LEXICAL SELECTION IN BILINGUALS:
PROACTIVE OR REACTIVE ADJUSTMENT TO LANGUAGE CHOICE

by

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ABSTRACT

This study was designed to test the claim that there are two components to bilingual language control (Green, 1998). The first is proactive control by which the language processing system prepares for an anticipated shift in language. The second is reactive language control, a mechanism by which the language processing system completes its preparation for a language shift on the basis of either an external or an internal stimulus.

In an experimental study of language switching, eighteen balanced English-French bilinguals named sequences of two pictures in either the same language or in different languages. Proactive control was examined by manipulating foreknowledge of whether the pictures would be named in the same language or in different languages. Reactive control was examined by manipulating the semantic relatedness between the two pictures in a pair.

A positive semantic priming effect was observed when languages were repeated but no negative priming effect was observed when languages were switched. Thus, the reactive inhibition hypothesis was not supported. As expected, a time cost was associated with switching languages but this unexpectedly occurred only when foreknowledge was available. Consistent with the notion of proactive processing response latencies on both switch and repetition trials were faster when foreknowledge was available. The overall pattern of results is consistent with models which postulate control components which operate at both a global level and a local level. Examination of the results in terms of the Language Mode Continuum framework (Grosjean, 2001) suggest that bilinguals can strategically adopt a preparatory state that especially facilitates language switching.
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CHAPTER 1: INTRODUCTION

1.1. Problem area

Proficient bilinguals have the ability to switch rapidly and effortlessly between their two languages. They are also able to keep their languages separate when circumstances require them to do so. This suggests that they are able to use their languages selectively. How do bilinguals control the use of their two languages and how is the language of the intended message specified? Most research in the area of bilingual lexical processing has focused on the organization of the bilingual lexicon but leaves open the question of how control of the intended language of output is effected. Over the last ten years, it has become clear that models of bilingual processing need to include a control mechanism if they are to account for bilingual performance.

Most models of bilingual language processing assume, albeit implicitly, that language control acts globally (i.e. that one of a bilingual’s languages can become more active than the other). One of the most influential proposals is the subset hypothesis (Paradis, 1987) according to which words belonging to one language form a subset which can be activated or deactivated in it’s entirety. This proposal is complemented by another, according to which languages can have one of three levels of activation: selected, active or dormant (Green, 1986). This relative activation of a bilingual’s languages is assumed to depend on such factors as frequency and recency of use, context and the speaker’s intentions. The idea that languages are functionally separate is implicit in these proposals, but none offer any speculative account of the processing mechanisms which underlie language separation during
bilingual performance.

The inhibitory control (IC) model of bilingual lexical processing (Green, 1998) provides a framework for thinking specifically about the nature of bilingual language control processes. According to the model, there are two levels of control. At one level, control operates outside the bilingual lexico-semantic system, is goal driven and is proactive. At this level, control mechanisms can be put into action before a language task is performed. At another level, control is effected on elements within the lexico-semantic system. This control mechanism is reactive and is only brought into play following presentation of a task relevant stimulus (i.e. once lexical access has begun). This reactive component is deemed necessary because it appears that the bilingual language processing system cannot be completely readied for a switch in language even when a switch is fully anticipated (Meuter and Allport, 1999). Instead, this process of reconfiguration is only completed in response to an internal or an external stimulus on which the system can act (Allport, Styles and Hsieh, 1994; Rogers and Monsell, 1995; Sohn 1998). In sum, according to the IC model, there are two sources of activation change regulating language control. One is endogenous control which acts on the basis of a goal and the other is exogenous activation which is brought about on the basis of an external stimulus.

The predictions generated by the IC model have been assessed against existing data from bilingual Stroop and language switching studies as well as against data from neuropsychological reports. These predictions, however, have not yet been tested experimentally. In the current study, my aim was to test the controversial claim of the IC model which is that there is a component of language control which is reactive and
inhibitory. This was done by embedding a semantic priming condition within a modified language switching design. Bilingual English-French participants were asked to name two sequentially presented pictures in one or the other of their languages. The language of response was determined by a color cue. The dependent variable was the response latency for naming the second picture of a trial pair.

It was predicted that the effect of semantic relatedness of the picture pairs should differ depending on whether language control is purely proactive or whether it also includes a reactive component. If the language processing system can proactively adapt to the task of switching, semantic relatedness of the pictures in a trial pair could either have no effect on switch trials or facilitate switch trials. Given the time cost that is likely to be incurred for a language switch, any facilitation effect would likely be of a lesser magnitude than that observed on same language repetition trials. If no effect is observed, this would suggest that global language activation/deactivation is sufficient to override any pre-activation of items in the non-target language. If a facilitation effect is observed, this would suggest that global activation/deactivation may be insufficient to override the pre-activation of items from a non-target language. Both types of results would support proactive control; however, the former would support a stronger global control component than would the latter. On the other hand, an inhibitory effect of semantic relatedness on picture pairs on switch trials would support the hypothesis that there is a reactive component to bilingual language control. If this is the case, this effect should be observable as an increase in the switch cost when pictures in a trial pair are semantically related. This is because reactive inhibition, which occurred during the performance of the first item of a trial pair, has increased the activation threshold for the
target in the semantically related condition. As a result, the response latency to switch trials should be greater in the semantically related condition than in the semantically unrelated condition.

This research constitutes a unique contribution to both the areas of bilingual language processing and task switching in a number of ways. First, a picture-naming task with a large set of stimuli was used. The only other language switching study which used a naming task employed a closed set of numerals as stimuli (Meuter & Allport, 1999). Second, a relatively new task switching design was employed which provided a means of isolating processes which were operative during each trial from those that were operative on the previous or subsequent trials. Third, to my knowledge, this is the first language or task switching study to manipulate the relationship between the stimulus for a current task and the stimulus for a previous task.

1.2. Literature Review

1.2.1. Overview

The inhibitory control (IC) model draws on a model of lexical representation outlined by Levelt and Roelofs (1999) as well as from a model of control of action developed by Norman and Shallice (1986). The control aspect of the model is based mainly on findings in the area of task switching since this paradigm offers a way to maximize participants’ use of control processes. Studies aimed at examining language control have used similar designs replacing the task switch with a language switch. Lexical decision tasks have typically been used in this type of study (e.g. Von Studnitz & Green, 1997) while naming task have only rarely been employed (e.g. Meuter & Allport 1999). The effect of relatedness between
consecutively presented stimuli has not yet been explored in switching studies but has been in monolingual picture naming studies. A semantic priming effect has been observed in monolingual naming studies in which the pictures in two consecutive naming trials are related (Huttenlocher & Kubicek, 1993). In the following section, I will discuss accounts of bilingual representation and of language control. This will be followed by a discussion detailing the components of the IC-model. The main findings from the three research areas which have contributed to the design of the current study, namely, task switching, language switching and priming will also be discussed.

1.2.2. Early accounts of bilingual lexical representation

Earlier studies of bilingual language representation were aimed at determining whether word forms and concepts were represented separately or in an integrated lexicon. Results, at first, appeared to be contradictory until tasks were more carefully analyzed. Kroll and De Groot (1997) noted that studies that used tasks requiring lexical level processing (e.g. lexical decision) tended to support the separate store hypothesis but that studies which used tasks requiring processing at the semantic level tended to support the shared storage hypothesis. Only multiple level models of lexical representation were able to account for these apparently conflicting results. These models postulate separate levels for form and meaning representations (e.g. Smith, 1997; Levelt & Roelofs, 1999; Kroll & De Groot, 1997), and although they differ in their detail, there is wide agreement that at the conceptual level representation is shared but at the word form and/or lemma levels storage is language specific.
1.2.3. Control, activation and resources

Most accounts of bilingual language processing assume, albeit implicitly, that language control operates at a global level. One of the most influential is the subset hypothesis put forward by Paradis (1987). According to this hypothesis, words (and syntactic rules, and phonemes) for both languages are stored in identical ways in a single extended system. However, words from each language form separate networks because they tend to appear in different contexts. In other words, items of one language form a network because they are more often used together resulting in stronger within language ties than between language ties. By virtue of these stronger ties, items within languages form a subset (or network) which can be activated or deactivated in its’ entirety. Another proposal, the Control, Activation, and Resource Framework, was put forward by Green (1986) and complements the subset hypothesis. According to Green, this proposal offers a unified way of explaining both normal and impaired performance. It is suggested that a language can have one of three levels of activation. A language can be selected, in which case it is the most activated and controls the output of the language processing system. Another possibility is that a language can be active but not selected. Finally a language can be dormant when it is not in regular use. A dormant language does not participate in any way to ongoing processing.

This language control framework incorporates the notions of activation levels as well as the resources (inhibitory and excitatory) required for altering these levels. Following this framework, the output from each language system can be either suppressed externally using external inhibitory resources from the other language or using internal inhibitory resources.
The internal inhibitory resources restrict the retrieval of word sounds. Naming in one language (La) requires increasing the level of activation of that language and decreasing the level of activation of the other (Lb). Green (1986) hypothesizes that when bilinguals are speaking only in one language, for example La, control is achieved mainly through external suppression (i.e. using the inhibitory resources of the La system to suppress the Lb system). For translation, the regulation of control is more complex because both language systems need to be active but only one should control output. To translate from La to Lb for example, output from La needs to be suppressed. It is suggested that this is accomplished internally using inhibitory resources from the La system to restrict word sound retrieval.

Green (1986) supported his proposal with data from neuropsychological reports of polyglot aphasia. Specifically, Green applied his framework to different recovery patterns observed in bilingual aphasia. The main assumption is that brain damage limits the capacity to inhibit and that this may result in an imbalance of resources available to each of the language systems. It is also assumed that a language is not used spontaneously because it has insufficient resources to suppress the other language rather than because it has become inactive. Green illustrates his proposal with a number of reported cases of polyglot aphasia. One of these involved a recovery pattern termed alternate antagonism concurrent with paradoxical translation which was reported in a single patient by Paradis, Goldblum, and Abidi (1982). This patient, AD, was a fluently bilingual nun who spoke both Arabic and French. On day 18 following her brain injury, AD was unable to use French spontaneously but was able to name objects and speak Arabic spontaneously. On the following day, the pattern was reversed and she could no longer speak Arabic spontaneously but naming and
spontaneous speech were good in French. This phenomenon was termed alternate antagonism. In addition, on the days AD could speak Arabic spontaneously she was unable to translate into it; she was, however, able to translate into French, the language she did not speak spontaneously. Similarly, on the days she could speak French spontaneously she was only able to translate into Arabic. This phenomenon was termed paradoxical translation.

According to Green (1986), these as well as other recovery patterns can be explained in terms of reduction in the inhibitory resources that are needed to regulate the relative levels of activation of each language. If on day 18, the inhibitory resources of the French language system (both internal and external) were depleted, this would prevent naming or spontaneous speech in French because it would be unable to dominate Arabic. Translation from Arabic to French is however possible, assuming both languages are active, because the Arabic language system still has resources to internally inhibit its output. This allowed for the production of a French translation of an Arabic word. The alternation of patterns is explained in terms of depletion of resources, which are not replenished at a rapid enough rate. In time, as the inhibitory resources of the Arabic language become used up, the French language system resources are now able to dominate Arabic. This results in the appearance of the opposite pattern. In sum, according to this framework, this and other bilingual aphasia recovery patterns can be explained in terms of a disparity between the relative inhibitory resources available to each language. This disparity is assumed to be caused by the slow replacement rate of these resources as they are expended resulting in a disruption in the capacity to control the relative activation levels of the two languages.

There is also some experimental evidence which supports the notion of different
levels of activation of a bilingual’s languages. Grosjean (1997) reports results from a laboratory study in which participants were told that they were taking part in a telephone chain experiment. Language mode was manipulated by changing the characteristics of the (fictional) listener to whom the story would be told. This manipulation was aimed at inducing the speakers to operate at different points along the bilingual mode continuum. The language mode of a bilingual speaker reflects the relative activation level of each language and can vary depending on context and interlocutor. At the monolingual end of the continuum, bilinguals are typically interacting with monolinguals. In this situation, one language is considerably more activated than the other. At the bilingual end of the continuum, the speaker is typically interacting with other bilinguals with whom he/she typically mixes languages. In this situation, both languages are activated, although one of the two, the base language, may have somewhat more activation. The results of this study showed more intrusions from the guest language (measured in number of syllables) when subjects were thought to be at the bilingual end of the continuum. Fewer of these intrusions were observed at the monolingual end of the continuum; however, more hesitations were noted. The latter finding is suggestive of an increase in level of attention required to direct resources at inhibiting the other language.

If fluency level in each of a bilingual’s languages can be taken as an index of the relative base activation level of each language, additional support can be found in studies which show differences in the magnitude of cross-linguistic interference effects depending on subjects’ relative proficiency in each language. Meuter and Allport (1999), using a bilingual numeral naming task, found that the cost of switching to a dominant language from a weaker
one was greater than the cost of switching from the stronger to the weaker language. These results were explained in terms of the relative strength of each language. The stronger language required more active inhibition than did the weaker language in order for the weaker language to dominate the output of the linguistic system. On switch trials, when naming in the dominant language, this active inhibition persisted resulting in an increase in response latency. Similar evidence comes from experiments which have used bilingual Stroop and bilingual flanker tasks (e.g. Mägiste 1984). Results of these experiments suggest that the amount of interference from words in another language is a function of a speaker's levels of proficiency in each of these languages. Mägiste also found that interference could be reduced when the language of the distractor word could be anticipated. To some extent, the finding that switch cost is reduced when a bilingual can fully anticipate a language switch also supports the notion that bilinguals can control their two languages by varying their relative levels of activation.

In conclusion, the subset hypothesis and the notion of different levels of activation are supported by data from clinical case reports as well as from experimental studies. The notion of language subsets and levels of activation have been adopted in various forms by a number of researchers (e.g. De Bot & Schreuder, 1993; Grainger & Dijkstra, 1992; Grosjean, 1988 & 1997). Implicit in most of these accounts is the notion that activation changes affect all of the items within a language subset; in other words that language control can be effected globally.
1.2.4. The inhibitory control (IC) model (Green, 1998)

The basic assumption of the inhibitory control (IC) model is that mental control in language processing can be likened to the control of action. The language processing aspect of the IC model draws on two theoretical frameworks bringing together theories of bilingual lexical representation and theories of bilingual lexical access and language control. The control aspect of the model draws Norman and Shallice’s (1986) model for the control of action. These various source frameworks will be discussed in the following sections.

1.2.4.1. Levels of lexical representation

Green (1998) based his conceptualization of the structure of the lexico-semantic system within the IC model on Levelt (1989), and Levelt and Roelofs (1999). According to these models, language assignment occurs at a level of pre-verbal message generation. Another aspect of the model is that there are three levels of lexical representation: a conceptual level, a lemma level and a phonological word level. At the lemma level, syntactic and semantic properties as well as language are specified. Green (1986, 1998) hypothesized that lemmas as well as concepts are specified for language by means of a language tag. A similar proposal is also made by Monsell, Matthews, and Miller (1992); and Poulisse and Bongaerts (1994), who assumed that words stored in a single network need to contain information identifying the language to which they belong. Most of these proposals postulate the existence of connections between levels as well as within levels. These connections allow for related concepts to become activated along with the target concept and also for related lemmas, including those tagged for the non-target language, to become
activated along with the target lemma. This is especially true when naming concrete objects which are more likely to share a number of meaning elements. Figure 1.1 adapted from Poulisse and Bongaerts (1994) illustrates the interconnections between levels and the way activation can spread throughout the network. It can be noted that in addition to conceptual information, there is a language component which also plays a role in activating individual lexical items. Lemmas are tagged with labels that specify the language to which they belong. The figure shows that in addition to the target, other lemmas are activated, which share similar meaning or conceptual information both within and across languages.

1.2.4.2. Norman and Shallice’s model for the control of action

The language control component of the IC model draws on a model of the control of action developed by Norman and Shallice (1986). Their proposal is a psychological model of control based on the production system architecture. In this type of system, production-like
entities called schemata are metaphorically conceived of as competing in a free market for
the control of action with some provisions in place to prevent anarchy. According to Norman
and Shallice, human action can be analyzed at a variety of different levels: High level
schemas control activities such as going to the doctor's; mid-level schemas are well learned
actions such as making coffee; and low level schemas include actions such as grasping and
pouring. A basic presumption of the IC model is that there are similarities between the
as a form of communicative action and draws a parallel between intermediate level action
schemas and experimental tasks such as translation or lexical decision. Schemas specifying
the articulation of a word form are low level schemas and are beyond the scope of the IC
model.

Intermediate level schemas control behavior in familiar tasks and need to be selected
in order for behavior to take place. Selection of a schema can be triggered by an external cue
or internal (cognitive) cue. For example, seeing a proffered hand may activate the schema for
a handshake even though it had been extended to receive an object. Proactive (top-down)
control may, however, determine whether or not the handshake is actually carried out.
Schemas can be activated to different degrees and the one that achieves threshold first is
selected. The process by which schemas compete with each other is called contention
scheduling. Contention scheduling is modulated by the degree of activation of each of the
mutually inhibitory task schemas that have been activated by a perceptual or cognitive clue.
This degree of activation is determined in part by factors of recency and frequency. Unless
other goal directed control mechanisms are in place, such a system would be limited to the
performance of habitual behavior. As an illustration, suppose a situation in which a speaker is unexpectedly required to speak in a formal and infrequently used register. These new sociolinguistic demands present the speaker with a number of choices. Possible greetings, for example, could range from the casual "hey" to a more formal "good morning". Speech registers compete to control output and if contention scheduling alone determines the outcome, the most frequently used speech register would always be selected. A goal directed mechanism could allow for selection to be biased in favor of the contextually appropriate speech register while failure of this control mechanism could result in contextually inappropriate language use. In sum, at some level of control, resources are put towards biasing the outcome of contention scheduling on the basis of contextual cues and speaker goals.

The Supervisory attentional system (SAS) is the component of the model introduced to bias the effects of contention scheduling when necessary. According to Norman and Shallice (1986), the SAS activates or inhibits lower level schemas based on representations of the environment and of the organism's intentions and cognitive capacities. It is an endogenous (i.e. goal driven) control component. The SAS becomes important when, for example, unfamiliar tasks are performed on familiar stimuli or if a task is dangerous or technically demanding. This is because an external cue can, in such circumstances, trigger habitual but inappropriate responses. In the previous example, such would be the case if the

Paradis (1997) draws a parallel between languages and registers and advances that linguistic functions such as borrowing, switching, mixing, and translating each have their monolingual counterpart.
proffered hand had mistakenly been grasped for a handshake. In sum, the SAS biases the contention scheduling of competing task schemas in accordance with a goal. It can be operative prior to the presentation of a stimulus if a change in task is anticipated and, in this sense, is a form of proactive control. Contention scheduling, on the other hand, is modulated by frequency and recency of activation and is mainly stimulus driven. The SAS may not always be able to override automatic stimulus driven activation if there is strong pre-activation from a recently performed action-set. This is why a reactive control component may be needed to control behavior once a new stimulus has been presented. This point will be discussed further in the following section.

1.2.4.3. Levels of language control

In terms of language control, Green (1998) hypothesizes that there is a component of language control that operates at the level of mutually inhibitory language task schemas. This level of control can globally affect the level of activation of each language subset. Since language task schemas alter the levels of activation of representations within the lexico-semantic system, selection of a language task schema will result in an increase in level of activation of one language subset and decrease in activation of the other. The second level of control operates at the lemma level and involves the use of language tags. To ensure that the correct response controls output, a "process of inhibitory control through tag suppression is engaged once lemmas linked to active concepts have been activated" (Green, 1998, p. 71). In other words, at an early stage in lexical access, active concepts will be linked to related lemmas in both languages; but at the later selection stage; items tagged with the incorrect language tag will be inhibited by the selected language task schema.
1.2.4.4. Proactive control versus reactive control

An important characteristic of the IC model is that control at the lemma level is reactive and inhibitory. This notion of reactive inhibition implies that at a later stage in the selection process, only activated items with incorrect language tags will be suppressed by the selected language task schema rather than all of the items in the irrelevant lexicon. The notion of reactive language control is at odds with the interpretation of pure proactivity of language preparation advanced by Meuter and Allport (1999) which implies the effective global activation/inhibition of a whole language subset. The IC model, does not, however, do away with proactive control processes. Instead, this form of inhibition is thought to occur at the task schema level. In other words, a system can proactively prepare for a switch by increasing the level of activation for the target schema and suppressing the competitor schema. Given that in language switching studies the switch cost is never completely eliminated even when language switches can be fully anticipated (Macnamara, Krauthammer, & Bolgar, 1968; Meuter & Allport, 1999; Von Studnitz & Green, 1997), it seems that this preparation is not sufficient to override the prior activation of items which are now in the non-target language.

Reactive language control has been criticized on the grounds that it is an inefficient mechanism. De Groot (1998) has argued that a system that is proactively readied for a task is much more efficient than a system that reactively adjusts to a change in task. However, the assumption of pure proactivity is problematic when one considers instances of dense code switching. In such cases, how is it more efficient to reactivate or deactivate all of the words from a language prior to each code-switch rather than to reactivate-deactivate only a small
subset of competing lexical items? It can be argued that, in such a case, an additional reactive control mechanism would be more cost efficient than a purely proactive control mechanism. For example, in many bilingual contexts it may be that languages do not compete strongly as both offer appropriate targets given the context. It may also be that, at times, the speaker intends to use one target language over another and thus language control needs to be exerted. In such a situation, it would conceivably be more efficient if both of a bilingual’s languages remained highly activated rather than alternatively being activated and suppressed when language control needed to be exerted. Language control in such a context would require less inhibitory resources if only a relatively small subset of competing lexical items were targeted for suppression at any given point in time rather than an entire language subset. This suppression of a limited number of items from the non-target language could be accomplished through reactive inhibition. This local inhibition would leave the remainder of items in both language subsets available for subsequent communication. On the whole, the proposal put forward by Green (1998) that language control is exerted mainly though inhibitory processes, is in line with other proposals; however, a unique aspect of the model is the notion that there is a component of language control which is reactive. It is this reactive component of the model which was tested in the current study.

1.2.5. Task switching

1.2.5.1. Overview

The current study is mainly concerned with language control processes, and therefore, the design needs to maximize the contribution of control processes to performance. Task switching offers a way to do this because it forces participants to reconfigure for a new task
on numerous trials (in some cases on every trial). Language switching studies have more or less paralleled general task switching studies, and findings in both domains have been interpreted similarly. In the following section, I will outline how the task switching paradigm has evolved over the years. This will include a review of those studies in which bilinguals switched between tasks that required the use of either one or the other of their languages.

Typically, in task switching studies, participants are instructed to repeat the same task or to alternate between two or more different tasks. The relevant task for each trial is generally signaled by an external visual cue and/or by the predictability of the sequence (e.g. AABBAA...). A non-switch trial is one in which the task to be performed is the same as the one just performed on the preceding trial. A switch trial, on the other hand, is one in which the task to be performed is different from the one that has just been performed. The main finding of most task switching studies is that response latencies on switch trials are longer than those on repetition trials. This may be because switching to a new task involves disengaging from one task and engaging in the new one whereas repeating a task only requires maintaining engagement of the same task (Sohn, 1998; Norman & Shallice, 1986). The difference between the mean response latencies on switch trials and the mean response latency on repetition trials is called the switch cost.

The task switching method, which was first developed by Jersild (1927), has been refined over the years in order to address in more specific ways the nature of the processes involved in reconfiguring the system for a shift in task. In order to examine some of the factors that affect this reconfiguration process, additional variables have been added to
subsequent designs. Some of these variables include the response to stimulus interval (RSI), which is the delay between a subject's response and presentation of the next stimulus, foreknowledge of an upcoming task transition, expectation and practice.

1.2.5.2. 'Alternating' or 'shift' paradigm

In Jersild's (1927) study, the experimental condition consisted of a series of alternating trials (e.g. ABABA...), while the control condition consisted of having participants perform only one task at a time (e.g. AAAA... or BBBB...). Subjects' mean response latencies in the mixed block were compared to mean response latencies in pure blocks. A measure of interference, which is the percent of time required by the shift performance over that required for the separate task, was calculated. This measure showed that there was a significant amount of interference attributable to the switching condition. This interference was called the 'shift loss'. Darlymple and Alford (1985) used a similar method but had bilinguals alternate between the task of reading words in one or the other of their languages. They compared reading times of monolingual word lists with reading times of bilingual word lists and found a 17 ms cost per switch (Experiment 1).

The shift variant was also used by Allport, Styles, and Hsieh (1994). They found a switch cost that averaged around 200ms using a wide range of tasks performed on Stroop-like stimuli such as color words or groupings of a repeated numeral. In some cases the participants alternated between responding according to one or the other of the relevant dimensions of a Stroop stimulus (e.g. color naming versus word reading); and in other cases, they alternated between responding to different types of incongruent Stroop stimuli (e.g. the word 'red' printed in blue ink or the digit '4' repeated in a group of five). The finding of
interest in these experiments is not the switch cost itself but that there remained a substantial
cost in conditions where switches could be fully anticipated and where sufficient preparation
time (up to 1.1 seconds) was provided between trials. Allport et al. found a reduction in
switch cost only with increases in response to stimulus intervals (RSI) of up to 500 msec
(Experiment 5). Further increases in RSI up to 1100 ms did not result in a reduction in
switch cost. In other words, it appears that even when an upcoming shift in task is
predictable and sufficient time is provided for task preparation, there remains a portion of the
switch cost that cannot be reduced. The authors inferred from this that only a portion of the
entire switch cost represented the time it takes to execute an anticipatory shift in task.

Allport et al. (1994) also observed a gradual decline in the switch cost over successive
trials in a run. The authors inferred from this that it takes more than one trial to overcome
activation from a previous task and that the irreducible portion of the switch cost reflects
persisting activation of a previous task into the processing of the current trial. In other words
the reduction of the switch cost as a function of an increase in RSI reflects disengagement in
the form of decay of a previous task. They call this the task set inertia hypothesis.
Interestingly, they also add that this persisting activation can only be overcome once the
stimulus for the subsequent trial is presented. This statement implies that in addition to a
passive decay process there is also some active disengagement process that is triggered by a
new stimulus. This idea is partly supported by results of later study by Meiran, Chorev and
Sapir (2000) which will be discussed shortly.

In summary, Allport et al. (1994) put forward the following interpretation of their
results: with foreknowledge, disengagement can be initiated but completion of this process
requires presentation of an external stimulus which will support the new task. It is also implicitly assumed that engagement of a new task can be initiated with foreknowledge but that the irreducible portion of the switch cost is due to interference from a previous task (i.e. from incomplete disengagement rather than from incomplete engagement).

A number of methodological problems inherent in the ‘shift’ variant of task switching were noted by Rogers and Monsell (1995). According to these authors, the main disadvantage of comparing mixed and pure blocks of trials is that it is was not clear whether the source of the switch cost is the extra demand of keeping two tasks active in the mixed condition or to the switching process itself. In other words, the problem with this design is that the switch cost cannot be attributed specifically to task switching since the memory demands inherent in the shift blocks exceed those inherent in the pure blocks. Other objections to between block comparisons include the possibility that the subjects may be adopting different strategies in the two types of blocks such as keeping one versus two tasks active at one time, and the possibility that subjects’ level of arousal may differ in the two conditions.

1.2.5.3. ‘Alternating runs’

As a solution to this problem, Rogers and Monsell (1995) devised the ‘alternating runs’ paradigm in which two or more consecutive trials of the same task are immediately followed by two or more consecutive trials of another task (e.g. AABBAABB...). If each run consists of two trials, each consecutive step results in either a switch or a non-switch trial depending on the identity of the task on the preceding trial. Participants are often provided with an external cue to help them keep track of the task that they are to be performing on any
given trial. The advantage of this over the 'shift' variant is that individuals can be timed on switch and non-switch trials within blocks. The switch cost is estimated by subtracting mean response latency (or error rate) on the switch trials from the mean response latency (or error rate) on the repetition trials.

Rogers and Monsell (1995) had participants alternate between the task of classifying digits as odd or even and the task of classifying letters as vowels or consonants. As expected, they found a time cost associated with switching. They varied the interval between a subject's response and presentation of the next stimulus. They observed a steady reduction in the switch cost with an increase in the response to stimulus interval (RSI) up to 600 ms. No further reductions were observed when the RSI was increased from 600 ms up to 1200 ms. They called this irreducible portion of the switch cost the residual switch cost. In addition, when they used longer runs (AAAABBBB...), they observed that the switch cost was borne only by the first trial of a run. They argue that this provides evidence against the task set inertia hypothesis (Allport et al., 1994). They reasoned that if passive decay was the process responsible for the switch cost, then it should persist over more than one trial. Furthermore they found that if the RSI was unpredictable, there was no reduction in switch cost. A similar result was obtained in an early task switching study by Macnamara, Krauthammer, and Bolgar (1968) who found that response latencies were shorter when switches were regular and predictable. These findings are not compatible with the notion of passive decay because this automatic process should not be affected by the predictability of the RSI. The authors suggested that because the reduction in switch cost seems to be related to the onset of the next stimulus, it must be associated with the process of engaging a new task. They
engagement that awaits completion.

Results of recent experiments by Meiran, Chorev, and Sapi (2000) using a cuing paradigm, suggest that both an active preparatory process and passive dissipation operate during task switching. Whether this active preparation involves both disengagement and engagement is not discussed, but in their interpretation, the decay component is clearly seen as reflecting a passive process. In these experiments participants responded to a series of trials in which the switch and repetitions were presented randomly. Participants alternated between the tasks of identifying the location of a stimulus along two dimensions: the vertical dimension (UP-DOWN) or the horizontal dimension (RIGHT-LEFT). A cue appeared at some point during the response to target interval (RTI) indicating the identity of the following task. Two manipulable intervals composed the RTI. The first is the response to cue interval (RCI) which according to Meiran et al. maps to passive disengagement time. The second is the cue to target interval (CTI) which maps to active reconfiguration time which is presumed to include both disengagement and engagement processes. By adjusting the RTI accordingly, it was possible to vary the length of either the RCI or CTI while keeping the other interval constant. The manipulations of RCI and CTI affected the reduction of the switch cost in different ways providing evidence that the components of the switch cost are empirically dissociable. For example, an increase in CTI up to approximately 500ms resulted in a sharp decline of the switch cost while a similar increase in RCI resulted in a more gradual decline. The preparatory component and the dissipatory component were also dissociable in terms of the effect of practice. An interaction was observed between RTI conditions and practice indicating that practice affected active preparation (CTI) but not the
dissipatory component (RCI) of the switch cost. Meiran et al. conclude that task switching
cost should not be taken as an index of a single process. First, their results support the notion
that there is a passive decay component to the switch cost, which is consistent with Allport et
al's 1994 proposal. Second, there appears to be a preparatory component, which is consistent
with the notion of an active reconfiguration process. Finally, results point to the existence of
a residual component which seems to reflect "a control failure or a lack of motivation to
engage in control" (Meiran et al., 2000, p.40). The composite nature of the preparatory
process is only alluded to briefly in this study, and therefore the issue of whether the residual
component of the switch cost reflects incompleteness of both disengagement and engagement
or of just one of these processes is not addressed. This issue was examined by Sohn (1998)
and will be discussed in section 1.2.7.

Summary

The proposals of Allport et al. (1994) and Rogers and Monsell (1995) are similar in that
they both attribute the residual switch cost to an incomplete reconfiguration process. The
former argue that the residual switch cost reflects incomplete disengagement while the latter
argue that it reflects incomplete engagement. Another difference is that Allport et al.'s
explanation is based on a concept of passive task set inertia which escapes executive control\(^2\)
while Rogers and Monsell's explanation is based on the concept of an active preparatory
reconfiguration which comes under executive control. Meiran et al.'s (2000) proposal

\(^2\) It should be noted that the existence of an active reconfiguration process is alluded to by
Allport et al (1994) in the form of the stimulus cued completion hypothesis. But the process
requiring completion is clearly referred to as disengagement (see p. 21).
reconciles these two views by providing evidence that both an active and a passive process are taking place during task switching. The evidence supports the notion that the passive decay reflects a process of disengagement. The active reconfiguration process is presumed to be composite and to involve both a process of disengagement from a prior task and a process of engagement of a new task (Sohn, 1998). The issue of whether engagement and disengagement are separate processes has only recently been addressed by Sohn (1998). He reasoned that these processes should be affected differently depending on the type of foreknowledge. Foreknowledge of task transition provides a participant with the information that disengagement from the previous task would optimize performance of the next trial. On the other hand, foreknowledge of a task identity provides the impetus to engage a new task. Because they had subjects alternate between only two tasks, both the interpretations of Allport et al. (1994) and Rogers and Monsell (1995) remain equivocal because foreknowledge of task transition (i.e. switch versus repetition) also include information regarding task identity.

In sum, the residual can be defined as the portion of the switch-cost which is left over when foreknowledge is available and when sufficient time is provided to proactively prepare for the new task. There appears to be some agreement that part of the reconfiguration process escapes executive (endogenous) control and is completed only on the basis of externally available information. Accordingly, this suggests that aside from incomplete disengagement due to the involuntary persistence of activation from a prior task, there may be two other components to the switch cost. One of these, endogenous control, is reflected in the reducible portion of the switch cost which is affected by foreknowledge. Foreknowledge
affects endogenous control because these processes which come under executive control are goal driven. The other component, exogenous control, is reflected in the irreducible portion of the switch cost and is unaffected by foreknowledge or RSI. This control process is stimulus driven and, in this sense, is a reactive component.

1.2.5.4. Language switching

One of the first language switching studies which used a naming task was undertaken by Macnamara, Krauthammer and Bolgar (1968). They compared total reading times of monolingual lists and mixed lists and found that response latencies were shorter for the monolingual lists. They also found that response latencies were shorter when switches were regular and predictable; however, they found no effect of the RSI duration. This latter result may be due to the fact that the available technology at the time of the study did not permit the succession of stimuli to be rapid enough. This may have resulted in RSI values that exceeded 0.6 seconds. Results of recent task switching experiments found that increases in RSI above this value did not further reduce the switch cost (Rogers & Monsell, 1995; Allport et al., 1994; Meiran et al., 2000). Von Studnitz and Green (1997) used the alternating runs method in a language switching experiment to examine the effect of language shift on the lexical decision latencies of German-English bilinguals. They found that response latencies on switch trials were, on average, 18 ms slower than on repetition trials (Experiment-1). The first experiment to use a naming task and to measure discrete reaction times was undertaken by Meuter and Allport (1999). They asked bilinguals to name numerals in either one of their two languages as indicated by a visual cue. As expected, they observed a time cost associated with language switching. They also observed an asymmetrical cost to language
switching depending on the direction of the switch. Cost was greater when participants had to switch from their weaker language to their stronger language (143ms) than when they switched from the stronger to the weaker language (85ms). They argue that this result lends support to the task set inertia hypothesis. They reason that language production in the weaker language ($L_2$) will require active suppression of the stronger language ($L_1$) while performance of a task in $L_1$ will require very little suppression of $L_2$. This explains why, on a switch trial to an $L_1$ task, more time is needed to overcome prior inhibition of the now relevant language. They also found that the number of preceding responses in one language had no effect on the switch cost. This finding suggests that there is no cumulatively increasing engagement of one particular language over successive same language trials.

The finding that the switch cost is borne only by the first trial of a run (Rogers & Monsell, 1995) and the finding that there is no improvement in performance over successive same task trials in a run (Meuter & Allport, 1999) have been used to argue opposing interpretations of the residual switch cost. The former is put forward as providing evidence against the incomplete disengagement hypothesis in favor of the incomplete engagement hypothesis while the latter is put forward as providing evidence in support of the incomplete disengagement hypothesis. Despite these differences, both findings have similar implications for language control. The findings that only one intervening trial is required to eliminate the switch cost (Rogers & Monsell, 1995) and that performance shows no improvement over successive trials in a run (Meuter & Allport, 1999) are consistent with the notion that the lexicon of one of a bilingual's languages can be selected as a whole unit rather than as a function of the cumulative activation of individual items. Meuter and Allport argue that their
data are consistent with the construct of supra lexical language nodes which can activate or suppress the lexicon of an entire language. It is unclear, however, whether their results support inhibition of a whole language or of only a small subset of items. This is because only a small set of stimuli (numerals 1-9) was used repeatedly. More substantial evidence for the hypothesis that language control is effected globally would be provided if these results hold with a larger stimulus set presented without repetition.

1.2.5.5. Summary

Task switching studies and language switching studies yield, on the whole, similar findings. First, there is a time cost associated with language switching as well as with task switching. Secondly, in both cases, full anticipation of a switch with a preparation interval of over one second does not result in the elimination of the switch cost. A control process that acts proactively is thought to be responsible for the partial reduction of the switch cost during the first half-second of the preparatory interval. In other words, it reflects endogenous goal driven control which acts before the actual performance of the switch trial. In the context of language switching studies, it is even hypothesized that this reduction in cost, which occurs when a switch can be fully anticipated, reflects the language processing system's capacity to globally activate one of a bilingual's languages. On the other hand, there is little agreement as to the interpretation of the residual switch cost. It has been attributed by some to the passive decay of persisting activation from a previous task and by others to the incompleteness of an active task reconfiguration process. Two conflicting hypotheses have been put forward to account for the residual switch cost. The incomplete disengagement hypothesis holds that the residual reflects incomplete disengagement while the incomplete
engagement hypothesis holds that it reflects incomplete engagement. Arguments have been put forward to support both hypotheses but on the whole, results still remain equivocal.

1.2.6. Incomplete engagement versus incomplete disengagement

The point of contention in switching studies pertains to the interpretation of the residual switch cost. If the performance of a new task requires both a process of disengagement from a previous task and a process of engagement of a new task (Meiran, 1996; Sohn, 1998), the residual switch cost could conceivably reflect the incompleteness of either one or both of these processes. Although evidence has been put forward in support of both incomplete engagement and incomplete disengagement, several methodological aspects of the studies just reviewed make it difficult to disambiguate between the possible contribution of each of these processes to the residual switch cost. One aspect is that foreknowledge was always available in these studies either because switch or repetition transitions were blocked, as in the shift variant, (Allport et al., 1994); or because the transitions were predictable, as in the alternating runs variant (Rogers & Monsell, 1995). Another problem is that foreknowledge of task transition (i.e. whether to switch or to repeat) was always confounded with foreknowledge of task identity (i.e. which task to perform) because participants alternated between only two tasks.

The distinction between foreknowledge of task identity and foreknowledge of task transition is an important one because these different types of foreknowledge are likely to affect disengagement and engagement processes differently. In order to disengage from a current task, it should only be necessary to know that the next trial will be a switch. On the other hand, in order to engage in a new task, it is necessary to have foreknowledge of the
identity of the upcoming task. For example, if a subject, currently performing task A, is required to switch between three tasks (A, B, and C), foreknowledge that the next task requires a switch does not, in itself, provide any information regarding which of the three tasks to begin engaging for the next trial. By arbitrarily engaging in task A, B or C a subject would run the risk of engaging the wrong task. Initiating disengagement in this case is, however, an effective use of the transition cue. There is also evidence that disengagement can be initiated strategically regardless of foreknowledge under certain conditions. In other words, although the process of engagement requires foreknowledge of task identity, it seems that initiation of disengagement does not necessarily require foreknowledge. Ruthruff, Remington, and Johnston (1996; cited in Sohn, 1998) manipulated the probability of switch trials occurring at each step in a sequence. Their results support the hypothesis that when expectancy of switching is high (i.e. 0.5), disengagement is strategically initiated by the subjects even in the absence of foreknowledge. In the current study, subjects' expectancy of switching will not be a variable; rather, the probability of switching will be held equal to the probability of repeating on all trials. For this reason, I will assume that strategic disengagement will be initiated on all trials. Results obtained by Sohn (1998), which will be discussed in the next section, also support this assumption.

1.2.7. ‘Two-Step’ variant

1.2.7.1. Task Switching

Sohn (1998) identifies two methodological problems with the previous task switching paradigms which make it impossible to determine whether engagement, disengagement or both are initiated during a preparatory interval when a switch is fully anticipated. These
problems also make it impossible to determine which of these two processes is reflected in the residual switch cost (i.e. which of the two remains incomplete after the preparatory interval). As mentioned in the previous section, the first methodological problem of the previous studies was that foreknowledge was always available. Furthermore because two tasks were used, the information conveyed by task transition could not be dissociated from that conveyed by task identity. The second methodological problem is linked to the fact that most trials are embedded in a long sequence. Because in both the shift and the alternating runs variants, the type of transition (i.e. switch versus repetition) was always predictable, performance on each trial could potentially reflect processes having to do with repeating as well as processes linked with switching. For example, in the alternating runs paradigm, a repeated trial is always followed by a switch trial while a switch trial is always followed by a repeated trial (AABBAABB...). This means that, on each trial, processes related to both switch and repeated tasks could be occurring. That is, when performing a repeated task, preparation for a switch could be occurring, and similarly, the performance of a switched task could occur concurrently with the expectation of having to repeat it.

Sohn's (1998) experiments address both of these methodological problems. In order to distinguish the effects of foreknowledge of task transition from the effects of foreknowledge of task identity, participants alternated between three tasks rather than two (Experiments 3 and 6). The addition of a third task meant that the identity of an upcoming task was no longer available with foreknowledge of task transition. To address the second problem, Sohn (1998) developed the 'two-step' variant of task switching. In this new paradigm, one trial consists of a pair of tasks performed in sequence. For example, in a picture naming
paradigm, a single trial would consist of naming one picture and then naming a second picture. Naming of the first picture corresponds to the first step of the trial and naming the second picture corresponds to the second step of the trial. A switch trial is one in which the two consecutively presented pictures are named in different languages, and a repetition trial is one in which the two pictures are named in the same language. Once naming in Step-1 and Step-2 is completed the trial ends. In Sohn's experiments, each trial was isolated from the following trial by a 10 sec intertrial interval. In the current study a visuo-spatial task was performed during this interval to maximize disengagement from the task performed on the preceding trial. Limiting each trial sequence to two steps and isolating it from the preceding and subsequent sequences maximizes its neutrality. Step-1 is assumed to be neutral because it is not switched or repeated from a previous task. This means that performance of a Step-1 task should not involve any process of disengagement from a related task performed in the preceding trial. Similarly, Step-2 being the last of a sequence should not involve any process of engagement for an upcoming trial.

Sohn (1998) measured the effect of switching on the response latencies to both Step-1 and Step-2 of a trial. Participants alternated between the task of classifying a letter as a vowel or a consonant or classifying a digit as odd or even. When the experiment involved shifting between three tasks rather than two, the third task was to classify symbols (e.g. ^, &) as having straight or curved lines. Sohn also examined the effect of foreknowledge on naming latencies. Foreknowledge of task identity informed participants whether to switch from or repeat the current task as well as which task to perform on the next trial. Foreknowledge about task transition, however, only informed participants whether to switch
from or repeat the current task but not which of the three tasks was to be performed next. The interval between subjects’ responses to Step-1 and presentation of the Step-2 stimulus was held constant at 1000 ms in order to allow sufficient time to complete endogenous preparation. Under these conditions, a switch cost should correspond to the residual switch cost because proactive control has presumably been completed. Three important findings with respect to the current study resulted from these experiments. First, response latencies to Step-1 were greater with foreknowledge about both task transition and task identity than with no foreknowledge. According to Sohn, this difference suggests that preparation for Step-2 occurred during performance of Step-1. Second, response latency to Step-1, in conditions where task transition information was available, was no different from Step-1 response latency in conditions where both task transition and task identity information was available. This suggests that, when only task transition information was available, the preparation process that occurred during performance of Step-1 was the same as the preparation that occurred when complete foreknowledge (i.e., task identity and task transition) was available. Since the additional information of task identity in the complete foreknowledge condition did not alter the Step-1 response latency and since task identity cues engagement, Sohn reasoned that initiation of engagement does not occur during the performance of the Step-1 task but only initiation of disengagement. Third, although engagement did not appear to be initiated during performance of Step-1, performance on Step-2 was improved only when foreknowledge included task identity. It seems that performance of Step-2 is not facilitated when the subjects are forewarned that the next trial will be a switch unless foreknowledge also includes the identity of the next task. This facilitation effect which occurs on Step-2 is
only observed when task identity information is available. This suggests that a process of engagement has been initiated during the RSI prior to the performance of Step-2.

Another finding was crucial to the interpretation of the time course of disengagement and engagement in relation to performance of Step-1 and Step-2 of a trial. Sohn (1998) reports that although Step-2 response latency was shorter with complete foreknowledge (i.e. task transition + task identity vs. task transition alone), the residual (i.e. the difference between a switch and a non-switch trial) was not affected. It seems that whether or not task identity information is available, the residual switch cost remains the same. These results could be interpreted as suggesting that neither incomplete disengagement nor incomplete engagement contribute to the residual switch cost since neither task identity information nor task transition information reduce it. There is another possible explanation for the apparent resiliency of the residual to foreknowledge availability. The results of a study by Ruthruff et al. (1996) suggest that when the possibility of switching was equal to the possibility of repeating then disengagement is strategically initiated on all trials. The adoption of a single strategy on all trials is further supported by Strayer and Kramer (1994) who found that when experimental conditions were blocked, participants tended to adopt different strategies but when experimental conditions were mixed a single strategy was adopted. In Sohn’s (1998) experiments the probability of switching was equal to the probability of repeating and he therefore assumed that strategic disengagement had taken place on all switch trials regardless of foreknowledge. To clearly determine the effect of foreknowledge of task transition on the residual switch-cost it would have been necessary to have blocks in which the probability of switching was low compared to the probability of repeating so that participants did not use
strategic disengagement. Though the added information regarding task identity did not affect the switch-cost in Sohn’s experiment, it did improve overall performance on Step-2. This strongly suggest that some advanced preparation in the form of task engagement has taken place. In light of the finding that foreknowledge of task identity improved performance on Step-2 while foreknowledge of task transition did not, Sohn proposes that when task identity is available, engagement is both initiated and completed prior to the presentation of the Step-2 stimulus and when task identity is not available engagement of a new task only takes place after stimulus presentation. Recall that the residual has been attributed to an incomplete process. Since the residual is the same in both foreknowledge conditions, Sohn reasoned that it must be the same process that remains incomplete in both foreknowledge conditions. Since engagement is not likely initiated when task identity is unavailable it is most likely that the residual reflects incomplete disengagement.

To recapitulate, there are three findings which, taken together, suggest that the residual switch cost reflects incomplete disengagement. First, there is evidence that disengagement can be initiated but not completed with or without foreknowledge (Ruthruff, Remington, and Johnston, 1996, cited in Sohn, 1998). Second, there is evidence that engagement can be initiated during the RSI (Sohn, 1998). Third, the residual switch-cost remains the same regardless of foreknowledge but overall performance on Step-2 switch trials is only improved with foreknowledge of task identity (Rogers & Monsell, 1995; Allport et al., 1994; Meiran et al., 2000). This finding can be explained if it is assumed that, in all foreknowledge conditions, disengagement was initiated and that engagement was either initiated and completed during the RSI when task identity was available or not initiated at all when task
identity was not available. In sum, the residual remains the same in all conditions because incomplete engagement does not contribute to it. On the other hand, strategic disengagement has occurred in all conditions and is the only process that is contributing to the residual. It has been proposed by many (Allport et al. 1994; Rogers and Monsell, 1995; Meiran, 1996 and; Sohn 1998) that this process is only complete once the new stimulus is made available.

The current study only utilized two tasks and therefore did not directly test the effects of the two different types of foreknowledge. Foreknowledge always included information about both task transition and task identity. It was therefore only possible to compare the effects of no foreknowledge with the effects of complete foreknowledge on the residual switch-cost. This provided an opportunity to replicate the similar pattern of results obtained in Sohn’s Experiments 1, 2, 4 and 6 in which only two tasks were used. The reasoning was that if complete foreknowledge (i.e task transition and task identity) had no effect on the residual switch cost this would lend some support to Sohn’s interpretation that the residual mainly reflects incomplete disengagement.

1.2.7.2. Two-step picture naming and priming

The present study adopted Sohn’s (1998) ‘two-step’ variant of task switching. The motivations for doing so are similar to his. First, it is important to ensure that the response latency to naming a picture in Step-1 does not reflect any process of disengagement from a previous trial and more importantly for this particular study, that it does not reflect any form of semantic priming (either positive or negative) from previous trials. Second, it is also important that response latencies for naming the pictures in Step-2 do not reflect any preparation for an upcoming trial. Each trial was isolated from the previous and subsequent
one by an intertrial interval of approximately 10 seconds during which participants performed an unrelated visuo-spatial task. Similarly to Sohn, I used a long RSI in order to provide sufficient time for strategic foreknowledge-based preparation to be completed. According to previous research (Meiran, 1996; Rogers, & Monsell, 1995; Allport et al. 1994), when switches can be anticipated, switch costs which occur when the RSI is beyond 600ms no longer reflect the time it takes to prepare for a switch but rather reflect mainly stimulus driven processes. Because the current experiment was aimed at revealing a component of the switch cost which is mainly driven by stimulus characteristics (i.e. which corresponds to the reactive control component of the IC-model), the response to stimulus interval was held constant at 1000 ms. This interval was presumed long enough to ensure that the observed switch cost in this experiment corresponds to the irreducible portion of the switch cost or the residual (Rogers & Monsell, 1995). The variable of interest for this study was the response latency to the Step-2 stimulus. The effect of foreknowledge on Step-2 response latency was to be examined as well as its effect on the switch-cost which given the availability of foreknowledge and the length of the preparatory interval should correspond to the residual. The current design was aimed at replicating Sohn’s finding that foreknowledge reduces the Step-2 response latency but has no effect on the residual. Sohn’s study is the first to unequivocally provide evidence for the hypothesis that the residual switch cost reflects incomplete disengagement. More specifically, I wanted to determine whether semantic relatedness between a Step-1 picture and a Step-2 picture would have a negative priming effect. Such a result would support the hypothesis that there is a reactive component to bilingual language control. In the following sections some of the main findings of picture-
picture priming studies and cross linguistic priming studies will be reviewed, and the rationale behind the expected effect of this variable on the residual will be discussed.

1.2.8. Priming

1.2.8.1. Overview

Priming is a term that designates both an experimental paradigm and the effect often observed in priming experiments (Glaser, 1992). In priming experiments, a target stimulus is generally preceded by another stimulus, the prime. The manipulated variables can include the instructions concerning the prime (e.g., ignore, use or perform same task as that performed on target) as well as the relationship between the prime and the target (e.g., phonologically similar or dissimilar, semantically related or unrelated). The response latencies to the target depends on the relationship between the prime and target. The depth of processing of the prime also affects response latencies. Depth of processing can be affected by the instructions concerning the prime as well as by the time interval between the prime and target. According to Glaser a priming effect results when a prime is voluntarily or involuntarily processed thereby activating internal nodes or links so that they are more readily available for the processing of a related target.

1.2.8.2. Picture-picture priming

In addition to the task switching paradigm, the current study also uses the picture priming paradigm. Participants were asked to name both the target and the prime. Semantic priming effects in a picture-picture naming task have been observed in several studies (Sperber, McCauley, Ragain, and Weil, 1979; Huttenlocher and Kubicek, 1983; and, Biggs and Marmurek 1990). All of these experiments included conditions where prime and target
were presented sequentially and subjects were instructed to name both the prime and the target. In these studies, the response to stimulus interval (RSI) varied between 600 ms and 1000 ms and the intertrial interval varied from 3 to 10 seconds. Pairs were generally formed with members of the same superordinate category and were also often strong associates. The proportion of related trials varied considerably from one study to the next from 12.5% to 50%. Results showed that picture naming was facilitated by the prior presentation of a semantically related picture. The priming effect in conditions that closely match those proposed here (i.e. instance naming of both prime and target and long RSI), varied between 32 ms and 62 ms.

The three abovementioned studies were aimed at examining the effects of different variables on priming. These include visual integrity of the target stimulus, probability of relatedness, and type of naming (i.e. superordinate versus instance naming). In addition to relatedness, defined as membership in the same superordinate category, Sperber et al. (1979, Experiment 2) manipulated the visual integrity of the target. The priming effect was greater when the target stimulus was visually degraded (112ms) than when it was visually intact (51ms). Huttenlocher and Kubicek (1983) manipulated subjects’ expectancy that the pictures in a pair would be categorically related. In the low expectancy condition 12.5% (5/40) of the pairs were semantically related and in the high expectancy group 87.5% (35/40) of the pairs were semantically related. They found that semantic relatedness under both high and low expectancy conditions resulted in significant priming effects. This effect was greater in the high-expectancy condition but this was not because they were faster at naming related targets but because they were slower in naming unrelated targets. The authors suggested that this
was due to a surprise effect. Then main finding was that, overall, target pictures were named, on average, 59 ms faster in the related condition than were those in the unrelated condition.

Biggs and Marmurek (1990) varied the type of stimulus pairing as well as the type of relationship. Four stimulus pair types were presented: word-word, picture-picture, word-picture and picture-word. Items were matched to form pairs with the following relationships: unrelated, same category, same label or synonym³. Results show that pictures are better primes than words. A priming effect was found in all relatedness conditions in the picture-picture condition. More specifically, a facilitation effect of 32 msec (Experiment 1) and of 61 msec (Experiment 2) was obtained for semantically related picture-picture pairs.

Not all studies in which both prime and target are named have shown semantic priming effects. Irwin and Lupker (1983) used picture-picture pairs and instructed subjects to either categorize or name the prime and then to name the target. Semantic priming was observed when the prime was categorized but not when it was named. Johnson and Giuliani (1999, Experiment 1) also asked subjects to name two sequentially presented pictures. There were two naming conditions: In the first, participants were to name the superordinate category of the prime and of the target (e.g., responding "animal" to the picture of a rabbit) and in the second participants were instructed to use instance names (e.g., responding "rabbit" to the picture of a rabbit). A small set of twelve pictures were used to form three pair types: SAME (e.g. rabbit-rabbit), SAME CAT (horse-rabbit), and DIFF (ball-rabbit). Significant priming was observed when the items in a pair were the same. Same category pairs showed

³ Participants were trained with lists prior to the experiment and distinct verbal labels were attached to each of two different picture representations of the same concept.
significant priming in the superordinate naming condition (109 ms) but not in the instance naming conditions (20 ms). Since in both these studies subjects were trained with a list prior to the experimental trials, it is possible that familiarity with a relatively small set of stimuli contributed to washing out the priming effect that was detected in other studies.

1.2.8.3. Cross-linguistic priming

Cross-linguistic priming has been used in experiments aimed at gaining an understanding of how the two languages of a bilingual are represented in the mind. The rationale behind these experiments was that priming effects between languages support the hypothesis that languages are not functionally separate. The absence of priming, on the other hand, is generally taken as evidence for functionally separate language representations. In the monolingual picture naming studies reviewed above, a target picture was named faster when a related prime has just been named as opposed to an unrelated prime. This is because when naming the prime, activation spreads to related items. Processing time for the target is shortened because it has been preactivated during the processing of the preceding naming trial. If there is semantic priming in monolingual naming studies from one naming trial to the next, and if there is parallel activation of items in both of a bilinguals lexicons during lexical access as is suggested by many cross-linguistic priming studies (e.g. Costa, Miozzo, & Caramazza 1999), then it is reasonable to expect a cross linguistic priming effect in a picture-picture priming task where bilinguals are required to name the prime picture in one language and the probe picture in the other.

The predicted direction of the cross-linguistic priming will depend upon whether reactive inhibition is assumed to occur. Studies which have looked at the time course of
semantic priming (Schriefers, Meyer & Levelt 1990; Costa et al., 1999) generally support the notion that priming occurs at in the early stages of lexical access. If, as Green (1998) hypothesizes, reactive inhibition occurs at a later stage, semantic relatedness of the two pictures in a switch trial should lead to negative priming. This result would occur because, if it were semantically related to the picture name in Step-1, the Step-2 picture name would have been activated early as a related item but also inhibited later as a non-target language lexical entry. Step-2 picture names that were not related to the picture name in Step-1 would have incurred neither previous activation or previous inhibition. This possible interpretation of negative priming in the semantic relatedness conditions has been drawn mainly from how interference effects in selective attention experiments have been interpreted. In many ways a bilingual naming task is similar to those used in selective attention experiments. "By definition, selective attention is required whenever only a subset of the entirety of information currently on display or represented in memory is relevant for the goal directed behavior of the moment" (Neuman, McCloskey, & Felio, 1999, p. 1051). Similarly, to name a picture in one language (La), the translation equivalent of the concept it represents needs to be ignored in the other language (Lb). Other related items from the non-target language subset which have become activated during the early stages of lexical access will also require suppression. This will ensure that the target language controls output and that the correct word is produced. On the other hand, if Green's hypothesized reactive language-based inhibition is not assumed to occur, positive cross-linguistic priming should occur since the Step-2 name would have been activated early in Step-1, albeit in Lb and remain in a heightened state as Lb becomes appropriate. This cross-language priming effect would likely
be smaller than the effect observed within language because the connections between related items is likely stronger within languages than between languages. Such a finding would nevertheless lend support to the hypothesis that whole languages can undergo inhibition but not to the hypothesis that reactive inhibition also occurs (i.e. that a small set of items from the noon-target lexicon undergo extra inhibition.) The reactive inhibition hypothesis would only be supported if cross-linguistic negative priming is observed when the pictures in a pair are semantically related.

To my knowledge, there have been no studies of cross-linguistic semantic priming where the subject’s task was to name both the prime picture and the target picture. The reason for this is probably that any negative semantic priming effect could not be dissociated from the time cost generally attributed to switching. The main challenge lies in finding a way to detect this effect in the face of the time cost resulting from the language switch itself. A possible solution to this problem is to determine the effects of semantic relatedness on the residual switch cost rather than its effect on the total naming latency. As mentioned previously, the residual switch cost is the portion of the switch cost that is left over when foreknowledge and a sufficient time interval have allowed proactive (or endogenous) preparation to take place. It is a robust finding observed in most task and language switching studies which have shown that it is only affected within the first $\frac{1}{2}$ second of preparation time (Allport et al., 1994; Rogers & Monsell, 1995; Meiran 1996). It was thought that creating conditions that favor completion of all proactive control processes would ensure that the resulting switch cost corresponds to the residual and that any change in the residual would most likely be attributable to priming. The current study attempted to achieve this result by
providing language foreknowledge as well as a sufficiently long time interval (1000 ms) to prepare before a semantically related or unrelated target picture was presented.

1.2.9. The current study

The design of the current study draws on a number of lines of research. First and foremost are task switching and priming. To some extent, work in the area of selective attention has also contributed to its conceptual development. Participants were required to switch frequently between the task of naming pictures in one language and the task of naming them in another. Within this language-switching paradigm, a foreknowledge condition and a semantic relatedness condition were embedded. Interpretation of the results will draw on multiple-level models of lexical representation as well as the model for the control of action (Norman & Shallice, 1986), both of which have been incorporated into Green's (1998) IC model of bilingual language control. One particular control component of the model, reactive language inhibition, is the focus of the current study.

1.3. Research question and hypotheses

This study addressed the question of the nature of control processes in language control. More specifically, it was aimed at addressing whether lemma level language control is achieved through reactive (stimulus driven) inhibition or whether the language processing system can be proactively (endogenously) adapted to the task of switching to another language. In other words, the question posed was: Can language control be exerted through the inhibition of a small subset of items from an irrelevant language rather than through inhibition of the entire lexicon of that language? Participants were required to switch between both of their languages while performing a series of picture naming trials. The
language of response was cued prior to or simultaneous with each naming trial. A switch trial consisted of consecutively naming two pictures in different languages while a repetition trial consisted of consecutively naming two pictures in the same language. On a proportion of trials, the two consecutive pictures of a trial pair were semantically related.

The following questions are addressed by this study:

1. Is there a time cost associated with language switching?
2. Is a component of the switch cost subject to proactive (endogenous) control?
3. Is there a portion of the switch cost that is irreducible?
4. Is there a reactive component to language control.

The hypotheses derived from these questions are as follows:

1.3.1 Switch-cost

Hypothesis 1: A main effect of task transition will be observed such that mean naming latency for the second items of a trial pair will be greater on switch trials than on repetition trials (see Figure 1.2).
Figure 1.2. Predicted outcome 1. Step-2 response latency as a function of task transition in both foreknowledge conditions.

Reasoning

It takes time to reconfigure the system for a new language (or task) and this reconfiguration includes both the process of disengaging from the previous language (or task) and engaging a new one (Sohn, 1998). Previous task switching and language switching studies have shown that response latencies are longer when a new task is performed than when a task is repeated.

1.3.2 Foreknowledge

Hypothesis 2a): A main effect of foreknowledge will be observed such that naming latencies will be shorter in the foreknowledge condition than in the no-foreknowledge condition (see Figure 1.2).
Reasoning

Reconfiguration of the system for a new task can begin prior to the presentation of a new stimulus when a switch can be anticipated and if sufficient time is provided. Foreknowledge that the next trial is a switch initiates disengagement of the previous language and foreknowledge of the language for the next naming trial initiates engagement of this language. Studies that have used cuing methods or predictable sequences of tasks have found that response latencies on switch trials were shorter when a switch could be anticipated. Foreknowledge, in the current study, includes both task transition (whether to switch or repeat languages) and task identity (which language) and will therefore allow for initiation of disengagement and engagement prior to presentation of the Step-2 stimulus. This advanced reconfiguration will result in shorter processing time for the second picture of a trial pair.

Hypothesis 2b): A main effect of task transition will be observed in the foreknowledge condition (See Figure 1.2).

Reasoning

Results of previous task switching and language switching studies have shown that even when a switch is fully anticipated and sufficient time is provided for preparation, switch cost is not eliminated. If there remains a cost to switching in conditions where the switch can be fully anticipated and sufficient time is provided, this will support the notion that there is an irreducible component to the switch cost.

Even if foreknowledge is not expected to eliminate the switch cost, it would be reasonable to expect that it should at least reduce it. It is possible, however, that
foreknowledge may not affect the switch cost in the current experimental conditions because they promote strategic disengagement (see section 1.2.6 for a discussion). Sohn (1998) found that when subjects alternated between two tasks, foreknowledge did not affect the residual switch cost. The following hypothesis is derived from Sohn's finding and complements Hypothesis 2b.

**Hypothesis 2c:** There will be no interaction between foreknowledge and task transition. In other words the residual switch cost will be the same in both foreknowledge conditions (see Figure 1.2).

**Reasoning**

Sohn (1998) found that performance on both switch and repetition trials was improved with foreknowledge but that the switch cost was not reduced and that it was the same in both conditions. In light of the results of Ruthruff et al (1996; cited in Sohn, 1998) he maintained that the switch cost observed in both foreknowledge conditions corresponded to the residual because strategic disengagement had occurred on all switch trials even when foreknowledge was not available.

1.3.3 Semantic relatedness

**Hypothesis 3:** An interaction is expected between task transition and semantic relatedness such that Step-2 naming latencies on related repetition trials will be shorter than on non-related repetitions trials but will be longer on related switch trials that on unrelated switch trials. In other words, the residual switch cost will be greater when the pictures in a trial pair...
are semantically related (see Figure 1.3).

**Reasoning**

If disengagement of a language is only completed once a new stimulus is presented, this completion should be more difficult when the stimulus for the new trial bears some relationship to the stimulus for the previous trial. This is because this relationship may serve a source of activation for the previous language task. This would be consistent with findings of selective attention experiments which show that when information that is relevant for the current trial has recently been suppressed, this typically results in an increase in response latency (Neuman et al., 1999). Reactive inhibition of related lexical items on a prime trial will result in increased response latency if one of these items corresponds to the target on the probe trial.

More specifically, when naming a prime picture, activation spreads from its conceptual representation to other related concepts. This activation also spreads to the lemma level where items in both languages become activated and thus enter the competition for selection. Spreading activation is also thought to occur between related items at the lemma level. Eventually, the lemma that receives the most activation or achieves a certain activation threshold first will be selected. In a condition where the prime picture and probe picture are
Figure 1.3. Predicted outcome 2. Step-2 response latency as a function of task transition in both relatedness conditions.

Semantically related, the target lemma for Step-2 is likely to have undergone some activation prior to the selection stage in Step-1. During the selection stage for the Step-1 naming trial, the activated items which don’t have a language tag that matches the language task schema, will be suppressed according to the IC model. If the language of response during Step-2 is the same as for Step-1, the response latency should be shorter owing to pre-activation of the lemma for the probe target during Step-1. On the other hand, if the subsequent trial is a switch trial, the response latency will be greater. This is because during the selection stage on the previous trial this particular lemma underwent inhibition due to its possessing the non-target language tag. In other words, information that is relevant for the current trial needed to be suppressed on the preceding trial. In sum, semantic relatedness should interfere with
processing of the probe on switch trials because information now relevant for the probe trial was previously suppressed during processing of the prime. On the other hand semantic relatedness should facilitate processing of the probe picture on repetition trials. The combination of these two effects should result in an increase in the residual switch cost. This negative priming effect on switch trials would correspond to the reactive inhibition component of the IC model of language control.

Figures 1.4 and 1.5 illustrate the possible relative underlying activation of lexical items after a Step-1 naming trial for the picture of an apple. In the early stages of lexical access, the items related to the concept *apple* (A) became activated in both languages (represented by the numerals). These related items are represented here by the two items for *banana* (B1 and B2). At a later stage, whole language activation-suppression activated other unrelated items from the same language and suppressed items in the non-target language. Unrelated items are represented by the two items for *car* (C1 and C2). Figure 1.4 illustrates the relative state of activation prior to Step-2 if reactive inhibition is directed specifically at the related item in the non-target language. As can be seen in the figure, prior to the Step-2 naming trial, a same language related item has received activation from two sources (whole language activation and activation due to spreading from the prime) while the same language unrelated item has received activation from only one source (i.e. whole language activation). Due to this difference in activations levels, naming latency on repetition trials should be shorter for a related Step-2 than for an unrelated Step-2 picture. The figure also shows that prior to Step-2 stimulus presentation, the related non-target language item has received activation from the prime and has undergone two types of inhibition (whole language inhibition and reactive
**Figure 1.4.** Relative language activation levels with reactive inhibition. Following Step-1 naming of the picture of an apple (A) in language 1 but prior to the presentation of a Step-2 Stimulus. (B= banana; C= car)
Figure 1.5. Relative language activation levels without reactive inhibition. Following Step-1 naming of the picture of an apple (A) in language 1 but prior to the presentation of a Step-2 Stimulus. (B= banana; C= car)
inhibition) while the unrelated non-target language item has only undergone whole language inhibition. Reactive inhibition which is assumed to be a late occurring process, specifically targets pre-activated items in the non-target language. This difference in relative levels of activation will result in longer Step-2 naming latencies for related switch trials than for unrelated switch trials.

Alternatively semantic relatedness, could either have no effect on the response latency to switch trials (see Figure 1.6) or even have a facilitatory effect (see Figure 1.7). If semantic relatedness has no effect on the residual switch cost, this would provide some support for the purely proactive view of language control. Such a result would suggest that global control is sufficient to overcome prior activation of items from a non-target language. The relative state of activation of items prior to Step-2 for the proactive view is illustrated in Figure 1.5. The strength of such an interpretation would depend on whether semantic priming occurred on repetition trials. If semantic priming is not observed on repetition trials, there would be little basis to expect that semantic relatedness should have affected the switch trials in any way. If, rather than having no effect on switch trials, semantic priming had a facilitatory effect, this would also support the purely proactive view of bilingual language control. In sum, whether semantic relatedness has no effect or has a facilitatory effect on switch trials, both results would support a purely proactive view of bilingual language control. The former view would support a stronger proactive control component than the latter because the absence of priming would suggest a more effect suppression of the non-target language.
Figure 1.6. Predicted alternative outcome 1. Step-2 response latency as a function of task transition in both relatedness conditions.
Figure 1.7. Predicted alternative outcome 2. Step-2 response latency as a function of task transition in both relatedness conditions.
CHAPTER 2: METHOD

2.1. Overview

Proficient English-French bilinguals were required to switch between both of their languages while performing a series of picture naming trials. The "two-step" switching paradigm was employed with the manipulation of three experimental variables: task transition, foreknowledge, and relatedness. Task transition involved either switching or repeating languages from one naming trial to the next. A switch trial consisted of consecutively naming two pictures in different languages while a repetition trial consisted of naming two pictures in the same language. In the foreknowledge condition, the language of response was cued prior to the beginning of each naming trial for both pictures. In the no-foreknowledge condition, the language cue for Step-1 preceded picture presentation but for Step-2, the language cue appeared simultaneously with the picture. On 33% of the trials, the two consecutively named pictures were semantically related while on the other trials the pictures were unrelated.

2.2 Variables

2.2.1 Dependent measures

The dependent measure for the current experiment was the naming latency to the second picture of a trial pair. This was measured from stimulus presentation to the onset of the verbal response via a voice activated key. It is assumed that the differences in naming latencies in the different experimental conditions reflect the time required to effect language control in bilingual lexical selection. Although the issue of when preparation for Step-2 took place is ancillary to the aim of current study, naming latencies for the Step-1 pictures were
also recorded. It was hypothesized that if naming responses to Step-1 are higher on switch trials than they are on repetition trials, this would suggest that preparation for Step-2 begins during the performance of Step-1.

2.2.2 Independent variables

This study was designed to evaluate the effects of foreknowledge and semantic relatedness on language switching costs. Switching cost is the difference between the mean Step-2 response latencies on switch trials and repetition trials. A within-subject design with three independent variables was used. These were task transition (switch or repetition), foreknowledge (foreknowledge or no-foreknowledge) and semantic relatedness (related or unrelated).

Task Transition

Two types of task transition were included: switch and repetition. On switch trials, the language of response for the two pictures in a trial pair was different. This was indicated by two language cues of different color. On repetition trials, both language cues were of the same color indicating that the language of response for both pictures in a trial pair was the same.

Foreknowledge

Two foreknowledge conditions were included in the current study. In the foreknowledge condition, subjects were aware of the language of response for both Step-1 and Step-2 pictures prior to the presentation of the first picture. In the no-foreknowledge condition, subjects knew in advance, only the language of response for the Step-1 picture but needed to await Step-2 stimulus presentation to know the language of response for the second
picture. Foreknowledge was manipulated in the following two ways:

1) Foreknowledge: two color-filled squares appeared in the upper portion of the computer screen 1000 ms prior to the presentation of the Step-1 picture stimulus. The color of the leftmost square indicated the language of response for the first picture of the trial pair and the rightmost square indicated the language of response for second picture of the trial pair (see Figure 2.2). These language cues remained on the screen for the duration of the trial. Foreknowledge cues appeared on half of the experimental trials. There were two types of cues in the foreknowledge condition: switch cues (English-French or French-English) and repetition cues (French-French or English-English). The directionality of the switch was not considered as a variable in the current study.

2) No-foreknowledge: One color-filled square appeared in the upper left portion of the screen and one outlined squared appeared in the upper right portion of the screen 1000 ms prior to the presentation of the Step-1 stimulus. Since the color filled square appeared on the left only it always indicated the language of response for the Step-1 picture. A 1000 ms interval elapsed following the initiation of response to Step-1, and then the Step-2 stimulus appeared simultaneously with the color-fill indicating the language of response. In both conditions, language of response for Step-1 preceded picture presentation by 1000 ms in order to ensure that the preparatory process was uniform for Step-1 across all trials. No-Foreknowledge cues appeared on half of the experimental trials. The possible language cue combinations were the same as those available in the foreknowledge condition. The difference was the delay in the appearance of the Step-2 cue until the Step-2 stimulus was presented.

The combination of task transition and foreknowledge provided a total of four possible
types of cues. The type of cue that would be assigned to each trial was randomly determined by the E-prime computer program.

Semantic relatedness

Two semantic relatedness variables were included. In the related condition, the two pictures in a trial pair were semantically related. In the unrelated condition, the two pictures were semantically unrelated. Semantic relatedness was determined by membership on the same superordinate category (e.g., truck-car, hat-glove; see Appendix B).

2.3 Participants

Twenty seven proficient English-French bilinguals were recruited from the University of British Columbia and from the neighboring community to serve as volunteer subjects. High proficiency in both languages was important to the current study because the direction of the switch (i.e. from a weaker to a stronger language or the reverse) has been shown to affect the magnitude of the switch cost. Meuter and Allport (1999), found an asymmetrical cost to language switching depending on the direction of the switch and participants' relative proficiency in each language. The cost of switching was greater when subjects switched from their weaker language to their dominant language while it was symmetrical in proficient bilinguals. Criteria for selection therefore included the following: acquisition of the second language before age 12, self-reported proficiency in both languages and current regular use of both languages. Age and context of acquisition for both languages as well as language usage patterns were assessed by having the participants fill out a language background questionnaire which was administered following the experimental session.

Data was excluded for subjects if technical difficulties occurred on more than 10 % of
the trials. These difficulties were due to the accidental triggering of the voice key by extraneous noise, such as coughing, stuttering or saying "ah" before responding and the failure to trigger the voice key by speaking too softly. Data for 9 of the subjects were excluded using this criteria. Four of these 9 subjects had other difficulties with the task. One required 3 practice runs which is more than any other subject. Another presented with a stutter which interfered with the proper triggering of the voice key. A third subject was unable to remain on task during the experimental session, and finally a fourth subject did not meet the age of acquisition criteria. Of the remaining 18 subjects 12 participants were female and 6 were male. Average age was 29 years (SD= 6.8, range = 18 to 42 years). All 18 subjects reported acquiring their second language before the age of twelve and also reported using both languages regularly. Six participants reported feeling more comfortable speaking French, 4 participants reported feeling more comfortable speaking English, 8 reported feeling equally comfortable in English or French. All participants had self-reported normal or corrected to normal vision.

2.4 Materials

2.4.1 Stimuli

Pictures pairs

A set of 104 pictures were selected from 400 black and white line drawings of common objects taken from Cycowicz, Friedman, Rothstein and Snodgrass (1997). These pictures were downloaded from the Internet: www.wjh.harvard.edu/~alario/pages/articles/FilesNorms.html. Drawings with English and French verbal labels that were cognates or quasi homophones were eliminated (e.g., ball-balle, ski-ski). It was not possible
to match words across languages for number of syllables so, as a compromise solution, only words of one and two syllables in length were included. Name agreement was also considered because the number of response alternatives to a picture is likely to affect response latencies. It is measured by the number of different responses provided to a single picture stimulus across subjects. Name agreement of 100% indicates that all participants agreed on the name of the pictured object. The lower the value, the more names this picture solicited from the subjects. For most of the items name agreement in both languages was at least 79% based on the norms cited in Cycowicz et al. 1997 for English and in Alario and Ferrand, 1999 for French; however, some items with lower name agreement in French were also included. Because these items were normed on a European-French (EF) population, exceptions were made to include words if the low name agreement value was judged to be due to an alternative name that was highly uncommon in Canadian French (CF). For example, *bread* was included although it had low name agreement in EF because the synonyms "pain de mie" or "mie" are highly unlikely in CF. Similarly, items with high agreement were eliminated if CF non-dominant names were judged to be in common usage. For example, although *corn* has a high name agreement value in EF it was excluded because there were two likely names in CF "maïs" and "blé-d'inde". The average value for name agreement for all items across both languages was 94% (SD=13.3, range = 46 - 100).

Frequency of the picture names ranged from 1 to 591 occurrences per million for English (mean = 56, SD = 130) following Francis and Kucera (1967) and from 1 to 892 occurrences per million for French (Mean = 70, SD = 93) following Content and Moustic (1990; cited in Alario & Ferrand 1999).
A total of 52 picture pairs were formed. Of these, 18 were semantically related and 34 were semantically unrelated. The 18 semantically related pairs were formed by intuitively matching pictures from the same category, favoring when possible, a strong associative relationship (e.g., sun-cloud; hand-foot). The remaining pictures were matched to form 34 unrelated pairs with the restriction that there be no obvious semantic or associative relationship between them. Four fixed random lists were generated with the restriction that the semantic relatedness between the pictures occurred on no more than two consecutive trials. Presentation of the lists was counterbalanced by participant.

Language cues

Each language cue consisted of 2 (3cm X 3 cm) squares presented side by side in the upper portion of the computer screen. The language of response was dictated by the color of the square. The leftmost square indicated the language of response for the first picture of the trial pair and the rightmost square indicated the language of response for the second picture of a trial pair. The color green was associated with French while the color orange was associated with English. Since no effect of color was anticipated, the color-language assignment was not counterbalanced across subjects. In some conditions the squares were outlined only and the color-fill only appeared simultaneously with the presentation of the stimulus.

Intervening task.

For the intervening visuo-spatial task, nine slides, each with a cross at one of nine

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4 Meuter & Allport (1999) counterbalanced the assigned of colour and language across participants and did not report an effect of colour.
different locations were drawn using the E-Prime program. These nine locations roughly correspond to the nine locations of the digits on the number pad of the computer keyboard.

2.4.2 Language background questionnaire

Bilinguals with equal proficiency in both of their languages are extremely rare, and means of effectively assessing relative language proficiency have not yet been developed. It is most likely that one language is always dominant and furthermore that dominance in one or the other language is context or domain dependent. In other words, a bilingual may be dominant in one language in the professional domain but be dominant in the other in the context of family life. For the proposed study, bilinguals who have as near to equal proficiency as possible in both of their languages were tested to avoid the necessity of including language dominance as a factor in the current design. However, since true balanced bilingualism is unlikely, it was important that in addition to the initial subject screening more information be gathered in case additional factors are needed to explain inter-subject variability. For this reason, a brief language questionnaire was designed to elicit information on the type and amount of exposure participants have to each of their two languages.

The questionnaire was comprised of 19 items which focused on factors that are typically regarded as being important to language proficiency (see Appendix 1). These factors were gleaned from studies in the area of bilingualism and second language acquisition (Cutler, Mehler, Norris, & Segui, 1992; Feuerverger, 1989; Flege, Munro, & MacKay, 1996; Spada, 1986). The first six items pertain to basic demographic information of age, gender, place of birth and length of residence in British Columbia. Twelve questions were designed
to elicit information pertaining to the context and extent of language use. One item was aimed at having participants assess their relative proficiency in both languages and the last item was a forced choice question. This question was used by Cutler et al. (1992) as well as by Flege et al. (1984). In a study on speech segmentation strategies of adult French-English bilinguals, Cutler et al. assigned participants to groups based on the answer to this forced choice question. Their main finding suggests that fluent bilinguals only use one speech segmentation strategy (either stress-based or syllable based) regardless of the language of input. The forced choice was the one factor that divided participants according to the preferred speech segmentation strategy. It seems therefore that this type of forced choice question has some value in ascertaining a bilingual’s dominant language.

Following Flege et al. (1996) a seven point rating scale was used for seven of the questions aimed at estimating extent of language use, with 1 corresponding to never and 7 corresponding to always. Only one language was specifically targeted in each of these questions. The authors reasoned that if one language is used frequently in a particular context the other would be used infrequently. This reasoning was supported by previous statistical analysis on a similar questionnaire, which showed a negative correlation between extent of use of one language and extent of use in another within a given context.

2.5. Procedures for data collection

Participants were tested individually within a single 1-hour session. The stimuli were

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5 "Suppose you developed a serious disease, and your life could only be saved by a brain operation which would unfortunately have the side effect of removing one of your languages, which language would you choose to keep?" (Cutler, Mehler, Norris, & Segui, 1996, p.390)
presented on a computer monitor. The E-prime program Beta 5 Version (Psychology Software Tools, Inc., 2000) controlled stimulus presentation and also recorded the participants' response times to the stimuli. The experimenter sat behind the participants and to the side in order to view the computer screen and score the subjects' response accuracy and error types. Participants' verbal responses were also recorded with a tape recorder for further documentation of their specific responses to each stimulus. Following the naming trials each participant filled out the language background questionnaire.

2.5.1 Experimental session

Participants were seated at an approximate distance of 60 cm from a 21-inch computer monitor which was set at a resolution of 1024 by 768 pixels. A head-mounted microphone was worn and kept at a distance of approximately 2.5 cm from the mouth. The microphone was connected to a serial response box and served to trigger the voice activated key. Participants were informed that on each trial two pictures of common objects would be presented consecutively on the computer screen and that their task was to name each of the pictures aloud. They were told that the purpose of the experiment was to see how fast they could name pictures in each of their languages and that the cues above each picture would indicate the language of response for each picture. The experiment began with a practice block of 18 trials. Correct responses for both Step-1 and Step-2 were monitored by the experimenter who coded correct and incorrect responses using the button box following each trial. In order for a trial to be correct both the Step-1 and Step-2 picture had to be named accurately in the language indicated by the cue. Following the practice trials, percent correct scores were computed. If the score did not attain the criteria of 80% correct, the practice
block was performed again until criterion was attained. Once the percent correct score attained criteria the experimental trials began. The stimuli were presented in two blocks of 52 pairs with a one minute break between blocks.

The presentation of each of the four fixed random lists was counterbalanced by participant. The language cues were randomly assigned to each of the trials: Fifty percent of the trials were pre-cued for both Step-1 and Step-2 while the remainder were pre-cued only for Step-1. Also, 50% of the trials were switched while the remainder were repeated. Half of the repetition trials were English-English trials while half were French-French trials. Similarly, on half of the switch trials, the transition was from English to French while on the remainder the transition was from French to English.

2.5.2 Trial sequence

Figure 2.1 illustrates the sequence of events in a trial, while Figures 2.2 (a-d) illustrates the relationship between the language cues and the picture stimuli during a single trial in each of the foreknowledge conditions. Each trial began with the appearance of the language cue(s) along with a fixation cross which appeared off center to the left. On foreknowledge trials, both squares were color filled and on no-foreknowledge trials, only the left most square was color filled while the rightmost square was outlined only. After an interval of 1000 ms the Step-1 picture stimulus was presented and remained on the computer screen until a verbal response was initiated (see Figure 2.2 a and b). The computer timed the interval from picture onset to the initiation of the participant’s naming response by means of a voice activated relay. Initiation of naming terminated the display of the first picture of the pair while the language cues remained on the screen and a fixation cross appeared below the
rightmost square (Figure 2.2 c). The language cue remained on the screen during the 1000 msec response to stimulus interval. Following this interval, the Step-2 stimulus picture appeared on the screen and remained until a response was initiated. On the no-foreknowledge trials color-fill appeared in the rightmost square simultaneously with the presentation of the Step-2 picture (Figure 2.2 d). Response latency was measured in the same ways as for the first picture. The experimenter used a written form to record participants' responses as correct or incorrect during the intertrial interval. Technical difficulties such as false starts and failed voice key triggering were also recorded on a written form during the intertrial interval. Additionally, participants' verbal responses were tape-recorded for future reference. After the two pictures in a trial pair were named, an intervening visuo-spatial task designed to take approximately 10 seconds separated each trial. The task was to track the location of an object on the computer screen. The object was a cross which moved randomly between 9 different positions on the screen. The cross appeared in each location for a maximum of 1100ms. Once the object was correctly located by key press, the display was terminated. An interval 550 ms separated the response from the presentation of the cross at the next location. The participants had to track its' movements by pressing a corresponding key on the number pad. The response keys were assigned to each position according to their spatial arrangement on the number pad. For example, if the cross was located at the top right corner of the screen the corresponding response was "7" because this key is located at the top right corner of the number pad.
## 2.6. Analysis

### 2.6.1 Correct and incorrect responses

A trial was coded as correct if both the Step-1 and Step-2 pictures were given the correct name in the language specified by the cue. Errors were coded according to two main types: performance errors and technical errors. Performance errors included mislabeling or
Figure 2.2 Relationship between language cues and picture stimuli in the no-foreknowledge condition.
naming the pictures in the wrong language. Technical errors were mainly related to
equipment sensitivity (e.g., premature triggering of the voice key due to extraneous noise
from the environment or sounds the participants made just before naming such as breathing,
stuttering or saying "um" before the naming response). Another type of technical error was
the failure of the voice key to trigger due to participants speaking too softly. The
experimenter had approximately ten seconds to code responses as correct or incorrect on a
written form while the participants performed the intervening task.

2.6.2 Intervening task

There were two reasons for including a long inter-trial interval (ITI) as well as an
intertrial visuo-spatial task in the experiment. The first was to maximize disengagement
from the language task just performed in Step-2 of the previous trial. The second was to
minimize the possible persistence of semantic or language activation of Step-2 into the
processing of the subsequent Step-1. The inter-trial task was designed in such a way that the
ITI could reach a maximum of 14.5 seconds if unattended to or be as short as 9.5 seconds
with a consistent tracking RT of 500 ms.

2.6.3 Naming Latency

Naming latency was measured from picture onset to the onset of the verbal response
and was recorded by the E-prime program with millisecond accuracy. Mean response
latencies for each of the eight experimental conditions were computed for each participant
and then were submitted to an analysis of variance. Results of this analysis will be presented
in the following section.
CHAPTER 3: RESULTS

3.1. Overview

The data from this study was analyzed using analyses of variance to verify the hypotheses that were formulated in Chapter 1. The next section describes the way in which the data were prepared prior to analysis and presents the results of this experiment.

3.2 Preparation of the data for analysis

3.2.1 Step-2

For a number of trials participants had word finding difficulties and reaction times exceeded several seconds. For this reason, specific cut-off values were selected for Step-1 and Step-2 reaction times prior to any calculation of means. Trials in which Step-1 exceeded 2000 ms or in which Step-2 exceeded 1600ms were excluded. This procedure resulted in the elimination of 13.7% of the data. Following this, the data were trimmed using a procedure adapted from Tyler (1992). First, the means and standard deviations for Step-2 were calculated for each condition. This allowed for the appropriateness of the selected cut-off values for clear outliers to be verified. For each condition, maximum and minimum cut-off values of two standard deviations above or below the mean were calculated. Across all conditions, the high cut off values exceeded the clear outlier cut-off value (1600 ms) by at least 179 ms and at most 354 ms. This suggests that the selected value for the elimination of outliers was conservative and within an appropriate range from the overall mean. Following the elimination of clear outliers, any values falling more than 2 standard deviations above or below the mean for each condition were trimmed and replaced. Values that fell below the lower cut-off were replaced by the minimum value and those that fell above the higher cut-
off were replaced by the maximum value. This procedure resulted in the trimming and replacement of less than 6.2% of the data that remained in each condition. Descriptive statistics were obtained once again for each condition. The clear outliers which were identified and eliminated in the first stage of trimming were then replaced by these new means. The means and standard deviations for each condition were calculated a final time. As a result of the entire data preparation procedure 17.6% of the data were trimmed and replaced.

3.2.2 Step-1

The same procedure as the one used to prepare the Step-2 data was used for the preparation of the Step-1 data. For analysis, however, since semantic relatedness only became a relevant factor once the Step-2 picture was presented, this factor was not considered.

3.3 Results

3.3.1 Step-2

A 2 X 2 X 2 (task transition, foreknowledge, relatedness) repeated measures design was used to analyse the data. The results of the ANOVA show significant main effect for task transition \((F(1, 17) = 3.84, MSe = 5574.77, p = .00003,\) foreknowledge \((F(1, 17) = 120.93, MSe = 4276.94, p < .00000\) and relatedness \((F(1, 17) = 34.74, MSe = 4249.86, p = .00001.\) All two way interactions were also significant; namely for task transition and foreknowledge \((F(1, 17) = 11.73, MSe = 3547.49, p = .004;\) task transition and semantic relatedness \((F(1, 17) = 10.6458, MSe = 4951.113, p = .003;\) and foreknowledge and semantic relatedness \((F(1, 17) = 6.4647, MSe = 5331.63, p = .02.\) There were no significant three way
interactions. *Post hoc* comparisons were carried out using Tukey's honest significant difference (HSD) test to verify the basis of the two way interactions.

**Task transition and foreknowledge**

Means for each of the four Task transition-Foreknowledge conditions are presented in Table 3.1, and Figure 3.1 shows the mean Step-2 RT as a function of task transition in each foreknowledge condition. Response latency was significantly faster on switch trials with foreknowledge (830 msec) than on switch trials without foreknowledge (916 msec) and was also significantly faster on repetition trials with foreknowledge (727 msec) than on repetition trials without foreknowledge (881 msec). This shows that participants named pictures faster when they knew the language of response in advance of the naming trial whether they switched or repeated languages. Naming responses were significantly faster on repetition trials with foreknowledge (727 msec) than on switch trials with foreknowledge (830 msec); however, although mean response latency on repetition trials in the No-foreknowledge condition (881 msec) appeared to be faster than mean response latency on switch trials in the no-foreknowledge condition 916 msec) this difference was, not significant. Thus, it appears that there is a switch cost (i.e. a difference between repetition and switch trials) only when participants know the language of response prior to the naming trial.
Table 3.1

Mean response latency for Step-2 pictures in msec in each task transition-foreknowledge condition

<table>
<thead>
<tr>
<th></th>
<th>Foreknowledge</th>
<th>No-Foreknowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>830</td>
<td>916</td>
</tr>
<tr>
<td>Repetition</td>
<td>727</td>
<td>881</td>
</tr>
</tbody>
</table>

Mean Step-2 RT as a function of Task Transition in both Foreknowledge conditions

2-way interaction

$F(1,17)=11.73; \ p = .003$

![Graph showing mean naming latencies for Step-2 pictures as a function of task transition in the foreknowledge condition (lower) and in the no foreknowledge condition (upper).]

Figure 3.1. Mean naming latencies for Step-2 pictures as a function of task transition in the foreknowledge condition (lower) and in the no foreknowledge condition (upper).
**Task transition and semantic relatedness**

Means for each of the four Task-transition-Relatedness conditions are presented in Table 3.2, and Figure 3.2 shows the mean Step-2 RT as a function of task transition in each relatedness condition. There was a significant effect of semantic relatedness on repetition trials. Related repetition trials (749 msec) were named faster than unrelated repetition trials (859 msec). Related switch trials (857 msec) were named faster than unrelated switch trials (889 msec) but this difference was not statistically significant. This shows that participants named Step-2 pictures faster if the previous Step-1 picture was semantically related and named in the same language. When the Step-2 picture was named in a different language than the Step-1 picture, there was no effect of semantic relatedness on naming latency.

<table>
<thead>
<tr>
<th></th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>857</td>
<td>889</td>
</tr>
<tr>
<td>Repetition</td>
<td>749</td>
<td>859</td>
</tr>
</tbody>
</table>
Figure 3.2. Mean naming latencies for Step-2 pictures as a function of task transition in the related condition (lower) and in the unrelated condition (upper).

**Foreknowledge and semantic relatedness**

Means for each of the four Foreknowledge-Relatedness conditions are presented in Table 3.3, and Figure 3.3 shows the mean Step-2 RT as a function of foreknowledge in each relatedness condition. Response latency was faster on related trials when foreknowledge was available (727 msec) than when foreknowledge was not available (878 msec). This
difference was also present in unrelated trials (829 msec vs 918 msec). When foreknowledge was available, response latency was faster on related (727 msec) than on unrelated trials (829 msec). When foreknowledge was not available response latency was faster on related trials (878 msec) than on unrelated trials (918 msec) but this difference was not significant. In other words, participants were quicker at naming a Step-2 picture when the previously named Step-1 picture was semantically related provided they knew in advance, the language of response. When foreknowledge of the Step-2 language was unavailable, semantic relatedness had no significant effect on naming latency.

Table 3.3

Mean response latency for Step-2 pictures in msec in each foreknowledge-relatedness condition

<table>
<thead>
<tr>
<th></th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreknowledge</td>
<td>727</td>
<td>829</td>
</tr>
<tr>
<td>No-Foreknowledge</td>
<td>878</td>
<td>918</td>
</tr>
</tbody>
</table>
Figure 3.3. Mean naming latencies for Step-2 pictures as a function of foreknowledge in the related condition (lower) and in the unrelated condition (upper).

3.3.2 Step-1

A 2 X 2 (task transition, foreknowledge) repeated measures design was used to analyze the Step-1 data. Results of the ANOVA show a significant effect for task transition, $F(1, 26) = 6.11620, MSe = 9407.09, p = .020251$. The interaction between task transition and foreknowledge was also significant $F(1, 26) = 12.24060, MSe = 11515.34, p = .001702$.

Post hoc comparisons were carried out using Tukey’s honest significant difference (HSD) test to verify the basis for the two way interactions.
Means for the four Step-1 Task transition-Foreknowledge conditions are presented in Table 3.4, and figure 3.4 shows the mean Step-2 RT as function of task transition in each foreknowledge condition. Response latency was significantly slower on switch trials in the foreknowledge condition (938 msec) than on switch trials in the no-foreknowledge condition (846 msec). This pattern was reversed for the repetition trials and slower response latencies were observed in the no-foreknowledge condition (872 msec) than in the foreknowledge condition (820 msec). There was no significant difference between switch trials (846 msec) and repetition trials (872 msec) when foreknowledge was not available whereas a significant difference was observed in the foreknowledge condition between switch trials (938 msec) and repetition trials (820 msec). This show that participants were slowed on switch trials when they performed Step-1 if they new the language which they needed to use in Step-2.

Table 3.4

Mean response latency for Step-1 pictures in msec in each task transition -foreknowledge condition

<table>
<thead>
<tr>
<th></th>
<th>Foreknowledge</th>
<th>No-Foreknowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch</td>
<td>938</td>
<td>846</td>
</tr>
<tr>
<td>Repetition</td>
<td>820</td>
<td>872</td>
</tr>
</tbody>
</table>
Mean Step-1 RT as a function of Task Transition in both Foreknowledge conditions

2-way interaction

F(1,26)=12.24; p = .002

Figure 3.4. Mean naming latencies for Step-1 pictures as a function of task transition in the foreknowledge condition and in the no foreknowledge condition.

3.3.3 Summary of results

The main results of this study can be summarized as follows:

1. Step-2 pictures were named faster overall when foreknowledge was available.

2. It took longer to name Step-2 pictures on switch trials than on repetition trials when foreknowledge was available but when foreknowledge was not available, switch trials were
not significantly slower than repetition trials.

3. Step-2 pictures that were related to the previously named picture were named faster than unrelated pictures on repetition but not switch trials.

4. It took longer to name a Step-2 picture on switch trials than on repetition trials when the previously named picture was related, but when the two pictures in a trial were unrelated, Step-2 pictures on switch trials were named as fast as pictures on repetition trials.

5. Step-2 pictures which were related to Step-1 pictures were named faster than unrelated Step-2 pictures when foreknowledge was available but not when foreknowledge was unavailable.

6. Step-1 pictures took longer to name on switch trials but only when foreknowledge was available. There was no significant difference in the naming latencies for Step-1 pictures in all other experimental conditions.
CHAPTER 4: DISCUSSION

4.1 Introduction

This study was designed to test the IC model's claim that there are two components to bilingual language control. The first is proactive control by which the language processing system can ready itself for an anticipated shift in language. The second is reactive language control, a mechanism by which the language processing system completes its preparation for a language shift on the basis of either an external or an internal stimulus. A picture naming task was employed in which participants named the two pictures of a pair in either the same language or in different languages. Proactive control was examined by manipulating foreknowledge of whether the pictures would be named in the same language or in different languages. It was expected that foreknowledge would provide some preparation benefit resulting in faster naming latencies. Reactive control, on the other hand, was examined by manipulating the semantic relatedness between the two pictures in a pair. It was thought that support would be found for the reactive control hypothesis if semantic relatedness affected switch and repetition trials differently. More specifically, it was expected that semantic relatedness of the two pictures in a pair would facilitate naming of the second picture when both pictures were named in the same language but that it would have a negative priming effect when the pictures were named in different languages.

The results presented in chapter three are surprising in that, in certain experimental conditions, they do not replicate the most robust finding of previous task-switching and language switching studies viz., that language switching is associated with a decrement in performance. This finding has generally been impervious to a wide range of experimental
manipulations. Previous studies which tried to maximize participants' use of strategic control processes by manipulating foreknowledge (in the form of sequence predictability) and length of RSI, have shown a time cost associated with switching. This residual switch-cost was generally attributed to the need for the task relevant stimulus to be present in order for preparation to be completed. In the current study, a switch-cost was observed in one experimental condition while it was surprisingly absent in another. As will be discussed in the following sections, the results support the notion of proactive global control as well as the notion of local level control but they do not support the hypothesis that local control is reactive. In addition, it will be argued that the difference in magnitude in the effect of semantic relatedness within languages as compared to its effect between languages is consistent with a model that posits a limited pool of activation resources available for language control such as the one proposed by Paradis (1986). In the following section, the results will be discussed in relation to the hypotheses formulated in chapter one. Following this, some of the differences between this and other switching studies will be discussed in order to address some of the findings that appear to be unique to this study. Finally, a general discussion will focus on some of the implications of the results of this study in terms of models of bilingual language control.

4.2 Hypotheses

4.2.1 Language switching cost

Switch-cost was defined in chapter one as the difference in response latency between a switch trial and a repetition trial. It was hypothesized that participants would take longer to name pictures when the preceding picture was named in a different language than if the
preceding picture was named in the same language (Hypothesis 1). Results of this study did show that participants named pictures faster when language was repeated; however, examination of the interactions show that this occurred only under certain conditions. A switch-cost was observed only when participants had foreknowledge of task transition or when the pictures in a trial pair were semantically related. When neither of these conditions were met, there was no switch-cost observed.

An unexpected finding of the current study was that switch cost seemed to occur only with foreknowledge. If switch cost reflects the extra time it takes to shift from one language task to a competing language task, foreknowledge should have allowed for advanced preparation and hence led to a relatively lower switching cost. The fact that performance overall was enhanced by foreknowledge indicated that some from of executive control processes were indeed at work. Why then the unexpected pattern of switch cost? It seems possible that the no-foreknowledge condition, by withholding language information, actually provided an unintended second form of foreknowledge. The two sorts of foreknowledge could then each have led to extensive, albeit different, types of strategic processing and created the observed data pattern. I will argue in section 4.2.2, that the absence of a language cue prompted participants to adopt a specific preparatory state that especially facilitates language switching.

Another unexpected finding was that a switching cost was incurred only if the pictures in a trial pair were semantically related. It may be that the switch cost represented in Figure 3.2 by the slope of the bottom line should be interpreted in terms of semantic priming rather than in terms of switch cost. When pictures are named in the same language, the first picture
primes the naming of the second picture; however, when related pictures are named in different languages, there is no priming effect observed. The absence of a significant difference between switch trials and repetition trials in the unrelated condition (upper line in Figure 3.2) may be due to the fact that the means include values from both foreknowledge conditions and, since there is no switch-cost on trials without foreknowledge, this may have reduced the effect of task transition when means are collapsed within the foreknowledge level. It would be useful to examine the effect of relatedness in each foreknowledge condition separately; however, the absence of any three way interactions precludes any meaningful conclusions to be drawn from comparisons between means at this level. In section 4.2.3 the effect of semantic relatedness will be discussed in further detail as it relates to the reactive control hypothesis and in terms of a resource activation model of language control.

4.2.2 Proactive control

Proactive control was defined in chapter one as the goal driven component of the bilingual language control system. This component could be put into action before a stimulus was present on which the system could act (i.e. before the language task was performed). It was hypothesized that participants would name pictures faster when they knew the language of response in advance of the naming trial (Hypothesis 2a). Results from the study support this hypothesis. Participants named the second picture of a trial pair faster on both repetition and switch trials when they knew the language of response prior to the trial (see Figure 3.1). They also named the second picture of a trial pair faster in the foreknowledge condition on both related and unrelated trials (see Figure 3.2). Thus, there appears to be some preparation benefit afforded by foreknowledge in both task transition conditions and in both relatedness
It was also specifically hypothesized that there would be an interaction between task transition and foreknowledge, and indeed, a switch cost was observed in the foreknowledge condition (Hypothesis 2b) but not in the no-foreknowledge condition. The absence of switch cost when foreknowledge was not available, was not anticipated and raises some questions about the nature of proactive control.

The reasoning underlying Hypothesis 2b was that foreknowledge would have the effect of reducing the switch cost but not of eliminating it. The resulting switch-cost would then correspond to the residual (i.e. the portion of the switch-cost that cannot be eliminated). The provision of foreknowledge and of sufficient preparation time was aimed at ensuring that all proactive preparation processes had been completed before the Step-2 naming trial began. The hope was that, with reasonable certainty that the switch cost obtained in the foreknowledge condition was a residual, any effect of semantic relatedness on switch trials could reasonably be attributed to processes which escaped executive control, in this case, to semantic priming. This would have provided a strong test of the reactive control hypothesis.

Previous task-switching studies with a similar set of conditions (i.e foreknowledge manipulation and RSIs between 1 and 1.2 seconds) showed patterns of results which strongly suggest that the observed difference between switch and repetition trials reflected a residual switch-cost (Rogers and Monsell, 1995; Sohn 1998, Meiran, 1996; and Meiran et al., 2000).

Assuming the switch-cost observed in the current study does reflect a residual, we must ask why switch cost did not appear in the no-foreknowledge condition. One possible explanation is that a switch-cost appears only when there is a clear commitment to one
language over another. When participants had no foreknowledge of whether to switch or repeat languages on Step-2 of a trial, they may have kept both languages at relatively close activation levels, and selection of one language task, which is presumed to be necessary for task execution, may not have involved strong suppression of the competing task. This would explain why there was no switch-cost observed in the no-foreknowledge condition. This explanation is also consistent with the overall slower response latencies in the no-foreknowledge condition. Resolving the competition between two language tasks in the no-foreknowledge condition would require more time if their activation levels were similar. In addition, activation of two languages may require more resources than the activation of a single language. This is also consistent with the over all slowing of performance which is observed in the no-foreknowledge condition.

A second possible explanation arises out of an alternative hypothesis presented in chapter one. It was hypothesized that the switch cost in both foreknowledge conditions could remain the same (Hypothesis 2c). This hypothesis was included because results of a study by Ruthruff, Remington, and Johnston (1996, cited in Sohn, 1998) showed that when the probability of switching was equal to the probability of repeating, as it was in this study, the switch-cost remained the same in both foreknowledge conditions due to strategic preparation (see section 1.2.7.1 for a discussion). Although the current findings do not support his hypothesis, the notion of strategic preparation remains useful. The switch cost with foreknowledge can be explained if the availability of foreknowledge encourages participants to proactively prepare switch and repetition trials differently, while the absence of a switch cost can be explained if the absence of foreknowledge encourages participants to strategically
remain in a preparatory state which is similar for both switch and repetition trials. This point will be discussed further in the next section on strategic control.

In sum, the results obtained in this study support the proactive control hypothesis. This is in line with most other proposals of language control. In this study proactive control was reflected by faster naming latencies on both switch and repetition trials when foreknowledge was available. Although the absence of switching-cost could be used to rule out the hypothesis that there is a component of the switch cost which is irreducible, it was argued instead that this finding reflects the absence of executive commitment to one language task over another when foreknowledge was not available. It appears that the current paradigm favours strong strategic involvement in the no-foreknowledge condition, contrary to what has been assumed. A switching strategy seems to have resulted in overall slower performance but also in the elimination of switching-cost. The next section explores this strategy in more detail.

Strategic control

The pattern of results obtained in this study strongly suggests that strategic control processes are operative in both foreknowledge conditions. The absence of a switch-cost in the no-foreknowledge condition can be explained by participants adopting an equalizing strategy at the onset of each trial. When foreknowledge was not available, participants may have tried to equalize the relative state of activation of each language subset. The strategy may have been employed to maintain this state for the duration of the entire trial or to use the response to stimulus interval to reset the relative levels to a more neutral state after Step-1 was executed. In other words, at some point during the execution of trials where foreknowledge is
remain in a preparatory state which is similar for both switch and repetition trials. This point will be discussed further in the next section on strategic control.

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not available, the activation levels of the language subsets are set to a state akin to the bilingual language processing mode in preparation for the presentation of the second picture of the trial (see section 4.4.2 for a discussion of language modes). This strategy would allow them to remain in a relatively neutral state with both languages active prior the presentation of the second picture. In this neutral position, the relative state of activation of each language would have been relatively close prior to each Step-2 naming trial regardless of whether or not languages were to be switched or repeated. This would explain the finding of no-switch cost in the no-foreknowledge condition.

The appearance of a switch-cost in the foreknowledge condition suggests that, in this condition, the relative state of activation for each language prior to Step-2 was different on switch and repetition trials. On foreknowledge-repetition trials, participants could set themselves up to be in a more or less monolingual mode for the duration of the trial given that they were aware that a 10 second interval separated each of the trials and that they would not need to immediately switch back to the other language. They will have had over 2 seconds (this includes the cue-to-stimulus interval for Step-1 as well as for Step-2) in order to set the relative activation levels of each language to clearly favour the repeated language. On switch trials, there is less time to set up the relative activation levels of each language in favour of the Step-2 language because participants would first need to complete or at least begin lexical access in one language before reconfiguring the system for naming in the other language. It is not clear when preparation for Step-2 begins on switch trials, but given the increase in response latency on Step-1 of switch trials with foreknowledge, it seems reasonable to assume that preparation actually begins during the performance of Step-1. This would mean that
there is less than 2 seconds for reconfiguration on foreknowledge switch trials. The difference in preparation time between a switch and a repetition trial would result in a difference in relative activation levels for the two language subsets prior to the execution of the Step-2 naming trial on switch and on repetition trials. This difference could explain why a switch cost appears in the foreknowledge condition only.

**Preparation benefit of foreknowledge or generalized slowing in bilingual mode?**

It appears that the overall effect of foreknowledge was to speed up naming latencies. Alternatively, slower naming latencies in the no-foreknowledge condition may have resulted from a generalized slowing effect, a possibility that was briefly alluded to in section 4.2.2.

Results of previous switching studies show that a clear preparation benefit is derived from the availability of foreknowledge (Sudevan and Taylor, 1987; Sohn, 1998; and Meiran, 1996), and figure 3.3 clearly shows that when task transition is collapsed foreknowledge has the overall effect of a relatively faster naming response. This may reflect a stronger commitment to one language over another in the foreknowledge condition on both switch and repetition trials. However, a general slowing account provides an appealing alternative explanation as it is consistent with the “equalizing” strategy discussed in the previous sub-section. This overall slowing of trials in the no-foreknowledge condition can be attributed to the amount of activation resources being allocated to keeping two languages active and in part by the additional time it takes to select a “winner” between the two language tasks when their activation levels are similar.

The notion that activation is limited in resources is outlined in Green (1986). In his model, regulation requires setting the amount of activation of internal components. Activation
resources can become depleted and hence limit the system’s capacity to effect control. Such a limitation may be reflected in speed of processing rather than in error. In an experiment which compared the response latencies of monolinguals and bilinguals, Amrhein (1999) found no difference between the response latencies of monolinguals and bilinguals in a picture-word translation task when stimulus and response modalities were blocked. Differences were, however observed when stimulus and response modalities were mixed (e.g. word-word translation with picture-word translation). She concluded that bilinguals can function in monolingual mode under certain conditions. These findings are consistent with the notion that when two languages need to be active, item selection requires more time because activation resources are shared between two languages rather than one.

In sum, if only the foreknowledge factor is taken into account, it seems that switch-cost appears only when experimental conditions favour a clear commitment to one language over another. In situations such as the no-foreknowledge condition in the present experiment, it is strategically sound to equalize the relative state of activation of the two language subsets prior to the execution of the Step-2 naming trial. Hence, when foreknowledge is not available, neither a repeated nor a switched language is favoured prior to the execution of a Step-2 stimulus. This explains why there is no switch-cost observed in the no-foreknowledge condition. In the foreknowledge condition another strategy may be adopted. In this condition, it may be strategically effective to profit from the long RSI in order to set the relative activation of each language subset in favour of either a repeated or a switched language. The appearance of the switch-cost in this condition would result from there being less time to reset the language subsets’ activation levels on switched trials than there is on repetition trials.
There may also be an overall benefit to having foreknowledge as reflected by the faster naming latencies in this condition. But it remains possible that this effect of foreknowledge may also result from limited processing resources and generalized slowing in the no-foreknowledge condition which would be consistent with a strategy which involves equalizing the relative levels of activation of both language subsets.

4.2.3 Reactive control

Reactive control was defined in chapter one as the component of the bilingual language control system that was driven by the presence of a task relevant stimulus. According to the IC-model, this control component is only set into action once lexical access has begun. At this level, control is thought to operate within the lexico-semantic system while proactive control is thought to operate outside the lexico-semantic system. In terms of bilingual language control, reactive inhibition would target only pre-activated competitors which possess non-target language tags. Based on this, it was hypothesized that semantic relatedness would facilitate repetition trials but that it would inhibit switch trials (Hypothesis 3). Assuming this were true, negative priming should have been observed on switch trials and positive priming should have been observed on repetition trials. The results show that repetition trials were indeed named faster if the pictures were related. However, related switch trials were neither named significantly faster nor significantly slower than unrelated switch trials. As discussed in chapter one (section 1.3.3) such a pattern is consistent with the hypothesis that language control is purely proactive.

A proactive language control system, may be able to prevent the spread of semantic activation from one language subset to another prior to the naming trial by sufficiently
increasing the level of activation of the target language and sufficiently decreasing the level of activation of the competitor language. This type of processing would correspond to a highly proactive language control process and would imply that semantic activation does not spread from one language subset to another. There is, however, sufficient evidence in support of cross-linguistic priming to warrant alternative explanations.

Alternatively, it is possible that early cross-linguistic semantic activation of lexical items did occur but that global control was able to override it and inhibit activation of items within the non-target language subset. This means that on a subsequent trial there would no longer be differential activation between those previously preactivated items and the other items that were in the non-target language subset. In other words, global control may come into play at a later stage in lexical access and still be able to suppress any semantic activation that could have spread from one language subset to another during an earlier stage of lexical access. Results of cross-linguistic priming studies suggest that semantic priming does occur across languages but that some form of global control comes into play at a later stage (i.e. during lexical access) to prevent items from different languages from competing at the lexical selection stage. In a recent study by Costa et al. (1999), which employed a picture-interference task, facilitation effects were observed when distractors were in the same language as that used to name the picture as well as when they were in a different language. They argue that if languages had been competing, then cross-linguistic inhibition should have been observed. Further manipulation of the type of relationship between the target and interfering stimulus (i.e. semantic versus phonological) as well as the SOA showed same-language facilitation when distractors were phonologically related to the probe but no
phonological facilitation through translation. These findings led them to conclude that during early lexical access, activation spreads to related items in both languages but that at the later selection stage, only items from the target language are considered for selection. In other words, language selection in bilinguals is language specific.

This explanation is consistent with the current results. It is conceivable that, at an earlier stage of lexical access, semantic activation spreads from the target item to semantically related items on both the target and the non-target language. Then, at a later stage of lexical access (the selection stage), the activation level for these non-target items is brought back down to the general activation level of the language subset to which they belonged. This would explain the absence of semantic priming on switch trials. The mechanism by which language selection is effected remains unclear, and whether this is accomplished through global language suppression or through the selective suppression of the set of semantically related items with the wrong language tag (reactive inhibition) cannot be determined by the results if this study. The only evidence in support of reactive inhibition would have been provided by the finding of negative priming on switch trials in the related condition.

Although the results do not support the hypothesis that there is a reactive component to bilingual language control, they do not rule out the possibility that this mechanism is extant. It may be that the experimental conditions were highly favourable to strong proactive control. Strong global inhibition of one language could eliminate any differential activation between items within a given language which may have resulted from cross-linguistic priming whether it be positive or negative priming. With hindsight, it may be that reactive control would be more detectable in conditions where proactive processing is minimal. This statement is in
contradiction with the idea that initially supported the current design. The idea was that proactive processing should be maximized so that any effect of semantic relatedness could be more readily attributable to positive or negative priming rather than to preparation. But, if reactive control is mainly required when proactive control is limited, then increasing task demands by, for example, reducing the RSI, may heighten the effect of priming and possibly make it possible to detect cross-linguistic negative priming. Additionally reducing the interval between trials may discourage strong commitment to the Step-2 language in the foreknowledge condition. In the current study, the length of the interval between trials (approximately 10 seconds) may have favoured such a commitment. This seems likely since participants were aware they would have sufficient time to adjust for Step-1 of a new trial. Because of the strong likelihood that the task favoured strong proactive control, it remains possible that reactive inhibition does have some function in language control under other conditions.

The results of the current study do not allow for any conclusions to be drawn regarding the relative contributions of foreknowledge and relatedness to the switch-cost. As can be seen in Figure 3.3, when foreknowledge is not available, semantic relatedness had no effect on the mean response latency. This result is surprising given the assumption that was made in chapter one that semantic relatedness would mainly affect processes which escape executive control. This finding may be due to the inclusion in the means of both switch and repetition trials. As can be seen in Figure 3.2, there is no significant semantic priming on switch trials, it is therefore possible that the inclusion of switch trials in the means in the no-foreknowledge condition (Figure 3.3) reduced the effect of semantic relatedness. But why then should this not
also hold true in the foreknowledge condition? In figure 3.3, the effect of semantic relatedness in the foreknowledge condition is significant. One possible explanation is that foreknowledge availability on repetition trials encourages the priming of the semantic field. Taken together the pattern of results observed in Figure 3.2 and 3.3 show that semantic priming is observed only in conditions where foreknowledge and repetition converge on half of the trials within an experimental condition. Another possible explanation may be that the amount of activation resources expended to activate two languages in the no-foreknowledge condition left very little of this resource for automatic spreading of semantic activation. In order to further elucidate the extent to which foreknowledge and relatedness each contribute to this apparent switch cost, it would be useful to examine the effect of relatedness separately within each foreknowledge condition; however, the three way interactions were not significant and therefore prevent any conclusions from being drawn from the apparent differences between the means.

4.2.4 Summary

The results of this study show that naming pictures on switch trials takes longer than naming pictures on repetition trials. Examination of the interactions show that this observed difference is limited either to trials with foreknowledge or to trials where the picture pairs are semantically related. Strategic processes can explain why a switch-cost only appears in the foreknowledge condition as well as why there is no switch-cost in the foreknowledge condition. Two possible explanations were offered to account for the overall effect of foreknowledge. On the one hand, the preparation benefit afforded by foreknowledge would explain the faster naming latencies as well as the switch cost in this condition. On the other
hand, the slower response latencies in the no-foreknowledge condition could result from an overall slowing of performance due to an increased expenditure of resources required to keep two languages active and/or to the additional time required to resolve the competition between two equally activated language tasks. This parallel activation of two languages minimizes the switch-cost.

The hypothesis that language control has a reactive component was not supported because no negative semantic priming was observed on switch trials (see Figure 3.2). It was, however, argued that since the current paradigm appears to favour strong proactive processing in the foreknowledge condition, this may have suppressed the potential effects of semantic priming across languages prior to execution of Step-2 or during lexical access. In the no-foreknowledge condition, the absence of priming (see figure 3.3) may be due to activation resources being otherwise engaged in keeping two languages active precluding the automatic spreading of semantic activation. Modification in the pacing of the task which could be brought about by reducing the intervals between trials and between stimuli could alter task demands in a way that would favour the use of reactive control. In conclusion, the reactive control hypothesis has not been entirely ruled out by the current findings. The results are, however, consistent with a highly adaptable proactive control mechanism which seems to have the capacity to adjust the bilingual language processing system to relatively short-lived situational variations.

4.3 Comparisons with previous switching studies

4.3.1 Explaining the absent switch cost

As was mentioned in the introduction to this chapter, the results of this study are not
entirely consistent with one of the most robust findings of task switching and language switching studies, viz. that there is a time cost associated with switching. This discrepancy merits some attention and will be discussed in the current section. The discussion will mainly focus on the differences between the current study and previous switching studies. The possible effect of using the two-step switching paradigm as opposed to the use of alternating runs as well as using a large set of stimuli as opposed to a small set will be discussed. Finally, the characteristics of the participants in this study will be discussed as they may also have contributed to the unusual finding of an absent switch-cost.

The main difference between the 2-Step paradigm and the alternating runs paradigm is the presence of a long intertrial interval (ITI). In the two-step paradigm, each trial consisted of a short run of two trials. After each trial, participants performed an intervening task which took approximately 10 seconds to complete. In the alternating runs paradigm, each block of trials consisted in an alternation of short runs of trials performing one task and short runs of trials performing another task (e.g. AABBAA....). The response to stimulus interval generally remained under one second and thus the interval between the presentation of the two pictures rarely exceeded two seconds. There is evidence that participants likely adopted a single strategy for all of the trials in a block when conditions are mixed (Strayer and Kramer, 1994a; 1994b). In the current experiment, the length of the ITI may have favoured the adoption of two basic strategies depending on whether or not foreknowledge was available. One of these

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6 When different experimental conditions were blocked, participants tended to adopt different strategies that were efficient for different conditions. However, when the conditions were mixed in one block, they tended to adopt one general strategy although it may not have been an optimal strategy for all conditions.
strategies may have been to keep the activation levels for both languages at relatively equal levels when foreknowledge was not available. The other strategy would have been to bias language activation in favour of the known target language when foreknowledge was available. It seems possible that the strategy is selected once the Step-1 language cue is presented. If the cue only provides information regarding the Step-1 language, then the system will strive to equalize the levels of activation of the language subsets prior to performance of Step-2 because of uncertainty regarding the language for the upcoming trial. If, on the other hand, the cue provides information for both Step-1 and Step-2 languages then, once Step-1 is performed, activation levels can be biased in favour of the Step-2 target language whether it is switched or repeated. Such a commitment to one of the two languages would be effective at this point considering that the 10 second ITI is likely to provide sufficient time to re-equalize the activation levels of the two languages in anticipation of the following trial. Thus, it may be that the length of the ITI along with the cueing method, provided the context for an 'equalizing' strategy to emerge which would explain why a switch cost was not observed in the no foreknowledge condition contrary to what had been expected.

Another important difference between the current study and other switching studies is the use of foreknowledge as a variable. In most studies foreknowledge was always available in the form of task sequence predictability, and although pre-cues have been used, the variable which was generally manipulated in this case was the time interval between the cue and the target stimulus. In the current experiment, foreknowledge was not always available because in some conditions, participants remained uncertain of which language to use right up until Step-2 picture presentation. To my knowledge this is the first language switching study in which
foreknowledge was either available or not available. Without foreknowledge, it may be an effective strategy to remain in a more language neutral state prior to performing Step-2 of the trial. Thus, whether languages are switched or repeated from Step-1 will make no difference in naming latency, and this would explain the absence of a switch cost in this condition. In sum, the two differences just discussed namely the use of foreknowledge as a variable and the length of the ITI, may have both favoured the use of two different strategies by participants depending on foreknowledge conditions. One of these strategies, the 'equalizing' strategy provides an adequate explanation for the absence of a switch cost in the no-foreknowledge condition.

4.3.2 Stimulus set size

The current experiment differs from other language switching studies because it used a large set of stimuli while the other naming study reviewed in Chapter 1 used a closed set of numerals from one to nine. The effect of a closed set which is used repeatedly may be to strengthen connections between small subsets of items. This conceivably occurs when one set of responses is associated with one type of stimulus or cue while another set of responses is associated with another type of stimulus or cue. The effects observed in such studies do not necessarily reflect bilingual language processing but rather some artifact of the task and experimental designs. Evidence for this type of artifact is provided by a language switching study by Loasby (1998; cited in Meuter and Allport, 1999). Proficient bilinguals were extensively trained with a list which included words form both of their languages. Following this, naming latencies for pictures were measured. The language switches were cued and predictable. The stimulus list contained items from the trained list as well as novel items. In
other words it contained items from an artificially created strong language (L1) and words from an artificial weak language (L2). Loasby’s results replicate those obtained by Meuter and Allport (1999) which showed that bilinguals incurred a greater cost when switching from their weaker language to their dominant language. This suggest that the effect observed may not reflect bilingual processing but rather demonstrate the effect of familiarity with the stimuli. This familiarity with the stimuli may result in a stronger effect of switching than would be incurred in more naturalistic language use. In the current study, use of a large set of stimuli with only one repetition, increases the ecological validity of the task because the perceived pool of potential response candidates approximates the whole set of picturable items represented in the mental lexicon. It is conceivable that the higher ecological validity of this study combined with the characteristics of the participants may have contributed to the current study’s finding of no-switch-cost. It is possible that such a finding would not emerge if the bilinguals under study did not engage in any form of language mixing behaviour (and thus were not practised at language control) and if a small set of stimuli were used. Repeated use of a small stimulus set could cause the representations for subsets of these objects to become activated in response to a triggering stimulus such as a language cue. Thus the effects observed could be attributed to practice effects rather than to the way a bilingual’s languages are organized in the mind.

4.3.3 Participants characteristics

Participants for this study were all proficient bilinguals who acquired both of their languages as children. They all reported that they still used both of their languages regularly and all engaged in code-switching behaviour with the experimenter who was also bilingual.
Although other language switching studies have used 'proficient' bilinguals, in none of these were the criteria as stringent as they were for the current study, which required early acquisition and current use of both languages. In some of the language switching studies reviewed, the participants were identified as proficient bilinguals but most of these had acquired their second language formally at school, generally at the university level. In Meuter and Allport (1999), the aim of the study was to explore the performance asymmetry due to language dominance and therefore the bilingual participants were unbalanced bilinguals who clearly had a dominant language.

Bilinguals who code-switch may often find themselves in gatherings where they must interact with speakers whose language usage pattern differs from their own. In other words, they may need to interact at times with monolingual speakers of either one of their two languages, as well with bilinguals who don’t code switch. In a laboratory study reported in Grosjean 1997, results suggest that bilinguals modified the degree to which they mixed their languages depending on the characteristics of their listener. If they find themselves conversing with a monolingual, they must prevent intrusions from the non-target language. This might be done by setting the activation level of the target language much higher than the activation level of the non-target language. When interacting with members of their own speech community, language mixing will likely tend to occur freely and smoothly without pauses or hesitations. In such a situation, the difference in activation levels between both languages may be relatively small. Finally, when interacting with bilinguals who do not engage in code-switching, intrusions from the other language are less acceptable and therefore are monitored more closely. The nature of the switches that do occur may also
differ from those observed between code-switchers. For example, instead of engaging in a wide variety of smooth switches including full sentential switches and spontaneous single word borrowings, speakers may reduce the length and frequency of the switches and might highlight their switches with gestures, pauses or hesitation.

It is likely that, for the bilinguals tested in this experiment, language control is a much more practised skill than it is for bilinguals with different language backgrounds. The ability to equalize language activation may be determined by practice which, in turn, is determined by the extent to which a speech community accepts and practices language mixing. Since it is more likely for a bilingual who code-switches to accommodate to a non-switching interlocutor than vice versa, this finely tuned ability to adjust language activation in response to often subtle contextual cues is likely to be more developed in bilinguals who regularly engage in code-switching.

In conclusion, it may be that in addition to factors pertaining to task design, the absent switch-cost may also be explained by the type of bilinguals tested in the current study. These bilinguals may have the ability to use an equalizing strategy while other types of bilingual may use an ‘either/or’ strategy where one language is always more activated than the other. If one language is always clearly more activated than the other, a language shift is likely to always result in a switch-cost.

4.4 Relation to models of bilingual language control

4.4.1 Language subsets and language tags

Models of bilingual language processing have addressed either issues of representation or issues of control. These were discussed in sections 1.2.2 through 1.2.2.4.
The IC model is one of the first to bring together in a single model the questions of representation and bilingual language control. The current study was aimed mainly at exploring aspects of bilingual language control. In particular, it was designed to test the hypothesis that there are two levels of control. One of these was thought to act globally while the other was thought to act at a local level. Local control was thought to be reactive and inhibitory in nature. The results did not support the hypothesis that there was a reactive component to bilingual language control, but in the following section, it will be argued that the results are consistent with models that postulate two levels of control. It will also be argued that the results are consistent with a bilingual language representation model which incorporates Paradis' (1997) notion of an integrated bilingual lexicon in which each language forms a subset. Such a model will also require that each lexical entry be associated with a language tag or language feature.

Two very different findings were observed in each of the foreknowledge conditions. A switch-cost was observed when foreknowledge was available but not when it was not available. As will be discussed in the following section, the finding of a switch-cost is consistent with the notion that the non-target language subset could be suppressed as a whole resulting in longer naming latencies when this language became relevant on the following naming trial. The absence of a switch cost is, on the other hand, consistent with the notion that when foreknowledge was not available, the lexicon of the balanced bilingual could function as an integrated system in which the language subsets are activated to similar degrees. In such a system, the language production system must have a way of recognizing language affiliation on an item by item basis as a way to differentiate the target from its translation.
equivalent. A language tag or language feature associated with each item would allow for this type of identification.

An integrated bilingual lexicon would include items from each language, organised into subsets by virtue of the stronger ties connecting same language items than different language items. This type of language organization would allow the control of language to operate at a global level. Additionally, individual items would have a language tag (or feature) which would allow language control to operate at a local level. For example, take the lexical entry “arm” and its French equivalent “bras”. In a bilingual picture naming task, the picture of an arm should activate the concept for arm as well as other related concepts though to a lesser degree. Similarly, the language context, specified in the current experiment by a colour cue will prime the target language. Lexical access will involve the spread of activation from the concept “arm” to the lexical entry for “arm” and “bras” as well as to other semantically related entries in both languages. If the language context is clear, then at the selection stage, the target language will be strongly activated compared to the non-target language and the competition between the two translation equivalents will be easily resolved. This corresponds to global language control. If on the other hand, language context is ambiguous (i.e., constantly changing) then language may not be specified clearly in the early stages of lexical access and global control may not have time to sufficiently bias language activation before the selection stage. At this point, the two translation equivalents “arm” and “bras” may be activated to similar degrees. Choosing the item in the intended language may require that the competition between translation equivalents be resolved by specifically targeting non-target language competitors for inhibition. Thus, in the current
example, if the target language were English then "bras" as well as other French entries semantically related to "arm" would be targeted for inhibition. These items could be targeted because each lexical entry has a language tag which would allow for item specific inhibition based on its language affiliation.

Following the model just proposed, one language can be inhibited and the other activated when clear contextual indicators, such as the colour cues in this study, are present. This corresponds to proactive control which acts globally (i.e. on an entire language subset). When context is ambiguous or constantly shifting, both languages may be called upon at any given moment. In such a situation, the subsets are activated to similar degrees and function as an integrated lexicon. In an unrestricted language switching context, it may be that the first item to reach a certain level of activation is selected. If, however, language specific production is required within short time delays, as it was in the no-foreknowledge condition of the current study, then language specific control becomes necessary. In such a situation, there is insufficient time for proactive control to be engaged and thus control is mainly exerted at the local level where the language tag or feature comes into play to allow for the selection of only one of the translation equivalents. These two levels of control do not necessarily act independently, and global control may act in conjunction with local control when the context clearly dictates favouring one language over the other. This would presumably result in faster processing than when the language context is mixed.

To summarize, in order to account for the results of this study, a model of bilingual lexical selection would need to include elements allowing it to function at least in two modes. One of these is a non-competing mode where the lexicon functions as an integrated set of
entries and differentiates language affiliation by using the language feature or tags. The other is a competing mode in which the organization of languages into subsets can be used proactively to bias the relative level of activation of all of the items belonging to the target language.

4.4.2 Language modes

The model just proposed, is compatible with the concept of language mode developed by Grosjean (1997, and 2001) which offers a strong framework for understanding the current results. The concept of language mode incorporates aspects of Paradis’ subset hypothesis and elements of Green’s (1986) control activation and resource framework. Grosjean (2001) defines language mode as “the state of activation of the bilingual’s languages and language processing mechanisms, at a given point in time” (p. 2). Two independent factors underlie the concept of language mode: first, there is the chosen base language, and second, the relative level of activation of each language. Figure 4.1 adapted from Grosjean (2001), illustrates language mode along two dimensions. The horizontal axis represents the language mode continuum which ranges from monolingual mode on the left and bilingual mode on the right. The bilingual’s languages are represented in the vertical axis by the circles. The relative level of activation of each language is depicted by the degree of shading. The base language is the most activated language. In the figure, Language A is the most activated and thus is the base language while language B is less activated. The activation of language B is higher as the position along the language continuum shifts toward the bilingual end. This can be seen by the increase in degree of shading in the bottom circles on the figure. Base
Figure 4.1. Two dimensional representation of the language mode continuum (adapted from Grosjean 2001)

language can change while a speaker remains at a single point along the language mode continuum. There are two possible ways of interpreting the results of this study in terms of language mode. One possibility is that, in addition to changing base languages, participants in the study also changed language modes depending on the experimental conditions. Another possibility is that participants were in a bilingual language mode for the duration of the experiment and only changed the base language depending on foreknowledge conditions.
4.4.2.1 Mode shift

With Foreknowledge

A change in language mode depending on foreknowledge availability could occur if each trial was construed as a short block. When foreknowledge was available, the bilinguals in this study may have been positioned toward the monolingual end of the continuum on both repetition and switch trials. In other words, when participants knew, in advance, the language of both Step-1 and Step-2 pictures, they could “safely” commit to one base language when they reached Step-2 of the trial. This strong commitment to one language in the foreknowledge condition resulted in a switch cost. On repetition trials, participants may have been in monolingual mode from the outset of the trial and were committed to one language because they knew that they would be using the same language to name both pictures on a pair. Additionally, on repetition trials, no base language change would be required to name the second picture of the trial pair. This would explain why naming latencies are fastest on foreknowledge repetition trials. On switch trials, it is conceivable that speakers are positioned toward the bilingual end of the continuum on Step-1 because they are aware that the other language will become relevant on the second step of the trial. This would mean that activation resources are expended to activate two language subsets which could explain the slowed response latency observed on Step-1 of foreknowledge switch trials. Once step-1 is completed, bilinguals may shift toward the monolingual end of the continuum in preparation for Step-2. This shift would be effected because speakers are aware that, following Step-2, no shift in language will be required for at least ten seconds, and thus they commit more readily to the Step-2 language.
Without foreknowledge

When foreknowledge is not available, the bilingual participants' language mode is set to “bilingual” with relatively equal levels of activation for both languages. Base language is likely selected for Step-1 because the colour cue for this step appears one second before the picture. Following completion of Step-1, the relative activation levels of each language promptly return to a more neutral state in anticipation of either a switch or a repetition in response language on the following naming trial. Thus, whether the language of the Step-2 naming trial was switched or was repeated, the relative activation of the competing languages will have been almost equal prior to Step-2 picture presentation. This would explain why there was no switch-cost observed in the no-foreknowledge condition.

Summary

According to this scenario, a mode change would occur only in the foreknowledge condition and only on switch trials. When a language is repeated, a monolingual mode can be maintained for the duration for the trial. When languages are switched, however, a bilingual mode is set for Step-1 then a shift to monolingual mode is effected for Step-2 of the trial in addition to a shift in base language. This means that, on switch trials with foreknowledge, the relative activation of both languages prior to Step-2 is such that the position on the language mode continuum is not as close to the monolingual end as it would be on repetition trials. This would explain the switch cost in the foreknowledge condition. When foreknowledge was not available, bilinguals were set in bilingual mode for both switch and repetition trials. This means that prior to naming the Step-2 picture, activation levels of both language subsets are relatively close, and thus there is no cost associated with switching
from one to the other.

4.4.2.2 Base language shift only

Instead of changing language mode as well as shifting from one base language to another, it is possible that the only change effected when conditions changed was a shift in base language. This implies that the bilingual participants' language systems are at the bilingual end of the language mode continuum for the duration of the experiment. When foreknowledge is available one of the two base languages will be more activated than the other; however, when foreknowledge is not available, the activation levels of both languages are held at relatively equal levels, in other words no base language is clearly selected.

The entire experimental context was conducive to placing the speakers in a bilingual mode. It is arguably more plausible that, for the duration of the experiment, the participants were at the bilingual end of the continuum rather than at times, finding themselves at the monolingual end. Indeed, one of the assumptions made at the outset of this study was that participants would be in a bilingual mode given that they were aware that bilingualism was the area of study for the experiment, that the instructions were given alternately in English and in French, that a bilingual experimenter used both languages with the participants, and finally that the task required the use of both languages. In addition, in both blocks of trials, experimental conditions were mixed, which as was already discussed, would favour the adoption of a single overall strategy, in this case, the adoption of a bilingual language mode. There is evidence in support of the notion that single strategies are adopted when experimental conditions are mixed within blocks even though participants know the nature of the upcoming task well in advance of the trial. In a study which examined the effects of pre-
cueing on strategy adoption, Strayer and Kramer (1994b) found that pre-cues did not modify the differences between mixed and blocked conditions. They concluded that even with pre-cueing of a task subjects did not change their strategy in a mixed block. If, in the present study, participants were in bilingual mode for the duration of the experiment, then the observed switch-cost could be attributable solely to the time required to shift from one base language to another rather than to a combination of movement along the language mode continuum with a base language shift.

*With Foreknowledge*

When foreknowledge is available, bilinguals may clearly select a base language prior to Step-2. Since the same base languages would have been selected on Step-1 of repetition trials, base language activation prior to Step-2 stimulus presentation should then be higher on repetition than on switch trials because it will have had more time to accumulate. This difference explains the switch-cost observed in the foreknowledge condition.

*Without Foreknowledge*

When foreknowledge is not available, there would be no basis for the selection of a base language for Step-2. Thus, whether the languages are switched or repeated, the activation levels of each subset should be relatively equal prior to the presentation of the Step-2 picture. This would explain the absence of a switch-cost in this condition. As discussed previously, target selection in this case would need to be based mainly on local control which is effected through the languages tags or language feature.

*Summary*

According to this second scenario, base language change, which only occurs when
The answer to the first question is equivocal. In short, in some experimental conditions there was a cost associated with switching while in other experimental conditions there was no switch-cost observed. It seems that bilinguals can adapt their language production systems in response to contextual cues. When context does not clearly specify language, they can adjust the system to function in such a way as to eliminate the competition between their two languages. In such a situation, there is no cost associated with switching. On the other hand, when context clearly dictates language specificity and the bilingual has time to prepare, a switch cost will be observed.

The answer to the second question appears to be more straightforward because in all conditions, foreknowledge of task transition results in faster naming latencies. This supports the notion of an anticipatory control component. It must be noted, however, that the question
specifically asks whether a portion of the switch-cost is affected by foreknowledge. Implicit in the question was the expectation that if foreknowledge should have an effect, it would be to reduce the switch cost. Instead, a somewhat opposite pattern was observed where a switch cost was observed in the foreknowledge condition while no switch cost was observed in the no-foreknowledge condition. Given this pattern of results, it was not possible to compare a full switch cost with a reduced switch-cost. As was discussed in section 4.2.2, the idea was to compare response latencies in conditions where proactive control was minimal or absent (resulting in a full switch cost) with those in conditions were proactive control had sufficient time to be completed (resulting in a reduced or residual switch cost). The results of this study strongly suggest that even when foreknowledge was not available, there was proactive preparation albeit of a different kind than the preparation taking place when foreknowledge was available. Preparation in the no-foreknowledge condition seemed to involve a strategy which consisted in equalizing the activation levels of each language. The adoption of this strategy may have been due to the high probability (0.5) of switching on each trial. Thus, the current study does not provide an answer to the third question because the experimental design favoured proactive control even in the no-foreknowledge condition. It was argued, however, that given the experimental constraints, the observed switch-cost could reflect a similar form of residual as that observed in other switching studies. That residual may reflect limitations of proactive processing.

With respect to the fourth question, the results of the current study provide no evidence that there is a component of language control which is reactive. Such support would only have been provided by a finding of a negative priming effect on related switch-
trials. Nonetheless, it was argued that the results do not completely rule out the possible existence of a reactive language control component which may become detectable when task demands are different.

When examined in terms of theories and models of bilingual language representation, the findings of this study certainly suggest that the bilinguals examined in the current study possess a finely tuned ability to regulate bilingual language production in response to contextual cues. The current results are captured by the notion of an integrated bilingual lexicon in which items from different languages are grouped into subsets and in which all items possess a language tag or feature. In terms of bilingual language control, it was argued that the results showing a switch cost in some conditions but not in others, can be captured by a model which allows control to operate at two levels. The presence of a switch cost suggests that at one level, whole language subsets can be activated/deactivated. However, absence of a switch cost suggests that languages do not always compete. Given that participants generally responded in the intended language even in non-competitive conditions where there was no switch cost, the language production system must have a way of recognizing the language affiliation of individual items. It was proposed that the second level of control acts on individual items based on their language tag or feature.

This study also underlines two of the core problems facing researchers in bilingualism which have been identified and discussed at length by Grosjean (1997, 2001), namely, the need to control for the characteristics of the bilinguals under study as well as the importance of controlling for the language mode adopted by participants as they are tested. Some of the crucial factors identified by Grosjean (1997) include language history, language stability,
number of languages known and global competence in each, functions of each language, and
amount of code switching and borrowing normally done. To position a bilingual at the
monolingual end of the language mode continuum, Grosjean (2001) proposes that the
interviewer or experimenter be a monolingual, that the situation be monolingual, and that no
other person present be a speaker of the other language. He also notes that it is important to
avoid demonstrating interest in participants’ bilingualism. Finally, Grosjean warns that if
participants are tested in a laboratory known to work on bilingualism or if the stimuli are in
both languages or the task requires use of both languages then both languages will become
activated. To position a bilingual in bilingual mode Grosjean (1997) offers the following
suggestions: telling the participants that the purpose of the study is to investigate
bilingualism, engaging in language mixing while interacting with them, and explicitly telling
them to keep “their two language on at all times” p. 230.

4.6 Limitations of the study

A discovery of the current study was that task design allowed for two completely
different strategies to be adopted by participants, depending on experimental conditions.
Namely, to bias language activation in favour of the target language when foreknowledge was
available and to equalize the activation levels of both languages when foreknowledge was not
available. This rendered direct comparisons between conditions difficult unless these
included discussion of these strategies themselves. Examination of the results in terms of
strategies did, however, prove useful in discussing possible models of language
representation and the notion of the bilingual language mode continuum.
4.7 Future directions

In section 4.4.1, I speculated about the possibility that the capacity to function in a non-competitive language mode required extensive practice and hence, was characteristic of the type of bilingual tested in the current study. Further investigations using the current paradigm may be fruitful, particularly if bilinguals with different language backgrounds are tested and compared. Specifically, it would be of interest to replicate the robustness of the current findings with another group of balanced bilinguals, but it would be of particular interest to compare the strategies adopted by balanced bilinguals with those adopted by non-balanced bilinguals.

The question of reactivity still needs to be explored as the results of the current study neither supported nor adequately ruled out the existence of this form of inhibition. As was discussed in section 4.2.3, increasing task demands may limit the extent of proactive processing and heighten the effects of semantic priming. This would be because global language control will have less time to neutralize the differences in relative activation levels between unrelated and related items prior to the performance of Step-2. This would mean that, on switch trials, the semantically related items would be less activated than the unrelated items. On repetition trials, the related items would be more inhibited than the unrelated items.

4.8 Conclusions

The results of the current study support the notion that balanced bilinguals have a highly fine tuned ability to control their two languages. It would seem that when linguistic context is clearly monolingual bilinguals are able to favour appropriate language and when
language context is bilingual, they are able to minimize the competition between their two languages. The findings are consistent with a view of the balanced bilingual's lexicon as an integrated set of entries. Within this integrated lexicon, the functional separation of languages can occur in two ways. One way is to organize the bilingual lexicon into language subsets which allows for global activation of the items in only one of the languages. This mechanism of functional separation is likely called upon for proactive control when contextual cues clearly indicate the language context. An example of such a situation is bilingual engaged in a one-on-one conversation with a monolingual. Both languages are likely activated but it is likely more advantageous to keep the language dictated by the contexts considerably more activated than the other language. A change in interlocutor may be sufficient to cue the bilingual to globally activate the other language while suppressing the one just used with the previous interlocutor. In such situations speakers have sufficient time to adjust the relative activation of their language subsets. Another mechanism, is the language tag or feature which allows the language affiliation of each item to be detected during language processing. Such a mechanism may be called upon in conjunction with proactive control but becomes crucial to language control when illocutionary constraints change rapidly. Examples of such situations include a bilingual acting as an interpreter between two monolinguals or a language mixed conversation. In these situations, there is little time to prepare for changes in language. Control in this case would be reactive and mainly serve to resolve competition between items.
REFERENCES


Appendix A

Subject No.:_________

Mechanisms of control in bilingual lexical selection

Language background questionnaire (version date: Nov. 24, 2000)
(To be completed following experimental session)

Please answer the following questions as completely and as accurately as possible. All information gathered from this study will remain strictly confidential and will only be used for the purpose stated in the consent form signed by you prior to the experimental session. Do not put your name on the questionnaire.

1. Mother's native language(s) __________________________

2. Father's native language(s) __________________________

3. Age of exposure to English: _________

4. Age of exposure to French: _________

5. Age of exposure to other languages _________

6. Length of residence in British Columbia: _________

7. For an average week, estimate percentage use of French versus English:
   ______ % English vs. ______ % French

Check the most applicable to your situation:

8. □ English was spoken in my home when I was a child.
   □ French was spoken in my home when I was a child
   □ Both English and French were spoken in my home when I was a child.

9. □ I attended most of primary school in French.
   □ I attended most of primary school in English.
   □ I attended early French immersion.
   □ I attended late French immersion.

10. □ I attended most of high-school in English
    □ I attended most of high-school in French
    □ I attended a French immersion High school.

Please rate the following statements by circling one number

1 = never       7 = always

11. I use French with my mother
    1        2        3        4        5        6        7
12. I use English with my father  
   1 2 3 4 5 6 7  
13. I use French at work/school  
   1 2 3 4 5 6 7  
14. I use English with my relatives  
   1 2 3 4 5 6 7  
15. I use French with my friends  
   1 2 3 4 5 6 7  
16. I use English at social events  
   1 2 3 4 5 6 7  
17. I watch/listen French radio/television  
   1 2 3 4 5 6 7  
18. Please check the most applicable to you  
   □ I am more comfortable speaking French  
   □ I am more comfortable speaking English  
   □ I am equally comfortable in English and in French.  
19. Suppose you developed a serious illness and your life could only be saved by a brain operation which would have the side effect of removing one of your languages which language would you choose to keep?  
   Check only one answer  
   □ English  
   □ French
### Related pairs (18)

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<td>cup-glass</td>
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### Unrelated pairs (34)

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