www.sciencemag.org/cgi/content/full/1173947/DC1

Supporting Online Material for

Flexible Learning of Multiple Speech Structures in Bilingual Infants

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Published 9 July 2009 on *Science* Express
DOI: 10.1126/science.1173947

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Materials and Methods

SUPPORTING ONLINE MATERIAL
MATERIALS AND METHODS

Experiment 1

Participants

Forty-four healthy full-term infants were included in the analysis, 22 monolinguals (mean age 12.21, 12 girls) and 22 bilinguals (mean age 12.20, 12 girls), age-range 12.04 - 13.04. Nineteen infants were excluded (9 monolinguals) because of crying, fussiness or side bias. Bilinguals had parents with different mother tongues addressing them in different languages and daily exposure to both languages from birth. Most bilinguals (N = 14) heard Italian and Slovenian; others Italian and Spanish/French/English/Croatian. Infants came from middle-upper class families and were matched for their parents' socioeconomic status (level of education and occupation) and family size (number of brothers/sisters). Participants were recruited from Trieste (Italy), where bilingualism has old historic roots and present since generations. Parents of the infants participating in Experiment 1 and Experiment 2 gave informed consent before the experiments.

Stimuli

The tri-syllabic speech items could have repeated initial syllables (i.e., an AAB structure, as in **lo**-**lo**-vu), or identical first and last syllables (i.e., an ABA structure, as in **lo**-vu-**lo**). The familiarization comprised 36 trials containing six AAB and six ABA speech items constructed from three A (lo, du, za) and three B syllables (mo, ba, vu). The two AAB and two ABA test items were constructed from novel syllables (ke, gi), and were repeated twice yielding a total of 8 test items. Phoneme duration was 200 ms and a monotonous pitch of 200Hz was used. Syllables were separated by 250 ms pauses, and synthesized with MBROLA (DE7 soft). Visual stimuli were three pictures of colorful toys. These appeared inside one of two white squares on the left or right side of the screen. The toys loomed from 4 cm to 7 cm inside the squares for 2 s. The squares had a side-length of 8 cm, positioned at a distance of 13.5 cm. Toys and speech items were paired randomly.

Procedure

Stimuli were presented via an Apple Dual G5 computer running PsyScope X (http://psy.ck.sissa.it). Infants' gaze was collected with a TOBII 1750 Eye-Tracker.

Familiarization trials started with a display of two white squares on the sides and a central attention-getter. Then an ABA or AAB speech item was played in a pseudo-random order. The animated attention-getter was displayed until the offset of the speech item to keep the infant's gaze in the middle of the screen. One second after the speech item, a toy appeared in one of the squares, depending on the item structure. The ABA structure predicted the toys' appearance in one of the squares, while the AAB structure predicted the toys' appearance in the other square. The pairing of structures with toy-locations was counterbalanced across participants.

During test infants were exposed to 8 trials in a pseudo-random order that were similar to the familiarization trials, except that infants heard new AAB and ABA items, and no toys appeared. Two seconds later the next trial started.

Scoring and analysis

For the analysis we divided the screen into three equal parts, left, middle and right. Our principal measurement was infants' first fixation in search of the toy after hearing the new speech item in the test. Infants were coded as targeting the correct side (where the structure predicted the toy during familiarization) or the incorrect side. 75% of the trials contained a codeable look to one of the two critical (correct or incorrect) regions (74% monolinguals, 76% bilinguals). We computed difference scores ((#correct looks – # incorrect looks) / (#correct looks + # incorrect looks)) and compared them to the chance level of 0.

The results show that bilinguals looked more often to the correct side for both structures (AAB: $t(21)=2.24$, $p=0.03$; ABA: $t(21)=3.76$,

p=0.001) Monolinguals, in contrast, looked more often to the correct side when the speech items had the structure AAB, but not when they had the structure ABA, (AAB: $t(21)=2.37$, $p=0.03$; ABA: $p>.05$). Monolinguals were at chance for the ABA structure on the first and last test trials as well (first trial: 48% of infants looking to the correct side, 52% to the incorrect side; last trial: 50% correct, 50% incorrect). However, the two groups did not differ in their total (correct and incorrect) predictive looks ($F(1,42)=1.40$, $p=0.24$).

Furthermore, we analyzed the bilinguals' performance as a function of the similarity of the languages they learned at home, that is two languages from different rhythmic classes (e.g., Slovenian and Italian), or two languages belonging to the same rhythmic class (e.g., Italian/Spanish). To assess the influence of language similarity, we ran an ANOVA with the between-subject factor Language Similarity (Same rhythmic class vs. different rhythmic class) and the within-subject factor Structure (AAB vs. ABA) on the difference scores. We found no main effect of language similarity ($F(1,20)=1.18$, $p=0.28$), and no other effects or interactions. However, further studies involving larger samples are needed to explore how language similarity may influence the learning abilities of bilingual infants, since this was not among the aims of the current study.

Experiment 2

Participants were 20 healthy full-term monolinguals (mean age 12.22, age-range 12.04 - 13.04, 10 girls). Seven infants were excluded because of fussiness or side bias. Stimuli, procedure and data analysis were identical to Experiment 1, except that infants heard speech items following one structure in one voice (e.g., female, DE7 soft) and items of the other structure in a different voice (male, DE4). The voice, structure and side pairings were counterbalanced across participants.