DOES BILINGUAL EXPOSURE AFFECT INFANTS’ USE OF PHONETIC DETAIL IN A WORD LEARNING TASK?

by

CHRISTOPHER TERRENCE FENNELL

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Abstract

Fourteen-month-old infants raised in a monolingual English environment confuse phonetically similar words in a word-object association task (Stager & Werker, 1997); however, older infants, who are more proficient at word learning, do not (Werker, Corcoran, Fennell, & Stager, 2000). This temporary confusion of phonetic detail occurs despite the fact that 14-month-old infants still have the ability to discriminate native language phonemes in speech perception tasks not involving word learning. Therefore, it has been hypothesized that 14-month-olds fail because linking words to objects is difficult at the beginning stages of word learning, leaving infants with insufficient attentional resources to listen closely to the words.

Extending this hypothesis to infants raised in a bilingual environment generates two possibilities. (1) Bilingual infants will not show the temporary deficit at 14 months. As a function of growing up with two languages, they will have already developed a greater awareness of the sounds of words because more detail is needed to discriminate words in two languages. (2) Bilingual infants will perform at least as poorly as infants being raised with only English because of the cognitive load of learning two languages.

Bilingual infants of 14 months were tested in the word-object association task using the phonetically similar labels ‘bih’ and ‘dih’ paired with two distinct and colourful moving objects. Following habituation, infants were tested on their ability to detect a ‘switch’ in the word-object pairing. Bilingual language exposure was assessed with a structured parental interview. The 16 infants included in the sample had been exposed to two languages from birth and had at least 30% exposure to one language and no more than 70% to the other. The results showed that, like the monolingual-learning infants of the same age, the 14-month-old bilingual-learning infants confused similar sounding words. These data are consistent with the cognitive load hypothesis, and argue against the proposition that early bilingual exposure facilitates metalinguistic awareness. Future research with slightly older bilingual word learners who have reached the age
at which monolingual infants can successfully learn phonetically similar words will help to clarify if these bilingual infants maintain, or diverge from, a monolingual pattern of development.
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Introduction

Psychologists, philosophers, and linguists have long been interested in the beginnings of word learning. However, research into the ontogenetic origins of language increased dramatically in the latter half of the twentieth century, when Chomsky, Lenneberg, and their contemporaries made convincing claims about the importance and uniqueness of language acquisition. Concurrently, Liberman and colleagues published a set of studies that raised the possibility that the perception of speech is central to language processing, and that like other aspects of language use, speech perception might also be unique in comparison to the perception of other kinds of sounds. Speech perception is essential for language acquisition. It is necessary for an infant to segment a word from the speech stream in order to map a label onto an object or concept. It is also necessary to encode and represent the phonetic characteristics of their native language in order to consistently have a correct label for an object. Consequently, both language acquisition and speech perception researchers have recently begun to investigate the role of speech perception in word learning.

Despite the growing number of studies looking at speech perception in relation to lexical acquisition, the research ignores, and is therefore not directly applicable to, a major segment of the global population. All of the studies to date have focused on monolingual infants. Yet, many infants are raised in a bilingual environment, whether through national language policies or immigration. By focusing exclusively on monolingual children, researchers run the risk of erroneously concluding that their findings generalize to all children. The current study attempts to redress this issue by extending the study of speech perception and word learning to infants raised in a bilingual environment.

The current study examined how ‘bilingual’ infants perceive phonetic detail in a word-object associative task. Previous research has demonstrated that 14-month-old monolinguals have difficulty discriminating phonetically similar nonsense labels in a word-object associative
learning task (Stager & Werker, 1997). The monolinguals do not have difficulty discriminating the same words in a simple speech perception task. It appears that the cognitive demands of word learning interfere with the ability of the infant to discriminate fine phonetic detail. In a recent study, Werker, Corcoran, Fennell and Stager (2000) replicated the findings with infants aged 14-months, but discovered that 17- and 20-month-old infants easily learn phonetically similar nonsense words in a word-object associative task. It is postulated that the older infants are more proficient word learners and that the greater facility with word learning allows the infant to use fine discriminatory abilities in the task. Other researchers (e.g. Barton, 1978; Charles-Luce & Luce, 1990; Walley, 1993) also theorize that it is not until children become very familiar with words and word learning that they begin to detect fine phonetic differences in lexical forms. The question becomes: will bilingual infants perform similarly to monolinguals in a word learning task when presented with phonetically similar labels?

The existing theories yield conflicting predictions about bilinguals' attention to fine phonetic detail in a word learning task. Some bilingual researchers have claimed that bilingual toddlers and children show enhanced metalinguistic abilities (e.g., Bialystok, 1988; Bruck & Genesee, 1995; Lanza, 1997; Levy, 1985). If we extend these findings to the early stages of the word-learning period, one would predict that the 'bilingual' infants would have greater phonetic awareness, perhaps a rudimentary form of the metalinguistic skills found in older bilingual children (Bialystok, 1988; Lanza, 1997). This position would predict that the infants may be better able to attend to fine phonetic detail in a word-learning task. On the other hand, Stager and Werker (1997) postulated that it is the increased computational demands of word learning that interfere with fine phonetic discrimination. Learning words in more than one language may increase these demands. The infant needs to learn multiple labels, as well as divergent phonologies and grammar. Bilingual infants would have as much, if not more, difficulty attending to fine phonetic detail in a lexical task. The theoretical positions outlined above would
therefore predict two opposing answers to the question of how bilinguals will utilize phonetic detail in a word learning task.

**Infant Phonetic Perception**

Infants' difficulty with discriminating similar sounding words in lexical tasks is surprising considering they demonstrate highly sensitive speech perception abilities in non-lexical tasks. Eimas, Siqueland, Jusczyk and Vigorito (1971) conducted a classic study in speech perception in which they investigated the ability of infants to discriminate initial phonemes in a consonant-vowel (CV) syllable. They presented 1- and 4-month-old infants with pairs of syllables differing in voice onset time (VOT). There were equivalent differences in VOT between the items in each pair, but the paired items either crossed phonetic categories (e.g. ba vs. pa) or stayed within a phonetic category (e.g. one ba vs. another ba). The infants of both ages were able to discriminate the stimuli that crossed categories, but not the stimuli from within a category. This study demonstrated that even 1-month-old infants are capable of categorical-like speech perception. Eimas and his colleagues went on to demonstrate that infants as young as 2 months can detect other consonant differences, including /t/ vs. /l/ and /m/ vs. /n/, in the initial position of a CV syllable (Eimas, 1975; Eimas & Miller, 1980). These results indicate that the range of phonetic contrasts that an infant can discriminate is quite broad.

Researchers who completed a series of studies a decade later investigated the apparent broadness of categorical perception seen in the 1970's. Previous work had indicated that adults often had difficulty discriminating phonemes from a non-native language. To examine when the change from broad-based to language-specific processing may occur, Werker and Tees (1984) tested the perception of non-native contrasts from Hindi and Nthlakampx in three groups of Anglophone infants: 6-8-month-olds, 8-10-month-olds, and 10-12-month-olds. While the 6-8-month-olds discriminated all the native and non-native contrasts, the older groups discriminated only the native contrasts, with the oldest group showing the worst performance on the non-native
contrasts. These results were also seen in a study using a different set of Hindi contrasts. Anglophone infants of 10-12 months of age did not discriminate a synthesized Hindi contrast although their 6-8 month old counterparts did (Werker & Lalonde, 1988). Similarly, infants of 10-12 months of age fail at discriminating phonetic information that they are exposed to but which is not used to contrast meaning in their native language (Pegg & Werker, 1997). Finally, Werker and Tees (1983) found that 4-year-olds and adults also have difficulty discriminating non-native contrasts. The research of Werker has clearly demonstrated that the perceptual salience of phonetic units becomes language specific during the first year of life.

These studies suggest that the narrowing of phonetic sensitivities is due to the language environment in which the infant is maturing. Infants raised in Hindi and Nthlakampx continue to discriminate the contrasts at 10-12 months that their Anglophone peers fail (Werker & Tees, 1984). It thus appears that as infants become attuned to the phonetic inventory of their native language, they attend less to contrasts that do not indicate meaning in their language.

Other aspects of speech perception become language-specific over the first year of life. Jusczyk, Luce and Charles-Luce (1994) demonstrated that infants are sensitive to the phonotactics of their language, English in this case. They presented 6- and 9-month-olds with lists of high frequency and low frequency phonetic segments. The 9-month-olds, but not the 6-month-olds, listened significantly longer to the high frequency segments. Friederici and Wessels (1993) found that Dutch infants also show sensitivity to the permissible phonotactic sequences at 9 months. In a cross-language study, Jusczyk, Friederici, Wessels, Svenkerud, and Jusczyk (1993) discovered that 9-month-old English infants preferred words with English sounds patterns to those with Dutch sound patterns. The reverse pattern was found for 9-month-old Dutch infants. Infants also become sensitive to the stress patterns of their native language over the first year of life. Jusczyk, Cutler and Redanz (1993) found that 9-month-old, but not 6-month-old, infants displayed longer listening times to lists of words that conformed to the dominant stress
pattern of their native language. All these findings demonstrate infants’ exposure to their native language(s) has an organizing role on language discrimination abilities and preference.

**Phonetic Detail and Word Recognition in Infancy**

The increased perceptual tuning to the prosodic, phonetic, and phonotactic characteristics of the native language provides the infant with a set of sensitivities that enable them to segment words from the speech stream and to learn to recognize familiar word-sized units. Mandel, Jusczyk and Pisoni (1995) found that 4.5-month-old infants listened preferentially to their own names over other names that were matched on stress patterns, thus showing recognition of familiar word units. Hallé and de Boysson-Bardies (1994) tested 10-month-old infants on familiar and unfamiliar words. They based familiarity on words that are common in many infants’ early comprehension vocabularies. The researchers matched the familiar and unfamiliar words on level of phonetic detail. The infants listened significantly longer to the familiar words.

Another infant word recognition study, Jusczyk and Aslin (1995) investigated the abilities of 6- and 7.5-month-old infants to detect familiar words in fluent speech. The researchers familiarized the infants to pairs of words, such as “cup” and “dog”, for 30 seconds. The infants then listened to four passages, two of which contained the familiarised words. Each passage contained six sentences, with every sentence containing the test word in a different position. The 7.5-month-old, but not the 6-month-old, infants listened longer to the passages that included the familiar words. In an interesting reversal of the first experiment, Jusczyk and Aslin (1995) trained 7.5-month-olds on sentences that contained a target word. Once again, the word appeared in various positions across sentences. They then tested the infants on single words, including the target word. The 7.5-month-olds listened longer to the word found in the sentences to which they were familiarized. These two experiments clearly indicate that 7.5-month-old infants can pick out and recognize words in a sentential context.
Jusczyk and Aslin (1995) also investigated the amount of detail used by the infant in word recognition. They followed the same procedure as in the first study. However, they altered one detail of the word in the training phase. For example, instead of being trained on the word “cup”, the infants heard the non-word “tup”, which only differs on one phonetic feature from cup. The infants were then tested on the same phrases as before (i.e. the ones containing “cup”). The infants showed no preference for the phrases containing the similar, but slightly different, word. These results demonstrate that infants have encoded very detailed representations of word units\(^6\) at 7.5 months.

Hallé and de Boysson-Bardies (1996) found seemingly divergent results with older infants. The researchers examined the amount of phonetic detail used to recognize high frequency words. They found that 11-month-olds did not notice a difference in these words when the voicing of the initial consonant changed (e.g. “bonjour” and “ponjour” treated the same) or when the initial consonant was omitted (e.g. “bonjour” and “onjour” treated equally)\(^7\). Paradoxically, these results indicate that 11-month-old infants are not encoding as much phonetic detail in word units as the 7.5-month-olds from Jusczyk and Aslin (1995).

Hallé and de Boysson-Bardies (1996) postulate that it is the movement to word learning that accounts for the less detailed representations at 11 months. As the infant begins to associate meaning to word units, he or she will attend to less detail in the word form. There is other evidence to show that infants do not have detailed representations in their comprehensive vocabulary at the beginnings of word learning (Barton, 1978; see Stager, 2000 for a comprehensive review).

Although Hallé and de Boysson-Bardies (1996) had theorized that the less detailed representations seen in their study were due to those words being associated with a concept or object, they did not empirically test this assumption. The infants in that study could have been using the same simple, non-associative word form recognition found in Jusczyk and Aslin
(1995). Recently, Stager and Werker (1997) directly investigated the question of whether or not infants do encode phonetic detail when learning new words. This research would directly address the hypothesis put forth by Hallé and de Boysson-Bardies.

To test word-object associative links, Stager and Werker (1997) used the “switch” procedure developed by Werker, Cohen, Casasola, Lloyd and Stager (1998). This procedure involves one of the steps necessary to achieve full word learning: encoding the link between a label and an object. The switch procedure involves testing infants in a habituation paradigm where they are habituated to two object-label pairings. For example, the infants see Object 1 moving back and forth across a television screen and hear the nonsense label “lif” and then see Object 2, which also moves, and hear the label “neem”. These pairings are repeated until the infant is habituated. At this point, the testing begins. The test phase consists of a same trial and a switch trial. The same trial consists of a word-object combination that had been seen during the habituation phase. The switch trial consists of a pairing that violated the link between the habituated label and object (e.g. Object 2 would be labelled “lif” instead of “neem”). The key part of the design is that infants should only look longer at the switch if they encoded the link between the object and the label. Since they had become habituated to both Object 2 and “lif”, they should remain bored if they were only focusing on the labels and objects without attending to the link. This procedure provides researchers with a simple, direct, and contextually “pure” test of word-object associations.

When developing the procedure, Werker et al. (1998) tested 8- to 14-month-olds. Their results demonstrated that only the 14-month-old infants look longer at the switch trial, thus demonstrating an ability to encode word-object links. Although younger infants failed in the above task, they could detect changes in either the object or word after being habituated to a single word-object pairing. Other studies have also demonstrated that it is not until 13 to 15
months of age that infants begin to form word-object associative links (e.g., Schaffer & Plunkett, 1998; Woodward & Hoyne, 1999; Woodward, Markman & Fitzsimmons, 1994).

Werker et al. (1998) demonstrated that infants of 14 months could easily associate two phonetically distinct labels with two objects. But what if the two labels were phonetically similar? Stager and Werker (1997) investigated the degree of phonetic detail that 14-month-old infants attend to in a word-object associative task. In order to test this, the researchers used a minimally different pair of labels, “bih” and “dih”, and associated them with two distinct brightly coloured, moving objects during the habituation phase. This way, the infant would have to attend to very fine phonetic detail (i.e. the voicing of the initial consonant - /b/ vs. /d/) in order to notice a switch during the test phase of the study. There were no significant differences in looking times between the “same” and “switch” trials, thus indicating that the infants did not attend to the fine phonetic difference.

The possibility remained that it was the complexity of making two object-label associations in the task, not simply the case of phonetically similar words, that prevented the 14-month-olds from attending to the voicing difference. Stager and Werker (1997) simplified the task to a one object-label pairing similar to the one used with the younger infants in Werker et al. (1998). They tested 8- and 14-month-olds in the simplified procedure. Again, the older infants failed to notice the switch; however, the younger infants did look longer at the switch trial. Given that infants of 8-months are unable to link a word and object even when they are phonetically dissimilar (Werker, et. al., 1998), the younger infants are likely treating this procedure as a simple speech discrimination study. Even though the simplified version of the procedure can be passed by simple discrimination, it appears that the older infants are treating it as a word-learning task and, because of this, failing to encode fine phonetic detail.

Another possibility remained aside from the associative nature of word learning. Perhaps, it was an inability to discriminate the phonemes used in the procedure that accounted
for the results. The final experiment directly tested the infants’ ability to discriminate these phonemes. The moving objects were replaced with a stationary, unbounded checkerboard display, which an infant would most likely not treat as an object to be labelled (Spelke, Vishton & Van Hofsten, 1995). The fact that the 14-month-old infants did discriminate “bih” from “dih” in this task confirms that the infants’ failure in the word learning task cannot be accounted for by a perceptual discrimination deficit.

Taking all these results into account in their discussion, Stager and Werker (1997) theorize that the inattention to fine phonetic detail may be advantageous for early word learners. Since word learning is “computationally...demanding”, inattention to fine detail may reduce the cognitive load of this process and facilitate linking words to objects. (p. 382). If this explanation holds, one should see a re-emergence of the phonetic discrimination at a later age. At a later point in development, the infant has become better at learning words. This ease of word learning could allow the infant to devote more attentional resources to the task of listening more carefully to the fine phonetic detail in words.

A re-emergence of the discrimination of fine phonetic detail in word-learning tasks is exactly what Werker, Corcoran, Fennell and Stager (2000) discovered. Three age groups were the focus of this study: 14-, 17-, and 20-month-olds. The inclusion of 14-month-olds in this study provided a comparison to the participants in Stager and Werker (1997). The two older groups were included in the study in order to observe a possible developmental trend. Using similar stimuli to those found in Stager and Werker (1997), Werker et al. (2000) showed that 17- and 20-month-olds easily learned to link the phonetically similar labels to two different objects. The two groups of older infants looked significantly longer at the switch trial. The 14-month-old infants did not notice the switch, as in the original study. Even with the changes in stimuli, the younger infants could not learn the phonetically similar labels in the lexical task.
This pattern of results confirms that infants are more successful at encoding fine detail in a word-object associative task as they become better word learners.

Recent work by Swingley and Aslin (in press) also shows that older infants, from 18 to 23 months, have a detailed phonetic representation of words. These researchers recently demonstrated that 18- to 23-month-olds had delayed visual latencies to targets when the well-known object’s label was mispronounced on the initial consonant. An example of this would be labelling the visual target “baby” with the nonsense word “vaby”. This study shows that infants as young as 18 months have detailed representations of well-known words. Although Swingley and Aslin use this evidence to claim that early word learners have detailed lexical representations, we believe that their lack of data on infants at the beginning of word learning limits their conclusion to older word learners (Werker et al., 2000).

The studies reviewed thus far show that although infants can discriminate phonetic differences at a young age, they do not appear to be utilizing this ability in the early stages of word learning. However, these data come from monolingual, and mostly English monolingual, participants. Before extending these theories and findings to bilingual infants, it is necessary to give a brief introduction to what is known about the early speech perception and word learning abilities of this population.

Language Development in Infants Exposed to Two Languages

Despite the prevalence of bilingualism in our population, psychologists and linguists currently know very little about the course of bilingual infants’ overall language development or, more specifically, their development in the areas of speech perception and word learning. This limited knowledge is due not only to the small number of studies that have focused on infants who are raised in a bilingual environment, but also to methodological problems with the available studies. Many of the research reports are case studies involving one or two children.
Also, a number of studies lack strict measures of bilingualism, further restricting the generalizability of the results.

Bilinguals appear to follow a similar language development path as monolinguals. The evidence thus far indicates that bilingual infants pass language milestones, such as canonical babbling and two-word utterances, around the same ages as monolinguals and in the same developmental order (de Houwer, 1995; Oller, Eilers, Urbano & Corbo-Lewis, 1997). For example, in a study comparing bilinguals and monolinguals, Oller et al. (1997) discovered that the onset of canonical babbling in the two groups only differed by 4 days, a non-significant difference.

Despite this similar path of development, bilingual infants could use different processes to pass milestones at similar ages to monolinguals. A substantial debate in bilingualism research is whether bilinguals have a single or dual lexicon. In a classic article, Volterra and Taeschner (1978) proposed that bilinguals mix their two languages at the beginning of lexical development and then gradually begin to differentiate the two lexicons. This hypothesis has been heavily criticized over the past two decades (e.g. Pearson, Fernández & Oller, 1995; Pye, 1986; for a comprehensive review see de Houwer, 1995). While the field has yet to resolve the dual lexicon question, current theory leans toward differentiated lexicons from the beginnings of the word learning (Pearson et al., 1995; de Houwer, 1995; Quay, 1995; see Vihman, 1985 for an opposing opinion). The current study does not address this theoretical question. However, evidence that is heavily used in the dual lexicon question can demonstrate another point of more direct relevance to this thesis.

Volterra and Taeschner (1978) based the mixed lexicon conclusion on their finding, which was based on diary records from three children of linguists, that there are no translation equivalents\textsuperscript{11} in the bilingual’s early lexicon. The study can be critiqued for its experimental procedure. The use of linguists’ children challenges the generalizability of the results, as does
the small number of subjects. The use of diaries could lead to bias in reporting vocabularies. Finally, the children may not be representative of all bilinguals because they were primarily learning one language from one parent and the other language from the other parent. This learning situation would reduce their need for translation equivalents (Pearson et al., 1995).

Other researchers, using different, and perhaps more appropriate, experimental techniques, reach a different conclusion and report that bilinguals do have translation equivalents in their early vocabularies. Johnson and Lancaster (1998) and Quay (1995) both used case studies to investigate the presence of translation equivalents. Johnson and Lancaster used multiple measures (diaries, audio recordings, and the MacArthur Communicative Development Inventory, or CDI) in their research and discovered the presence of translation equivalents in the vocabulary of a Norwegian-English bilingual infant across the second year of life. Quay extrapolated vocabulary features from diary records and video recordings of a Spanish-English bilingual from birth to 22 months. Quay also found that translation equivalents were present in the infant’s vocabulary. Pearson et al. (1995) utilized a sample of 27 children in their study of translation equivalents. The ages of the participants in this study ranged from 8 to 30 months. Pearson et al. used the English and Spanish versions of the CDI to measure vocabularies. Through the comparison of the two versions of this parental measure, Pearson et al. found that all but one of the infants had translation equivalents present in their early vocabularies. On average, the translation equivalents made up 30.8% of the infant’s total lexicon. Despite the possible individual limitations of these three studies, the use of improved measures, the inclusion of a variety of bilingual infants, and the similarity of the findings across experiments and measures provides convincing evidence that translation equivalents are present from the beginnings of word learning.

The data from the three studies mentioned above argue persuasively that infants can learn words in both languages from the start of the word learning period. At 22 months, the
vocabulary of the infant in Quay's (1995) study consisted of 50% English words and 35% Spanish words (the remaining items were ambiguous between the two languages). At 14 months of age, the bilingual in Johnson and Lancaster (1998) was producing 40% of his words in English and 60% in Norwegian when measured using the CDI. In Pearson et al. (1995), translation equivalents, and therefore words in both languages, are present in infants as young as 12 months. These findings demonstrate that infants who are being exposed to two languages are learning words at these young ages, just like their monolingual peers. Also, the infants have the ability to match word units to their appropriate meanings in their two languages, even when they share the same meaning, as with translation equivalents.

Although there have been numerous cross-linguistic studies examining how monolingual infants perceive the units of their own versus another language (e.g. Werker & Tees, 1984), very few studies have examined speech perception abilities across the two languages of bilingual infants. Cross-linguistic studies demonstrate that phenomena like segmentation cue recognition (Christophe, Dupoux, Bertoncini & Mehler, 1994) and legal phonotactics preference (Friederici & Wessels, 1993) are present across languages. However, using monolingual data from two languages to demonstrate similar processes does not mean that a bilingual infant learning those two languages necessarily follows the same pattern. The interplay between the languages could lead to surprising results, as was found in the only published study to examine the speech perception abilities of infant bilinguals.

Bosch and Sebastián-Gallés (1997) tested 4-month-old monolinguals and bilinguals on language discrimination and familiarity to native languages. Using a visual orientation latency procedure where shorter latencies to stimuli indicated familiarity, the researchers compared infants being raised in monolingual environment with those being raised in a bilingual environment. The results from their first two experiments demonstrated that monolingual infants could easily discriminate their native language from a non-native language, even when the two
languages were prosodically similar. In their third experiment, the researchers low-pass filtered the language to remove most of the segmental differences, leaving the prosody of the languages. The monolingual infants still had significantly shorter orientation latencies to their native language, indicating that they utilized the rhythmic properties of the languages to perform the discrimination.

Having shown how monolinguals perform, Bosch and Sebastián-Gallés (1997) tested Catalan-Spanish bilinguals in the same tasks to see if bilingual speech perception differs from that of monolinguals. To their surprise, the researchers discovered that bilinguals showed longer, rather than shorter, orientation latencies to one of their native languages as compared to a non-native language, whether the non-native language was phonologically similar to the native language or not. This pattern is completely opposite of what was seen in monolinguals. Bosch and Sebastián-Gallés (1997) did not have a clear explanation for why this occurred. However, the results clearly demonstrate that bilingualism can affect speech processing, even in very young infants.

There is no work to date on the phonetic detail used in word learning by bilingual infants. Indeed, the finding that monolinguals do not detect fine detail in the earliest stages of word-learning is so recent that there is not yet even any specific speculation as to how a bilingual learning infant might perform. However, studies demonstrating that bilingualism affects language processing in the infancy period (i.e. Bosch & Sebastián-Gallés, 1997) raise the distinct possibility that bilinguals could perform differently from monolinguals in word learning tasks. Thus we have to turn to more general theorizing about language acquisition in bilinguals to find predictions in the literature.

One proposal is that bilinguals will show enhanced linguistic awareness. Even here, there is little research involving infants as participants. Vygotsky (1934/1962) theorized that the internal comparison of languages in bilinguals would lead to greater knowledge of the properties
of language. Following from this theoretical possibility, Ianco-Worrall (1972) studied Afrikaans-English bilinguals as young as 4 years old and found that they had a better understanding of the arbitrary nature of the relationship between word and referent. This finding was replicated by Bialystok (1988) using 6- to 7-year-old partial and fluent French-English bilinguals. Bialystok (1988, 1999) postulates that the bilinguals’ superior performance on these tasks is a function of their higher level of linguistic control, meaning that they can more easily attend to and manipulate critical aspects of language. Bialystok has demonstrated this advanced control in more abstract language areas (i.e. grammar, semantics), but has not shown it in a phonological language task. Further support for the possibility of enhanced linguistic awareness in young children comes from two studies that demonstrated that bilingual two-year-olds could translate words between languages and address a monolingual interlocutor in the appropriate language (Lanza, 1997; Levy, 1985). The finding that two-year-old bilinguals possess such sophisticated metalinguistic skills supports the possibility that enhanced language awareness extends to even younger ages.

Some language researchers have argued for a range of metalinguistic skills that extends to the infancy period. Lanza (1997), in talking about sociolinguistics and bilingualism, states that it is possible that infants may have a rudimentary form of metalinguistic awareness. The argument here is that the enhanced awareness is simply easier to see in older bilingual children because it is more explicit (e.g. you can ask an older child to translate a word or if two words rhyme). (See also Slobin, 1978.)

The only studies investigating phonological awareness in young bilinguals are those of Rubin and Turner (1989) and Bruck and Genesee (1995). Rubin and Turner used, among other tasks, a language analysis procedure in their study. This task consisted of the researcher saying a word aloud (e.g. mine) and then requesting that the child repeat the word without saying a part of the word (e.g. “Say mine. Now, say it again, but don’t say /m/.”) Rubin and Turner found that
“bilingual” 6-year-olds were significantly better at analyzing spoken words and non-words than monolinguals. Similarly, Bruck and Genesee discovered that “bilingual” kindergarten-aged children were better at onset-rime detection than monolinguals; however, this difference was not evident in children attending grade one. While the results of these studies are interesting, the criteria used for bilingualism in both studies are not as strict as would be ideal. The “bilingual” group consisted of Anglophone children attending their first years of a French Immersion programme. This is not an acceptable criterion for bilingualism when compared to the much stricter limits set by many other researchers (e.g. De Houwer, 1995).

No study has investigated the phonetic awareness of young bilinguals. The phonological studies mentioned above have the closest relevance to the current study. However, the poor experimental design and emphasis on literacy skills detract from their applicability. Nonetheless, if the enhanced language awareness in young bilinguals seen across various language areas extends to (1) phonetic awareness and (2) the infancy period, bilingual infants may be better able to attend to fine phonetic detail in a lexical task than their age-matched monolingual peers.

Hypotheses

The question addressed in the current study is: Can 14-month-old ‘bilingual’ infants attend to fine phonetic detail in a word learning task? As we have seen in Bosch and Sebastián-Gallés (1997), bilingual speech perception appears to differ from that of monolinguals. Perhaps bilingual infants’ attention to the phonetic detail of words is also different.

On the basis of the evidence concerning increased phonetic awareness in older bilingual children, it could be hypothesized that bilingual learning infants will be better able to learn phonetically similar words than are monolingual infants. Through the process of being exposed to two different languages (i.e. two different phonetic systems), the bilingual may have a greater ability to attend to phonetic information. This could be due to a need to keep the two languages separated. A contrasting, and equally plausible, hypothesis relates to the conclusion found in
Stager and Werker (1997). If the inattention to phonetic detail is due to the increased cognitive load of word learning, the bilingual infants would not be expected to be any better than monolingual infants in learning phonetically similar words. The young bilinguals would not only be word learning beginners, just like their monolingual counterparts, but they would have the added difficulty of learning two lexicons. Based on these assumptions, 14-month-old infants being raised in a bilingual environment would not notice the switch when the two labels are phonetically similar, just like monolinguals of the same age.
Method

Infants:

Sixteen bilingual infants successfully completed the study. An additional 18 infants were tested in the task but were not included in the analyses because they were fussy (n = 12), sleepy (n = 1), off-camera (n = 1), their parents interfered in some way during a test trial (n = 2), or due to experimenter/technical error (n = 2). The infants had a mean age of 14 months, 12 days (range = 13 months, 22 days - 15 months, 5 days). All subjects were without apparent health or hearing problems and were at least 37 weeks gestation.

The infants were selected from the infant database in Dr. J. F. Werker’s lab. The infants in this database were recruited by four means: (1) through visiting new parents at the B.C. Women and Children’s Hospital, (2) through public service announcements in the local papers and radio stations, (3) by placing posters in community centres, and (4) by giving handouts to participating mothers to give to other parents in their community. During recruitment, these parents agreed to be contacted at a later date for possible participation in a study. They were also invited to contact us at any time. Infants who participated in this study were given an “Infant Scientist” T-shirt and diploma. In addition, the parents were reimbursed for any parking or bus expenses they incurred.

To be considered bilingual, the infant had to have a minimum of 30 percent exposure to one language and a maximum of 70 percent exposure to the other. These limits are based on, but slightly more conservative than, the language exposure limits recommended by Pearson, Fernández, Lewedeg, and Oller (1997). After completing a study which examined the relationship between amount of language exposure and the child’s bilingual vocabulary, Pearson et al. recommended that the minimum language exposure for inclusion in an infant or toddler bilingualism study should be 75 percent of one language and 25 percent of the other. Another requirement for inclusion in the present study was exposure to the two languages from birth.
This is in accordance with de Houwer’s (1995) bilingual first language acquisition strict cut-off of one month of age. She theorized that in order to have native bilingualism, one has to be exposed to both languages regularly from the first month of life.

The infants’ language exposure was measured by a Language Exposure Questionnaire\textsuperscript{15}, which has been used to classify bilinguals in previous published research (Bosch & Sebastián-Gallés, 1997; See Appendix). The questionnaire requires parents to provide precise estimates of the infant’s exposure to both languages. An estimate is given for each major caregiver in the infant’s life (e.g., parents, grandparents, childcare workers). De Houwer (1995) argues that the use of this type of measure is a critical component for quantifying bilingual exposure.

Using the questionnaire, the researcher interviewed the parents after the infant had completed the study. The infants’ language exposure ranged from 30 to 66 percent for English, with a mean of 49.1 percent. The amount of exposure to other language ranged from 34 to 70 percent, with a mean of 50.4 percent\textsuperscript{16}. A full breakdown of participants’ languages and percent exposure to each language can be found in Table 1.

Audio Stimuli

The audio stimuli were three nonsense words: “bih”, “dih”, and “pok”. The habituation and test stimuli were “bih” and “dih.” These two labels were identical to those used in both Stager and Werker (1997) and Werker et al. (2000). These two labels differ only in the place of articulation of the initial consonant. The third label, “pok,” was used in the pre- and post-test trials. “Pok” was chosen because it differs from the habituation labels. Therefore, the infants should discriminate it with ease (see Stager, 1995, for a detailed discussion on the selection of both audio and visual stimuli).

A native-English, female speaker recorded the audio stimuli in a soundproof booth. Seven exemplars of each label were recorded, all in an infant-directed manner of speech. Each exemplar was approximately 0.7 s in duration, with a silent 1.5 s interval between tokens,
producing an audio file of 14.0 s in duration. The creation of a longer audio file resulted from
looping the original 14.0 s segment and cutting it during an interval at the 20.0 s mark. The file
was 20 seconds long to once again provide comparison to the English monolingual data in
Werker, Corcoran, Fennell and Stager (2000).

**Video Stimuli**

The visual stimuli used in the habituation and test phases of the study consisted of two
attractive objects, “poky” and “molecule.” The first object was made from red, blue and yellow
coloured modelling clay (see Figure 1), and the second was made using the green and turquoise
components from a chemistry set (see Figure 2). A store-bought, multicoloured toy water wheel
was used for both the pre- and post-tests (see Figure 3). All three objects were videotaped
against a black background and then transferred to laser disk format. The objects were filmed
moving back and forth across the screen at a slow and constant speed and the water wheel was
filmed moving around in a rotating motion. These visual stimuli matched the stimuli used in
Werker, Corcoran, Fennell and Stager (2000), thus providing a direct comparison to the
monolingual infants in this study.

**Apparatus**

The experiment took place in a 2.1m by 2.8m quiet room, which was dimly lit by a
shaded 60W bulb situated 60 cm to the left of the infant at a 45 degree forward angle. The infant
sat on the parent’s lap facing a 45 cm Mitsubishi HC3905 video monitor, which had a 640 dot by
480 line vertical resolution. The video display was 115 cm from the infant. The monitor was
surrounded by black cloth, which stretched the width and height of the room. The was
videotaped using a Panasonic AG-180 Pro-line video camera allowing looking time to be
recorded on-line by the experimenter in the control room. The lens of the video camera
protruded from of a 6 cm hole in the black cloth located 25 cm below the monitor. The audio
stimuli were played using a BOSE 101 speaker, located directly above the monitor. These stimuli played at 65 (+/-3) dB, as measured by a Radio Shack sound level metre.

As a control during testing, the parent wore Koss TD/65 headphones over which female vocal music was played from a Panasonic XBS portable stereo. The headband of the Koss headphones broke near the completion of the study, so the final few parents wore Peltor HT7A headphones, which have similar technical specifications. The headphones masked the audio stimuli.

The experiment was controlled by a version of the Habit program, created by Leslie Cohen’s infant speech laboratory at the University of Texas at Austin. The program was run on a Power Mac 8500/120 linked with a Sony LDP-1550 laser-disc player. The visual stimuli from the laser disc and the audio stimuli from a digitized audio file were synchronized and sent to monitor and speaker in the testing room.

The experimenter monitored the infant’s looking times via a closed circuit television system. The infant was displayed on a Panasonic 13-inch colour television in the observation room. A designated key was pressed on the computer keyboard during infant looks, which the Habit program recorded.

Procedure

The infant sat on the parent’s lap facing the television screen. Parents wore headphones through which they listened to a female voice singing with musical accompaniment. After making sure the parent was comfortable and understood the instructions, the experimenter left the room. The experiment began when the experimenter could see the infant’s eyes focusing on the television screen via the closed circuit television system. A flashing red light preceded the first trial to draw attention to the video display. The same light preceded subsequent trials. When the infant looked at the light, the researcher initiated a trial from the computer.
A modified habituation procedure was used in the study. During the habituation phase, the infants were exposed to two word-object pairings via the television and sound system. One pairing consisted of the "poky" object paired with the label "bih" and the other pairing was the "molecule" object paired with the label "dih". These pairings were presented in blocks of four, which consisted of two occurrences of each. There were six possible orders of the pairings in a block of four. The orders are listed in Table 2. The presentation of these six blocks was randomized at the beginning of each experiment using a random number table. These blocks were presented until the infant's looking time decreased to a set criterion, which was 50% of the total looking time of the first block, or until 24 word-object pairings had been presented. Once one of these two habituation criteria had been met, the two test trials were presented. The "same" test trial consisted of one of the pairings used during the habituation phase (e.g. "poky" - "bih"). In the "switch" trial, the object was labelled with the other object's name (e.g. molecule - "bih").

The researcher assigned one male and one female infant to each of eight possible presentation orders in the test phase of the experiment. The test orders are listed in Table 3. These orders counterbalanced label ("bih" or "dih") and object (pokey or molecule) association along with the presentation of same and switch trials. As a control, a novel word-object pairing, which had been presented as a pretest before the habituation trials (the "pok" – water wheel combination), was presented after the test trials to ensure that the children had become habituated to the stimuli and were not just fatigued or generally disinterested in the task. All trials were 20 seconds long.

Coding:

For on-line coding, the experimenter pressed a computer key when the infant was looking at the visual display, and released it when the infant looked away from the display. A second coder then performed reliability tests off-line by scoring 25% of the infants' videotaped
responses. A Pearson correlation of on-line (i.e. first coder) and off-line (i.e. second coder) trial scores was calculated and found to be significant (r = .997, p = .000).

Results

To ensure that the infants had habituated to the stimuli as a group, a planned comparison was run comparing the first block (first four habituation trials) of the habituation stimuli, the last block (last four habituation trials) and the post-test. Blocks were used in order to represent both object-label combinations. The results demonstrated that the last block significantly differed from the first block and the post-test, t(45) = 11.640, p = .000; M{subscript: FIRST BLOCK} = 15.089, SD = 3.531; M{subscript: LAST BLOCK} = 7.414, SD = 2.872; M{subscript: POST TEST} = 19.200, SD = 1.284. This indicates that the infants did habituate to the stimuli and the recovery to the post-test showed that they were not fatigued with the experiment.

To directly test the question of whether or not bilingual infants can learn phonetically similar words, a mixed 2 (trial type: same vs. switch) x 2 (gender: male vs. female) ANOVA was run. The trial type factor was not significant, F(1, 14) = .237, p = .634; M{subscript: SAME} = 7.075, SD = 3.554, M{subscript: SWITCH} = 7.681, SD = 5.212. See Figure 4 for a graph of the results. These results provide no evidence that the infants attended to the fine phonetic detail in the task. There was neither an effect for gender nor an interaction between the factors (see Table 4).

An analysis of the relationship between level of bilingualism and performance on the task was also conducted. An explanation of how these two variables were computed is in order. Level of bilingualism was determined by subtracting the percentage exposure to the non-dominant language from the percentage exposure to the dominant language. An example of this scoring technique will clarify this point. Referring to Table 1, one can see that Subject 1 had 62% exposure to one language and 38% exposure to the other. According to the scoring technique used, this participant's level of bilingualism score would be 24 (62 - 38 = 24). Therefore, the closer this score is to zero (50 - 50 = 0), the more balanced the infant's bilingual
exposure would be. Performance of the task was computed by subtracting the number of seconds on the "same" test trial from the total looking time to the "switch" trial. Higher positive scores on this measure indicate better performance on the task (i.e. longer looking times to the "switch" trial).

Using a bivariate correlation analysis, one would expect a significant negative correlation between these two variables if level of bilingualism (i.e. having balanced exposure to the two languages) aided performance in the task. Inversely, if level of bilingualism hampers performance on the task, a significant positive correlation should be found. The analysis showed that there was no significant correlation between the two variables \( r = -.052, p = .848 \).

**Discussion**

There were two possible outcomes for the study. The bilinguals could have noticed the switch, thus indicating that they attended to the fine phonetic detail. This would have supported the enhanced language awareness hypothesis. The other possibility was that the bilinguals would not notice the switch, just like the monolinguals. This inattention to the phonetic detail, if due to the demands of word learning, would support Stager and Werker's computational complexity hypothesis.

The results of this study indicate that the bilinguals are performing similarly to monolinguals in this word-object associative task. Infants who are exposed to two languages do not appear to be utilizing fine phonetic detail when learning word-object associations. These data correspond to other results that indicate that monolinguals and bilinguals follow similar paths in language development (de Houwer, 1995; Oller et al., 1997). The data are also consistent with the hypothesis put forth by Werker and Stager and their colleagues that the complexity of word learning leads to difficulty in applying phonetic discrimination skills in this task. The bilingual infants may be limiting their use of phonetic detail in order to complete the task successfully, just like their monolingual counterparts. This behavioural pattern fits well
considering these infants are also at the beginning of the word learning process. Moreover, they are learning words in two languages, which may be even more cognitively complex.

Therefore, the inattention to fine detail appears to be a pattern present across infants with very different language exposure backgrounds. Not only do monolinguals and bilinguals show a similar pattern of results, but, as indicated by the correlation analysis, level of bilingualism also has no effect on the pattern. Irrespective of amount of exposure to their two languages, the bilingual learning infants appear unable to notice the switch.

These results fit well with other recent findings that are consistent with the data found in Stager and Werker (1997) and Werker et al. (2000). Prat, Stager, Mitchell, Adamson and Sanders (1999) recorded the event-related potentials (ERP) to phonetically similar and dissimilar words in 14- and 20-month-olds. The event related potentials to nonsense words did not differ from phonetically similar known words at 14-months, but did differ at 20-months of age. A difference in ERP patterns was present at both ages when the nonsense word was phonetically dissimilar from the known word. These neurophysiological findings match the behavioural data found in the research of Werker and her colleagues. In a different kind of approach, Schafer (1999) used computational modelling to demonstrate that a network at a stage similar to the beginnings of word learning also cannot discriminate fine phonetic detail in a word-object associative task. Moreover, like the infants, the network can discriminate the same phonetic contrasts when they are not paired with an object. The replication of the original finding in Stager and Werker (1997) across methodologies, stimuli, measures, and populations serves to increase confidence in the data.

The results of the current study indicate that bilingual exposure did not increase the attention to phonetic detail in the present task. Therefore, an enhanced language awareness hypothesis does not appear to be supported at this age. The lack of evidence for this hypothesis could be due to many factors.
One possibility is that the phonemic awareness studies with older children are not applicable to children raised in a bilingual environment from birth. As was discussed in the Introduction, the participants in the cited studies were monolingual children starting schooling in another language. Higher socio-economic status or parental education could account for the enhanced phonemic awareness. Parents who enrol their children in immersion programmes tend to be highly educated and have a higher SES. Parents raising their children in a bilingual environment from birth may not all share these characteristics.

Another possibility is that the task is not appropriate for revealing enhanced linguistic awareness. Perhaps the bilingual infants do have greater phonetic awareness, but it is not seen in this study because the demands of word learning interfered (see Stager and Werker, 1997). A simpler speech discrimination task may reveal enhanced awareness.

Finally, enhanced phonetic awareness may not be evident until the child advances in more general metalinguistic knowledge. According to Lanza (1997), this conscious awareness of the properties of language usually emerges around the age of four, although she and Levy (1985) both state that bilinguals may have metalinguistic awareness around two years of age. Even if this earlier age were taken as accurate, 14-month-olds would not yet have a conscious awareness of language properties. Perhaps once bilingual children consciously realize that they are dealing with two languages, the phonemic awareness seen in older bilinguals may emerge.

Although numerous researchers have proposed differences between monolinguals and bilinguals (e.g. greater phonemic awareness in bilinguals), De Houwer (1995), in her review of bilingualism, points out that many studies, using very different methodologies, have found similarities between the two groups with respect to steps in language development. She believes that the "generalization that bilingual and monolingual development are highly similar....(is) a very robust finding" (p.244). The current finding contributes to the body of literature on which this "robust" finding is based. Despite having to deal with learning two languages and the
interplay between those languages, bilingual infants and children appear to lend credence to the consistency of the language learning process. Certainly, the 14-month-old bilinguals seem to be at the same developmental point as monolinguals in this task, although the possibility still remains that they may deviate from this path at an older age.

Limitations

There are two limitations to the current study. First, while all the infants had English as one of their two languages, the second language was free to vary. This decision to include multiple languages can be criticized for uneven exposure to the /b/ and /d/ phonemes across the languages. A bilingual infant who had greater exposure to /b/ and /d/ may be able to discriminate these phonemes better than an infant who has less exposure. However, it should be noted that these units, while they may have slightly different phonetic instantiations across languages, are two of the more common phonemes in the world’s languages (R. Shi, personal communication) and that all the infants in the study were guaranteed exposure to these phonemes because of their English exposure.

The second limitation of the study is the fact that the bilingual infants’ ability to discriminate the two phonemes in a straight speech perception task is assumed, not known. Previous research by Werker and her colleagues, as discussed in the Introduction, indicates that exposure to a native language permits an infant to retain sensitivity to the phonemes of that language while the sensitivity to non-native phonemes decreases. Theoretically extending this to bilinguals would mean that the bilingual infant retains sensitivity to the phonemes in both of their languages. However, this research has yet to be done. If the bilinguals do not show an ability to discriminate /b/ and /d/ in a straight perception task, it would demonstrate that they fundamentally differ from monolinguals in their basic ability to perceive these two phonemes, despite the similarities found between the two groups on the word-learning task. Monolingual infants can easily discriminate the phonemes in a non-word-learning task and the Stager and
Werker (1997) hypothesis was partially based on this finding. So, if the infants who are exposed to two languages (with one or both of the languages containing the relevant phonemes) do not discriminate the phonemes in a speech discrimination task, the reason behind their failure to learn the minimally different words in the current task would be due to a qualitatively different process that that proposed by Stager and Werker (1997) and Werker et al. (2000). There is no theoretical reason to believe that the bilingual infants would not discriminate the phonemes in a non-word-learning task. However, the work of Bosch and Sebastián-Gallés (1997) indicates that bilinguals can produce surprising results in speech perception tasks. Therefore, a study investigating this very issue is currently being run. Fourteen-month-old bilingual infants are being tested in a straight speech perception task. The results of this study will prove or disprove the assumption that bilingual infants can discriminate phonetic detail in a speech discrimination task.

Future Research

We know that 14-month-old bilinguals cannot learn phonetically similar words in a word-object associative task. The next logical step is to track this phenomenon developmentally. As mentioned before, our lab discovered that monolingual 17- and 20-month-olds could easily learn the phonetically similar labels in this task (Werker et al., 2000). Will infants who are exposed to two languages remain on the same developmental path as monolinguals? By testing these two older age groups, this question can be answered. An interesting possibility is that the bilinguals may actually take longer to use fine phonetic detail in the word-object associative task. If learning words in two languages is more demanding, then the process of ignoring fine phonetic detail may be useful for a longer period of time. This possible result would be observed in a developmental study.

Another line of future research involves restricting the bilingual sample to only one linguistic group (e.g. French-English bilinguals). This will restrict the amount of noise in the
data due to differing amounts of the /b/ and /d/ phonemes across languages. It also allows for the construction of stimuli that are more language specific. For example, English-French bilinguals can be exposed to minimally different English-type stimuli (based on phonemes, phonotactics) or minimally different French-type stimuli. This would allow for an investigation into possible language differences in the task. One may predict that if the bilingual is exposed to more of one language or if they prefer one of the languages, they may be able to discriminate the detailed phonetic stimuli in the word-learning task in that language before doing so in their other language.

**Conclusions**

Like their monolingual peers, infants being raised in a bilingual environment do not use fine phonetic detail in a word learning task. The enhanced language awareness postulated by some researchers was not observed in the current study. Despite having to deal with two different languages, these infants did not use more phonetic detail in the task than the monolinguals. The results provide further evidence for the hypothesis that this inattention to detail is adaptive for young word learners. The reduction in the use of phonetic detail may free cognitive resources for the complex task of learning words.

Despite the global prevalence of bilingualism, most of the previous research on early language acquisition has focussed exclusively on monolinguals. The current study begins to extend speech perception and word learning research to the significant portion of the population who are being raised in a bilingual environment. Through studies such as this, we can gain a clearer picture of language development in all infants.
Endnotes

1 De Houwer (1995) quotes Wölck's (1987) estimate that half of the planet's population is functionally bilingual, many from birth.
2 Of course, "bilingual" in this study refers to bilingual exposure, or regular exposure to two languages. Since the infants are producing few or no words, the term bilingual is not entirely appropriate, but is used for brevity's sake.
3 Metalinguistics refers to the conscious knowledge of language and the conscious manipulation of language input.
4 Voice onset time is a measure of time difference between the vibration of the vocal cords and the emission of sound from the vocal tract. For example, a small amount of VOT distinguishes /bl/ from /pl/.
5 Phonotactics are the rules that govern acceptable phoneme sequences in a language. For example, "tr" is acceptable in English, but not Japanese. "Lba" is not acceptable in English, but it is in Russian.
6 These are not words in the truest sense of the meaning. This is due to the fact that the units of sound are not being associated with any meaning.
7 The infants did notice a difference when the manner of articulation of the initial consonant was altered (e.g. "bonjour" to "vonjour").
8 Werker et al. (1998) found that the object has to move in order for the infant to succeed in pairing the object and label.
9 In order to adapt the procedure to older infants, the individual trial times were increased from 14s to 20s and the habituation criterion made stricter, changing from 65% to 50%. Finally, the researchers made the objects more visually distinct by changing one of the objects to a blue, molecule-shaped object. The audio stimuli remained the same. The changes were held constant across the three age groups.
10 There is an even greater scarcity of research on multilingual infants, who are defined as those being raised with more than two languages in their home environment. The field knows virtually nothing about these infants.
11 Translation equivalents are words found in both lexicons of the infant. For example, if a French-English bilingual child knows "milk" and "lait", that child is said to have at least one translation equivalent present in their overall vocabulary.
12 Both monolingual and bilingual infants can discriminate between languages (Bosch and Sebastian-Galles, 1997; Mehler, Jusczyk, Lambertz, Halsted, Bertoncini & Amiel-Tison, 1988; Moon, Cooper & Fifer, 1993), a pre-requisite for attending differentially to the speech sounds of each of their languages.
13 See Bosch and Sebastian-Galles (1997) for a more detailed explanation of this novel testing procedure.
14 Bialystok (1999) found that 3- to 6-year-old bilinguals also have greater levels of control in a non-linguistic task. The task involved sorting cards according to rule system based on colour or shape. The rule system would switch from colour-based to shape-based or vice-versa. The children's post-switch performance was the measure.
15 Laura Bosch sent the Language Exposure Questionnaire to the author in its original Spanish form. The author translated the questionnaire into English for use in this study. Two native Spanish speakers checked and confirmed the author's translation.
16 The two mean percentages do not add to 100 because one participant had a small amount of exposure to a third language (see Table 1).
References


Appendix: Bilingual Questionnaire

Bilingual Questionnaire

Personal Data

NAME OF PARENT: ________________________________

NAME OF BABY: ________________________________ AGE: ___ months ___ days

DATE OF BIRTH: _________________

DATE OF EXPERIMENT: _________________

Language Environment

LANGUAGES SPOKEN BY FAMILY:

Are there other people living in your home? YES □ NO □

If YES, please include them in the table below.

CARETAKERS/FRIENDS OF YOUR BABY (e.g., parents, grandparents, siblings, playmates, etc.):

<table>
<thead>
<tr>
<th>Who</th>
<th>Language Spoken</th>
<th>Since when?</th>
<th>Days/Week</th>
<th>Hours/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

DAYCARE

Since………………………. Hours/Day……………………..

Language(s) Spoken……………………………………..

AMOUNT OF CONTACT WITH PEOPLE WHO SPEAK DIFFERENT LANGUAGES THAN THOSE SPOKEN AT HOME:

__________________________________________________________________________
ESTIMATE AMOUNT OF EXPOSURE TO DIFFERENT LANGUAGES IN THE COURSE OF A DAY:

<table>
<thead>
<tr>
<th>LANGUAGE</th>
<th>HOURS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Are these different percentages on weekends or during vacations? YES □ NO □
If YES, please give those percentages: ________________________________

******************************************************************************

TOTAL ESTIMATE: .......... % L1/ .......... % L2/ .......... % other

DO YOU WISH TO PARTICIPATE IN OTHER STUDIES?: YES □ NO □
Table 1

Language Exposure Data

<table>
<thead>
<tr>
<th>Subject</th>
<th>Percent Exposure to English</th>
<th>Other Language</th>
<th>Percent Exposure to Other Language</th>
<th>Third Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>French</td>
<td>62</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td>Mandarin</td>
<td>71</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>Cantonese</td>
<td>50</td>
<td>---</td>
</tr>
<tr>
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<tr>
<td>6</td>
<td>35</td>
<td>Cantonese</td>
<td>65</td>
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<td>53</td>
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<td>62</td>
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<td>Italian</td>
<td>52</td>
<td>---</td>
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<td>Japanese</td>
<td>38</td>
<td>---</td>
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<td>16</td>
<td>60</td>
<td>Illongo</td>
<td>40</td>
<td>---</td>
</tr>
</tbody>
</table>
Table 2

Presentation Orders During Habituation

<table>
<thead>
<tr>
<th>Order</th>
<th>Sequence</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2 1 1 2</td>
</tr>
<tr>
<td>2</td>
<td>2 1 2 1</td>
</tr>
<tr>
<td>3</td>
<td>1 2 2 1</td>
</tr>
<tr>
<td>4</td>
<td>1 2 1 2</td>
</tr>
<tr>
<td>5</td>
<td>1 1 2 2</td>
</tr>
<tr>
<td>6</td>
<td>2 2 1 1</td>
</tr>
</tbody>
</table>

1 = the “pokey”-“bih” pairing
2 = the “molecule”-“dih” pairing
Table 3

Possible Testing Orders

<table>
<thead>
<tr>
<th>Order</th>
<th>Test Trial #1</th>
<th>Test Trial #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bih – Pokey</td>
<td>Bih – Molecule*</td>
</tr>
<tr>
<td>2</td>
<td>Dih – Pokey</td>
<td>Dih - Molecule</td>
</tr>
<tr>
<td>3</td>
<td>Dih – Molecule</td>
<td>Dih - Pokey</td>
</tr>
<tr>
<td>4</td>
<td>Bih – Molecule</td>
<td>Bih - Pokey</td>
</tr>
<tr>
<td>5</td>
<td>Dih – Molecule</td>
<td>Bih - Molecule</td>
</tr>
<tr>
<td>6</td>
<td>Dih – Pokey</td>
<td>Bih - Pokey</td>
</tr>
<tr>
<td>7</td>
<td>Bih – Pokey</td>
<td>Dih - Pokey</td>
</tr>
<tr>
<td>8</td>
<td>Bih – Molecule</td>
<td>Dih - Molecule</td>
</tr>
</tbody>
</table>

* Please note that the “switch” trials are bolded.
Table 4

ANOVA Results

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig. of F</th>
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</thead>
<tbody>
<tr>
<td>Test Trials (Same vs. Switch)</td>
<td>2.940</td>
<td>1</td>
<td>2.940</td>
<td>.237</td>
<td>.634</td>
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<tr>
<td>Gender</td>
<td>23.290</td>
<td>1</td>
<td>23.290</td>
<td>.816</td>
<td>.382</td>
</tr>
<tr>
<td>Test * Gender</td>
<td>.028</td>
<td>1</td>
<td>.028</td>
<td>.000</td>
<td>.988</td>
</tr>
</tbody>
</table>
Looking Times to Test Trials

Looking Time in Seconds

<table>
<thead>
<tr>
<th>Test Trial</th>
<th>Looking Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>7</td>
</tr>
<tr>
<td>Switch</td>
<td>8</td>
</tr>
</tbody>
</table>

The diagram shows the looking times in seconds for two test trials: "Same" and "Switch". The "Same" trial has a looking time of 7 seconds, and the "Switch" trial has a looking time of 8 seconds.