distractors on speech production presents an empirical paradox. According to most models of speech production, it is impossible to activate the phonology of alternative words without activating their semantics first. The primary goal of the present study was to determine whether phonology and semantics of unintended words are available in the language not to be spoken when bilinguals plan to speak a single word. The results of this work have important implications for understanding the scope of language selectivity and for explaining the mechanisms of control in bilingual speech production. A secondary goal of the present study was to use the distractor paradigm to test the assumptions of the Revised Hierarchical Model. The experiments were designed to examine hypothesized asymmetries in the degree to which conceptual information supports translation. To address these questions, six experiments were conducted using picture-word translation and naming tasks. The results showed that, under different conditions, both the phonology and semantics of distractor stimuli were activated. A critical finding in the translation experiments (Experiment 1, Experiment 2, and Experiment 3) was that the phonology of distractors became available even when the name was related only to the language of production. Another important finding in the translation experiments was that there was only evidence that the semantics of distractors was available when bilinguals translated from L1 to L2, supporting the Revised Hierarchical Model’s assumption that the L1 has privileged access to meaning.
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Background and Introduction

For a single word to be spoken, a series of mental actions must be completed. In a broad sense, the task requires retrieval of information pertaining to the word’s meaning and the way that it sounds. There are, in fact, a set of more intricate steps that a speaker must take to convert the message into a set of speech gestures that the listener can comprehend (Levelt, 1989). Converting the message requires the integration and exchange of different types of relations of word knowledge, including information about the word’s meaning and lexical form and possibly its syntactic function. For a bilingual, speaking even a single word must also involve the selection of the language in which the word is to be produced. There is now abundant evidence showing that a bilingual’s two languages are activated in parallel even when the context is limited to one language alone (Colomé, 2001; Costa & Caramazza, 1999; Costa, Caramazza, & Sebastián-Gallés, 2004; Costa, Miozzo, & Caramazza, 1999; Costa, Roelstraete, & Hartsuiker, 2006; Kroll, Bobb, & Wodniecka, 2006). That activation might be expected to generate errors of language selection. However, it is rarely the case that bilinguals accidentally produce words from the other language. Bilinguals are not only able to prevent the other language from intruding, but are often able to switch back and forth between languages with ease (Myers-Scotton, 2006). This suggests that bilinguals have a precise control mechanism that allows them to keep the two languages active without experiencing disruptive costs in production. A focus of current research is to understand how bilinguals control the activation of the two languages during speech production.

Bilinguals might be able to restrict the two languages by switching one language off and turning the other on. But there is not a good deal of support for this idea. One source of evidence that indicates both languages are active is the so-called cognate facilitation effect (e.g., Costa et
al., 2004). Cognates are words that have the same meaning in two languages but also overlap in spelling (orthography) and sound (phonology), e.g., the word hotel has the same spelling and close phonology in both Spanish and English. Bilinguals typically name pictures whose names are cognates faster than pictures whose names are lexically distinct (Costa et al., 2004; Janssen, 1999). When monolingual speakers name the very same pictures they do not show an advantage for cognate pictures. This suggests the cognate advantage in bilinguals is a consequence of having two converging sets of representations that are activated in parallel.

In production, speech begins with the intention to communicate a message that has been generated by the speaker (Levelt, 1989). If bilingual speakers can use the intention to speak in a single language as a cue to which language should be active, then they might be able to function as monolinguals in each language. On this view, words from the unintended language should not interfere with production. Since production is also initiated by a speaker’s communicative goal, rather than by a bottom-up process, interference from words that only overlap in orthographic/phonological properties would not be expected, unless there is spreading activation to the word’s lexical form. One goal of the current study was to investigate the circumstances that make bilingual production more open to competition between lexical competitors and to identify the circumstances that may reduce competition of non-target alternatives, and facilitate selection. A further goal of the study was to determine whether the phonology of unintended alternatives is activated in the process of specifying the intended target.

If the intention to produce a particular word could prevent other words from being active, monolingual speech production would provide a universal account that includes bilingual production as well. However, the consequences of becoming bilingual could potentially alter processes within production system. A question of interest is whether parallel activity found in
bilingual production is representative of language production in the broad sense.

Phenomenologically, it seems clear that even within a single language, we activate more than a single word during speech planning. These words sometimes come out as slips of the tongues. We may inadvertently produce an error such as “Did you talk the dog today?” Here, the word *talk* might have been produced because both *walk* and *take* (i.e. as in *take* the dog out) were activated. While on most occasions these unintended words do not intrude in speech output, the presence of speech errors suggests that there is activation of both intended and unintended alternatives even in monolingual speech (Harley, 1984; Harley, & MacAndrew, 1995; Harley & MacAndrew, 2001). It is interesting to note that bilinguals experience more tip-of-the-tongue (TOT) states than monolinguals, a situation in which there is a momentary lapse in the ability to retrieve a known word (Gollan, Bonanni, Fennema-Notestine, & Morris, 2005; Gollan & Brown, 2006; Gollan & Silverberg, 2001). Increased TOTs in bilinguals is an indication of increased competition across a bilingual’s two languages in speech production. Speech errors like the previous example demonstrate that the production system may be inherently open to parallel activation for intended and unintended words.

A critical question, then, is whether monolinguals face the selection problem in the same way that bilinguals do. Is there competition for selection in monolingual production? If so, how long does competition between word alternatives last? Monolinguals may experience fewer cognitive demands during speech planning and the reduced demands of speaking may allow them to select words with little consequence of activating unintended words. If this is true, we would expect minimal consequences of activating multiple words during speech planning in monolingual production. Monolinguals may experience parallel activation during production, but the skill in speaking the native language may reduce competition between words early during the
time course of speech planning. For bilinguals, the lower level of skill associated with second language may increase competition among lexical alternatives in both languages.

Some recent studies have challenged the idea that there is competition prior to selecting a word to be spoken. According to models of production that assume competition for selection (e.g., Damian & Martin, 1999; Roelofs, 1996; Starreveld & La Heij, 1996), unintended words that match the response criteria of the intended word are primed for production. One explanation as to why competition is expected is that word alternatives sharing a high overlap in meaning with the target are activated at a level that approximates that of the target word, making it more difficult to select the target. If this were true, the distance in meaning between intended and unintended words should predict the degree to which an unintended word interferes with production. Mahon, Costa, Peterson, Vargas, and Caramazza (2007) challenged the assumption that words compete for selection by investigating the consequences of decreasing the semantic distance between target words and distractor stimuli in a production task. In the task, participants named pictures while ignoring visually presented words that were members of the same semantic category. To vary the semantic distance, distractor words were selected such that they were category coordinate members (STRAWBERRY-target and LEMON-distractor) or from a different superordinate category (STAWBERRY-target and LOBSTER-distractor). The results showed that participants were faster to produce the target when the semantic distance was closer than more distant. Because decreasing semantic distance facilitated target, rather than causing interference, this was taken as evidence that words do not compete for selection.

Mahon et al.’s (2007) argument is not the only objection to the idea that competition takes place during lexical selection (e.g., Butterworth, 1992; Costa et al., 1999; Garrett, 1980; La Heij, 2005; Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992; Schriefers, Meyer, &
The approach used by Mahon et al. is compelling, and even unique, in that it directly targets the mechanism that is believed to drive competition during lexical selection. Different ways of framing the issue have been pursued in other studies of lexical selection. One commonality between these studies and the study conducted by Mahon et al. is that they rely on distracting information to probe the processes that transpire over the course of speech planning. The value of using distractors to probe the processes engaged in speech planning is that this method provides information about what types of cues may or may not be in place to identify the intended word as the response that must be produced, rather than all the other possible words. This issue is a particular one on which research on monolingual speech planning and bilingual speech planning converge.

In what follows, I first provide an overview of theories of monolingual speech production. Discussion will focus on prominent theories and the evidence that has been taken to support them. I then consider accounts of bilingual speech production, including the specific properties of bilingual production that may open the system to prolonged competition. I then describe the specific goals of the present study.

1. Lexical competition in monolingual production

Models of speech production assume that there are several stages that comprise speech planning. Levelt’s (1989) monolingual model of speech production was an attempt to capture the entire sequence of events that lead to the production of words and sentences (see Figure 1). The model includes both conceptual processes, such as forming a communicative plan, and a specification of the linguistic features that shape the speech act. The highest level component in the model, referred to as the conceptualiser, gathers information that is necessary to plan the message in a preverbal form. In some ways, this component can be thought as the gatherer of
“what” and “how” information. That is, the conceptualiser must decide which concepts need to be inserted into the message and how these concepts will be related to each other in a linguistic context. The formulator is hypothesized to be responsible for lexical access. Lexical access is the step that enables speakers to select a single word to be specified phonologically. This component transforms the preverbal message by assigning items from the mental lexicon, encoding those items grammatically, and retrieving their phonological form. The articulator is then proposed to adapt the phonological structure of the message to a motor plan, so that the message can be spoken. Finally, a speech comprehension system monitors the output to ensure that the message is articulated properly (see Figure 1.1).

![Levett’s (1989) Language Production Model](image)

**Figure 1.1.** A blueprint of the speaker (adapted from Levelt, 1989).

Levett’s (1989) model bought the intentional aspect of speech planning into focus and emphasized its role in determining which words were planned for production. According to the model (Levelt, 1989), a speaker begins planning by preparing the conceptual representation that
outlines what they want to say. At this point, all the information pertaining to the message is still preverbal. The conceptual representations are linked to a set of abstract word representations, or lemmas. Lemmas are word representations that are encoded for semantics (meaning). They are also specified for syntax and morphology. Lemmas are hypothesized to be connected to phonological representations. Only the lemma of the intended word is selected for phonological (sound form) encoding. The consequence is that the order of these stages is serial, such that retrieval of semantic information must be completed before phonological information is made available. The model assumes serial stages through the organization of connections within the production networks (see Figure 1. 2). Each of the levels of representations (i.e., conceptual, semantic, phonological) have connections between them, but the connections only traverse one another from the top level down.

It is critical to understand that Levelt’s (1989) model helped contribute to the idea that the intention to speak one word, as opposed to all the possible alternatives, results in “controlled” lexical access. Only the concept that the speaker intends to produce can be encoded phonologically. In subsequent sections, I will return to the issue of controlled lexical access by framing it in the context of bilingual production. To preview these sections, the focus will shift to whether controlled lexical access is attainable in bilingual production and whether there are certain constraints that dictate when it is possible. In the next section, I review alternatives to Levelt’s model that assume a more interactive process of language production.
Figure 1.2. The lexical network underlying single word retrieval (adapted from Levelt et al., 1999)

In contrast to Levelt’s (1989) model, Dell (1986, 1988) proposed a connectionist model of speech production that assumed interaction across the components of speech planning. Like Levelt’s (1999) model, semantic attributes that characterize a concept are represented at the conceptual level. These semantic attributes connect to conceptual nodes. The node is the element at which activation terminates at a representational level. It is selectable and can be passed through the system and processed at the next level. At the lexical level, a concept must be encoded to reflect the syntactic specifications of the sentence context in which the word will be uttered. For example, if the intended word requires number agreement then this type of grammatical encoding would be performed at the lexical level. Dell’s (1986) model of production was designed to include connections from higher levels of representations to lower levels and connections going the reverse direction. This model and future versions have been
used to account for errors in speech and disordered speech. However, Dell (1986) assumed that speech errors represent normal processes during speech planning. According to Dell’s model, the only processing difference between normal and disordered speech is that prior to speech errors, incorrect words receive more activation than correct words.

It is widely accepted that the process of mapping the intention to speak a word to its spoken form corresponds to two stages of processing, semantic retrieval and phonological encoding. However, models of lexical access differ in the assumptions made about whether these two stages interact or remain independent. All accounts assume that semantic information becomes available first. Serial accounts propose that only when the semantics of the intended word is selected does phonological encoding begin. The interactive account, on the other hand, proposes that activation of phonological information can begin before lemma selection is complete. A further distinction is made among interactive models. Interactive models include fully interactive models and cascaded models of production. Cascaded models of speech production assume that any semantic representations that have been activated will also activate their phonological representations. Within cascaded models, activation only flows one way (forward) throughout the system. Fully interactive models, or interactive-activation models, allow for activation to flow bi-directionally throughout the system. This creates a dynamic by which activation at the phonological level can be sent back up to the semantic (lexical) level. Critically, if the production system is fully interactive, the phonology of unintended words may be activated. Since phonological encoding is assumed to be a late stage of processing, one consequence of having a fully interactive system is that activation of unintended words can extend to advanced stages of speech planning.
The different models of lexical production allow distinct predictions to be generated about the presence and scope of activation of lexical candidates. Serial models (e.g., Butterworth, 1992; Garrett, 1980; Levelt, 1989, Levelt et al., 1991; Levelt et al., 1999; Roelofs, 1992; Schriefers et al., 1990.) predict that only the phonology of the lemma that has been selected will be retrieved. Other lemmas may compete at the semantic level, but the word forms of these lemmas will not. In contrast, cascaded models and interactive-activation models allow for phonological encoding to begin before lemma selection has completed. Cascaded models (e.g., Garrett, 1982; Harley, 1984) predict that the phonology of unselected lemmas will be available. Fully interactive models (e.g., Dell, 1986) predict that not only will the phonology of unselected lemmas compete, but it will also activate lemmas that do not overlap in semantics with the intended word. These lemmas will be activated on the bases of having some phonological overlap with activated lemmas. The model also predicts that feedback from the phonological level will boost activation for words that have both semantic and phonological overlap with the intended word.

Dell, Schwartz, Martin, Saffran, and Gagnon’s Aphasia Model (1997) is an example of a fully interactive model. It was intended to explain the speech errors in speech disordered and typical language populations. In particular, it focused on accounting for the pattern of errors observed in picture naming. Even though the model was developed to model disordered language, it is reviewed here because it also serves to describe lexical access in a single word context. A defining feature of the model is that it predicts a higher occurrence of mixed errors than would be obtained if the model did not permit feedback between the levels of representation. Mixed errors have both the semantic and phonological characteristics of the target word (e.g., saying “rat” instead of “cat”). If the architecture of the production system did
not include allow interaction between higher and lower levels of processing then there should not be a higher occurrence of these types of errors. Dell et al. (2007) tested different versions of the model against the error data from aphasic patients. The different versions of the model varied in the size of their connection weights. They found that a model with large connection weights, enabling interactivity, demonstrated the closest match to the error data.

Dell et al.’s (1997) Aphasia Model is shown in Figure 1.3. The figure depicts the process of lexical access when the intended word is “CAT”. As the figure shows, words from the same grammatical class (nouns) are activated when an individual prepares to say “CAT”. Furthermore, more activation is given to words that have the highest meaning similarity to “CAT”. Lemma selection occurs when the most activated word for the syntactic category is chosen. During phonological retrieval, the selected word receives more activation and the activation spreads from semantics down to phonology. “DOG” becomes activated because of its meaning similarity and “RAT” because of its phonological and semantic similarity with “CAT”. Lemmas that have been activated because of feedback from the phonological levels are “FOG” and “MAT”.

![Diagram of Dell et al.'s Aphasia Model](image-url)
Critics of Dell et al.’s model argued that a model must not only address disordered speech or errors. Levelt et al. (1999) asserted that the implementation of feedback throughout the network was unnecessary and not parsimonious. Levelt and colleagues claimed that a model could explain mixed errors without calling for feedback. Even though the Aphasia Model fit error patterns very well, it did not supply sufficient evidence to counter serial processing accounts.

Speech error data is not the only context in which monolingual speech appears to be interactive. Goldrick and Blumstein (2006) have found that activation on unintended words can even extend into the articulation of speech. When speakers produced tongue twisters, the phonological segments that had been made as errors contained traces of the intended word. Though the output sounded like it was produced incorrectly, its acoustic properties suggested that it had been modified to sound more like the intended sound segment. These data suggest that monolinguals do experience competition between word alternatives that is resolved relatively late in production. If the semantic and phonological properties of a word are activated simultaneously and they affect processing differentially, this would suggest that the semantic retrieval and phonological encoding stages are interactive. The use of this strategy for adjudicating between serial and fully interactive accounts has been supported (e.g., Starreveld & La Heij, 1995). It follows the ideas put forth in additive factors logic (Sternberg, 1969). As it pertains to lexical selection, in order for serial processing to occur there must be additive effects of jointly processing semantic and phonological information. The consequence of manipulating semantics and phonology jointly should be the same as adding the individual effects together. If
interactive processing occurs, then when the individual contributions of semantic and phonological are combined they should influence each other. According to the interactive view, feedback enables activation at phonological level to spread to the semantic level and influence activation there. One way that researchers can interpret whether there is additivity or interactivity is by comparing the magnitude of effects for when variables are kept separate or combined (Yap & Balota, 2007). The evidence for serial and interactive stages of processing draws from a variety of the methods that have been discussed. In the next section, I will review a set of empirical studies that have provided support for the two accounts of lexical access. Specifically, I will review studies that focused on speech planning in monolingual speakers.

II. Evidence for serial and interactive models

Starreveld and La Heij (1995) conducted a study to determine whether the phonology of unintended words becomes activated during production. They used the picture-word interference task to test their hypothesis. The picture-word interference task is a version of the classic Stroop paradigm (Stroop, 1935). A word is presented as a distractor and a picture as a target and the task is to name the picture and ignore the word. The pictures and the words are sometimes related to each other, making it difficult to ignore the presence of the distractor and focus on the target. The basic premise of the task is that participants will Stroop themselves out by processing the distractor word. The task also exploits the fact that there is a different time course for activation of semantic and phonological information in speech planning. Semantic activation is hypothesized to occur early in speech planning whereas phonological encoding is hypothesized to take place later. Therefore, the distractor’s ability to engage the speaker is dependent on the timing of its presentation. One prediction that can be made is that only semantic activation will be found at the early stages of production. Therefore, only semantically related distractors should
have an effect if presented at an early time point. This hypothesis is in agreement with the serial view of processing. However, if the phonology of the distractor interfered with production at an early time point as well this would support interactive accounts.

Starreveld and La Heij’s (1995) study included a group words that had both orthographic and semantic (orthographic-semantic) overlap (OOR-ear) with the target picture (OOG-eye). They compared presentation of these type of relations of words to distractors that only shared orthography (OOM-uncle), only shared semantics (VINGER-finger), or were unrelated (VILLA-villa) to the picture. There were additional distractor type of relations, but these are the most critical for the purpose of this discussion. In their experiment, different stimulus-onset asynchronies (SOAs) were used in order to segment out the time-course of activation for the different type of relations of distractors. Here, the term SOA refers to the interval between the onset of the distractor and the onset of the target (SOA). SOAs of -200 ms, -100 ms, 0 ms, 100 ms, and 200 ms were used. Dutch speakers named pictures in Dutch while ignoring the printed words. The most interesting finding was that significant effects of the orthographic-semantic distractors were found at the -100 ms and 0 ms SOAs. Their analyses also showed that no difference existed in the effect at the -100 ms and 0 ms SOAs. In addition, no differences were found for this effect across the whole set of SOAs. Since the -100 ms is thought to coincide with the early phase of lexical access and the 0 ms is thought to coincide with the late stage, orthographic-semantic distractor’s modulatory effect at the early SOA fails to support the predictions of serial models for which only semantic activation should occur at the early stage of lexical access. The other major finding concerns the nature of the interaction that was observed. Semantically related distractors caused interference, which is the typical outcome for these types of relations of distractors. Orthographically related distractors caused facilitation. For the
orthographic-semantic distractors, it appeared that the orthographic relationship modulated the semantic relationship such that the semantic interference was attenuated. If the combined effect of orthography and semantics were additive, there would simply be more interference for the orthographic-semantic distractors when compared to the semantic distractors. Starreveld and La Heij interpreted the results to support the interactive account of speech production.

Peterson and Savoy (1998) also conducted a study to determine whether the two stages of speech planning could interact. They used a version of the picture-word interference task in which target pictures had two synonymous names. For example, “SOFA” and “COUCH” are both acceptable names for a picture of a couch. On most trials, participants named target pictures. But on a small percentage of trials they were cued to name a distractor word. The idea was to bias participants to prepare the name of the picture by requiring picture naming on a high proportion of the trials. On the remaining trials participants saw a picture and after a delay a distractor word appeared. Participants had to switch from naming pictures to naming the word instead. The trials in which participants named the distractor words were critical for testing the mediation hypothesis. If the serial model is correct, then only one of the two synonym names should be selected prior to phonological encoding. It predicts that phonological relatives of the non-preferred synonymous name (e.g., “SODA” which looks and sounds like “SOFA”) should not have an effect on naming the dominant alternative. An effect of phonological relatives of the synonyms on naming would support interactive models. Peterson and Savoy found robust facilitation effects for words phonologically related to both the dominant and secondary names of the pictures and argued that the results were more compatible with interactive/cascading than with serial/discrete models of speech planning.
Jescheniak and Schriefers (1998) replicated the main features of Peterson and Savoy’s (1998) findings. They used a picture-word interference task that included similar conditions. Distractors were unrelated, phonologically related to the dominant name or secondary name, or phonologically related to a synonym for the dominant or secondary name. They found that there was inhibition for words phonologically related to the synonym name and facilitation for words phonologically related to the name the participant gave. Taken together, these three studies provide compelling evidence against the serial account of speech production.

Other evidence has shown that there are non-overlapping stages of activation during speech planning. Schriefers, et al. (1990) used the picture-word interference task to examine the sequencing of semantic and phonological activation in speech planning. In their experiments, a picture was named while participants ignored the presence of an auditorily presented word. In order to separate phonological and semantic effects, distractors were manipulated to include words that are semantically related (DESK-closet), phonologically related (DESK-devil) or completely unrelated (DESK-cap). Schriefers et al. presented the different distractor type of relations after variable delays relative to the onset of the picture. They found an interaction between distractor condition and SOA manipulations. There was only semantic interference at the -150 ms SOA (early delay), and only phonological facilitation at the 0 and +150 ms SOA (medium and late delays). In contrast to the evidence for interaction between lexical codes during speech planning, these data support a discrete planning stage in which phonological processes are initiated once semantic processing is complete.

Levelt et al. (1991) used a variant of the picture-word interference paradigm to determine whether the phonology of semantically related alternatives is activated. They tested for phonological and semantic effects of distractor words by comparing baseline lexical decision
responses to lexical decision responses in the context of picture naming. At a short SOA, there was a large interference effect in lexical decision for both semantically and phonologically related probes. There was also an effect for phonologically related words at a long SOA. The observation of phonological activation during the early SOA stands contrary to the predictions of the serial model. This study also included distractors that were phonologically mediated (e.g., picture = sheep, semantic distractor = wool, phonologically mediated distractor = wood). The authors found that phonologically mediated distractors produced a very small effect on latencies. They suggested that there was no evidence for interactive processing because they did not observe any semantic activation at the late SOA and because they did not observe phonological activation of semantic relatives at the early SOA. Together with the result of Schriefers et al. (1990), these data have been taken to be the strongest support for the serial discrete model.

The research reviewed above shows that monolingual speakers experience persistent interference from unintended words. Words that are not related to the intended word at all, except through their phonological or semantic relation to the target, become activated over the course of speech planning. The evidence from monolinguals also hints at an interaction between semantic and phonological information, although that interaction is sometimes elusive. Though it may not characterize monolingual speech production under typical circumstances, it does not necessarily mean that these observations are unrepresentative of the speech production system. For monolinguals, they might rarely encounter unintended words that overlap so closely that they will compete. In contrast, for bilinguals, there are many close lexical relatives because almost every word in each language has a close translation equivalent in the other language. Bilingual speech production thus provides a natural context for examining issues of competition and lexical selection.
To the extent that there is a translation equivalent in each language that has more or less the same meaning, one would expect activation of cross-language distractors. L2 speech, in particular, provides a context for testing hypotheses about lexical competition. This comes as a benefit since the demands associated with L2 speech may increase selection difficulty. In other words, the monolingual context is less ideal than the bilingual context for testing hypotheses concerning lexical access. Monolinguals have a great deal of experience speaking in their native language and as a consequence their speech planning is highly skilled. For a bilingual, speaking in the L2 may be a less practiced skill, and thereby more prone to error and more open to the influences of activated alternatives.

The idea that speech occurs in a discrete manner is has been difficult to reconcile with research findings on bilingual speech. If words from the bilingual’s two languages are active in parallel, this would suggest that the speech production system as the potential to be highly interactive. If one were to make a strong case for selectivity, then words from the unintended language should not enter into competition with words from the intended language at all.

Bilingual research on lexical access is an important tool for confirming predictions in monolingual cases. More and more research on lexical access in bilingualism also suggests that there are unique properties of competition for selection in bilingual speech. An additional use of studying bilingual of lexical access is for understanding precisely how these properties contribute to a set of specific cognitive advantages. In the following sections, I will discuss evidence for competition in bilingual lexical access and mechanisms that have been hypothesized to allow the control of the two languages.
III. Competition between phonological relatives in bilingual production

Recently, a number of studies have attempted to demonstrate that phonological relatives in the unintended language are active during production in single language context. The question is important because it provides insight into the nature of the competition between the two languages. For competition to remain unresolved at the level of phonology it would imply that the two languages are highly interactive. Even some selective models of speech production allow for co-activation of semantic competitors in both languages (Hermans, 2000; Poulisse & Bongaerts, 1994). Activation of semantically related alternatives may be more difficult to prevent. This may be due to the fact that the conceptual features that support semantic representations of words in the two languages overlap closely. Furthermore, conceptual features do not have to carry language-specific information. In other words, conceptual nodes are not specific to a given language. If this were the case, it is plausible that during production semantic alternatives in both the intended and unintended language are activated. This might set off a set chain of events that allow the phonology of unintended words to become activated as well. However, bilinguals might be able to use a language cue to ignore words from the other language. The language cue is the intention to speak in one language as opposed to the other. According to some accounts of bilingual language production (Costa et al., 1999; Roelofs, 1998), the language cue only permits words from the intended language to be considered as responses. If the language cue could function to constrain lexical selection to a single language, then the phonology of unintended should not compete with the intended word.

For some researchers, the language cue has been thought to function similar to a mental firewall. Words from the unintended language may become activated but they do not become a part of the set of words that compete for production. Therefore, even when their phonology
becomes available language production should appear to be selective. This is the view proposed by Costa and Caramazza (1999). Another proposal is that the language cue serves to constrain selection of phonological representations to those in the target language. The semantic representations of words across the language can become activated but they do not pass activation to their phonological representations (e.g., La Heij 2005). These alternatives will be described in further detail in subsequent sections. For now, it should just be recognized that there are some theories that predict that the language cue should restrict selection to the intended language.

Hermans et al. (1998) conducted a picture-word interference study with relatively proficient Dutch (L1)-English (L2) bilinguals to test the hypothesis that alternatives are activated in the unintended language. Participants were instructed to ignore distractors that were presented auditorily and to name the picture in English. They used SOAs of -300, -150, 0, and 150 ms. During one version of their task, participants saw distractors the language of production (English). Distractors were either phonologically related to the target (mouth-MOUNTAIN), phonologically related via its translation in Dutch (bench-MOUNTAIN), semantically related (valley-MOUNTAIN) or unrelated (present-MOUNTAIN). In another version of the task, participants heard distractors in the language that should be ignored (Dutch). Distractors were either phonologically related to the target (mouw-MOUNTAIN), phonologically related via its translation in Dutch (berm-MOUNTAIN), semantically related (dal-MOUNTAIN) or unrelated (kaars-MOUNTAIN).

In the version of the task with English distractors, there was simultaneous activation of phonologically related distractors and semantic distractors at most SOAs (-300, -150, and 0 ms SOAs). These results contradict serial views of production since the phonology of the word is
activated before the presumed offset of semantic activation. Hermans et al. (1998) also found that the phonological-Dutch distractor (bench) did not have a significant effect on picture naming. They hypothesized that this could be due to the fact that the distractor did not have a close phonological overlap with the Dutch translation equivalent of mountain (berg). When Dutch distractors were presented a different pattern of results emerged. The phonological-Dutch distractor (berm) was active at some SOAs. Because the phonological-Dutch word was not activated at the stage during which phonology is retrieved (i.e., the late SOA), they argued that the distractor was not activated all the way down to its phonology. Hermans et al. took these findings as evidence that activation of cross-language competitors is restricted to the level at which lemmas are selected. Unlike Jescheniak and Schriefers (1998) and Peterson and Savoy (1998), the additional overlap in phonological form did not increase the likelihood of the distractor influencing picture naming latencies.

Costa et al. (1999) used a picture-word interference task in which visually presented distractor words were drawn from both the response language and the non-response language. They tested whether there was activation of translation equivalents. Translation equivalents are simply words that mean the same thing in two languages (e.g. casa and house). They also tested whether distractor words that shared phonology with translation equivalents in the other language would facilitate picture naming. If translation equivalents activate their counterparts in the other language, then it is possible that words similar in phonological form via translation equivalents (translation mediated) will also facilitate processing. This is the similar to the idea that Hermans et al. (1998) tested. In Costa et al.’s experiment, the focus was on words whose translation equivalent in Catalan was similar to the target. For example, for the Catalan target “BALDUFA” the distractor from Spanish was “PELEA”. This word is translated as
“BARALLA” in Catalan, and thus phonologically related (same onset) via translation. There was no effect of the translation-mediated distractors on naming times. However, there was facilitation for the name of the translation equivalent. The translation facilitation effect is counterintuitive in the sense that it should be most difficult to name a picture in the L2 if the name of the word in the L1 is presented. According to a competition for selection model, the translation equivalent should produce more competition than any other semantically related alternative since it is also the name of the object. But Costa et al. found facilitation rather than interference and argued that the converging conceptual activation for the translation was the basis of the observed facilitation (but see Hermans, 2004).

The evidence from Costa et al.’s translation equivalent experiments can be used to support either the selective or non-selective model. If convergence across phonological nodes constrains activation to words from the selected language it may reconcile these two findings. In some ways it presents another challenge. To be precise, it allows lexical selection to be both selective and non-selective. According to Costa et al.’s (1999) view, phonological convergence is non-selective to the extent that it permits cross-language activation at the lexical level. But it is also language specific because it restricts lexical selection to the target language. The results from Hermans et al.’s experiments also appear to support either selective or non-selective views. The data supports selectivity because the items that were phonologically related via the translations did not have an effect during the period of activity that phonological processing is expected. However, to conclude that language selective activation was shown would be imprecise. The fact that the L1 words that shared a phonological relationship with the translation produced a reliable effect is not trivial. This finding corroborates Kroll et al.’s (2010) argument that, at least for low proficiency bilinguals, the increased demands associated with speaking in
the L2 may make competition between L1 and L2 more pronounced. Furthermore, this competition was evident in a context when the L1 was directly inter-mixed with the L2.

Another strategy for investigating the nature of the information available during the planning of spoken words has been to exploit the presence of distractor pictures whose names may become available prior to the selection of a target picture’s name. Morsella and Miozzo (2002) conducted a picture-picture interference study with a group of monolingual English speakers. In the picture-picture interference task, participants named target pictures while ignoring distractor pictures. One issue with picture-word interference tasks is that the observed interference may not be indicative of competition during production. The interference might be artificially induced because the written words have to be processed in close temporal succession to picture stimuli. The bottom-up processing of orthographic to phonological mappings in word recognition may induce phonological effects that would not otherwise be seen during speech planning. Presenting pictures as distractors avoids this limitation and also provides a converging method for testing alternative models of lexical access. Morsella and Miozzo’s study included phonologically related and unrelated picture pairs. All phonologically related words overlapped in onset, and differed by the final consonant. For example, phonologically related pairs include pictures such as “BED” and “BELL”. A group of Italian monolinguals, for whom the picture names were unrelated, served as a control. They hypothesized that if sensitivity to phonologically related words was found in English native speakers but not in Italians then there was a true effect of phonology. They found a significant facilitation effect for the native English speakers only and concluded that the results are in line with cascaded views of processing. They argued that the serial view of processing could not account for the data. These results are important because they provided another means of re-examining the selection problem in
monolingual production. In a task in which the interfering stimulus is a picture, production appears to be interactive. More research is needed to better understand the nature of distractor tasks in modulating lexical selection. For now, the results tentatively suggest that differences in processing for pictures and words can influence the extent to which alternatives compete in production.

Colomé and Miozzo (2010) performed a bilingual version of the picture-picture interference task to determine whether there is activation of competitors in the unintended language. In one condition of their study, Catalan (L1)-Spanish (L2) bilinguals named pictures in Catalan while ignoring the presence of distractors that were pictures with either cognate or non-cognate names. The idea was that if there is nonselectivity in language production, then the two translations of the cognate picture should be activated simultaneously. By comparing naming in the presence of cognate pictures to naming in the presence of non-cognates, they determined whether activating the name of the word in the unintended language interferes with production. They found that pictures whose names were cognates slowed down the time to name the target picture. In another version of their study, participants named pictures in the presence of distractors that were phonologically related via the unintended language. For example, the Catalan target picture ARMILLA (meaning vest in English) was paired with the distractor whose Spanish name was ARDILLA (meaning squirrel). They found that participants were faster to name the target picture when the distractor picture was phonologically related in the unintended language. This finding is similar to that of the monolingual picture-picture interference task because it demonstrates that alternatives are activated to the level of their phonology.

Bloem and La Heij (2003) suggested that the phonological facilitation found in the picture-picture task is an artifact of superimposing the pictures on top of each other. They
questioned whether participants could visually isolate the two pictures If Bloem and La Heij’s assumptions about word distractors are correct, then phonologically related words should influence production. When words are used as distractors, there is mixed evidence in favor of activation of phonology in the other language. In the picture-word interference task, pictures serve as the targets and words are the distractor. The participant’s task is to name the picture and ignore the word. There could be a discrepancy in the results from picture-word interference tasks and picture-picture interference tasks that is due to the modality of the target stimulus. Pictures, unlike words, lack features that could inform the speaker about the language to which it belongs. This may promote ambiguity with respect to the language in which the picture is planned for production. Differences in orthographic features are, at least potentially, available for bilinguals to exploit when they are processing text. If this were a useful cue to production, then one would predict that bilinguals whose two languages use different scripts could restrict activation to a single language.

Hoshino and Kroll (2008) investigated whether differences in script would constrain the activation of the two languages in a picture naming task. Though the orthography was never presented directly to the participants, orthographic information was hypothesized to be available as a consequence of being a skilled reader. Furthermore, they hypothesized that a life-time of experience reading words in the two scripts might prove sufficient to keep the two languages from interacting in a production task. In order to test these predictions, they compared naming of cognate and non-cognate pictures by Japanese-English bilinguals and Spanish-English bilinguals. Both groups of bilinguals were faster to name cognates than non-cognates, demonstrating the cognate facilitation effect. This evidence fails to support the prediction that orthographic cues are
sufficient to limit activation to a single language, at least when the orthography is not presented directly.

Miller and Kroll (2002) tested whether the language of the input could be used as a cue to selection. In their experiments participants performed a translation Stroop task. Spanish-English bilinguals were asked to translate a word while ignoring a visually presented distractor word. They translated from their L1 (Spanish) to the L2 (English) and from the L2 to the L1. Distractors related in form and meaning were presented. In one version of their experiment, distractors were presented in the language of the output. For example, if the participant had to translate CUCHARA to its English meaning SPOON, the semantic distractor would be FORK. The form related distractor would be SPOOL. In the other version, distractors were presented in the same language as the target word. Now CUCHARA would be presented with the semantic distractor TENEDOR (fork). The form distractor would be CULEBRA (snake). These manipulations allowed the researchers to test their hypothesis that the language of the target is a cue that filters competitors. These researchers found evidence that the visual input provided through written forms served as cue to restrict activation to the intended language. In contrast to Hermans et al. (1998) and Costa et al. (1999), Miller and Kroll found that only semantic competitors that matched the language of production produced interference in translation. One interpretation of their findings is that the cues provided by the written form of the distractor effectively diminished activation of semantic relatives in the unintended language.

While there is an accumulating body of evidence showing that speech planning does not proceed selectively, identifying candidates in the target language alone, there are some results suggesting that under certain contexts selective access is possible (see Kroll et al., 2006, for a discussion about the factors that may determine whether selectivity is observed). One question is
how the language control mechanism can allow early resolution of competition of cross-language alternatives in some instances and prolonged activation in other instances. Some insight from the research reviewed above is that bottom up and top-down information may influence production in different ways. Another suggestion in the literature is that language selectivity depends on L2 skill, with higher proficiency learners or bilinguals more likely to affect control that allows selection to proceed independently by language (Costa & Santesteban, 2004). In the next section, I review models of control in bilingual lexical access. A critical question is whether the language cue suffices to prevent competition between the two languages.

**IV. Models of control in bilingual lexical access**

One potentially unique aspect of bilingualism speech production, as compared to monolingual speech, is that bilinguals have to select the language in which they intend to speak. This aspect of bilingual speech production is impressive given that there is abundant evidence suggesting that both languages are activated in parallel (Colomé & Miozzo, 2010; Costa et al., 2000; Hoshino & Kroll, 2008). According to past views, modeled on the approach taken by Levelt (1989), the intention to speak in a particular language was assumed to be sufficient to ensure that only one language was activated for production. This idea was incorporated into Bot’s (1992) bilingual adaption of Levelt’s monolingual model of speech production.

When De Bot modified Levelt’s (1989) model to suit bilingual production, he drew particular attention to determining the component that would capture the intent to speak in one language. De Bot (1992) argued that Levelt made the assumption that the conceptualiser designated the language of production in the preverbal message. It is through Levelt’s register, a component within the conceptualiser, that bilinguals are able to cue the language of production.
The purpose of the register is to encode the specifications of the language’s functional and formal parameters. De Bot suggested that those specifications themselves could be the agents of language-specific activation. He also proposed that the production system had two formulators that operated in parallel. One language was selected and the other was simply active in the background. If the case arises that the other language was needed, the bilingual could easily switch into it. The model supported the idea that interaction between the languages had to be maintained to support such phenomena as language switching. Given that two sets of operations to retrieve a word are permissible and there is nothing to prevent words from both formulators to be selected, the model does not help clarify how the languages do not interfere with each other during production.

Other proposals for how to reconcile the possibility of parallel activation with limited occurrences of interference from an intruding language followed. Poulisse and Bongaert’s (1994) described a model in which the preverbal message contained information about which language was to be spoken. In their model, a language cue distinguishes what will become activated at the conceptual level. Words in the same language as the cue are thought to receive higher activation than words in the non-cued language.
To address the issue of controlling language selection directly, Green (1998) proposed the Inhibitory Control (IC) model. The model is based on a model of executive control proposed by Norman and Shallice (1986). It integrates their concept of the supervisory attention system (SAS) with a general production model. The purpose of the SAS is to regulate action tasks. In Green’s model, the SAS activates, maintains, and updates language tasks. The SAS performs these functions by manipulating language task schemas. A schema is conceived as a set of networks that help support a certain task. There can be a schema for word translation, a schema for silent reading, a schema for picture naming, etc. The task schema itself can help ensure that words from a particular language and not the other become selected. Take for example the case of translating from language A to language B. If my task is to translate from A to B, the goal itself will be activated and it specifies the language of the output already. Green suggested that
the specification that is promoted via the task schema restricts activation to the target language
concepts. In order to ensure that the correct word forms are selected, the language system tags
the lemma that has been associated with the concept.

Figure 2.2. The Inhibitory Control model (adapted from Green, 1998).

The language tag is not completely sufficient for ensuring the proper word will be
selected. Green raised the argument that a high degree of shared semantic features between
concepts across languages may allow words to become active in the other language, even if they
do not have the language tag. For this reason, he introduced the idea that lemmas without the
language tag were deactivated through suppression. The idea that conceptual representations are
shared in bilingual lexicons is still a matter of debate. In the next section, I will describe the
evidence for shared features. An effort will be made to explain how shared representations may
contribute to language competition.
V. Distributed conceptual features and shared conceptual storage

Perhaps if words are linked to each other at the abstract conceptual level and lexical access is driven by spreading activation, even the intent to speak in one language cannot restrict activation to one set of representations. This is essentially the idea that Green (1998) implied in his view of language control. Considering the research reviewed above, shared conceptual representations seem to be instrumental in determining whether there is competition for production. As mentioned previously, prolonged competition in monolingual lexical access is found when there is a high degree of conceptual overlap between targets and alternatives (such as near synonyms). For bilinguals, the scope of conceptual overlap between words is much greater since translation equivalents typically map on to the same concept across languages. If a common set of conceptual features support the retrieval of words in the both languages, then activating the two languages is unavoidable. Some researchers posit that these words are separated at the conceptual level of representation though. Therefore, the overlap in meaning might not present a significant problem to the production system.

It can not conclusively be stated that the conceptual store is shared between a bilingual’s two languages since there are results that can be interpreted either way. However, there is not much evidence that firmly counters the shared store hypothesis. A fair amount of evidence supports the claim. This evidence comes from a variety of experimental paradigms. Research on cross-language priming in lexical decision has provided some evidence for shared conceptual representations (De Groot, Dannenburg & Van Hell, 1994; De Groot & Nas, 1991; Van Hell &
De Groot, 1998, Schwanenflugel & Rey, 1986). In this paradigm, a word is presented that has to be ignored. A subsequent word is presented and the participant is instructed to indicate whether it exists as a real word or is a non-word. In the bilingual version of the task, primes are sometimes presented in the language that the lexical decisions task was performed in. Sometimes primes are presented in the other language. Facilitation has been found when the lexical decision word is primed by a word in the other language. This evidence supports shared conceptual access in comprehension.

Another source of support for shared conceptual representations across the bilingual’s two languages comes from studies using the translation recognition task. Here, participants decide whether a pair of words has similar meanings across languages. Sánchez-Casas, Suárez-Buratti and Igoa (1992) presented Spanish (L1)-English (L2) bilinguals with translations that were either cognates (león-lion,) or non-cognates (vida-life). Note that cognates are words that share the same meaning and similar orthographic/phonological features across language. They also included a set of translation pairs that did not completely have the same meaning across two languages (papel-paper, hoja-sheet). They found that non-cognates received less priming if the pairs of words were not identical in meaning across the two languages. It did not matter whether the cognates meant exactly the same thing or only had somewhat similar meanings. The amount of priming that these two types of relations of cognates produced was nearly the same. This suggests that, at least some words share conceptual overlap in the two languages. Furthermore, it

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1 De Groot’s Distributed Conceptual Feature model (De Groot, 1992) outlines the degree to which conceptual representations overlap across languages. In a set of experiments (De Groot, Dannenburg & Van Hell, 1994; De Groot & Keijzer, 2000; Van Hell & De Groot, 1998) have found that factors such as concrete words and cognates show an advantage over abstract words and non-cognates when individuals learn vocabulary in their foreign language and when bilingual perform language processing tasks. The implication of these results is that there are constraints on conceptual overlap between words in the two languages.
provides strong evidence that the extent to which the languages interact at the lexical level is modulated by the degree to which conceptual representations overlap.

Other support for shared conceptual representation is provided by studies relying on the bilingual picture-word Stroop task. As mentioned previously, Costa et al. (1999) found picture naming was facilitated when translation equivalents matched the language of production and when it did not match the language of production. One way to interpret this finding is that both translations were considered as responses because of having identical meaning representations. Similarly, Hermans et al. (1998) found that semantically related distractors presented in Dutch (the language to be ignored) and English (the language of production), produced similar interference on picture naming. Both of these studies demonstrate that the semantics of candidates across languages are activated in the picture-word Stroop task regardless of the match between the language of naming and the language of the distractor.

VI. Different routes of access to meaning for lexical access in L1 and L2

The level at which cross-language competitors are active may also be a matter of which language (L1 or L2) provides the competing lexical information. Another factor that could influence competition between the two languages is language dominance. In the literature on lexical access in speech production there has not been a systematic approach to investigating the joint contribution of language dominance and the language of production in the experimental task. This is one explanation for why it has been difficult to discern which view the findings in bilingual studies of lexical access truly support. There are many contrasting hypotheses that one can build based on the interaction between the language dominance and the language of production. Some of these predictions can be drawn from the Revised Hierarchical Model,
henceforth referred to as the RHM (Kroll and Stewart, 1994). This model outlines the relationship between conceptual and lexical information for bilinguals who acquired their L2 later. A less proficient L2 speaker is presumed to have direct links between the L1 and conceptual representations but indirect links between the L2 and conceptual representations. As the speaker gains more proficiency in the L2, they will strengthen their L2 conceptual links. However, in the initial stages of learning they will rely on lexical links from the L2 to the L1 to access conceptual representations.

The RHM predicts that bilinguals will be differentially susceptible to the influence of distractors depending on the language of production. The model predicts that form related distractors will have a larger effect on translation or picture naming when bilinguals translate from L2 to L1 than when they produce speech in the L2. In contrast, it predicts that semantic distractors will have a larger effect on translation from the L1 to the L2 than when producing speech in the L1. However, the role of proficiency is also recognized. Therefore, bilinguals who have attained high proficiency in their L2 may be able to access semantics directly and more symmetrically across the two languages. In this case, semantic distractors would be expected to influence translation from L2 to L1.

The RHM is considered a model that describes the structure and development of representations in bilinguals. It has not often been cited as a theoretical basis for making predictions about competition via cross-language activation. Unlike models such as Green’s ICM and Levelt et al.’s (1989) model of production, the RHM does not specify how its components might initiate task processes and control lexico-semantic processes that support speech production. That is, there are no units or components built into the model itself that regulate activation of different type of relations of lexical information. However, the RHM is intended as
a model of speech production (Kroll, Van Hell, Tokowicz, & Green, 2010). Its particular focus is on the skill of bilingual translation (Kroll et al., 2010).

In a seminal study, Kroll and Stewart (1994) tested whether the two languages exploit conceptual information similarly. In order to do so, they compared picture naming and translation. Picture naming is believed to rely on conceptual mediation. Past research findings that support this idea have demonstrated that picture naming in the L1 takes longer to complete than word naming (Potter & Faulconer, 1975; Smith & Magee, 1980). Potter, So, von Eckhardt, and Feldman (1984) found that picture naming in the L2 was as fast as translation from the L1 to the L2. They took this as evidence that translation was conceptually mediated as well. This was true even for less proficient bilinguals. Contrary to Potter et al.’s results, Kroll and Stewart predicted that that translation may not be conceptually mediated in both directions. In order to test their prediction, they compared translation in each direction (L1 to L2 and L2 to L1) when the words to be translated were organized in categorized lists (e.g., all items of clothing) or random lists. They found that only translation from L1 to L2 was affected by categorizing the lists. Because categorizing is supposed to cause interference by introduce competing conceptual entities, it should only affect tasks that are conceptually mediated. The fact that only L1 to L2 translation was affected was taken as support that conceptual mediation is involved in this direction but not in L2 to L1 translation.

Sholl, Sankaranarayanan, and Kroll (1995) performed another study to test whether translation asymmetries between bilinguals’ two languages exist. This experiment raised the question of whether translation in the two languages would benefit equally from conceptual priming. In this experiment, participants translated words from both languages. The names of the words that were to be translated were also the names of pictures that they had been pre-tested on.
Sometimes the pictures were instructed to be named in the L1 and sometimes in the L2. They also manipulated the concordance between language of picture naming and language of translation. In other words, sometimes the language used to name the object and the language that the word that labels the object was the same. The logic behind presenting the pictures in a separate session is that participants should have retrieved the name or attempted to retrieve it and that act will transfer to the translation task. It should speed the time it takes to retrieve the name again. But, the facilitation should only occur if the processes the underlie naming and translation are the same. Only L1 to L2 translation was facilitated by presenting the pictures beforehand. Once again, there was evidence that only L1 to L2 translation is conceptually mediated. An important finding from this study is that processing conceptual information (e.g. the pictures) in both languages facilitated L1 to L2 translation. The access to relevant meaning is what led to the advantage, not retrieving the word form.

Critics of the RHM have argued against the assumption that conceptual access from L2 to L1 does not take place. They claim that proficiency is not the primary determinant of whether information is accessed through lexical pathways or conceptual pathways. Duyck and Brysbaert (2004) have argued that other factors, such as a word’s frequency and the alignment in meaning between translation equivalents, may additionally determine the pathway through which information becomes available. In light of this, they have proposed that a model of bilingual lexical representation must account for these kinds of word-level properties. The rationale for proposing this addition to the model is to accommodate evidence that even very recently acquired word representations can be accessed through the conceptual route in the L2. This evidence is derived from studies of foreign language or artificial vocabulary training. In this paradigm learners are trained on a set of novel words and afterwards they are then tested on their
knowledge of meaning of these new words. Some researchers have found that even after brief exposure to novel words through training, learners are sensitive to the words’ meaning.

Altarriba and Mathis (1997) conducted a vocabulary training study to examine the predictions of the RHM. In their study monolingual English speakers were taught a small set of words in Spanish and their English translations. In a single session, participants were taught a set of 36 Spanish-English word pairs (e.g. HILO-THREAD). Shortly after training, these learners were tested on translation recognition. The learners were then given a translation recognition task to determine whether they had formed connections between the L2 word and its meaning. In their translation recognition task, a Spanish word appeared and was replaced by the English word. The participant had to press a key to indicate whether the English word was the correct translation or not. The experimenters manipulated the English word such that it was the correct translation (THREAD), orthographically related to the correct translation (THREAT) or unrelated (PARENT) to the translation. The learners’ performance was compared to a group of English-Spanish bilingual speakers. They found that the bilinguals and the leaner’s were slower to respond to orthographically related words compared to unrelated words. In a separate experiment, a group of monolinguals learned the same set of translation pairs. This time, during the translation-recognition task semantically related words (e.g., NEEDLE) were included. Contrary to the RHM, they found that learners and bilinguals were slower to respond to semantically related words compared to unrelated words. The fact that novice learners show evidence of being able to access the semantics of L2 words was taken to invalidate the RHM.

Similar to studies involving fast-paced L2 learning, some researchers have used number translation to investigate whether connections to meaning are established early in L2 learners. Numbers have been argued to be processed semantically because the magnitude of the number
influences how quickly it is retrieved. For example, the number two can be retrieved faster than the number eight because it is smaller in magnitude. Duyck and Brysbaert (2004) asked whether low proficiency L2 bilinguals were sensitive to the magnitude of numbers during translation. In their task, a group of Dutch (L1)-French (L2) speakers performed translation from L1 to L2 and from L2 to L1. The group included low and high proficiency bilinguals. They compared the performance of the two groups to determine if they differed in their sensitivity to number magnitude in the two directions of translation. Their result showed that the latency to begin translation was longer as the magnitude of the number increase. This was true of both directions of translations. Most importantly, there was no difference between the size of the latency in L1 to L2 translation and L2 to L1 translation. This was true for both low proficiency and high proficiency bilinguals. They concluded that these results demonstrate that both directions of translation are conceptually mediated.

Why do these studies show that low proficiency bilinguals can access semantics in the L2 and other studies do not? The discrepancy in findings might be explained by the frequency of items that are used during testing. The words that were trained in Altarriba and Mathis’s (1997) study are high frequency words. It is not clear precisely how frequency might alter a learner’s ability to integrate meaning into their representation for a new word. However, it is logical that learners may require less exposure to high frequency words to add them into their vocabulary. Thus, by teaching learners just high frequency words they are advancing the learners to a level at which they can perform like high proficiency bilinguals. In other words, it is presumed that longer exposure to the L2 is what helps strengthens connections between L2 words and their meaning, but high frequency words might not need as much exposure. Because they are high frequency words, their meaning representations may be pretty stable in the L1. If the word’s L1
representations are stable, then the word might not have to be embedded in different context for the meaning to be understood in the L2.

Additionally, all of the translations that were trained in Altarriba and Mathis’s study were concrete nouns. Concrete nouns, like high frequency words, may require less experience with to grasp their meaning. This is one explanation for how low proficiency learners are sometime able to access the meaning of words in the L2. There is evidence that when a word is more difficult to process, such as abstract words translation asymmetries are found and this evidence has been taken to support the idea that frequency/concreteness might alter the level at which bilinguals can perform conceptual access (Kroll et al., 2010).

The RHM has also been opposed because the retrieval of conceptual and lexical information in the two languages is said to be governed by more global aspects of the language user’s ability (i.e., language proficiency). Critics have claimed that the RHM ignores the influence of a word’s inherent properties on retrieval. In fact, the RHM has articulated that the manner by which language proficiency operates is to bring different properties of the word into focus. This suggests that the way that proficiency influences word retrieval is much more subtle than an all-or-nothing process. For example, the RHM has been used to take a critical look at changes in the organization of connections between the two languages when learners increase their proficiency. The model proposes that during the initial period of L2 acquisition the bilingual will be more reliant on form relationships between L1 and L2 words. Kroll and colleagues (Jared & Kroll, 2001; Kroll, Tokowicz, Michael, & Dufour, 2002) have asked how sensitivity to form relationships changes with time. Kroll et al. (2002) found that both higher and lower proficiency L2 learners were sensitive to the orthographic and phonological overlap between L1 and L2 words. Learners were faster to translate cognate words faster than non-
cognate words in both directions of translation. This suggests that, regardless of their overall sensitivity to semantics in L2, additionally sharing form overlap with a word in the L1 facilitates access to meaning.

Figure 3.1. A schematic representation of the RHM (adapted from Kroll & Stewart, 1994).

To summarize, critics of the RHM may be correct in that the word-level properties are essential to understanding what enables retrieval of conceptual information to take place. It is well-established that word-level properties to have consistent effects on comprehension and production in a variety of experimental contexts (e.g., Hoshino & Kroll, 2008; Schwartz & Kroll, 2006). With respect to translation in the two directions, the evidence that they have found using number words and high frequency/concrete words seems to support this notion. Additionally, the evidence that Kroll and colleagues have found on the interplay between orthography/phonology and the meaning of words reinforces this notion. Finally, it is important to recognize that the predictions of the RHM were not meant to be interpreted through the lens of language comprehension. Rather, the RHM’s focus was on production. But it is precisely in
comprehension that the evidence for direct access to semantics in the L2 has been found (Kroll et al., 2010). Kroll et al. (2010) argue that speaking is where the asymmetries between the two languages should be most apparent. Speaking requires the mapping of concepts onto their word forms. They argue that because the L1 is highly practiced, it requires less control to map concepts onto their word forms (lexicalization). But lexicalization in the L2 is much more difficult because it is less practiced, and the L1 more practiced. The L1 is likely to compete with the L2 for selection.

The RHM makes clear predictions regarding the consequence of presenting semantic and phonologically related distractors during translation. To the best of my knowledge, only two studies have been examined the predictions of the RHM in production tasks involving distractors (e.g., La Heij et al., 1996; Miller & Kroll, 2002). La Heij et al. (1996) performed a series of experiments that provide a test of the model’s predictions in the context of translation task using pictures as distractors. Translation and picture naming are similar in the sense that they both begin with conceptual processing. However, translation and picture naming differ in that in translation, the written form of the word provides information about which language should be in use. Thus, it could potentially act as a language cue. In addition, the set of words that are likely to be activated when a picture is shown include those that have similar visual and semantic features. Words, on the other hands are more likely to activate a set of words that overlap in form (Miller & Kroll, 2002). The logic behind using pictures as distractors, rather than words, is that it increases the likelihood that any conceptual processing performed on the distractor will spill over when targets are processed.

In La Heij et al.’s study, Dutch (L1)-English (L2) bilinguals translated from L1 to L2 and from L2 to L1. The word that had to be translated was presented simultaneously with a picture.
The word was superimposed on the picture, to ensure that they would be processed simultaneously. Participants were told to ignore the picture and to translate the word. The pictures were either semantically related to the target word or unrelated. In addition, there was a separate portion of the experiment during which participants named the distractor words. The naming condition was included so that their performance in naming could be compared to their translation performance. Naming, or reading words aloud, is recognized as a lexically based process. Past evidence shows that people do not need to retrieve the meaning of words to read them. Therefore, if translation resembled naming it would show that translation was mediated by lexical processes.

La Heij et al. (1996) provide evidence that suggests both directions of translation can be achieved through direct conceptual access. First, it is important to note the different outcomes for naming conditions and the translation conditions. Only the task that begins with conceptual processing provided evidence for conceptual mediation. These results imply that naming and translation are differentially sensitive to conceptual activation of non-target words. Additionally, both directions of translation were influenced by the presence of semantic distractors. The RHM would not predict this. It states that only L1 to L2 translation should be conceptually mediated. However, the predictions of the RHM cannot be entirely ruled out based on these findings. La Heij and colleagues might have found facilitation for both directions of translation because their bilinguals were highly proficient in Dutch and English. The participants were characterized as being relatively proficient in English, but they are likely to be on the upper range of L2 proficiency. Like other bilinguals who are described as relatively proficient, these bilinguals learned their L2 during their adolescence. However, Dutch-English bilinguals’ linguistic environment is particularly geared towards English in a way that other bilingual environments
are not. There is a great deal of English used in their media and used in instruction. This type of experience may promote increased proficiency beyond what is anticipated for bilinguals with their duration of L2 learning.

La Heij et al. (1996) also found that translation in the context of a semantically related picture was faster than in the context of an unrelated picture. This was true in both directions of translation. There are two aspects of the La Heij et al. results that are important to note. First, they observe facilitation in translation in the presence of semantically related pictures. In the research on picture-word interference, there is typically interference for semantically related distractor words when naming a picture (Levelt et al., 1991, Schriefers et al., 1990). Second, in both picture naming in the presence of word distractors and translation in the presence of picture distractors there are semantic effects. In contrast, the research on picture naming in the presence of picture distractors has not produced robust semantic effects.

It is a reasonable assumption that the distractors’ effect on the target should not be contingent on the modality of the target used (e.g., pictures or words). Again, this is not what has been demonstrated. An insight into the issue comes from direct comparisons of picture distractors and word distractors in translation. Bloem and La Heij (2003) performed a study to uncover the mechanisms that cause a reversal of the semantic effect in word translation. Using the exact same parametric manipulations across experiments, they found that distractor pictures produced facilitation while distractor words produced interference. Because words activate their names first, lexical information is available early. This is the explanation offered for why word distractors produce interference. However, pictures are processed conceptually first. By virtue of activation of the picture being constrained to the conceptual level, there is facilitation. Bloem and La Heij claimed that if the name of the picture was available, picture distractors would cause
interference as well. Bloem and La Heij’s study is important because it provided an explanation for the lack of semantic effects in picture-picture interference tasks.

Although evidence that the semantics of distractor pictures is not available during picture-picture interference tasks, there are numerous findings suggesting the phonology of the picture is activated (Colomé & Miozzo, 2010; Damian & Meyer, 2007, Morsella & Miozzo, 2002; Navarrete & Costa, 2005). The name of the picture would have to be available in order for it to produce facilitation. Bloem and La Heij (2003) have argued that the phonological facilitation found in picture-picture interference tasks is artificially induced by the spatial arrangement of targets and distractors. Because distractors and targets are superimposed on each other, it is not clear if the interference is simply the result of difficulty separating the images. However, Leoncini et al.’s (2010) study demonstrated that the distractor’s effect is not dependent on the spatial proximity of the items. Even when distractors were visually separated they influenced the time taken to name the target. Since Leoncini et al. did not include a phonological condition, it is unclear whether the phonological facilitation effect would persist when the spatial distance is increased.

**Goals for the current study**

The language selective and non-selective accounts of bilingual production represent two extremes on a continuum. At the far end of the selective view, words from the other language are active but *do not compete* with words in the intended language. The extreme view of language non-selectivity asserts that it is possible for the unintended word to interfere with the actual speech output. This view means that not only do words become activated in the other language, but their phonological representation and articulatory representations can intrude upon
production. It is possible that the point at which competition between alternatives in the two languages is flexible. In the current study, I investigate a set of factors that might change the production system’s permeability to activation from non-target words within a language (in monolingual speakers) and across languages (in bilingual speakers).

One of the factors that I investigated was the properties of the tasks being used. I examined whether a difference in how the production act begins (e.g., with lexical processing or conceptual processing) influences the degree to which unintended words compete with intended words. In order to do so, I included two tasks that differ in this aspect, translation and word naming. In one condition of the experiments a group of participants performed translation in the context of a distracting picture. In another condition, a different group of participants named words in the context of a distracting picture.

Another goal of the research was to examine whether cues that can inform the speaker about the language of production is a factor that influences selectivity. In order to do so, I tested the extent to which the language of the input can restrict activation of the other language. By examining language production in a group of relatively proficient but L1-dominant Chinese-English bilinguals, I was able to ask whether the effect of distracting information on production reflects asymmetries in the strength of the bilinguals’ two languages. For these bilinguals, the L1 is clearly more dominant and proficient than the L2.

Another aim of this study was to determine whether there are any connections between within language competition in monolingual production and cross-language competition in bilingual speech production. There is some evidence that when monolinguals cognitive resources’ are taxed their performance on linguistic tasks resembles bilingual performance more
closely. If this is true, then monolingual speech production may be less susceptible to the effects of within language competition and only during stressed production would there be evidence for prolonged activation of alternatives. Monolingual production might be less open to competition because they have accrued a lifetime’s worth of skill in speaking their one language. One question that remains is whether there are parallels between monolingual production and bilingual production with respect to interactivity within the production system. Can the phonology of unintended words become available during monolingual speech planning? In order to examine this question, I tested production in monolinguals using a task in which they named words in the context of picture distractors.

In addition, the current study examined whether conceptual mediation supports translation in both directions. Although La Heij et al. (1996) compared translation in the context of distractor pictures in both directions of translation, it is not clear whether their results present an accurate representation of the extent to which conceptual mediation can be used by relatively proficient bilinguals to perform translation. The current study included experiments in which a group of relatively proficient bilinguals served as participants. Although the bilinguals that served as participants in La Heij et al. learned English past puberty, the environment in which Dutch-English bilinguals learn their L2 is likely to boost their ability to speak English. The reason is because Dutch-English bilinguals are exposed to English in a way that other bilingual speakers are not. Unlike the participants from La Heij et al.’s study, the relatively proficient bilinguals included in these experiments were immersed in an environment in which their L1 is the primary language spoken.

The experiments described below included an assessment of individual differences in working memory and inhibitory control. There are at least two reasons to include these measures.
First, and most critically for present purposes, they provide a means to match across different participants in the experiments conducted. Second, they provide a means to examine the role of cognitive resources in modulating cross-language competition and within-language competition. Though it is still unclear how to characterize the mechanism(s) that allow bilingual to control the two languages, there is a suggestion in the literature that the mechanism might be suppression of words from the unintended language (Green, 1998). It has been hypothesized that the bilingual advantage in inhibitory control may develop because of the need to negotiate competition during speech production. The idea is that every time bilinguals attempt to speak they have to exercise inhibitory control. Some research has demonstrated that when compared to age matched monolingual peers, bilinguals outperform them on tasks of inhibitory control and executive functions (Bialystok, Craik, Klein, & Viswanathan, 2004). Conversely, monolinguals do not gain as much skill in inhibitory control because it may not be required for speech production. One question as yet to be answered is whether cognitive resources such as inhibitory control are utilized by both bilinguals and monolinguals during speech production. In order to answer this question, bilingual and monolingual participants were given a number of measures to test for individual differences in working memory and executive function.

Overview of the Experiments and General Methodologies

Six experiments were conducted using variations of the picture-word task in which target words were either translated or named in the presence of distractor pictures. The first five experiments were behavioral studies that used response times and accuracy as the dependent measures. The final experiment used event related potentials (ERPs) to track the time course of processing in the translation task. The materials that were used closely mirrored those used in La
Heij et al. 1996. In addition to including items that were semantically related, a critical manipulation was to have items that were phonologically related.

There are three sets of relevant predictions for all of the experiments. The first set of predictions is specifically in reference to the model described in Bloem and La Heij (2003). According to Bloem and La Heij, there is only phonological activation for the word a speaker intends to produce. When a word has to be produced, the intended word and multiple alternatives may be activated at the conceptual level. However, the conceptual representation of the intended becomes selected because it is receiving more activation from the level at which the task has been encoded. Only the representation activated from the task level will be phonologically encoded and prepared for articulation. Their threshold model is a modification of Starreveld and La Heij’s (1996) model.

The model proposed by Bloem and La Heij is shown in Figure 4. 1. The dashed lines indicate that semantically related picture distractors are connected to the conceptual representation of the target words. Activation of the distractor’s meaning boosts activation for the target's meaning. The solid bar indicates that there is a threshold that regulates which concepts go on to be encoded phonologically. Critically, the figure shows that only the lexical representation of the target receives task input and that serves as the mechanism for bringing activation of the target concept past the threshold. If Bloem and La Heij’s (2003) model is correct, then the phonology of non-target words never becomes activated. Because the phonologically related words used in the current experiments only bear similarity to the target at the form level (i.e., they do not overlap in semantics as well), they should not influence production. The semantically related words should produce facilitation.
A further set of predictions is related to whether the two directions of translation are directed by conceptual access. According to the RHM (Kroll & Stewart, 1994) the L1 has strong connections to the conceptual store whereas the L2 has weak connections. Because the L2 has weaker connections to conceptual representations, the act of translating from the L2 to the L1 is hypothesized to rely on an indirect route to meaning retrieval. L2 to L1 translation will be mediated through lexical connections. A strong interpretation of the RHM would predict that translation production from L2 to the L1 should not be influenced by semantically related distractors. Furthermore, a strong view would predict that L1 to L2 translation should not be influenced by phonologically related distractors. The L1 is able to access meaning directly, so lexical links should not be the basis of translation from L1 to L2. However, there is some research showing that L1 to L2 translation is influenced by connections at the level of orthography and phonology. Therefore, a less stringent view would acknowledge the possibility that L1 to L2 translation can be lexically mediated. If this were true then, both directions of translation should be influenced by phonologically related distractors.
Duyck and Brysbaert (2004) have suggested that both directions of translation can be conceptually mediated. If both directions of translation are conceptually mediated, then the semantically related pictures should be exploited in both cases. There would be facilitation in the context of semantically related for both directions of translation. The results of La Heij et al. do not support this hypothesis. La Heij et al. (1996) suggested that naming is a lexically mediated process and can be accomplished without accessing the meaning. Therefore, word reading in both directions would serve as an appropriate comparison to translation in both directions. According to the RHM, word reading and L2 to L1 translation should appear to be similar. In order to evaluate the opposing predictions, the present study compared word naming in both directions to translating in both directions. Based on results from previous studies (Bloem et al., 2004), it is not clear if the evidence that the phonology of words does not become activated is a general finding. In Bloem et al.’s study, translation was always performed from L2 to L1, with production occurring in the more dominant language. The failure to observe phonological effect could reflect the high degree of skill associated with speaking in the L1.

A final goal of the study was to determine whether the input provided by the target could serve as a cue to the language of production. Following Miller and Kroll (2002), the picture distractor could only have an effect on translation if it is related to the word that must be produced. Semantic information may be pulled from the same source across languages. In other words, this would mean that conceptual representations are not language specific. Because pictures lack language specific information, it may initiate activation of conceptual information regardless of the language to be produced in. However, if the input can restrict which language is prepared then only competitors in the language of production should have an effect. If the
language of the input is not a strong cue, then it is possible that words phonologically related to the input and the output could compete.

**General Method**

**Participants**

Three groups of bilinguals participated in the experiments that are reported. All bilinguals had as their first or dominant language a language other than English and English served as their L2. Spanish-English bilinguals and Korean-English bilinguals participated in Experiment 1. They were living in the US so immersed in an L2 environment. Chinese-English bilinguals in Beijing participated in Experiments 2-6. These bilinguals were immersed in an L1 environment. In Experiment 1, a group of native English speaking monolinguals were also tested. These participants were functionally monolingual in English and were recruited from the Psychology subject pool at The Pennsylvania State University.

**Language History Questionnaire**

All participants completed a paper-based questionnaire that asked them to describe their language experience (see Appendix A). They provided information about their native language and any foreign languages that they learned inside and outside of the home, their language dominance, experiences traveling abroad, and self-assessments of their L1 and L2 speaking, listening comprehension, reading, and writing abilities. Self ratings were made on a scale of 1 to 10 with 1 indicating very low proficiency and 10 indicating very high proficiency.

**Individual Difference Measures**

**The Simon Task.** The Simon Task (Simon & Rudell, 1967) is considered a measure of inhibitory control and has been used in many studies to assess whether bilinguals have an advantage in executive functioning when compared to monolinguals (e.g., Bialystok, Craik,
Grady, Chau, Ishii, Gunji, et al., 2005; Bialystok, Craik, Klein, & Viswanathan, 2004). In the present study, participants responded to the color of the square that appeared on the computer screen by pressing one of two keys. Blue or red squares appeared to the left of the fixation sign in the center of the computer screen, or to the right of the fixation sign. The “red” response was made by pressing the TAB key and therefore, the left side of the keyboard was always used for red responses. The “blue” response was made by pressing the BACKSLASH key and therefore, the right side of the keyboard was always used for blue responses.

The Simon Task included central, congruent and incongruent trials. Central trials occurred when the square appeared at the same location as the fixation sign (i.e., the center of the screen). A trial was congruent whenever the location of the square and the response key were on the same side. An incongruent trial occurred when the location of the square and the response key were on different sides. Responses are typically slower on incongruent trials because spatial information from the visual stimulus has to be ignored to make the correct keyboard response. For example, if the blue square appears on the left side, the participant has to override the fact that the square is on the opposite side as the correct key. The Simon score is computed by subtracting the mean reaction time (RT) on congruent trials from the mean reaction times on incongruent trials.

*Materials and procedure for the Simon Task.* Each trial began with a centralized fixation sign (+) that was presented for 350 ms and succeeded by a blank screen for 150 ms. At the offset of the blank screen, the blue or red square appeared on the screen for 850 ms at 2 ° to the left or right of the computer screen. The square was presented for 2000 ms or until the participant made a response. If the response was correct, a new trial began. The inter-trial interval was 850 ms. If an incorrect response was made the participant received feedback that
was printed (the word ERROR was displayed) on the computer screen for 1500 ms. After 850 ms the next trial began.

Trials were divided into three blocks with a total of 126 trials. There were seven trials presented in each condition. Conditions were differentiated by color (red or blue) and location (centralized, left, right), resulting in 42 trials per condition. The order of trials was randomized across participants.

**Simon Task: Data Analysis.** The data were trimmed such that trials in which a response occurred after 1500 ms were removed. Trials in which a participant responded incorrectly were also removed. Trials that followed an error were excluded as well. Subsequently any RTs outside of 2.5 standard deviations from the participant’s overall mean were excluded. Mean RTs and mean error percentages were computed for each congruency condition (central, congruent, and incongruent). The Simon score was found by subtracting the mean congruent RT from the mean incongruent RT.

**Operation Span Task.** The Operation Span task (O-SPAN), is a measure of working memory resources (e.g., La Pointe & Engle, 1990, Turner & Engle, 1989).

**O-Span: Materials and Procedure.** Participants were presented arithmetic problems (e.g., 2*2-1 = -1) to which they responded and then memorized a word that had to be retained for later recall. The problems were presented with a solution and the participants were asked to determine whether the solution was correct or incorrect. After participants made the response to the equation, a word appeared on the screen. The participant’s objective was to retain the word. Arithmetic problems and the words that followed them were presented in sets ranging from two to six. The word RECALL appeared on the screen to inform the participant that the set was done and that they had to list all of the words from the set. In total, participants saw 60 equations and
60 words throughout the experiment. These materials were taken from Tokowicz, Michael, and Kroll (2004), who adapted the paradigm from Turner and Engle (1989).

Materials were adapted to other languages so that participants could perform the task in their native language. Spanish materials were used with the Spanish-English bilinguals and Chinese materials for the Chinese-English bilinguals. The experimenter sought help from a native Korean speaker of English in translating the materials to Korean, but they had difficulties typing the words in the Korean alphabet. Therefore, the Korean-English bilinguals in Experiment I used the English materials. Please see Appendix B for the full set of materials.

Participants began each trial by pressing the “yes” (TAB) or “no” (BACKSLASH) key. Then, a fixation sign (+) appeared on the screen for 1000 ms. At the offset of the fixation sign the equation appeared. Participants pressed the “yes” or “no” key to indicate whether the solution to the equation was correct. If the participant made their response or did not respond by 3750 ms, a word appeared in the middle of the screen for 1250 ms. When the word disappeared, a fixation sign appeared again. The next equation followed this fixation sign. This procedure continued until the set was finished. The size of the equation/word set increased from the beginning to the end of the experiment. Participants begin with a set of two equation-word pairs and after three sets of the same size were presented, the size increased. When participants recalled the words from the set, they typed them in to the computer. They were instructed to list as many words as they could remember. They were also told that the order of the recalled words did not have to be identical to the order in which they were presented. The only rule was that they could not type the last word that they saw first. When participants finished typing the words, they pressed the ESCAPE key (ESC) to begin a new set.
**O-Span: Data Analysis.** Mean RTS were computed separately for trials in which participants responded “yes” and “no”. If the participant’s RT on a trial was 2.5 standard deviations outside of their mean, the trial was not included in analysis. The total number of correctly recalled words when the “yes” or “no” response was also correct was taken as the O-SPAN score.

Performance on the Simon Task and on O-Span were used to match different groups of participants as closely as possible across experiments. They also provided a means to later determine whether individual differences in cognitive resources influenced the degree to which participants were sensitive to the influence of picture distractors during speech planning.

**Measures of Lexical Knowledge**

**Lexical Decision Task.** The Lexical Decision Task (LDT) was used to assess participant’s English vocabulary. The task has been shown to be a sensitive measure of L2 vocabulary knowledge (Huibregtse, Admiraal, & Maera, 2002).

**LDT: Materials & Procedure.** Materials included 56 English words and 56 English nonwords. The words were taken from Azuma and Van Orden (1997). They varied in the number of meanings they could denote (i.e., few or many) and in the degree of relatedness between those meanings (i.e., low or high). Words with four or less meanings were categorized as having few meanings whereas words with six or more meanings were considered to have many meanings. Using Hoshino’s (2006) classification, words with a score of less than 3.0 in the Azuma and Van Order (1997) study formed the low relatedness group. As in Hoshino’s (2006) study, words with a score of 3.5 formed the low relatedness group. There were 14 words in each of the four word conditions. The nonwords were pseudohomophones that sound like real words (e.g., weard). The use of pseudohomophones prevents decisions based on the phonology
of the real words. Items were organized into four pseudo-randomized lists with the constraint that no more than three items from the same condition be presented back-to-back. These lists were counterbalanced across participants.

Participants sat in front of a computer screen and read the instructions that were presented. They were told that they would see letter strings on the computer screen and their task was to decide if the string was a real word in English or not. Participants responded by pressing the “C” key if the string was a real word and the “M” key if it was a nonword. Each trial began with a fixation sign (+) that was presented for 500 ms at the center of the screen. Then the letter string appeared immediately after that and remained on the screen until the participant made a response. Following the response, a blank screen appeared for 500 ms to separate the trials. There were 10 practice trials that preceded the experimental trials. Items were also presented in two blocks with a break occurring after the 56th trial.

**LDT: Data Analysis.** Incorrect responses and responses made after 3000 ms were excluded from analysis. In addition, RTs that were outside of 2.5 standard deviations of a participant’s mean were excluded. The mean accuracy for words and nonwords was computed.

**Picture Naming.** A simple picture naming task was used as an additional index of participants’ vocabulary knowledge in English. The task, presented after the primary experimental task, also served to confirm that participants knew the name of the pictures that served as distractors in the main experiment. Because the phonological condition in the main experiments involved the name of the picture in English, it was critical to know that non-native speakers of English were able to retrieve the English names.

It was also important to test participants’ ability to name the picture distractors because they did not receive pre-training on them. Many research studies focusing on production tasks,
such as picture naming or translation, train participants on the correct name of the stimuli before the experimental session (e.g., Bloem & La Heij 2003; Bloem & La Heij, 2004; Costa et al., 2000; Costa & Santesteban, 2004; La Heij et al., 1996; Jescheniak & Schriefers, 1997). This is helpful because it reduces the number of errors and increases the number of good trials. However, because participants are corrected when they do not know the right name for an item or have simply rehearsed the name beforehand, it cannot be said that their performance on the main task reflects the same processes that would be engaged normally when attempting to retrieve the name of a picture or to translate a word. With pre-training it is possible that speech planning reflects memorization particularly in the weaker L2. Therefore, pre-training was not used in this study. Instead, a criterion for inclusion was based on performance on the simple picture naming.

**Experiment 1: Translation into the L2 and naming in the L1 and L2 in the presence of picture distractors**

The goal of Experiment 1 was to test the prediction based on Bloem and La Heij (Bloem & La Heij, 2003; Bloem et al., 2004) that only the semantics but not the phonology of alternative lexical candidates is available during speech planning. In the experiments performed in those studies, production always occurred in the L1 because translation was performed from L2 to L1. In the present experiment, translation was performed from L1 to L2 to determine whether the less skilled language would be more likely to be affected by the phonology of the distractor picture. Experiment 1 was also performed at a relatively long SOA of 750 ms to further determine whether under conditions in which there is sufficient time to retrieve the picture’s name, there will be phonological as well as semantic effects of the distractor. Bloem and La Heij used much shorter SOAs of 0 ms and 250 ms. Thus, the combination of production in the highly
skilled L1 and the short SOA may have prevented a phonological effect from being available. The use of L2 production at a long SOA in the current experiment should increase the likelihood of observing phonological effects if they are present.

Like the experiments reported by La Heij et al. (1996), a set of word naming controls was also included to determine whether any effects of the picture distractors in translation are truly due to conceptually-driven processes engaged by speech planning or to the unique demands of speaking the L2 at a long duration. Word naming is typically slower in L2 than in L1 (e.g., Kroll, Michael, Tokowicz, & Dufour, 2002). But naming, unlike translation, is less likely to engage the semantic processes that characterize speech planning initiated at a higher level. La Heij et al. (1996) did not find any effects of semantically related context pictures. Because the Dutch-English bilinguals in the La Heij et al. study were highly proficient, it is possible that competitor effects might not have persisted long enough to be detected. To test this hypothesis, we compared two groups of speakers naming words in the presence of pictures, one in their L1 (monolingual English speakers) and one in their L2 (Korean-English bilinguals). In all of these experiments, the question was whether translation or word naming would be influenced by the presence of a semantically or phonologically related picture.

Experiment 1 was performed as a pilot prior to traveling to China to collect data there. The resulting samples in each of these groups were relatively small but served to provide useful preliminary data for designing the materials for the later experiments.

Method

Participants. All participants were recruited from The Pennsylvania State University. Ten Spanish-English bilinguals participated in the translation condition. Eleven monolingual
English speakers and 13 Korean-English bilingual speakers participated in the naming conditions. Nine Korean-English bilinguals and 11 monolingual English participants contributed data to the study. Data from four Korean-English bilinguals were removed because of technical difficulties. Of the 10 Spanish-English bilinguals, seven Spanish-English bilinguals were included in the final data set. Three Spanish-English participants were excluded because their accuracy on the translation task was lower than 80%.

**Materials.** Forty-eight black-and-white line drawings were sampled from Snodgrass and Vanderwart (1980) and Szekely et al. (2003, 2004). One picture was removed from the analysis because it had a name that was a cognate in Spanish and English (*taxi*) and had been mistakenly included in the Spanish materials. None of the remaining pictures or the remaining words had a cognate status in the language pairs. Sets of related and unrelated words were formed by matching them to the picture distractors. Four words were assigned to each picture that were semantically related, phonologically related, matched to the semantically related word but otherwise unrelated to the picture, and matched to the phonologically related word but otherwise unrelated to the picture. These words served as the targets in all of the translation and naming tasks. The lexical properties on which the target words were matched included length (number of letters, number of syllables), word frequency, phonological neighbors, orthographic neighbors, and a number of lexical performance variables taken from the English Lexicon Project (Balota, et al., 2002). Phonologically related words were selected on the additional criterion that they share at least their onset with the name of the picture. There were some items that had more overlap in phonology. This resulted in 192 target words being included in the study. The characteristics of the pictures and the words are displayed in Table 5.1. All of the English stimuli were selected first. When the experimenter created the Spanish stimuli, she searched a web
dictionary (www.wordreference.com) using the English items that were going to be used as search terms. For each English word, the word provided from the website that matched the English sense was selected as the Spanish translation. These translation pairs were then judged for their meaning equivalence by an English-Spanish bilingual laboratory member. The properties of the Spanish stimuli have not yet been analyzed but will appear in a future version of the manuscript.

Table 5.1 Lexical Properties of the Stimuli Used in Each Experimental Condition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pictures</th>
<th>Phonologically Related</th>
<th>Semantically Related</th>
<th>Phonologically Unrelated</th>
<th>Semantically Unrelated</th>
<th>p-value (ANOVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of letters</td>
<td>4.63</td>
<td>5.06</td>
<td>4.78</td>
<td>4.92</td>
<td>5.19</td>
<td>ns</td>
</tr>
<tr>
<td>Number of syllables</td>
<td>1.23</td>
<td>1.40</td>
<td>1.31</td>
<td>1.44</td>
<td>1.52</td>
<td>ns</td>
</tr>
<tr>
<td>Frequency per million words a</td>
<td>50.02</td>
<td>53.85</td>
<td>51.60</td>
<td>51.60</td>
<td>52.67</td>
<td>ns</td>
</tr>
<tr>
<td>Phonological neighborhood</td>
<td>21.55</td>
<td>19.80</td>
<td>21.90</td>
<td>17.35</td>
<td>16.13</td>
<td>ns</td>
</tr>
<tr>
<td>Orthographic neighborhood</td>
<td>9.40</td>
<td>7.90</td>
<td>8.70</td>
<td>7.00</td>
<td>6.69</td>
<td>ns</td>
</tr>
<tr>
<td>Picture naming Accuracy b</td>
<td>.99</td>
<td>1.00</td>
<td>.99</td>
<td>1.00</td>
<td>.99</td>
<td>ns</td>
</tr>
<tr>
<td>Picture naming latencies (ms) b</td>
<td>595</td>
<td>603</td>
<td>603</td>
<td>613</td>
<td>606</td>
<td>ns</td>
</tr>
<tr>
<td>Word naming accuracy</td>
<td>.97</td>
<td>.98</td>
<td>.98</td>
<td>.98</td>
<td>.98</td>
<td>ns</td>
</tr>
<tr>
<td>Word naming latencies (ms) b</td>
<td>600</td>
<td>602</td>
<td>601</td>
<td>607</td>
<td>607</td>
<td>ns</td>
</tr>
</tbody>
</table>
Notes. a Kucera & Francis (1967). b Data from the English Lexicon Project database (Balota et al., 2002).

Table 5.1 shows that there were no significant differences between the picture distractors and the target words for any of the lexical characteristics on which they had been matched. Target words came from three different grammatical classes (nouns, adjectives, and verbs). Although an effort was made to balance the proportion of words from each grammatical class across the four target conditions, there were a higher proportion of nouns in the semantically related condition (see Table 5.2). We discuss later the possible consequences of these differences across conditions.

**Table 5.2. Proportions of Items Within a Grammatical Class by Condition**

<table>
<thead>
<tr>
<th></th>
<th>Phonologically Related Word</th>
<th>Semantically Related Word</th>
<th>Phonologically Unrelated Word</th>
<th>Semantically Unrelated Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjectives</td>
<td>0.10</td>
<td>0.00</td>
<td>0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>Nouns</td>
<td>0.77</td>
<td>0.98</td>
<td>0.71</td>
<td>0.66</td>
</tr>
<tr>
<td>Verbs</td>
<td>0.13</td>
<td>0.02</td>
<td>0.17</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table 5.3 provides examples of the distractor picture names and target word conditions. It is important to note that in Experiment 1, all participants who performed the word naming task, both Korean-English bilinguals and English monolinguals, saw all of the target words in English. The Spanish-English bilinguals who performed the translation task saw the target words in Spanish only but had to produce the name of the translation in English. Thus production was in English for all three groups. The phonological relationship existed between the picture and the English form of the phonological relative. No phonological relationship existed between the any of the Spanish words and the names of the distractor pictures. For Spanish-English bilinguals, the
phonological relationship was mediated through the English translation equivalent. To illustrate, *hielo* is phonologically related to *eye* because its English translation *ice*, the word to be produced, shares phonological segments with it. The full set of the stimuli can be found in Appendix A.

Table 5.3 *Examples of Materials by Condition*

<table>
<thead>
<tr>
<th>Language of Presentation</th>
<th>Picture</th>
<th>Phonologically Related Word</th>
<th>Semantically Related Word</th>
<th>Phonologically Unrelated Word</th>
<th>Semantically Unrelated Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>eye</td>
<td>ice</td>
<td>hair</td>
<td>rent</td>
<td>fall</td>
</tr>
<tr>
<td>Spanish</td>
<td>eye</td>
<td>hielo</td>
<td>pelo</td>
<td>aquilar</td>
<td>caerse</td>
</tr>
</tbody>
</table>

**Procedure.** The same general procedure was carried out in each of the experiments within this study. Each participant was tested in a sound-attenuated room individually. They were seated in front of a computer monitor that was connected to the button box and a digital recorder. Participants completed the translation or naming task, followed by simple picture naming in English, the operation span task, the Simon task, the Flanker task and the language history questionnaire.

In the both translation and naming, participants were informed that they would see a picture on the screen in isolation. They were told that the picture would disappear and reappear with a word superimposed on top of it. In the translation task, their task was to ignore the picture
and translate the word as quickly as possible. At the beginning of each trial, a fixation sign (+) appeared at the center of the computer screen. The fixation sign was replaced with the distractor picture for 500 ms. Next, a blank screen appeared on the screen for 250 ms. Finally the picture appeared with the word superimposed on it for 3000 ms. Participants had to either translate the word within the 3000 ms interval or name the word aloud, otherwise the picture-word composite disappeared. If they did not know the translation, they were instructed to say “no.” Once participants responded (or the composite stimulus timed out) a new trial began. They received 10 practice trials. The displays for the naming and translation conditions differed in only that in translation in Experiment 1, the words appeared in Spanish whereas for naming they appeared in English.

Figure 5.1. Illustration of a sequence of events in a single translation trial in which the language of production is English.
Results and Discussion

Language History Questionnaire. Data from the Language History Questionnaire were first analyzed to provide a comparison of native and second language proficiency and language experiences between speaker groups. These data will be discussed first before describing the results from the main task.

Table 5.4. Characteristics of Speakers in Experiment 1.

<table>
<thead>
<tr>
<th></th>
<th>Monolingual (n= 11)</th>
<th>Korean-English (n= 9)</th>
<th>Spanish-English (n= 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>20.0 (3.0)</td>
<td>22.0 (4.7)</td>
<td>29.7 (5.2)</td>
</tr>
<tr>
<td>L1 self-ratings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>9.3 (0.8)</td>
<td>9.4 (1.3)</td>
<td>9.7 (0.6)</td>
</tr>
<tr>
<td>Writing</td>
<td>9.1 (1.7)</td>
<td>8.1 (3.1)</td>
<td>9.4 (0.8)</td>
</tr>
<tr>
<td>Speaking</td>
<td>9.0 (1.7)</td>
<td>9.6 (1.0)</td>
<td>9.7 (0.8)</td>
</tr>
<tr>
<td>Listening</td>
<td>9.6 (0.5)</td>
<td>9.9 (0.3)</td>
<td>9.9 (0.4)</td>
</tr>
<tr>
<td>L2 self-ratings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>3.6 (1.5)</td>
<td>8.0 (1.7)</td>
<td>9.4 (0.8)</td>
</tr>
<tr>
<td>Writing</td>
<td>4.1 (2.5)</td>
<td>7.2 (2.2)</td>
<td>9.0 (1.1)</td>
</tr>
<tr>
<td>Speaking</td>
<td>3.9 (1.7)</td>
<td>7.7 (2.6)</td>
<td>9.3 (0.8)</td>
</tr>
<tr>
<td>Listening</td>
<td>3.9 (2.3)</td>
<td>8.4 (1.9)</td>
<td>9.4 (0.5)</td>
</tr>
<tr>
<td>O-span Recall (1-60)</td>
<td>47.3 (4.5)</td>
<td>44.7 (8.4)</td>
<td>40.6 (7.5)</td>
</tr>
</tbody>
</table>
Simon Score (ms)  
31.8 (18.5)  
37.1 (16.2)  
42.6 (11.3)  

Note. Standard deviations are in parentheses.

A one way ANOVA was conducted on the responses from the Language History. Overall, participants were closely matched on ratings of language proficiency although there was a significant difference in the age across groups, reflecting the fact that Spanish-English bilinguals were somewhat older than the monolinguals and the Korean-English bilinguals $[F(1, 24) = 5.59, MSE=193.18, p = .01]$. The Korean-English bilinguals also rated themselves slightly lower than English monolinguals in reading $[F(1, 24) = 3.81, MSE=5.39, p < .05]$ and lower than monolinguals in writing $[F(1, 24) = 3.81, MSE=4.53, p < .05]$. It is difficult to know whether these differences reflect cultural variation in assigning proficiency (e.g., see Hoshino, 2006 for a similar finding for Japanese-English bilinguals) or genuine differences in language skill. Given the Korean-English bilinguals’ high accuracy in the naming task and their ability to perform well in a working memory test conducted in English, it seems that their lower self-ratings may be indicative of cultural differences in use of the questionnaire.

Data trimming for translation and naming tasks. Responses were transcribed and coded for accuracy. For the translation condition, both a liberal and a strict scoring procedure were used. For the strict scoring, participants only received credit for translations that were selected by the experimenter. For the liberal coding, participants received credit if they gave translations that were synonyms of the correct translation (e.g. jacket for coat). If a response was not the anticipated translation or a synonym, began with a hesitation, or was self-corrected at any point, it was scored as an error. Responses that were not picked up by the microphone were also removed from analysis. Because the strict coding procedure would have eliminated too many trials from the translation data, only the liberal coding will be reported. After excluding these
errors, responses were trimmed if they fell outside the range of 300 to 3000 ms. Any items outside of 2.5 standard deviations of the remaining items were excluded from analysis. Using this scoring procedure, all participants performed above 80% in the task. Responses that were outliers constituted 5% of the data in the translation condition, 5% of the data in L2 naming condition, and 3% of the data in the L1 naming condition.

RT data with subjects as a random factor to examine the effects of the type of distractor relation (phonological or semantic) and relatedness (related or unrelated). One ANOVA was performed on the data from the translation condition and the other on the data from the naming conditions. The naming analysis included a between-subject factor of speaker group (Korean-English bilinguals speaking L2 or monolingual English speakers in L1).

Response Latencies. The results for the translation condition are shown in Figure 5.2. There was a significant main effect of relatedness \(F(1, 6) = 27.84, \text{MSE}=32232.1, p < .01\], a marginal effect of type of relation \(F(1, 6) = 4.15, \text{MSE}=5157.1, p = .09\], and no interaction between them \(F(1, 6) < 1\]. Like the results reported by Bloem and La Heij (2003; Bloem et al., 2004), there was facilitation in translating words in the presence of a semantically related picture. However, unlike Bloem and La Heij there was also facilitation when the name of the picture was phonologically related to the word to be produced.
Figure 5.2. Mean translation latency as a function of relatedness and type of relation.

The results for the word naming conditions are shown in Figures 5.3 and 5.4 for the monolingual and L2 speakers, respectively. Although the Korean-English bilinguals naming words in English in their L2 were slower overall than the monolingual English speakers naming in their L1, the group difference was not significant \([F(1, 18) < 1]\). There was a marginally significant interaction between type of relation, relatedness, and speaker group \([F(1, 18) = 3.93, MSE = 395.12, p = .06]\). Paired-sample \(t\)-tests performed with the Bonferroni correction revealed that Korean-English bilinguals were slower to name words from the phonological condition than monolinguals \([t(19) = 5.31, p < .05]\) and that Korean-English bilinguals were slower to name related words than monolinguals \([t(19) = 8.16, p < .001]\). The ANOVA also revealed a significant main effect of type of relation \([F(1, 18) = 5.65, MSE = 558.41, p < .05]\), with slower naming latencies overall in the phonological conditions than in the semantic conditions. There was also a significant main effect of relatedness, such that related words were named slower than unrelated words \([F(1, 18) = 18.96, MSE = 1318.10, p < .001]\). The interaction between type of relation and relatedness failed to reach significance \([F < 1]\).
Figure 5.3. Mean naming latency as function of type of relation and relatedness for monolinguals speaking English as the L1.

Figure 5.4. Mean naming latency as function of type of relation and relatedness for Korean-English bilinguals speaking English as the L2.

The results for the naming condition show that unlike translation, naming was not facilitated by the presence of a related picture distractor. In that sense, the results are similar to
those reported by La Heij et al. (1996). In the more highly skilled L1, native English speakers were, if anything, slower to name words in the presence of a semantically related picture. If the semantics are not fully encoded during word naming normally, then the presence of the picture distractor may have served to activate the semantics and require an additional process to be completed. However, the fact that the semantically unrelated condition was faster than the related and unrelated phonological conditions might be taken to argue against this interpretation, assuming that the lexical properties of the items functioned as they were matched. In the less skilled L2, Korean-English bilinguals were, if anything, slower to name words related to the phonology of the picture. That result does show that the phonology of the picture’s name may require additional processing time to be available, as the effect of phonology of the distractor’s name was only apparent in L2 naming. In Experiment 2 we will return to the question of whether the presence of facilitation in the translation results was due to the relatively long 750 ms SOA in Experiment 1.

Accuracy. The accuracy data for translation are shown in Figure 5.5. The same analyses were carried out on the accuracy data as for the RT data. In translation, that there was a marginally significant effect of type of relation \(F(1, 6) = 5.04, MSE = .009, p = .07\) that was qualified by a significant interaction between type of relation and relatedness \(F(1, 6) = 16.99, MSE = .019, p < .01\). Although the semantic conditions overall were slightly more accurate than the phonological conditions, there was only an effect of relatedness for the semantic condition such that participants were less accurate in translating in the presence of a semantically related picture. Given that translation is a production task rather than a binary choice task, we can ask whether the semantic facilitation that was observed in the RT data correspond to a cost in accuracy of production because related semantic information may be more likely to induce
occasional production errors in which a semantically related word (i.e., an error) is spoken as the translation. At this point, the nature of the errors has not been analyzed, but the relation between the RT and accuracy data suggest that it may be important to consider this possibility. The accuracy data for the naming conditions are shown in Figures 5.5 and 5.6. The analysis failed to reveal any significant main effects or interactions.

Figure 5.5. Mean percent correct in the translation condition as a function of type of relation and relatedness
Figure 5.6. Mean percent correct for monolinguals as a function of type of relation and relatedness

Figure 5.7. Mean percent correct for Korean-English bilinguals as a function of type of relation and relatedness

Experiment 1 asked whether the semantics and the phonology of alternatives would become activated using translation and naming in the context of distracting pictures. The results
replicate the findings of Bloem and La Heij (2003) and Bloem et al. (2004) in showing that there was facilitation in translation in the presence of a semantically related picture distractor. However, they also extend the earlier studies in showing that it was possible to observe facilitation in translation from L1 to L2 (the Bloem and La Heij studies examined only L2 to L1) and under conditions in which there was a relatively long SOA. Critically, the present results show that there was also facilitation in translation in the presence of a phonologically related distractor, demonstrating that the name of the distractor picture, and potentially of other competing lexical alternatives, become available over time. The naming data show, if anything, interference rather than facilitation. The small effects in naming and the different form that the naming data take compared to translation suggest that the different pattern observed in translation was not due simply to the potential intrusion of competing alternatives in the process of articulation but rather to the type of information that becomes available during conceptually-driven speech planning.

To investigate the extent to which the effect of semantic and phonological distractors depend on having a sufficiently long SOA, in Experiment 2 the translation condition was conducted at a short SOA. In addition, the Chinese-English bilinguals who participated in Experiment 2 translated words in both directions. A comparison across the two directions of translation allows us to ask whether production in the less skilled L2 is responsible for the results of Experiment 1. If so, then production in the dominant and more highly skilled L1 in Experiment 2 should more closely replicate the Bloem and La Heij (2003) results suggesting a more limited scope for cross-language activation in the more skilled language. In addition, the comparison of the two directions of translation in Experiment 2 will enable us to test the
A prediction of the RHM that translation in the forward direction, from L1 to L2, is more sensitive to semantic influences than translation in the backward direction, from L2 to L1.

**Experiment 2: Chinese-English translation with a constant SOA**

The goal of Experiment 2 was to determine whether the predictions of Bloem and La Heij (Bloem & La Heij, 2003; Bloem et al., 2004) would be supported when translation was performed in both directions. If the semantic and phonological facilitation observed in translation in Experiment 1 was found because production took place in the less skilled language, then a similar pattern would not be expected when production occurs in the more skilled L1. Unlike speaking in the L2, there is a high level of automaticity and control associated with L1 production which may enable speakers to resolve competition early in speech planning. The manipulation of the direction of translation was also included to determine whether both directions of translation are processed conceptually. La Heij et al. (1996) found evidence for concept mediation in both directions of translation for a group of relatively proficient Dutch-English bilinguals. Although these bilinguals were relatively proficient in their L2, it is not clear whether or not the unique manner in which their exposure to English develops might substantially alter their expertise in the L2. Specifically, the Dutch-English bilinguals’ abilities to use conceptual mediation may be enabled by the nature of their L2 exposure. In the present experiment, the participants were relatively proficient Chinese–English L2 bilinguals who were identified as being dominant in their L1 but in whose language environment English was less prevalent than in for the Dutch-English bilinguals in the La Heij et al. study. According to the RHM, the highly L1 dominant Chinese-English bilinguals may be more likely to show evidence for semantic processing in L1 to L2 translation than in L2 to L1 translation. In Experiment 2, a
shorter SOA of 250 ms was used to ensure that the facilitation found in Experiment 1 was not a result of the use of a longer SOA.

Method

Participants. Thirty-two Chinese-English bilinguals were recruited from Beijing Normal University. Participants were relatively proficient in their English L2, but dominant in their Chinese. They were paid 35 Yuan, or the equivalent of 5 US dollars. Data from three participants were lost due to recording failure and data from 10 participants were removed due to excessively high errors. Data from an additional six participants were removed from the data because they did not reach an accuracy of 70% overall. Thirteen participants contributed data to the analysis.

Materials and Procedure. The materials and procedure were identical to those described in Experiment 1 with the following exceptions. The Chinese translation equivalents of the English targets were added and they were presented in the form of simplified Chinese characters (see Appendix B). Because the two directions of translations were compared, the total of 192 trials were divided to include an equal number of Chinese and English words. Within each condition, there were 24 trials in which L1 to L2 translation was performed and 24 trials in which L2 to L1 translation was performed. Trials were blocked by direction of translation. There were 16 consecutive trials presented in a single language before the direction of translation switched. After the 16th trial a message appeared on the screen stating, “You will now be switching languages. Press any key to continue.” The order of materials within a list was pseudorandomized using Mix software (Van Casteren, 2006) such that whenever a particular picture distractor appeared, it could not be immediately followed by a trial using the same distractor. There were at least two trials using different distractors that intervened. The order of
the direction of translation was counter-balanced across participants so that the first block of trials began in either direction.

**Results and Discussion**

*Data trimming.* A native English speaker coded the responses produced in English and a native Chinese speaker coded the responses given in Chinese. The same scoring procedure described in Experiment 1 for translation was used here.

A 2 x 2 x 2 repeated measures ANOVA was conducted on the mean correct RTs and accuracies to examine the effects of direction of translation in the presence of picture distractors in the four distractor conditions. Direction of translation (L1 to L2 or L2 to L1), type of relation (semantic or phonological), and relatedness (related or unrelated) were treated as within-subjects factors. Note that the design of the materials was such that the phonologically related distractors were always related to the English name of the picture. Thus in translation from L1 to L2, the phonology of the picture’s name in the phonologically related condition was related to the word to be produced. In translation from L2 to L1, the phonology of the picture’s name was related to the target L2 word to be translated.

*Response Latencies.* The results for each direction of translation are shown in Figures 6.1 and 6.2. Unlike the results for L1 to L2 translation in Experiment 1, the data for the same conditions in Experiment 2 at the short SOA revealed no effect of the semantic distractors but facilitation for the phonological distractors. The pattern for L2 to L1 translation shown in Figure 6.2. appears to be just the opposite, with semantic facilitation but no phonological facilitation.

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3 It is important to remember that in experiments conducted in China, the phonologically related condition is slightly different than Experiment 1. The phonologically related picture distractor is only phonologically related to the English targets, not the Chinese. Therefore in translation, it is phonologically related to what is produced when translation is performed from L1 to L2.
facilitation. A comparison across the two figures also shows a difference in overall speed of translation, with faster RTs in translation from L1 to L2 than from L2 to L1. Like La Heij et al. (1996), participants were faster to translate from L1 to L2 than from L2 to L1 [$F_1 (1, 12) = 10.09, MSE = 257514.92, p < .01$. This is the opposite pattern that has been reported in most of the past studies that have tested the predictions of the RHM (e.g., Kroll et al., 2002). Two interpretations of the reversal are possible. The faster latencies for L1 to L2 translation could indicate that lexical access was more automatic when production took place in the L2 rather than the L1. Because the bilinguals were dominant in the L1, this is not the likely explanation. Rather, the results suggest that the presence of the pictures facilitated their ability to plan speech from the L1 to the L2 (and see Sholl et al., 1995, for evidence that suggests that priming translation with picture naming produces a reversal of the typical translation asymmetry).

There was also a marginally significant main effect of relatedness [$F_1 (1, 12) = 4.74, MSE = 20464.79, p = .05$]. The main effect revealed that participants were faster to translate words if they were presented in the context of a related distractor. The main effect was qualified by a significant three-way interaction between translation direction, type of relation, and relatedness [$F_1 (1, 12) = 4.62, MSE = 15970.39, p = .05$]. A post-hoc analysis using paired-sample t-tests indicated that there was no difference in forward translation (L1 to L2) when participants translated in the context of semantically related or unrelated distractors [$t_1 (12) < 1$]. In addition, there was no significant difference for translation in the context of semantically related or unrelated distractors in backward translations [$t_1 (12) < 1$], although Figure 6.2 suggests that there was an absolute difference in the direction of facilitation. The analysis also revealed marginally significant phonological facilitation in L1 to L2 translation [$t_1 (12) = -2.08, p = .06$]. Translation
was faster in the context of phonologically related distractors in forward translation, replicating the phonological facilitation found in Experiment 1.

**Figure 6.1.** Mean latency (in milliseconds) during L1 to L2 translation. Latencies are plotted as a function of type of relation and relatedness.

**Figure 6.2.** Mean latency (in milliseconds) during L2 to L1 translation. Latencies are plotted as a function of type of relation and relatedness.
Accuracy. The accuracy of translation is shown for each direction of translation in Figures 6.3 and 6.4. An analysis of these data revealed that there was a main effect of relatedness \[ F(1, 12) = 6.59, \text{MSE} = .04, p < .05 \], which was qualified by a significant interaction between direction of translation and type of relation \[ F(1, 12) = 5.71, \text{MSE} = .01, p < .05 \] and a marginally significant three-way interaction between direction of translation, type of relation and relatedness \[ F(1, 12) = 3.28, \text{MSE} = .02, p = .09 \].

Figure 6.3. Mean percent correct as a function of type of relation and relatedness in L1 to L2 translation.
Overall participants were more likely to make errors when the picture was related to the word; however, there were more errors when semantically related pictures preceded L1 to L2 than unrelated pictures. This is similar to the result obtained in Experiment 1. There was virtually no difference in the accuracy for semantically related and unrelated conditions in L2 to L1 translation. Like Experiment 1, the accuracy will be analyzed in the future to determine the nature of the speech errors.

Taken together, the findings of Experiments 1 and 2 suggest that when speech is planned in the L2, the less practiced of the two languages, it is possible to activate the phonology of unintended words. These results contradict Bloem and La Heij’s (2003) findings in that no phonological facilitation was observed in the presence of picture distractors in their studies. However, it is possible that the failure to observe phonological facilitation was due to the fact that they examined production only in the L1. The present results also failed to replicate Bloem
and La Heij’s finding of semantic facilitation for semantically related picture distractors at short SOAs. However, critical differences in the characteristics of the bilingual speakers may explain the observed differences across studies. The relatively proficient bilinguals tested here had less experience speaking in the L2 than the Dutch-English bilinguals tested in Bloem and La Heij’s studies. More importantly, the Chinese-English bilinguals were probably less likely to switch between the two languages in naturalistic settings. Since the task forced them to do so, they may have experienced difficulty executing speech planning routines efficiently in the experimental context. Overall, this may have hindered their ability to rely on conceptually-based processing for the purposes of speaking. To investigate this hypothesis, in Experiment 3 translation performance was compared in the presence of picture distractors but following a short (250 ms) or long (500 ms) SOA. The question in Experiment 3 was whether there be evidence that the phonology and semantics of distractors were activated when there was additional time to plan speech.

**Experiment 3: Chinese-English translation with variable short and long SOAs**

**Method**

**Participants.** Thirty Chinese-English bilinguals were recruited from the same population. Participants were paid 35 Yuan for their time. Two participants’ data were not included due to technical problems with recording. A criterion was set such that participants had to achieve an overall accuracy of 70% for their data to be included. Eleven participants’ data were excluded due to high error rates. Data from 19 participants will be discussed here.
**Materials and Procedure.** The materials were identical to Experiment 2. The design of the experiment was nearly identical to Experiment 2, with the exception that two SOAs were presented. The short SOA was kept at 250 ms to enable comparisons across experiments. A long SOA of 500 ms was also included. The SOA conditions were manipulated within subjects so that each participant was presented half of the trials at the 250 SOA and half at the 500 ms SOA. SOAs were mixed within lists. There were an equal number of trials (12) per SOA, direction of translation, and distractor condition. SOAs were mixed within blocks. The procedure differed from Experiment 2 only in that the distractors were presented at either a 250 or 500 ms SOA.

**Results and Discussion**

**Data Trimming and Analysis.** The raw data were scored and trimmed the same way as in Experiments 1 and 2. A 2 x 2 x 2 x 2 repeated measures ANOVA was carried out on the mean response latencies and accuracy. Direction of translation, type of relation, relatedness, and SOA were treated as within subject factors.

**Response Latencies.** The results for each direction of translation for the semantic conditions only are shown in Figures 7.1 and 7.2 and for the phonological conditions only in Figures 7.3 and 7.4. The ANOVA revealed that there was a significant main effect of translation direction \( F(1, 18) = 8.25, \text{MSE} = 540169.36, p = .01 \). L1 to L2 translation was faster than L2 to L1 translation. This replicates the findings from Experiment 2 and La Heij et al. (1996). Since the participants tested here have a language background similar to the participants in Experiment 1, it is likely that faster latencies in L1 to L2 translation occurred for the same reason. The presence of contextual information seems likely to have helped participants translate into the L2 from the L1. There was also a significant interaction between type of relation and relatedness \( F(1\)
Translation was faster in the context of phonologically related pictures than unrelated pictures and slower in the context of semantically related pictures than unrelated pictures. The two-way interaction between type of relation and relatedness was qualified by a significant four-way interaction between all of the variables of interest \(F_1(1, 18) = 21.59, \text{MSE}=181492.20, p < .001\) (See Table 7.1).

**Table 7.1.** Mean response latencies (in milliseconds) and accuracy to translate words in both directions of translation as a function of the stimulus of asynchrony (SOA), type of distractor (phonological or semantic), and relatedness of the distractor to the word to be spoken.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Related</th>
<th>Unrelated</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Language</strong></td>
<td>Mean RT (%)</td>
<td>Mean RT (%)</td>
<td>(Related-Unrelated)</td>
</tr>
<tr>
<td>L1-L2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short SOA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological</td>
<td>1038 (78)</td>
<td>1120 (84)</td>
<td>-82</td>
</tr>
<tr>
<td>Semantic</td>
<td>1119 (80)</td>
<td>1034 (83)</td>
<td>85</td>
</tr>
<tr>
<td>Long SOA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological</td>
<td>1065 (79)</td>
<td>1039 (88)</td>
<td>26</td>
</tr>
<tr>
<td>Semantic</td>
<td>1091 (82)</td>
<td>1075 (78)</td>
<td>16</td>
</tr>
<tr>
<td>L2-L1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short SOA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological</td>
<td>1176 (82)</td>
<td>1162 (84)</td>
<td>14</td>
</tr>
<tr>
<td>Semantic</td>
<td>1143 (76)</td>
<td>1165 (86)</td>
<td>-22</td>
</tr>
<tr>
<td>Long SOA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological</td>
<td>1094 (80)</td>
<td>1246 (86)</td>
<td>-152</td>
</tr>
<tr>
<td>Semantic</td>
<td>1148 (81)</td>
<td>1122 (80)</td>
<td>26</td>
</tr>
</tbody>
</table>

Below are two figures showing the data for the semantic conditions. For translation from L1 to L2, RTs were longer when the picture was semantically related than unrelated but the effect was larger at the 250 ms SOA than at the 500 ms SOA. A post-hoc analysis using paired t-tests revealed that only the semantic interference at the 250 ms SOA was significant \(t_1(18) = 2.81, p < .05\). The findings differ from those in Experiment 2 in which participants failed to show
a semantic effect at the 250 ms SOA. They also differ from Experiment 1 in which the Spanish-English bilinguals showed an effect of semantic facilitation at a longer SOA. The semantic effect in Experiment 3 suggests that participants relied on conceptual mediation to perform forward translation.

![Figure 7.1](image)

**Figure 7.1.** Mean response latency as a function of SOA and relatedness in L1 to L2 translation. Note: These are data from the semantic conditions only.

For translation from L2 to L1, the differences across related and unrelated were small and no significant. These findings fail to replicate Bloem and La Heij’s findings of semantic facilitation in L2 to L1 translation. One hypothesis is that the increased time to plan speech might be critical for allowing conceptual mediation to appear. However, the ability to use conceptual mediation to perform translation does not appear to be dependent on the amount of time that is available to process the distractor and was absent at the long SOA when sufficient time should have been available. In fact, in L1 to L2 translation, participants appeared to exploit the semantic overlap between targets and distractors at the short SOA. The results suggest that the two directions of translation are differentially supported by conceptual mediation, in that it is
present in forward translation but not reliably in backwards translation. These results support the predictions of the RHM and fail to support models (e.g., La Heij et al., 1996) that assume equivalent conceptual processing in both directions of translation. However, the finding of interference for semantically related distractors in the present experiment for L1 to L2 translation at the short SOA stands in contrast to the facilitation observed in Experiment 2 under the same SOA conditions. It is possible that the uncertainty associated with the mixed SOA conditions in Experiment 3 and particularly with the timing of the presentation of the word to be translated, affected the encoding of the name of the picture distractor.

Figure 7.2. Mean response latency as a function of SOA and relatedness in L2 to L1 translation. Note: These are data from the semantic conditions only.

We now turn to the data for the phonological conditions (Figures 7.3 and 7.4). For translation from L1 to L2, translation was faster in the context of phonologically related pictures than unrelated pictures at the 250 ms SOA. At the 500 ms SOA, RTs were slightly longer in the
context of phonologically related pictures than unrelated pictures. Paired $t$-tests showed that only the phonological facilitation found at the 250 ms SOA was significant [$t(18) = -2.486, p < .05$]. Phonological facilitation was also found at the short SOA in L1 to L2 translation, suggesting that it is not limited to long SOAs in which there is additional preparation time.

![Figure 7.3](image)

**Figure 7.3.** Mean response latency as a function of SOA and relatedness in L1 to L2 translation. Note. These are data from the phonological conditions only.

For translation from L2 to L1, performance was somewhat slower in the context of phonologically related unrelated pictures at the 250 ms SOA. At the 500 ms SOA, translation was faster in the presence of phonologically related words compared to unrelated words. Paired $t$-tests revealed that there was significant phonological facilitation at the 500 ms SOA [$t_1 (18) = -4.91, p < .001$]. It is important to remember that the phonological relation in the L2 to L1 direction was with the target word to be translated, not with the word to be produced. Unlike L1 to L2 translation, the interval in which phonological facilitation occurred was delayed. One explanation for the delayed activation in backwards translation is that performance was slower in
this direction overall. Phonological facilitation may have been delayed because the name of the picture had to be activated in the unintended language (i.e., the L2), the only language in which targets and distractors shared phonology, in order to perceive a meaningful connection between the distractor and the target. Since the L2 is the less skilled language for the bilinguals, it may have taken an extended period of time for activation of the phonology to appear.

![Figure 7.4](image)

**Figure 7.4.** Mean response latency as a function of SOA and relatedness in L2 to L1 translation. Note. These are data from the phonological conditions only.

**Accuracy.** There was a significant main effect of relatedness \( F(1, 18) = 8.62, MSE = .12, p < .01 \). The result showed that participants made more errors translating in the presence of related pictures than unrelated pictures. A marginally significant interaction between direction of translation, type of relation, and relatedness was found \( F(1, 18) = 3.90, MSE = .04, p = .06 \). A post-hoc analysis using paired sample t-tests was performed on the data, revealing that participants made more errors translating in the presence of phonologically related pictures than unrelated pictures in L2 to L1 translation \( t(18) = -2.21, p < .05 \). There was no difference
between percent accuracies for translation in the presence of semantically related and unrelated pictures. For L1 to L2 translation, participants were also less accurate translating in the presence of phonologically related pictures than unrelated pictures \( t(18) = -1.96, p = .07 \). They also made more errors translating in the presence of semantically related pictures than unrelated pictures in this direction, \( t(18) = -2.14, p < .05 \). The patterns in the accuracy data indicate that there was a strong relationship between the rate of errors produced and the response latency data. Significant facilitation and interference came at the expense of accuracy, suggesting that there was a cost associated with activating the name of the picture.

The results of Experiment 3 suggest that the variable SOA influenced the strategy adopted for translation. In Experiment 4 we take the logic used in Experiment 1 to compare translation to word naming. If the results in Experiment 3 are due to the effect of encoding the picture under conditions in which the word was presented at a variable SOA, then there may be similar differences observed in word naming when it occurs at a fixed SOA (Experiment 4) or at a variable SOA (Experiment 5). Experiment 4 is similar to the word naming conditions of Experiment 1 except that the short SOA was used and Chinese-English bilinguals named word in each of their two languages in separate blocks. In Experiment 1, the two naming tasks, in L1 and L2, were performed by different speakers, monolinguals in their L1 and non-native speakers of English in their L2. Recall that La Heij et al. (1996) did not find any evidence that a picture distractor’s semantic information influenced word naming performance. The results are Experiment 4 are predicted to replicate those from the naming conditions in Experiment 1.
Experiment 4: Word naming at a short and fixed SOA

The goal of Experiment 4 was to use word naming as a comparison to translation. Word naming differs from translation because it begins with processing at the lexical level and as a consequence, words that share orthography and phonology (i.e., lexical neighbors) should be activated when the target word is processed. Because lexical neighbors will become available in word naming prior to semantically related candidates, one might not predict that semantically related picture distractors will influence naming (e.g., La Heij et al., 1996). Here we again consider whether semantically related distractors become activated in a lexically-based task.

Bloem and La Heij (Bloem & La Heij, 2003; Bloem et al., 2004) argued that the names of picture distractors do not become available if the pictures are not named explicitly. They would therefore not predict any phonological effect in the current experiment. Because it is only the English (L2) names that correspond to the phonologically related pictures in the present experiment, we might predict that there will be phonological effects in word naming only when naming is performed in the L2. However, the general evidence for cross-language nonselectivity suggests that even when the phonology is active in the L2, it may come to influence the L1.

Method

Participants. Twenty-five Chinese-English bilinguals were recruited from the same population as Experiments 1-3. Data from two participants were excluded because of recording failure. Nine participants’ data were excluded because the achieved less than 60% accuracy in the simple picture naming task. Data from 15 participants were included in the data discussed here.
**Materials and Procedure.** The materials were identical to those used in Experiments 1-3. The design mirrored that of Experiment 2 but using the procedure for word naming described in Experiment 1.

**Results and Discussion**

*Data trimming.* Data were removed following the same procedure used in Experiments 1-3. A $2 \times 2 \times 2$ repeated measures ANOVA was performed on the response latency and accuracy data. Language of naming, type of relation, and relatedness were treated as within-subjects factors.

*Response Latencies.* The word naming results are shown for L1 and L2 in Figures 8.1 and 8.2, respectively. There were significant main effects of the language of naming and relatedness. The main effect for language of naming revealed that participants read words in Chinese faster than words in English [$F_1 (1, 14) = 47.49$, $MSE= 190019.25$, $p < 0.001$]. The observation of faster naming latencies in Chinese indicates that the bilinguals were dominant in their L1 and reinforces the idea that the faster translation for L2 to L1 (Experiments 2 and 3) resulted from the presence of picture distractors, not from greater facility in producing words in English. The main effect of relatedness showed that words were read faster in the context of related pictures than unrelated pictures [$F_1 (1, 14) = 5.52$, $MSE= 909.86$, $p < .05$]. There were no significant interactions.
Figure 8.1. Mean naming latency as a function of type of relation and relatedness in Chinese naming only.

Figure 8.2. Mean naming latency as a function of type of relation and relatedness in English naming only.

Although the relatedness effect in naming was small, its presence supports the idea that participants exploited the relationship between targets and distractors even when naming a word
aloud. Semantically related pictures facilitated naming in the L1 and the L2 (see Figures 8.1 and 8.2). However, the semantic facilitation was not significant \( t_1 (14) < 1 \). These results replicate La Heij et al. (1996), who found no evidence that semantic alternatives were activated in their naming task. The fact that there was some evidence for semantic facilitation, although not significant, is important. Like the finding from Experiment 1, this suggests that when the picture is present it encourages semantic processing in naming. It appears that phonologically related pictures were activated as well, again challenging Bloem and La Heij’s (Bloem & La Heij, 2003; Bloem et al., 2004) claim that the names of pictures are not activated. The results from the phonological conditions also counter initial predictions. Phonologically related pictures interfered with naming in the L2, similar to the findings in Experiment 1. In the L1, there was if anything, facilitation. However, the phonological effects in L1 and L2 naming were also not significant. The lack of any phonological effects in the current experiment, in contrast to Experiment 1, may very well be due to the use of a shorter SOA. The name of the picture may only become active when there is sufficient time to access it. We examine this issue in Experiment 5, in which the variable SOA conditions of Experiment 3 are used but with the naming task instead of translation.

**Accuracy.** The results are shown in Figures 8.3 and 8.4 for L1 and L2 word naming, respectively. A significant main effect of language was found \( F1 (1, 14) = 12.11, MSE = .09, p < .01 \). The main effect revealed that participants named words more accurately in Chinese than in English. There was a significant interaction between type of relation and relatedness \( F1 (1, 14) = 5.07, MSE = .01, p < .05 \), which was qualified by a three-way interaction between language, type of relation and relatedness \( F1 (1, 14) = 5.28, MSE = .02, p < .05 \)
Figure 8.3. Mean percent correct as a function of type of relation and relatedness in Chinese naming only.

The interaction between type of relation and relatedness showed that naming was more error prone when the word was accompanied by a phonologically related picture than unrelated.

Figure 8.4. Mean percent correct as a function of type of relation and relatedness in English naming only.
Naming was more accurate when there was a semantically related picture in the context \[ F_1 (1, 14) = 5.07, \text{MSE} = .01, p < .05 \]. The three-way interaction between language, type of relation and relatedness revealed that there was no difference in accuracy between any of the conditions when words were read in Chinese (see Figure 8.3). The high level of accuracy in reading Chinese words aloud suggests that these L1 Chinese speakers were at ceiling in what is typically a relatively simple task.

During word naming in English, the L2, participants made more errors when pictures were phonologically related than when they were unrelated (see Figure 8.4). They were more accurate when they read words in the context of semantically related pictures \[ F_1 (1, 14) = 5.28, \text{MSE}, p < .05 \]. Although the error rates within the English conditions were small, closer inspection of the types of errors made in each condition may potential help to disambiguate two important questions. The first is whether or not the lower accuracy in phonologically related conditions reflects a speed accuracy trade-off or if the name of the distractor actually interfered with production. An analysis of the types of errors made can also help determine whether the semantic interference in the English naming latencies reflects slower processing to check their response to avoid intrusions from the picture because its name was activated.

**Experiment 5: Word naming with a variable short and long SOAs**

The results of Experiment 4 suggest that semantic and phonological information becomes activated during word naming. The main purpose of Experiment 5 was to ask whether closer examination of the time-course of activation for distractors would reveal differences in sensitivity to relationships between the target and the distractor. This experiment is the word naming analog to Experiment 3. There, we found that translation performance was affected
differently at the short SOA when it was mixed with a long SOA than when it had been
presented alone in Experiment 2. If the difference in the observed results for translation is due to
a strategy imposed by the mixing of the SOAs, then a similar pattern would be predicted in word
naming.

**Method**

**Participants.** Twenty-four Chinese-English bilinguals from Beijing Normal University
were recruited. Data from one participant was not included due to recording failure and data
from eight more participants were excluded because the participants did not achieve 60% accuracy in the simple picture naming task. The data from 15 participants were included in the analysis.

**Materials and Procedure.** The same materials were used as in Experiments 2-4. The design
was the same as Experiment 3 but using procedure for word naming.

**Results and Discussion**

**Data trimming and analysis.** The raw data were scored and trimmed the same way as in Experiments 1 and 2. A 2x 2 x 2x 2 repeated measures ANOVA was carried out on the mean response latencies and accuracy. Language of naming, type of relation, relatedness, and SOA were treated as within subject factors.

**Response Latencies.**
Figure 9.1. Mean response latency as a function of SOA and relatedness in Chinese naming. Note: These are data from the semantic conditions only.

Figure 9.2. Mean response latency as a function of SOA and relatedness in Chinese naming. Note: These are data from the phonological conditions only.
Figure 9.3. Mean response latency as a function of SOA and relatedness in English naming. Note. These are data from the semantic conditions only.

The ANOVA revealed significant main effects of language, SOA and relatedness. The main effect of language showed that words Chinese words were read faster than English words
The main effect of SOA demonstrated that words were read faster when the word followed the picture distractor after a long than a short SOA \([F_1 (1, 14) = 28.78, \text{MSE}=48955.38, p < .001]\). The main effect of relatedness indicated that words were read faster when they appeared in the context of a related picture \([F_1 (1, 14) = 10.12, \text{MSE}=5743.58, p < .01]\). There was a significant interaction between type of relation and relatedness \([F_1 (1, 14) = 9.84, \text{MSE}=5740.79, p < .01]\). There was also a significant interaction between language, type of relation and relatedness \([F_1 (1, 14) = 6.06, \text{MSE}=9010.67, p < .05]\). More critically, a significant four-way interaction between language, SOA, type of relation, and relatedness was found (See Table 9.1).

**Table 9.1.** Mean response latencies (in milliseconds) and accuracy to name words in both languages as a function of the stimulus of asynchrony (SOA), type of relation (phonological or semantic), and relatedness of the distractor to the word to be spoken

<table>
<thead>
<tr>
<th>Relatedness</th>
<th>Language</th>
<th>Condition</th>
<th>Mean RT(%)</th>
<th>Mean RT( %) (Related-Unrelated)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Short SOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phonological</td>
<td>633(97)</td>
<td>628(96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semantic</td>
<td>612 (97)</td>
<td>632(97)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long SOA</td>
<td>611(96)</td>
<td>577(99)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phonological</td>
<td>582 (99)</td>
<td>611(96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semantic</td>
<td>663 (97)</td>
<td>668(94)</td>
</tr>
</tbody>
</table>

More critically, a significant four-way interaction between language, SOA, type of relation, and relatedness was found (See Table 9.1).
To investigate this interaction further, paired-sample t-tests were performed on the data. First, I will discuss the data from the English naming conditions. At the 250 ms SOA, there was no difference in naming latencies when pictures were phonologically related or unrelated. At the 500 ms SOA, naming was faster when phonologically related pictures were presented \([t(14) = -3.41, p < .01]\). Naming was faster when semantically related pictures were presented at the 250 ms SOA \([t(14) = -3.73, p < .01]\). There was no difference between naming in the context of semantically related pictures unrelated pictures at the 500 ms SOA. Now I will discuss the data from the Chinese naming conditions. At the 250 ms SOA there were no differences between naming latencies for phonologically related and unrelated conditions. Naming was slower when phonologically related pictures were presented at the 500 ms SOA \([t(14) = -2.93, p < .05]\). There was no significant difference between semantically related and unrelated conditions at the 250 ms SOA. Naming was faster in the presence of semantically related pictures at the 500 ms SOA \([t(14) = -2.70, p < .05]\).

The results support the hypothesis that the phonology of alternatives becomes activated at the later SOA. This suggests that activation of the English name of the picture was delayed in a task in which the goal is simply to name the word. Phonological interference was found when participants named words in Chinese and facilitation was found when they named words in English. Unlike Experiment 1, in which bilinguals who named words in the L2 experienced phonological interference, the bilinguals here experienced facilitation as a consequence of encoding the distractors’ phonology. There are differences in the overall speed of naming between the Chinese-English bilinguals tested in Experiment 5 and the Korean-English bilinguals who were tested in Experiment 1. One might predict that if Korean-English bilinguals were slower in naming than the Chinese-English bilinguals, this might explain why their speech...
production was open to interference. However, the Korean-English bilinguals were actually faster to name words than the Chinese-English bilinguals, which does not support this explanation. Another possibility is that Korean-English bilinguals generally had higher activation of their L2 when performing the task as a consequence of being immersed in the L2 environment and using English in their daily environment. The Chinese-English bilinguals were immersed in their L1 environment and had fewer opportunities to speak the L2. Importantly, finding any phonological effect contradicts Bloem and La Heij’s predictions (e.g., Bloem and La Heij, 2003; Bloem et al. 2004) and predictions of models that assume that speech planning can be accomplished selectively. The results also show that the semantics of the picture were activated during naming, again contrary to La Heij et al.’s (1996) claim that word naming does not engage conceptual processing.

Like Experiment 4, there was semantic facilitation for L1 and L2 naming. It is not clear why the semantic facilitation effect was found at the later SOA. One explanation for the finding is that these bilinguals have more competition among alternative lexical candidates when they encode the picture distractor in a task that will require the L1. For example, a relatively proficient bilingual might know basic animal category members in the L2 but may not be able to distinguish between SHEEP and LAMB, given that the subtle difference in meaning (i.e., knowing that a lamb is a baby sheep). However they might have these distinctions in their L1 and as a consequence, it might take more time to allow a particular label to win out as the picture’s name. Therefore, at the early SOA all of these labels may be slightly activated. But, perhaps by the later SOA there is additional activation and competition among alternatives. Unlike the translation conditions, the naming conditions revealed that there was no asymmetry in conceptual mediation in the two languages. We will examine these conceptual activation effects
more closely in the final experiment in which we use ERP methodology to examine the time-course of activation in translation.

**Accuracy.** There was a main effect of language, such that naming was more accurate in Chinese than English \( F(1, 14) = 9.31, \text{MSE} = .08, p < .01 \). There were no other significant main effects. The analysis revealed a significant interaction between SOA, type of relation and relatedness \( F(1, 14) = 5.82, \text{MSE} = .01, p < .05 \) (See figures 9.1 and 9.2). Paired-sample t-tests were performed to examine the three-way interaction further.

![Mean percent correct as a function of type of relation and relatedness for the 250 ms SOA condition.](image)

Figure 9.5.
The $t$-tests revealed that there was only a significant difference at the 500 ms SOA for semantic conditions. Participants made more errors naming words in the context of semantically related pictures than unrelated pictures [$t(14) = 2.23, p < .05$]. This finding suggests that activating the semantics of the picture came as a cost to naming accuracy.

**Experiment 6: Examining the time course of translation using ERPs**

In Experiment 6, I used event related potentials (ERPs) to test the predictions of the RHM. To the best of my knowledge, this experiment is the first to use ERPs to investigate the component processes engaged by the two directions of translation. The goal of Experiment 6 was to determine whether conceptual mediation is used to support forwards and backwards translation. Based on the behavioral findings in this study and in past studies (Kroll & Stewart,
1994; Sholl et al., 1995), we predicted that only L1 to L2 translation would elicit an N400 effect (see below). Translation in the context of semantically related words should exhibit a smaller negative-going peak while translation in the context of semantically unrelated words should show a larger negative peak. This would support the idea that only L1 to L2 translation is sensitive to the semantics of the distractor, and thus conceptually mediated.

In the next section, I will describe the ERP methodology in general and then describe N400 component in detail. This component was the focus because it is possible to generate specific predictions about the presence of the N400 in relation to the experimental conditions used in the translation experiment.  

The use of ERPs in language production tasks has been undertaken more recently. Because movements of any sort are so disruptive to the signal, it is crucial to design a procedure that avoids introducing these types of artifacts into the recording. One technique that has been used to avoid speech artifacts is delayed naming (e.g., Jescheniak, Hahne, & Schriefers, 2003; Jescheniak, Schriefers, Garrett, & Friederici, 2002). In the delayed naming approach participants are instructed to wait before responding to the stimuli. This allows the experimenter to collect data on the components of interest without the articulatory movements shifting the waveforms.

The N400.

The N400 was first reported by Kutas and Hillyard (1980). It is characterized as a negative-going wave that peaks around 400 ms after stimulus presentation. The N400 is usually

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4 As the design was kept the same as in the behavioral experiments, the phonological conditions were included. However, I did not have any a priori assumptions about the difference between ERP responses in the two phonological conditions. Therefore, I will include them in the analysis of the data (because of the repeated measures design) but for present purposes I will not reference them in the results or conclusions and only consider them a filler condition.
found at centro-parietal electrodes and is usually larger on right-hemisphere electrodes (Luck, 2005; Swaab et al., in press). Though the N400 peaks at around 400 ms, for visually presented words it typically begins 200 ms after a stimulus is presented and lasts about 300 ms (Swaab et al., in press). There are earlier components in the N400 time window that map on to different stages of lexical processing. Grainger and Holcomb (2009) state the N/P150 component is related to processing the visual features of a word. The subsequent component, the N250, is characterized by Grainger and Holcomb as indexing letter-to-sound mapping. The next component, the N325 is sensitive to the lexical status of items (i.e., whether a letter string is a real word or pseudoword). Grainger and Holcomb consider it important for distinguishing whole word constituents. Finally, the N400 is believed to reflect integration of form and meaning features.

The N400 is a very prominent language-related component, being found in language processing at the sentence level (Federmeier & Kutas, 1999; Kutas, Lindamood, & Hillyard, 1984; Van Petten, Weckerly, McIsaac & Kutas, 1997) and single-word level (Bentin & Peled, 1990; Chwilla, Hagoort, & Brown, 1998; Brown & Hagoort, 1993; Chwilla, Kolk, & Mulder, 2000; Hamberger & Friedman, 1992; Holcomb, Grainger & O’Rourke, 2002; Holcomb & Neville, 1990; Karayanidis, Andrews, Ward, & McConaghy, 1991; Swaab, Baynes & Knight, 2002). Using a sentence comprehension task, Kutas and Hillyard (1980) found that readers were sensitive to the semantic coherence of sentences. In their study, participants read sentences like “He spread the warm bread with socks”. These sentences contained sequences of words that violated the readers’ expectations about what would fit semantically. Participants also read sentences that had no semantic violations, such as “It was my first day at work.” Kutas and Hillyard compared the wave-forms from sentences in which there was a semantic violation to
sentences without violations. They found that sentences that contained a violation elicited a
negative peak around 400 ms, the N400. The peak in the wave form for regular sentences was
reduced relative to that of the semantically anomalous sentences. The N400 effect, in sentence
comprehension tasks is interpreted as the reduced negativity for control items to those that
contain semantic violations.

In single-word tasks, such as semantic priming the N400 is interpreted similarly but the
comparison between semantically related and unrelated conditions is interpreted a bit differently.
In a typical semantic priming task, there are trials in which two consecutive words are presented.
Sometimes the words are semantically or associatively related, such as “boy-girl” and sometimes
unrelated pairs like “dog-ticket” are presented. The comparison between the waveforms for
semantically related and unrelated pairs usually demonstrates that there is a larger N400 peak for
unrelated word pairs than related pairs (Bentin et al., 1985, Chwilla, Hagoort, & Brown, 1998;

If translation from is conceptually mediated then an N400 should be present in the ERP
data with a modulation of the effect for the semantically related distractor condition. The
question in this experiment as whether there would be a similar N400 in both direction of
translation.

**Method**

**Participants.** Twenty-eight Chinese English bilinguals were recruited from Beijing
Normal University. They were paid 50 Yuan for their time. Data from 16 participants were
excluded from analysis due to a high proportion of errors. Data from two participants were
removed due to a high number of ocular and head movement artifacts. The remaining
participants achieved a minimum of 60% accuracy in all the experimental conditions. Data from the remaining 10 participants are discussed here.

**Materials and Procedure**

The materials and design were identical to those used in Experiment 2. The procedure was nearly identical to the Experiment 2 except for a few changes in the time parameters to accommodate electrophysiological responses and to minimize ocular artifacts. Each trial began with a fixation sign (+) that was displayed for 1000 ms. Participants were told that they could blink while the fixation sign was on the screen and to avoid blinking when the fixation was no longer on the screen. The fixation sign turned red after 700 ms, to notify the participant that the fixation was going to disappear soon. Following the fixation sign, a blank screen was presented for 250 ms. Then the picture appeared for 500 ms and was replaced by the picture-word composite. The picture-word composite remained on the screen for 1000 ms. Participants were told they could respond when the picture-word composite disappeared. A blank screen was presented for 2000 ms after the composite. Then the next fixation sign appeared. As in the behavioral experiment, trials were presented in blocks of 16. Participants were told to take a break whenever the screen appeared to inform them that the language of production would change. There were an additional four breaks in the experiment that did not coincide with the screen that appeared to notify upcoming language switches. The experimenter set breaks in the experiment after every three blocks in order to give participants more rest and to check that the electrodes had remained in place. This time was also used to inform participants of the eye movements or head movements. There were ten practice trials that were given before the experimental session. If participants did not understand the task, as indicated during practice, the
experimenter and a Chinese-English bilingual assistant repeated the instructions and restarted the practice.

**EEG Recording and Analysis.** The continuous electroencephalogram (EEG was recorded using a 32-channel sintered Ag/AgCl electrode array mounted in an elastic cap (QuikCap, Neuroscan Inc.) according to the 10-20 system (Jasper, 1958). During the recording session, FP2 was pasted over the right mastoid (M2). A linked-mastoid was referenced from FP2 and left mastoid channel (M1). Electrode impedances were kept below 5 kΩ. Lateral eye movements were measured by placing electrodes on the outer canthus of each eye. Electrodes were placed on the upper and lower orbital ridge of the left eye to measure vertical eye movements. Eye recordings were later used off-line to reject contaminated trials. The electrophysiological signals were amplified using Neuroscan Synamps with a band pass filter of 0.05 to 100 Hz and a sampling rate of 500 Hz.

Using the data trimming procedures from the behavioral experiments, only correct trials were included in the analysis. A pre-stimulus baseline of 100 ms and an epoch duration of 1000 ms post-stimulus were used to compute the average ERPs per condition. Trials with eye movement artifacts or blinks and peak-to-peak deflections over 200 μV were rejected. A digital low-pass filter of 30 Hz (24/dB/oct) was applied when analyzing the data offline. The linked-mastoid was re-referenced offline to include M1 (left mastoid) and M2 (right mastoid).

Based on my hypothesis, the N400 was chosen as a component of interest and one time window was selected for further investigation. Mean amplitudes were calculated over a time window between 300 and 600 ms. Three separate repeated measure ANOVAs were conducted to assess the N400 effect at three sites on the cap. One was performed on the electrodes from the
midline site (Fz, FCz, Cz, CPz, Pz, and Oz). Another was performed on the first group of lateral electrodes and the analysis divided these electrodes by hemisphere (F3/F4, FC3/FC4, and C4/C3, CP4/CP3, P3/P4, and O1/O2). The last analysis was performed on the second group of lateral electrodes and divided these electrodes by hemisphere (F7/F8, FT7/FT8, T7/T8, TP7/TP8, and P7/P8). The relative location of these electrodes can be seen in Appendix D. Only results including the factors of direction of translation or type of relation are reported, since general topographic differences in electrodes or hemisphere are not of primary interest in this study.

**Results and Discussion**

*Data trimming and analysis.* The data were coded and trimmed using the same procedure as Experiments 1-5. A 2 x 2 x 2 repeated measures ANOVA with direction of translation, type of relation and relatedness, treated as within subject factors was carried on the response latency and accuracy data.

*Response Latencies.* The analysis revealed a main effect of direction of translation \[F1 (1, 9) = 19.24, MSE = 494335.59, p < .01\]. Like the previous translation experiments, in Experiment 6 L1 to L2 translation was again faster than L2 to L1 translation. There were no other significant main effects or interactions. The result suggests that the picture context picture differentially primed production in the L2. In a follow-up experiment, we plan to test this explanation directly by having a similar group of bilinguals perform translation with or without the picture context. If bilinguals did rely on the picture to facilitate translation into the L2, then participants should be slower to perform L1 to L2 translation without the picture context.

*Accuracy.* The same analysis was performed on the accuracies. The analysis revealed a significant main effect of relatedness \[F1 (1, 9) = 6.57, MSE = .04, p < .05\]. There was also a
significant interaction between direction of translation and relatedness, such that L1 to L2 translation was less accurate in the presence of a picture distractor whereas accuracy for L2 to L1 translation was unaffected by the picture distractor \[ F(1, 9) = 9.75, MSE = .02, p < .05 \].

Figure 10.1. Mean percent correct as a function of direction of translation and relatedness.

The main effect showed that participants translated targets less accurately when related pictures were shown compared to unrelated pictures. The interaction revealed that when participants translated from L1 to L2 they made more errors in the context of related pictures than unrelated pictures \[ t_{1/2}(9) = -3.42, p < .01 \]. However, when participants translated from L2 to L1 there was no difference in the percent of errors made. This result indicates that participants were sensitive to the semantics. The pattern further suggests that participants activated the semantics of the distractor but at a cost. Because there are a substantial number of errors in the data, a fine-grained analysis of the types of errors could reveal whether the interference was due to activating the name of the picture. This analysis will be completed in the future.
Now we turn to the ERP results. Although there were no interactions between the direction of translation and other variables in the behavioral RT data, the accuracy data provided some evidence that participants were differentially sensitive to the relationship between targets and distractors in each direction of translation. It is possible that the electrophysiological measure could reveal sensitivity to the semantics, despite the absence of differences in the RT data. This has been found in previous studies using a combination of behavioral and ERP methods. For example, Tokowicz and MacWhinney (2005) found evidence that low to relatively proficient Spanish-English bilinguals, with a similar level of L2 proficiency as the Chinese-English bilinguals tested here, were sensitive to violations of grammaticality as indexed by ERPs but not by behavioral performance.

Based on visual inspection, the ERP results revealed a general pattern on the N400 roughly similar to that described by Holcomb and Grainger (2009). There was a negative-going wave that peaked around 150 ms post stimulus-onset and a positive-going wave that peaked around 250-300 ms post stimulus-onset. This component was followed by an additional negative-going peak that occurred around peaked around 400 ms. Because of the low accuracy that was observed within the behavioral data, the analyses that I will report are based on a small subset of the participants. Therefore, it should be noted that these results are preliminary. In the next section, I will review the results found in the N400 window only, specifically focusing on the CPz electrode, at which the N400 effect is maximal.

**The N400**

**Midline site.** A 2 x 2 x 2 x 6 repeated measures ANOVA was performed with direction of translation, type of relation, relatedness and electrode treated as within-subjects factors. The
repeated measures ANOVA on the midline electrodes revealed a marginally significant interaction between language, of relation, and relatedness (See Figure 10.2).

Math equation:
\[
F(1, 9) = 4.90, \text{MSE} = 141.634, p = .05
\]

There were no other significant interactions that involved language or type of relation.

The analysis of the waveforms at the central electrodes revealed that there was no difference between the mean amplitude of the response for semantically related and unrelated conditions in L2 to L1 translation. However, the mean amplitude of the response was more negative-going when translation was performed in the context of unrelated pictures in L1 to L2 translation. This indicates that there is differential sensitivity to the semantics in the two directions of translation. L1 to L2 translation appears to be conceptually mediated, while L2 to L1 translation does not. This finding supports the prediction of the RHM.
First lateral site. A2 x 2 x 2 x 2 x 6 repeated measures NOVA was performed on the data, with direction of translation, type of relation, relatedness, laterality, and electrode treated as within-subjects factors. There were no significant main effects or interactions involving language or type of relation at this site.

Second lateral site. The same analysis that was carried out on the first lateral site was performed on the second lateral site. A significant interaction between type of relation, relatedness, laterality and electrode was revealed [F1 (1, 9) =3. 153, p < .05]. The result showed that there was less negativity at the right posterior electrode (P8) when semantically related distractors were presented compared to unrelated distractors.

General Discussion

In six experiments, I investigated the processes that support lexical access when translating and naming words in the presence of distracting pictures. The results of Experiment 1, in which Spanish-English bilinguals translated words into the L2 in the presence of distractors, replicated the previous findings of La Heij et al. (1996). The additional manipulation of a phonological condition, which had not been included in the La Heij et al., study demonstrated that there was also facilitation when words were translated in the context of phonologically related picture distractors. In Experiment 2, translation was performed in both directions by a group of Chinese-English bilinguals who were relatively proficient in the L2 but living in an L1-dominant environment and somewhat less proficient in English than the Spanish-English bilinguals in Experiment 1. In Experiment 2 there was phonological facilitation when translating from 1 to L2 translation was performed but no phonological effect in L2 to L1 translation. In
Experiment 3, I manipulated the interval between the presentation of the distractor and target when another group of relatively proficient bilinguals performed forwards and backwards translation. I predicted that, with additional time to process the distractor, participants’ translation performance would be influenced by the semantics and phonology of distractors. The results of Experiment 3 did not yield consistent findings with respect to the SOA manipulations. The findings were actually the opposite of what had been anticipated, with semantic interference and phonological facilitation emerging at the early SOA (250 ms) in L1 to L2 translation. Experiment 3 replicated the findings from Experiment 2, in that there was phonological facilitation in L2 to L1 translation.

In order to fully replicate La Heij et al.’s experiments, naming in the context of distractors was used a control to translation. In Experiment 1, Korean-English bilinguals and monolinguals named words in their L1 (monolinguals) and L2 (bilinguals) while ignoring distractor pictures. The results showed that when the bilinguals performed naming, there was clear evidence that the phonology of distractors caused interference. In contrast, when monolinguals performed naming there were no reliable effects of the distractor. However, there was a hint that the semantics of the distractors introduced interference. In Experiment 4, a group of relatively proficient Chinese-English bilinguals named words in either their L1 or L2 while ignoring distractors. I found that neither the phonology nor the semantics influenced naming for this group of bilinguals. As was done in translation, I performed a follow-up experiment in which the SOA was manipulated (Experiment 5). Here, the results of manipulating the SOA were somewhat clearer. There was evidence that the phonology of the distractors influenced naming at the late SOA (500 ms) when words were named in both Chinese (L1) and English (L2). In addition, I found that there was semantic facilitation at the early SOA (250 ms) when
words were named in English and semantic facilitation at the late SOA when words were named in Chinese.

An analysis of the production errors has not yet been performed. However, I anticipate that they will provide converging evidence that there was activation of the semantics and phonology of the distractors.

Implications for selectivity and non-selectivity in speech production.

The issue of selectivity has been addressed within a variety of models of bilingual speech production. In the stricter account of selective processing, it is implied that bilinguals can restrict competition between words across the languages to the point that speech appears to suffer minimally from parallel activation of multiple words (Costa et al., 1999; Hermans, 2000; Poulisse & Bongaerts, 1994). Monolinguals are assumed to experience few costs in speech production as a consequence of activating unintended words, which has led some researchers to hypothesize that the flow of information during speech planning must proceed in a serial fashion (Levelt, 1989, Levelt et al., 1999). The research discussed here questioned whether the comparison between bilingual selective access and monolingual production is really that simple to make. There are indeed some models of monolingual speech production that have claimed that competition between words within the language is resolved without allowing alternatives to compete at the level of their phonology models (e.g., Dell, 1986, 1988; Garrett, 1982; Harley, 1984) There are also models of monolingual production that have claimed the opposite (Levelt, 1989; Levelt et al., 1999). While the analogy between selective access in bilingual production and monolingual production seems logical enough, there is one very important distinction that has to be made between them. That distinction pertains to how difficult of a problem choosing a
word for production poses for bilinguals and monolinguals. For a bilingual speaker, every concept has at least two words, i.e., one translation in each language. Thus, bilingual speakers have many more words that can vie for selection during speech planning.

With this issue in mind, Experiment 1 was conducted to determine the level at which competition is resolved in monolingual and bilingual speakers. To frame the question another way, Experiment 1 asked whether processing of the sort described by selective models of bilingual production is found in monolingual speakers. If monolinguals can restrict activation of within-language competitors to the semantic level, then this would support the claim that prolonged activation of alternatives does not occur in monolingual speech. In effect, speech would appear to be serial because only the word that was intended for production would be selected. The results of Experiment 1 suggests that monolingual speech production allows a high degree of interactivity between words during speech planning, such that the phonology of both intended and unintended words competes for production.

In Experiment 1, I compared monolingual speech production to bilingual speech production using naming and translation in the presence of distractors. To the extent that it was established that participants in each group (monolingual or bilingual) did not differ in cognitive resources, this allowed a meaningful comparison between production in the L1 and in the L2. For the bilingual speakers, it was shown that there was activation of the distractor at the level of the phonology. This was indicated by the phonological facilitation found when bilinguals translated words from the L1 to the L2 and the phonological interference found when bilinguals named words in their L2. Critically, the results of Experiment 1 also provided evidence that not just the semantics, but also the name of the distractor had been activated when monolinguals performed naming. Although the result was not significant, it suggests that competition for
selection may be fundamentally inherent to speech production in all speakers, not only bilingual speakers.

In reviewing the findings from the current study, it is also important to note that both the naming and translation tasks provided evidence for competition between L1 and L2 alternatives. Translation is a task in which the cue to which language must be spoken is explicit. In order to translate a word, the word that serves as the input must be produced in the other language. Therefore, the language of the input serves as a cue for which language must be spoken and which language should be ignored (Miller & Kroll, 2002). If bilinguals could use the language of production as a cue to restrict activation to a single language (i.e., perform translation in a selective manner) then there should not be evidence that words were activated in the other language. But this is precisely what was found in the translation experiments (Experiments 1, - 3). Not only was this outcome found when bilinguals produced in their weaker L2 but also when they produced in their L1. Taken together, the results from the translation experiments do not support the hypothesis that translation provides a cue that can enable bilinguals to ignore words from the other language. In addition, the results from this study challenge the claim that bilingual speech production is selective.

**Conceptual access in the two directions of translation**

There has been large debate as to whether forward and L2 to L1 translation are both conceptually mediated (e.g., Kroll et al., 2010). One account of translation asserts that even second language learners at early stages of acquiring the L2 are able to use conceptual access to translate in the two directions. The RHM (Kroll & Stewart, 1994), on the other hand, proposes that there is an asymmetry in the two directions of translation. For less proficient bilinguals or
bilinguals in the initial stages of L2 acquisition, only L1 to L2 translation relies on conceptual mediation. Translation from L2 to L1 exploits links between lexical items in the two languages. As bilinguals gain more proficiency in the L2, they are able to use conceptual mediation to translate in both directions.

Previous research has found support for both accounts of bilingual translation; however, there appears to be evidence for conceptual mediation in both languages under very specific experimental contexts. Less proficient bilinguals have been shown to rely on conceptual mediation to translate from L2 to L1, but most of the evidence is drawn from experiments that investigated specific contexts, such as number translation (Duyck & Brysbaert, 1994). Other evidence supporting a lack of asymmetry in bilingual translation has been found when bilinguals are trained on a very small set of L2 vocabulary and tested on it shortly after training (Altarriba & Mathis, 1997). In the current study, translation was performed while ignoring distracting stimuli with words and concepts that may be more representative of the vocabulary knowledge that bilinguals have.

In Experiment 1, in which highly proficient bilinguals performed translation from L1 to L2, there was semantic facilitation, supporting the idea that there is conceptual mediation in forwards translation. However, the critical issue concerns whether or not conceptual mediation is used to perform L2 to L1 translation. The translation experiments (Experiments 2, 3, and 6) within the current study, in which relatively proficient bilinguals performed translation in both directions, showed that only L1 to L2 translation was influenced by the presence of semantic distractors. This was indicated by the measure of response latency to produce the translation in addition to the measurement of the electrophysiological response to the semantic distractors in

5 But see the experiments by De Groot, Dannenburgm & van Hell, 1994.
Experiment 6. In sum, the current study provided consistent evidence that only L1 to L2 translation relies on conceptual mediation.

**Effects of picture contexts in production tasks**

The set of translation and naming experiments also addressed specific predictions about whether the name of picture distractors becomes available. Recent studies, using the picture-picture interference task have found evidence to suggest that the phonology of picture distractors is available when target pictures have to be named (Colomé & Miozzo, 2010; Morsella & Miozzo, 2002; Meyer & Damian, 2007; Navarrete & Costa 2005). According to Bloem and La Heij (2003), distractor pictures do not become activated beyond the level of their semantic representation. As a consequence, their names cannot be accessed and prevents the name from interfering with producing the target word’s name. Similar to the current study, Bloem and La Heij performed several experiments in which participants translated in the context of picture distractors. They found that word distractors induced interference while picture distractors induced facilitation. They also found that the name of pictures did not become activate using a range of SOAs, ruling out the possibility that it requires more time for the name of the picture to be activated.

In the current study, I found consistent evidence that the name of distractor pictures became activated. In Experiments 2-5, the early SOA was comparable to Bloem & La Heij’s translation experiments (Bloem & La Heij, 2003; Bloem et al., 2004). The results of Experiment 2 showed that the phonology of the distractors was activated. If Bloem & La Heij were correct in that the activation of lexical alternatives was constrained to the semantic level then there should not have been phonological facilitation. The results of Experiment 3 showed that semantically
related pictures interfered with translating the target word and that phonologically related pictures facilitated translation. These two findings, although qualitatively different, both indicate that the name of the picture was activated. In summary, the results of this study do not support the idea that activation of picture distractors is constrained to the level of semantics.

**Implicit and explicit measures of conceptual access**

In Experiments 1 and 3, I found evidence supporting the hypothesis that only L1 to L2 translation is accomplished through conceptual mediation. In Experiment 6, I used ERPs to find electrophysiological evidence supporting this hypothesis. Interestingly, the behavioral results of the participants who were tested in Experiment 6 did not provide any evidence that the two directions of translation differ in whether or not they rely on conceptual mediation. However, the ERP results from Experiment 6 provided clear evidence that conceptual mediation supports L1 to L2 translation, but not L2 to L1 translation. This confirms the predictions of the RHM (Kroll & Stewart, 1994) that for relatively proficient bilinguals, who have asymmetries in the strength of the L1 and the L2, conceptual mediation can only be used to perform L1 to L2 translation. The ERPs revealed a robust effect of direction of translation and thus, I was able to detect differences in the electrophysiological responses between the semantic conditions. This finding highlights the importance of using converging methods to provided evidence for hypotheses.

**Conclusions and future directions**

In this study I found support for activation of the semantics and phonology of picture distractors. This suggests that not only alternatives compete for production at very late stages in speech planning. Importantly, the findings are not limited to when bilinguals produce
speech in their weaker L2. Rather, I found evidence that even when the more dominant L1 is produced, there is evidence for competition between intended and unintended words.

To follow up with the experiments that were conducted within this study, I plan to examine forwards and backwards translation with highly proficient bilinguals. This will be done to address the question of whether asymmetries in the use of conceptual mediation in translation are found in a more proficient group of bilingual speakers. It is expected that highly proficient bilinguals will be able to exploit the semantics of the distractor during translation in both directions.

In addition, I plan to investigate whether the shorter latencies for L2 to L1 translation found in the current study were a consequence of having picture contexts to support production from the weaker language to the more dominant language. I anticipate that the latencies will be longer for L2 to L1 translation than L1 to L2 translation, when there is no picture context to support production.

The experiments conducted in this study add insight into the nature of speech planning in monolingual and bilingual production. Contrary to selective views of bilingual production, the current experiments suggest that bilingual speech is open to extended activation from alternatives in the other language, such that they compete at the level of their phonology. The experiments also provide evidence that prolonged activation of words in the other language is not merely a consequence of speaking in the weaker L2. Even under circumstances in which speech is highly rapid and automatic, as in monolingual production, it appears that competition for selection takes place. Prolong activation of unintended words in the more dominant language and the weaker
language, implies that the underlying architecture of the speech production system is fundamentally supported by interactivity and competition.


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Morsella, M., & Miozzo, E. (2002). Evidence for a cascade model of lexical access in speech


APPENDIX A

LANGUAGE HISTORY QUESTIONNAIRE

| Subject Number: _____________________ | Date: ____________________ |

Language History Questionnaire

This questionnaire is designed to give us a better understanding of your experience with other languages. We ask that you be as accurate and as thorough as possible when answering the following questions.

Part I

1. Gender: _____________________

2. Age: ______ years

3. Do you have any known visual and/or hearing problems (either corrected or uncorrected)?
   - No
   - Yes [Please explain: ___________________________________________________________]

4. Native Country/Countries (Please check all that apply.)
   - United States
   - Other [Please specify: ____________________]

5. Native Language(s) (Please check all that apply.)
   - English
   - Other [Please specify: ____________________]

6. Language(s) spoken at home. (Please check all that apply.)
   - English
   - Spanish
   - German
   - Chinese
   - Other [Please specify: ____________________]
Part II

The next section of the questionnaire deals with your second language learning experience.

7. Have you studied any second language(s)?
   - No → If NO, please go to Part IV (on the final page of this questionnaire).
   - Yes → If yes, which language(s)? ________________________________

8. If you studied any second language(s) before college, please check all of the following that apply and indicate the starting age and length of study for any second language(s) learned before college.
   - Home/Outside of School – Language(s): _____________________________________
     Starting age? ________ For how long? ___________
   - Elementary School – Language(s): _____________________________________
     Starting age? ________ For how long? ___________
   - Middle School – Language(s): _____________________________________
     Starting age? ________ For how long? ___________
   - High School – Language(s): _____________________________________
     Starting age? ________ For how long? ___________

9. Have you studied any second language(s) in college?
   - No → If NO, please go to Question # 13.
   - Yes → If yes, which language(s)? ________________________________
     For how long?
       - Less than one semester
       - 1-2 semesters
       - 3-4 semesters
       - 5-6 semesters
       - 7-8 semesters
       - 8+ semesters

10. Please list the most advanced second language course(s) you have completed in college:
    ________________________________

11. Are you currently taking at least one second language course in college?
    - No
    - Yes → If yes, which course(s)? ________________________________
12. Are you: (Please check all that apply and indicate which language each applies to if you have studied more than one second language at college.)

- A Spanish, German, etc. 3 student.
- Taking a second language for a requirement but interested in being a major or minor.
- Taking a second language for a requirement; NOT interested in being a major or minor.
- A second language minor.
- A second language major.
- A second language graduate student.
- Other [Please explain: _______________________________]

13. Have you studied and/or lived abroad?

- Yes
- No

If YES, where and when did you study, for how long, and what language(s) did you speak?

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14. What do you consider to be your primary second language? (You may check more than one if you feel that you have multiple “primary” second languages.)

- English
- Spanish
- German
- Chinese
- Other [Please specify: _______________________________]

15. What language do you currently think is your dominant language (i.e., the language you are most comfortable using on a daily basis)? (Please check one)

- English
- Spanish
- German
- Chinese
- Other [Please specify: _______________________________]
Part III
The next section asks you to rate your skills in your primary second language. If English is your primary second language, then rate yourself on your native language in this section (you will rate your English skills later). If you have more than one “primary” second language, please indicate your skills for each language separately by writing the language next to the number that matches your skill level.

What language(s) are these ratings for? ________________________________

16. Your reading proficiency in this language. (1=not literate and 10=very literate)

1  2  3  4  5  6  7  8  9  10

17. Your spelling proficiency in this language. (1=not good and 10=very good)

1  2  3  4  5  6  7  8  9  10

18. Your writing proficiency in this language. (1=not literate and 10=very literate)

1  2  3  4  5  6  7  8  9  10

19. Your speaking ability in this language. (1=not fluent and 10=very fluent)

1  2  3  4  5  6  7  8  9  10

20. Your speech comprehension ability in this language. (1=unable to understand conversation and 10=perfectly able to understand)
21. In my second language classes, I get:

- Mostly As
- Mostly As and Bs
- Mostly Bs
- Mostly Bs and Cs
- Mostly Cs
Part IV

The next section of the questionnaire deals with your English language skills. Please rate yourself on each measure by circling the appropriate number.

These ratings are for ENGLISH.

22. Your English reading proficiency. (1=not literate and 10 = very literate)

1 2 3 4 5 6 7 8 9 10

23. Your English spelling proficiency. (1=not good and 10=very good)

1 2 3 4 5 6 7 8 9 10

24. Your English writing proficiency. (1=not literate and 10=very literate)

1 2 3 4 5 6 7 8 9 10

25. Your English speaking ability. (1=not fluent and 10=very fluent)

1 2 3 4 5 6 7 8 9 10

26. Your English speech comprehension ability. (1=unable to understand conversation and 10=perfectly able to understand)
27. Do you have any additional comments to make? Please include any additional language experience that you have not included in other portions of this questionnaire.

Thank you for your participation!
## APPENDIX B

### STIMULI USED IN EXPERIMENTS

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## APPENDIX C

### INDIVIDUAL DIFFERENCE MEASURES FOR BILINGUALS IN EXPERIMENTS 2-5

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<th>Dependent measures</th>
<th>Exp 2</th>
<th>Exp 3</th>
<th>Exp 4</th>
<th>Exp 5</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simon task</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simon score (ms)</td>
<td>52 (32)</td>
<td>44 (25)</td>
<td>42 (25)</td>
<td>36 (20)</td>
<td>ns</td>
</tr>
<tr>
<td>RT for neutral (ms)</td>
<td>426 (66)</td>
<td>456 (79)</td>
<td>450 (76)</td>
<td>425 (51)</td>
<td>ns</td>
</tr>
<tr>
<td>RT for congruent (ms)</td>
<td>407 (56)</td>
<td>436 (64)</td>
<td>432 (77)</td>
<td>413 (49)</td>
<td>ns</td>
</tr>
<tr>
<td>RT for incongruent (ms)</td>
<td>459 (81)</td>
<td>480 (76)</td>
<td>475 (80)</td>
<td>449 (55)</td>
<td>ns</td>
</tr>
<tr>
<td>Accuracy for neutral %</td>
<td>98 (4)</td>
<td>99 (2)</td>
<td>96 (2)</td>
<td>99 (2)</td>
<td>ns</td>
</tr>
<tr>
<td>Accuracy for congruent %</td>
<td>99 (1)</td>
<td>99 (1)</td>
<td>94 (6)</td>
<td>99 (2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Accuracy for incongruent %</td>
<td>96 (3)</td>
<td>96 (5)</td>
<td>95 (4)</td>
<td>97 (4)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>OSPAN task</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Operation span (1-60)</td>
<td>52 (5)</td>
<td>50 (5)</td>
<td>50 (5)</td>
<td>49 (5)</td>
<td>ns</td>
</tr>
<tr>
<td>RT on judgment (ms)</td>
<td>1863 (227)</td>
<td>1937 (318)</td>
<td>1990 (353)</td>
<td>1884 (305)</td>
<td>ns</td>
</tr>
<tr>
<td>Errors on judgment (1-60)</td>
<td>4 (5)</td>
<td>6 (3)</td>
<td>5 (4)</td>
<td>5 (2)</td>
<td>ns</td>
</tr>
</tbody>
</table>

Note. Standard deviations in parentheses.
**APPENDIX D**

**PROFICIENCY MEASURES FOR BILINGUALS IN EXPERIMENTS 2-5**

<table>
<thead>
<tr>
<th>Dependent measures</th>
<th>Exp 2</th>
<th>Exp 3</th>
<th>Exp 4</th>
<th>Exp 5</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-ratings on LHQ</strong></td>
<td></td>
<td></td>
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<tr>
<td>L1 Ratings (Chinese)</td>
<td></td>
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<tr>
<td>Reading Proficiency (1-10)</td>
<td>9.1 (0.8)</td>
<td>9.0 (1.2)</td>
<td>8.8 (1.4)</td>
<td>8.4 (2.4)</td>
<td>ns</td>
</tr>
<tr>
<td>Spelling Proficiency (1-10)</td>
<td>9.2 (1.0)</td>
<td>9.0 (1.1)</td>
<td>8.9 (1.1)</td>
<td>8.2 (1.3)</td>
<td>ns</td>
</tr>
<tr>
<td>Writing Proficiency (1-10)</td>
<td>8.8 (1.2)</td>
<td>8.5 (1.5)</td>
<td>8.6 (1.2)</td>
<td>7.7 (1.5)</td>
<td>ns</td>
</tr>
<tr>
<td>Speaking Proficiency (1-10)</td>
<td>9.5 (0.7)</td>
<td>9.1 (3.0)</td>
<td>8.9 (1.3)</td>
<td>8.0 (1.9)</td>
<td>&lt;.05</td>
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<tr>
<td>Listening Proficiency (1-10)</td>
<td>9.3 (0.8)</td>
<td>9.3 (1.0)</td>
<td>8.6 (1.3)</td>
<td>8.3 (1.4)</td>
<td>ns</td>
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<tr>
<td>L2 Ratings (English)</td>
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<tr>
<td>Reading Proficiency (1-10)</td>
<td>7.5 (0.7)</td>
<td>7.0 (1.3)</td>
<td>6.8 (1.1)</td>
<td>6.9 (1.1)</td>
<td>ns</td>
</tr>
<tr>
<td>Spelling Proficiency (1-10)</td>
<td>7.5 (1.5)</td>
<td>6.7 (1.4)</td>
<td>7.3 (0.9)</td>
<td>6.3 (1.1)</td>
<td>ns</td>
</tr>
<tr>
<td>Writing Proficiency (1-10)</td>
<td>7.2 (1.4)</td>
<td>6.2 (1.4)</td>
<td>6.8 (1.0)</td>
<td>6.1 (1.0)</td>
<td>ns</td>
</tr>
<tr>
<td>Speaking Proficiency (1-10)</td>
<td>7.6 (0.8)</td>
<td>6.3 (1.5)</td>
<td>6.8 (1.2)</td>
<td>5.6 (1.7)</td>
<td>&lt;.01</td>
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<tr>
<td>Listening Proficiency (1-10)</td>
<td>7.8 (1.1)</td>
<td>7.3 (1.2)</td>
<td>7.0 (1.0)</td>
<td>6.1 (1.3)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note. Standard deviations in parentheses.
APPENDIX E

A BACKGROUND OF ERP METHODOLOGY

The use of event-related potentials (ERPs) in studies of language production has a fairly recent history. Their use as a measure of cognitive activity extends as far back as the beginning of the 20th century, when Hans Berger first demonstrated that brain activity could be recorded using electrodes placed on the scalp and amplified their signal (Berger, 1929). The brain activity that Berger reported is known as the electroencephalogram (EEG). Before discussing ERPs in detail, I first overview the background EEGs (for a more detailed overview please see Coles & Rugg, 1997; Luck, 2005; Molfese, Molfese, & Kelly, 2001; Swaab, Ledoux, Camblin & Boudewyn, in press). The neurons in the brain send signals to each other through electrical impulses. One of the primary electrical impulses is referred to as the postsynaptic potential. A postsynaptic potential occurs when neurotransmitters attach to the receptor of a neuron and change the voltage at its membrane. Recordings can detect post-synaptic potentials, generally, because they are easier to recode from the scalp (Luck, 2005). Post-synaptic potentials are easier to record because they reflect the summed activity in a cell and are not likely to cancel each other out. The electrical signal can be detected on the scalp when a group of neurons each form opposing charged electrical currents, or dipoles, at the cell body and the dendrites. The group of neurons must form dipoles at the same time and along the same spatial orientation (Luck, 2005).

Because the neural impulse travels through cortical tissue, the skull, and the scalp it undergoes some distortion. The folds in the brain and the resistance in the scalp/skull spread the signal out over large distances. Therefore, it is difficult to use ERPs to reveal is the locus of brain
activity (see Van Petten & Luka, 2006). However, since they have high temporal resolution, ERPs are suitable for recording brain activation evoked by a particular stimulus.

In order to measure the brain activity in response to a specific stimulus, the presentation of that stimulus is marked in the continuous EEG record. This is known as “time-locking”. Then the EEG signal is averaged over many trials, providing the ERP. The signal from individual trials contains noise. The assumption behind averaging over numerous trials is that the noise is not systematic but random (Luck, 2005). Averaging will reduce the random noise in individual trials. What remains in the signal should be activity that is related to the stimulus. The average waveforms will have peaks that correspond to positive and negative voltage deflections, respectively. These peaks are often mapped onto particular cognitive processes. The word “component” is typically used to denote peaks or other structural aspects in waveforms that are found in response to particular stimuli. Components are usually denoted by the latency at which it occurs relative to stimulus presentation and the polarity of the peak. For example, a P200 is a positive-going wave occurring around 200 ms after the onset of the stimulus.