The roots of bilingualism in newborns

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ABSTRACT

The first steps towards bilingual language acquisition have already begun at birth. When tested on their preference for English versus Tagalog, "monolingual" newborns, whose mothers spoke only English during pregnancy, showed a robust preference for English. In contrast, "bilingual" newborns, whose mothers spoke both English and Tagalog regularly during pregnancy, showed equal preference for both languages. A group of Chinese-English bilinguals showed an intermediate pattern of preference. Preference for two languages does not suggest confusion between them, however. Study 2 showed that both English monolinguals and Tagalog-English bilinguals could discriminate English from Tagalog. The same perceptual and learning mechanisms that support acquisition in a monolingual environment thus also naturally support bilingual acquisition.

INTRODUCTION

The human affinity for language begins at or before birth. Neonates show many perceptual sensitivities that are important for language acquisition (Gervain & Werker, 2008). In monolingual acquisition, infants must detect and learn the regularities that characterize a single language. In bilingual acquisition, infants must simultaneously detect and learn the regularities of each of two languages. This requires recognizing both languages as native while at the same time continuing to discriminate them. What tools do neonates have available to negotiate a bilingual environment?

To break into two languages and bootstrap acquisition, one source of information that bilingual infants might use is rhythmicity (Mehler, Dupoux, Nazzi, & Dehaene-Lambertz, 1996). Traditionally, the world's languages have been classified into three rhythmic classes: stress-timed (e.g. Dutch), syllable-timed (e.g. French), and mora-timed (e.g. Japanese). Ramus, Nespor, & Mehler (1999) identified two acoustic dimensions that correlate with rhythmic class distinctions: the standard deviation of the duration of consonantal intervals within each sentence (ΔC), and the proportion of vocalic intervals (i.e. vowels) within each sentence (%V; see Grabe & Low, 2002, for an alternate measurement scheme). Studies have revealed that although categorical divisions are useful, languages fall somewhat continuously along these dimensions (Figure 1).

Research has demonstrated the importance of rhythmicity in early language processing. Newborn infants exposed to only a single language prenatally show greater interest in their native language than in an unfamiliar language from a different rhythmic class (Mehler et al., 1988; Moon, Cooper, & Fifer, 1993). Preferential attention to the native language shows an early effect of learning on language processing, either during

prenatal development or immediately after birth[1]. Studies also show that monolingual neonates can discriminate languages from different rhythmic classes even if both are unfamiliar, but typically fail at discriminating languages within the same class (Hauser, Miller, Morris, & Mehler, 2000; Mehler et al., 1988; Nazzi, Bertoncini, & Mehler, 1998; Ramus, 2002). These findings are understood as evidence that, although language preference is learned through experience, the ability to discriminate languages from different rhythmic classes is an evolutionarily-deep perceptual bias that operates independent of learning (Ramus et al., 2000). Moreover, it has been asserted that the ability to discriminate languages is foundational to bilingual acquisition (Nazzi, Bertoncini, & Mehler, 1998). No studies to date, however, have actually tested either language preference or language discrimination in neonates with prenatal bilingual exposure. Here, we provide the first empirical test of the hypothesis that the same initial perceptual biases and early learning mechanisms that underlie monolingual acquisition operate in the bilingual neonate to propel bilingual acquisition.

To test this hypothesis, we explored the earliest foundations of two capacities crucial to bilingual acquisition. We compared preference for (Study 1) and discrimination of (Study 2) English and Tagalog (languages from different rhythmic classes) in "bilingual" newborns whose mothers spoke both languages regularly during pregnancy, to those of "monolingual" newborns whose mothers spoke only English during pregnancy. Although it could be the case that infants only gradually develop the skills to negotiate a bilingual environment (Arnberg & Arnberg, 1985), our results demonstrate

[1] It is difficult if not impossible to separate the influence of prenatal experience from the possible effects of very early postnatal experience. However, given the much greater amount of prenatal as compared to postnatal listening, we have highlighted prenatal experience throughout this paper.

that, from birth, the recognition and discrimination skills that support monolingual acquisition also support bilingual acquisition.

STUDY 1A

No previous studies have investigated language preference in bilingual neonates. While monolingual neonates orient more towards their native language than towards an unfamiliar language in preferential listening tasks, for optimal learning, infants growing up bilingual should orient to both of their native languages. To investigate the impact of prenatal experience on language preference at birth, we tested newborn infants for their preference for syllable-timed Tagalog (a major language of the Philippines; Bird, Fais, & Werker, 2005), relative to English, a stress-timed language (Ramus et al., 1999; see Figure 1). Two groups of neonates were tested: English monolinguals (whose mothers spoke only English during pregnancy) and Tagalog-English bilinguals (whose mothers spoke both English and Tagalog regularly during pregnancy). We expected that monolinguals would be significantly less interested in Tagalog than in English, as Tagalog was unfamiliar (Mehler et al., 1988; Moon et al., 1993). The previously untested prediction is that bilinguals would be interested in both of their native languages.

Testing was conducted at a maternity hospital in Vancouver, Canada, a multicultural city where English is the majority language but many other languages are widely used. Thirty newborn infants (0-5 days old), half from monolingual English backgrounds and half from bilingual Tagalog-English backgrounds (henceforth called Tagalog bilinguals) completed the study[2]. Mothers of Tagalog bilinguals reported speaking each language 30%-70% of the time.

[2] Data were excluded from an additional 28 infants in Study 1 (preference), and 87 infants in Study 2 (discrimination) because of crying (12 preference/27 discrimination), falling asleep/stopping sucking

Stimuli were sentences matched for pitch, duration, and number of syllables. They were recorded from native English and native Tagalog speakers, and low-pass filtered to a cutoff of 400Hz in order to remove surface segmental cues while preserving rhythmicity. Infants were tested using a high amplitude sucking preference procedure, which capitalizes on newborns' sucking reflex. Newborns sucked on a rubber nipple, and were played a sentence contingently on producing a suck in the upper 80% of their sucking range. Infants heard 10 alternating minutes of 3 different English and 3 different Tagalog sentences (language counterbalanced). To assess preference, the number of high amplitude sucks produced during Tagalog minutes versus English minutes was compared.

A preference score was computed for each infant, as the difference in the average number of sucks produced during Tagalog minutes minus those produced during English minutes (Figure 2). One English monolingual and one Tagalog bilingual outlier were removed whose preference scores were more than 2 standard deviations from their group's mean[3]. Preliminary analyses suggested heterogeneity amongst group variances, $F_{Levene}(1, 26) = 4.87$, p=.036; therefore subsequent analyses employed Welch's correction. This correction often yields non-integer estimates of degrees of freedom.

To determine whether the groups could be characterized as having significant absolute preference for one language over the other, two-tailed one-sample t-tests were conducted comparing infants' preference scores to zero. Monolingual English infants were significantly less interested in Tagalog than in English $t(13)$=-3.44, p=.004. Tagalog

(12/31), experimenter or technical error (3/3), spitting out the rubber nipple (1/5), high amplitude sucks during <2 test minutes (0/10), failure to habituate (0/6), parental/hospital staff interference (0/4), and hiccups (0/1).

[3] Including these infants yielded the same pattern of results.

bilinguals did not show a significant preference for either language, $t(13)=1.76$, $p=.103$. To directly compare the performance of the two groups, a planned directional comparison of infants' difference scores was conducted. Relative to their interest in English, English monolinguals had significantly less interest in Tagalog than did Tagalog bilinguals, $t(18.8)=3.08$, $p=.003$.

The results of this study demonstrate that prenatal bilingual exposure impacts infants' preferences. While English monolingual newborns were less interested in Tagalog than in English, Tagalog bilinguals were similarly interested in their two native languages. Bilinguals' attention to both languages is consistent with their having learned about two languages prenatally.

A counter-explanation consistent with these data is that Tagalog bilinguals recognized neither language as native. Because bilinguals' time is divided between two languages, their experience with each language may have been insufficient to have an effect on perception. The "insufficient experience" explanation leads to a clear prediction: regardless of the particular native languages, any group of bilingual newborns should show the same pattern of language preference. Conversely, evidence that two groups of bilingual newborns demonstrate different patterns of preference would support the position that bilingual newborns have had sufficient experience to learn about each language prenatally.

STUDY 1B

To directly test the "insufficient experience" explanation, we sought a second group of bilingual newborns to evaluate on their preference for Tagalog versus English. As English was a common language to the two groups tested in Study 1a, it was

necessary to find another group of bilinguals that had also heard English prenatally. Chinese-English bilinguals were such a group that was available in our community.

Similarities and differences between Tagalog and Chinese make Chinese-English bilinguals an interesting test case. Both Chinese (Mandarin and Cantonese) and Tagalog have been classified within the larger typological category of syllable-timed languages (Lin & Wang, 2007; Mok, 2008). But as shown in Figure 1, Tagalog and Chinese show rhythmical differences, and there is evidence that 4-month-old bilingual infants are sensitive to intra-class differences (Bosch & Sebastián-Gallés, 1997; Bosch & Sebastián Gallés, 2001). Further, Chinese is characterized by lexical tone (perceptible by adults even in filtered speech; Fu, Zeng, Shannon, & Soli, 1998), while Tagalog is not. Overall, we expected that Tagalog would be somewhat, although not completely, familiar to the Chinese bilingual infants. Thus, as Tagalog is neither completely novel (as it is to English monolinguals), nor completely familiar (as it is to Tagalog bilinguals), we predicted that Chinese-bilingual infants would show a preference intermediate to the preference shown by the two other groups, and statistically different from each of them.

Fourteen neonates whose mothers spoke both English and Chinese (Cantonese, Mandarin, or both) regularly during pregnancy were tested for their preference for Tagalog versus English, in a procedure identical to that used in Study 1a. The results demonstrated that Chinese bilingual neonates did not show an outright preference for either language, $t(13)=-.49$, $p=.63$. As predicted, however, these infants showed a pattern of preference distinct from that of both English monolinguals and Tagalog bilinguals. Planned directional comparisons showed that their interest in Tagalog relative to English was greater than that of English monolinguals, $t(25.5)=1.89$, $p=.035$, but less than that of

Tagalog bilinguals, $t(20.4)=1.77$, $p=.046$. Therefore, relative to their interest in English, Chinese bilingual infants were less interested in Tagalog than were Tagalog bilingual infants (for whom Tagalog was native), but more interested in Tagalog than were English monolingual infants (for whom Tagalog shares few similarities with the native language). These results demonstrate that bilingual newborns' language preference is affected by the specific languages they heard before birth, indicating that bilingual newborns have indeed learned about both their native languages prenatally.

STUDY 2

Studies 1a and 1b demonstrated that by birth, bilingual neonates have already learned about their two languages and, like monolinguals, use this information to direct their attention. However, to successfully acquire the structures of two languages, bilingual infants must also separate and discriminate these languages. A possible interpretation of the results of Study 1a is that experience with two languages can overwrite the perceptual biases that facilitate language discrimination, and that Tagalog bilingual neonates have no preference because they lump English and Tagalog into a broad class of familiar language sounds.

Previous research supports the idea that any newborn can discriminate two languages as long as the languages are from different rhythmic classes (Mehler et al., 1988; Nazzi et al., 1998; Ramus, 2002). However, systematic studies have not been conducted to date with bilingual newborns. As monolinguals are only familiar with one language, discrimination of any particular language pair involves either discriminating a rhythmically familiar language from an unfamiliar one, or discriminating two rhythmically unfamiliar languages. For bilingual infants, successful acquisition requires

their discrimination of two familiar languages, a potentially challenging and as yet untested task.

To investigate whether newborns with prenatal bilingual experience discriminate their native languages, Study 2 tested 50 newborn infants for their discrimination of English and Tagalog in a high amplitude sucking habituation procedure. As in Study 1a, newborns from a Tagalog-English bilingual background were compared to newborns from a monolingual English background.

Infants were habituated to either 4 English or 4 Tagalog low-pass filtered sentences (counterbalanced) until sucking declined, such that the number of high amplitude sucks across a two-minute window was at least 25% fewer than that produced in the previous minute. Infants habituated in an average of 7 minutes (range: 5-15; not different across groups, $F(2,47)=.49$, $p=.62$). At test, infants in the experimental group heard 2 novel sentences from a new speaker in the other language (N=32; 16 monolingual, 16 bilingual infants) for 4 minutes. To rule out spontaneous recovery (Jeffrey & Cohen, 1971), a control group (N=18; monolinguals) heard 2 novel sentences from a new speaker in the same language. Bilingual controls were not tested, as spontaneous recovery is not expected to differ across groups. If infants can discriminate the languages, then those in the experimental condition should show increased sucking at test, while those in the control condition should not.

Both English monolingual and Tagalog bilingual infants discriminated between the two languages (Figure 3). The number of high amplitude sucks was computed in three blocks: last two habituation minutes, first two test minutes, and second two test minutes. Preliminary analyses showed no effects or interactions with test order (English-first vs.

Tagalog-first). A mixed 3 (block) x 2 (condition: control, experimental) ANOVA showed a significant block by condition interaction, $F(2, 96)=3.20$, $p=.045$. A follow-up repeated measures ANOVA showed that in the control group, sucking did not differ as a function of block $F(2, 34)=2.04$, $p=.15$. In the experimental group, a similar ANOVA with an additional factor of exposure group (English monolingual, Tagalog bilingual) showed a significant effect of block, $F(2, 60) = 4.64$, $p=.013$, but no block by exposure group interaction, $F(2, 60)=.40$, $p=.67$. Planned directional t-tests compared sucking in the final habituation block to the average across the four test minutes (both test blocks). Both English monolingual infants, $t(15)=2.00$, $p=.032$, and Tagalog bilingual infants, $t(15)=1.99$, $p=.033$, showed a significant recovery of sucking during test. Tagalog bilingual infants, then, were still able to discriminate their two languages, despite having shown similar preference for the languages in Study 1a.

GENERAL DISCUSSION

Previous work with bilingual infants has shown that 4-month-olds can discriminate their languages auditorily (Bosch & Sebastián-Gallés, 1997), and visually (Weikum et al., 2007). The current work reveals that language discrimination in bilinguals is robust at birth and that language preference at birth reflects previous listening experience. Monolingual newborns' preference for their single native language directs listening attention to that language. Bilingual newborns' interest in both languages helps ensure attention to, and hence further learning about, each of their languages.

This study investigated neonates who were learning rhythmically distinct languages. Still unanswered is whether the same sensitivity to rhythm can also support infants acquiring two languages from the same rhythmic class. The differential preference

for Tagalog by Tagalog-English bilinguals in comparison to Chinese-English bilinguals hints that bilingual neonates have some sensitivity to intra-class rhythmic differences or to other differences between language pairs in the same rhythmic class. Further research is required to directly test these possibilities.

In sum, these findings show that from the very beginning, the same perceptual and learning mechanisms that support monolingual acquisition are also available to support bilingual acquisition. Moreover, our results confirm that infants exposed to two languages throughout gestation have already begun the process of bilingual acquisition at birth.

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Figure 1. Mean location of languages in the (%V, ΔC) plane. Rhythmic classes are indicated in parentheses. Measurements for example languages are from Ramus, Nespor, & Mehler (1999). Measurements for Tagalog are from Bird, Fais, & Werker (2005), for Cantonese are from (Mok, 2008), and for Mandarin are averaged from Mok (2008) and Lin & Wang (2007).

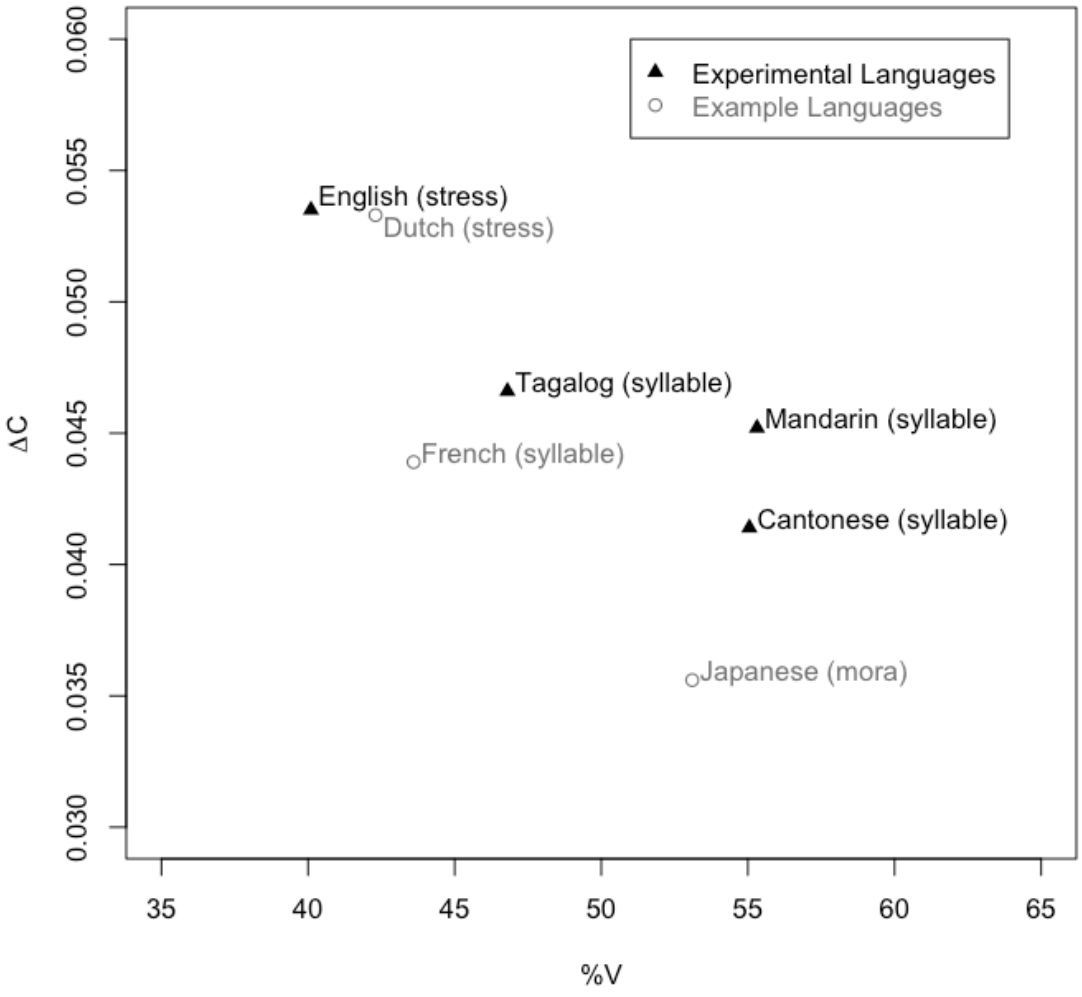

Figure 2. Individual preference scores and group averages for monolingual English, Chinese bilingual, and Tagalog bilingual infants in Studies 1a and 1b (preference). Error bars represent the standard error of the mean. Preference scores were calculated by subtracting the average number of high amplitude sucks produced during English minutes from the average number of high amplitude sucks produced during Tagalog minutes. Significance values adjacent to group means are for comparisons to zero.

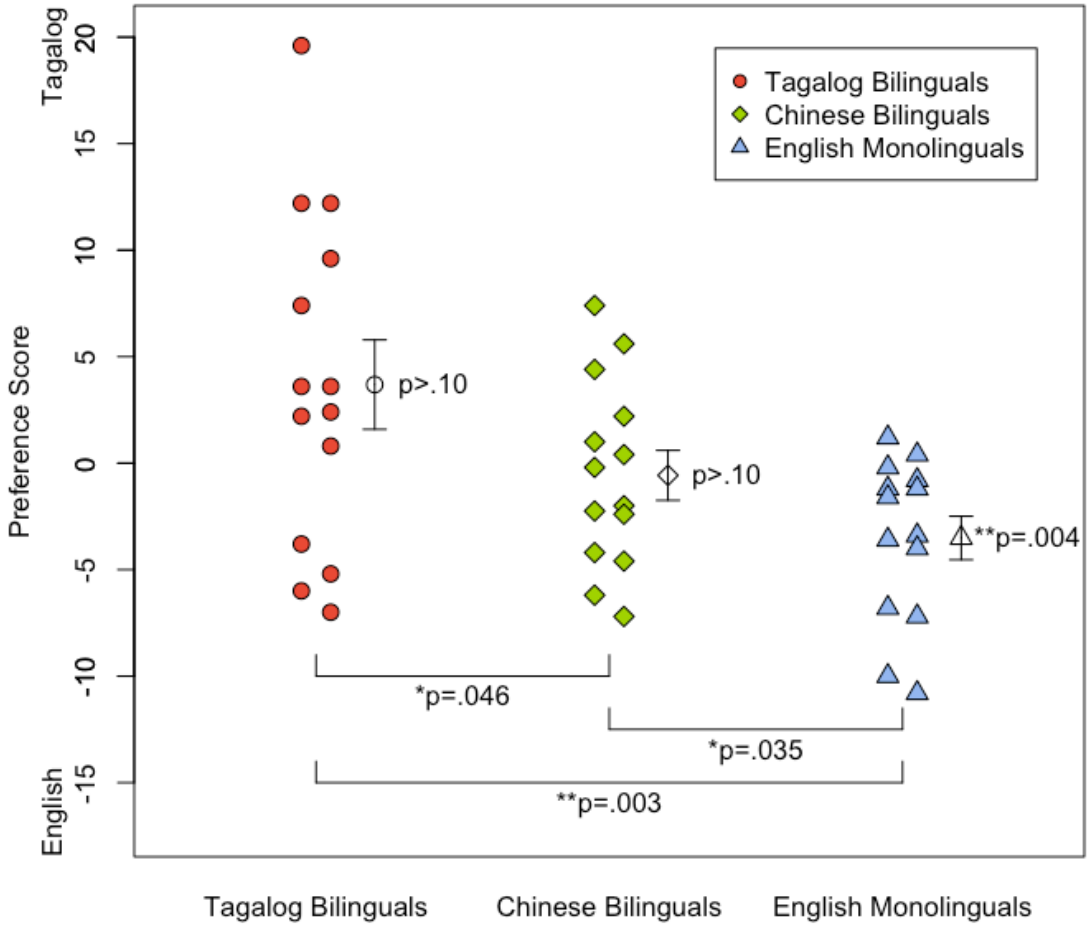

Figure 3. Number of high amplitude sucks per minute across experimental blocks for the control and experimental (monolingual English and Tagalog bilingual exposure) groups in Study 2 (discrimination). Error bars represent the standard error of the mean.