Statistical Learning of Multiple Structures by 8-Month-Old Infants

Federica Bulgarelli, Viridiana Benitez, Jenny Saffran, Krista Byers-Heinlein, and Daniel J. Weiss

1. Introduction

Over the last two decades, many studies have demonstrated that infant and adult learners are capable of tracking distributional properties of sensory input in order to infer the underlying structure of the environment. In the realm of language acquisition, statistical learning has been found to operate at many levels, including phonetic learning (e.g., Maye, Werker, & Gerken, 2002), speech segmentation (e.g., Saffran, Aslin, & Newport, 1996), word learning (e.g., Smith & Yu, 2008), and grammar learning (e.g., Reeder, Newport, & Aslin, 2013). Notably, the vast majority of research in this field to date has assumed, at least implicitly, that the task of the learner is to acquire a single pattern. That is, almost all studies of statistical learning, particularly with infants, have presented learners with a uniform structure such that sampling at any point during familiarization yields the same statistical information. In the real world, however, the underlying statistical distribution of the input varies meaningfully over time, for example when encountering different topics, dialects, or languages. The ability to cope with multiple statistical structures is thus particularly relevant for learners in bilingual environments, who must learn multiple underlying structures in order to acquire both of their languages.

This issue has begun to be addressed in adult studies of statistical learning. For example, Weiss, Gerfen, & Mitchel (2009) presented learners with two artificial languages interleaved in two minute intervals for twenty four minutes. They found that learners could acquire both languages only if the statistics were compatible across languages (i.e., the collapsed statistics preserved the transitional probability information). When the languages were not statistically compatible (i.e., the combined statistics across languages diminished the statistical cue to word boundaries), learners were only successful at acquiring both languages when they were accompanied by an indexical cue. When each

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 Proceedings of the 41st annual Boston University Conference on Language Development, ed. Maria LaMendola and Jennifer Scott, 128-139. Somerville, MA: Cascadilla Press.

language was presented in a different voice, both languages were learned (see also Mitchel & Weiss, 2010). Similarly, Gebhart and colleagues (2009) presented adult participants with two artificial languages each for five minutes, and found that in the absence of any corresponding contextual cues marking the change in language, participants only learned the first of the two presented languages. The two languages partially overlapped in syllable inventory, such that participants had to track the statistics of each language separately in order to learn. However, when exposure to the second language was tripled in length (i.e. 15 minutes), participants successfully acquired the statistics of each language. Additionally, when participants were explicitly informed that they would be learning two languages, and the language switch was marked by a 30 second pause, participants also learned both languages. However, not all contextual cues are equally effective, and when one of the two languages was pitch-shifted to signal a change in speaker identity, learning of the second language did not significantly improve. Together, these studies suggest that for adult learners, tracking two structures that overlap may rely on having an effective contextual cue that corresponds to the change in structure.

The primacy effect observed when two languages are presented with a single transition (i.e., Gebhart et al., 2009) appears to be a function of overlearning. Bulgarelli & Weiss (2016) found that additional exposure to the first language after learning has already occurred can cause learners to become entrenched in the statistics of the first language, precluding learning of the second language. However, when exposure to the second language is individually timed to when each participant shows mastery of the first language, a significantly higher percentage of participants demonstrate learning of both languages. Similarly, a recent fMRI study showed that the learners who showed the least activation during L1 learning – considered the most efficient learners, – showed the strongest primacy effects when presented with two artificial languages in succession (Karuza et al., 2016). Thus, it is possible for adult learners to acquire multiple structures even without contextual cues, although many factors, such as the method of presentation and individual differences in learning, can impact the outcome.

There is very little published research addressing the question of how infants acquire multiple sets of statistics. Perhaps the most relevant studies were conducted by Kovacs and Mehler, who studied how monolingual and bilingual infants acquire multiple rules. In an anticipatory looking study, 7-month-old monolingual and bilingual infants were taught that a specific verbal or visual sequence led to a visual reward in one location (e.g. an animation appearing on the left side of a screen). Once the infants learned this contingency they subsequently switched to a new sequence predicting the reward in a novel location (e.g. the right side of the screen). Only the bilingual infants succeeded at inhibiting their initial response to learn the new contingency (Kovacs & Mehler, 2009a). In a similar study with 12-month-old monolingual and bilingual infants, the authors found that bilinguals were able to acquire two rules (ABA and ABB; see Marcus et al., 1999) whereas monolinguals only learned one, unless each rule was presented by speakers of different genders (Kovács & Mehler, 2009b). These studies point to the possibility that the experience of growing up in a bilingual environment may influence abilities such as inhibitory control (see Kroll, Dussias, Bice & Perrotti, 2015 for a review), or perhaps the readiness to find multiple structures in a novel input. Other lines of research suggest that in order to acquire multiple regularities, 12-month-old monolingual infants require a correlated contextual cue or that the conflicting regularities be sufficiently separated in time (see Gonzales, Gerken, & Gòmez, 2015).

In the present study, we sought to explore whether 8-month-old monolingual infants are able to use statistical learning to acquire two artificial languages presented in succession, much like the paradigm used by Gebhart and colleagues (2009) with adult learners. Given that 8-month old infants are capable of learning a single artificial language (e.g., Saffran, Newport, & Aslin, 1996), we were confident that children at this age are sensitive to the statistical regularities which separate words (i.e. statistically congruent units) from non-words (i.e. statistically incongruent units) in each language in our statistical learning paradigm. The use of statistical regularities affords a high level of precision at test, as acquiring the words of two artificial languages whose statistics are incompatible (i.e., combining across languages reduces statistical cues to word boundaries) requires encapsulating the statistics of each language, at least to some extent (see Weiss, Poepsel, & Gerfen, 2015). Consequently, in a series of experiments using the Headturn Preference Procedure, we tested whether infants could use statistical learning to acquire two artificial languages. Experiment 1 tested each language in isolation, while Experiments 2 and 3 tested the learning of either the first and second language (respectively) when the languages were presented successively during familiarization. In Experiment 4, we tested the same streams presented successively with contextual cues that corresponded to the change in structure.

2. Experiment 1 – Isolated language presentation

2.1. Participants

Twenty-four typically developing 8-month-old monolingual English-learning infants (Mean: 8.1 months, Range: 7.33- 8.60 months; 13 males) participated in the study. Thirteen of the infants were familiarized with language A and 11 were familiarized with language B. An additional 10 infants were excluded (6 due to fussing out and 4 due to experimenter error).

2.2. Stimuli

We created two artificial languages, each consisting of three trisyllabic words and recorded by a single female native English speaker in a monotone voice (see Table 1). To create the speech streams, each syllable of each word was recorded in every possible context in which it would appear in the artificial language to preserve coarticulation and to ensure that acoustic cues to word boundaries were not provided. Each syllable was then manually extracted from each recording using Praat (Boersma, 2002), normalized for pitch, duration, and intensity, and concatenated together into a continuous stream.

Each language included 30 repetitions of each word. The words were randomly ordered (with the constraint that the same word could not be presented twice in a row) and combined without any acoustic cues to the word boundaries. The only cue to the boundaries was the transitional probabilities (TPs) between syllables, which were 1.0 within words. TPs between words ranged from 0.43 to 0.53 with a mean of 0.49 for each language. The transitional probabilities in each language reliably marked the word boundaries (i.e., the TPs at word boundaries were always the lowest in the stream; see Table 1). However, since the languages shared four of the nine syllables, the transitional probabilities collapsed across both languages were unreliable, as a subset of within-word probabilities matched those found at word boundaries. The beginning and end of the recording was faded in and out to avoid any additional cues to word boundaries. Both languages were approximately 1.5 minutes in length.

Test items (see Table 2) consisted of words and positionally-sensitive non-words presented in isolation. The test items were recorded in isolation and were normed for pitch, intensity, and duration. Words were defined by their transitional probabilities. Positionally-sensitive non-words were created from strings of syllables that never occurred together during familiarization, but maintained the correct syllable position of the words from which they were drawn. For example, the non-word 'pabutu' is a novel string that maintains the syllable position of each syllable from the original words (i.e. 'pa' only occurred at the onset, 'bu' occurred medially, and 'tu' occurred in word final position). Two words and two non-words were presented at test. Each word and non-word occurred once within each block of four test trials, such that each test item occurred within each block.

Table 1: Language structure, bolded syllables are ones that overlap across languages

Language	Words	Transitional probabilities within language	Transitional probabilities across languages
A	**Pa**biku	1.0, 1.0, 0.5	0.5 1.0 0.5
	Tibudo	1.0, 1.0, 0.5	0.5 0.5 0.5
	Golatu	1.0, 1.0, 0.5	0.5 1.0 0.5
B	**Bugo**fay	1.0, 1.0, 0.5	0.5 0.5 0.5
	Tifaso	1.0, 1.0, 0.5	0.5 1.0 0.5
	Mu**pa**di	1.0, 1.0, 0.5	1.0 0.5 0.5

Table 2: Test items

Language	Words	Positionally sensitive non-words
A	Pabiku	Pabutu
	Tibudo	Tilaku
	Golatu	Gobido
B	Bugofay	Bupaso
	Tifaso	Tigodi
	Mupadi	Mufafay

2.3. Procedure

During this experiment, participants sat on their caregiver's lap in a sound attenuated testing booth facing a monitor. Two additional monitors were placed at either side of the infant. Caregivers wore headphones that played music to ensure they could not hear the experimental stimuli. The experiment consisted of two phases, a 90 second familiarization phase in which the speech stream was played on speakers in the booth, and a 12-item test phase. Each participant was exposed to only one of the two artificial languages to ensure that they were learnable in isolation. The experimenter sat outside the booth and coded the infants' head turns using corresponding button presses. To ensure the experimenter was blind to the experimental procedure, they could see the infant's head turns, but could not hear the stimuli that was being presented.

During familiarization, while participants listened to the continuous speech stream, the lights flashed in response to the infant's looking behavior to expose them to the contingency between their looking behavior and the activation of each screen. For example, if the infant looked to the light flashing on the front monitor, the light would stop playing on the front monitor and start playing on one of the two side locations. If the infant looked to the side monitor, the light on that monitor remained active until the infant disengaged attention for longer than 2 seconds, at which point the light activated at the center location. During test trials, the test item played only when the infant looked to the side monitor, and the length of time the infant looked was recorded. Similar to familiarization, when infants looked away for longer than 2 seconds, the presentation of the test item ended. Additionally, if infants attended to a test item for less than 2 seconds, the item was repeated at the end of the experiment. Side of stimulus presentation was counterbalanced, and the experimenter was blind to which test-items were being presented on any given trial.

2.4. Results and discussion

Infants listened to the positionally-sensitive non-words for 7.91 seconds on average (sd = 3.32), and to words for 6.85 seconds (sd = 2.03). A t-test revealed a significant preference for the non-words over the words, $t(23) = -2.47$, $p = .02$, 95% CI [-1.95, -0.17], see Figure 1. There was no effect of which language (A or B) was tested, $F(1.23) = .64$, $p=.43$. These results demonstrate that infants could learn either of the languages when presented in isolation.

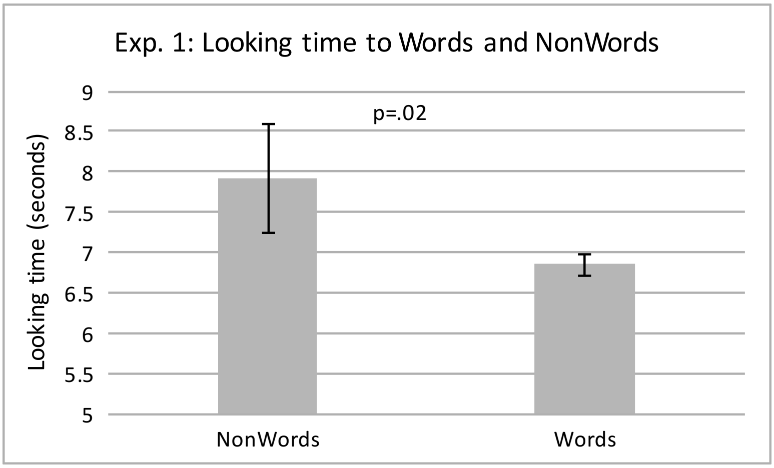

Figure 1: Experiment 1 Results

3. Experiment 2

Having established that infants could learn both languages when presented in isolation, Experiment 2 tested learning when both languages were presented in succession during familiarization. Following familiarization, infants were tested using words and positionally-sensitive non-words from the first presented language only (hereafter L1).

3.1. Participants

Twenty-four typically developing infants (Mean age: 8.11 months, range: 7.5- 9.2 months; 13 males) from monolingual English homes participated in Experiment 2. Half of the participants heard Language A first, and the other half heard Language B first. Five additional infants were tested but excluded due to fussing out.

3.2. Stimuli

Stimuli were the same as those used in Experiment 1, except that the two languages were concatenated so that there were no pauses or breaks between the two languages. The entire stream with the two languages together was 3 minutes in length. The beginning and end of the recording was faded in and out to avoid any additional cues to word boundaries.

3.3. Procedure

The procedure was the same as that used in Experiment 1, except that participants were exposed to 90 seconds of each language (counterbalanced for order) and then tested on just the first of the two presented languages. Thus, the test phase remained the same length as that in Experiment 1.

3.4. Results and discussion

Infants listened to the positionally-sensitive non-words for 6.89 seconds (sd = 2.04) and the words for 6.26 seconds (sd = 2.31), see Figure 2. A t-test revealed the listening times for each test item were not significantly different from each other; $t(23) = -1.43$, $p=0.17$, 95% *CI* [-1.53, 0.28]. There was no effect of which language (A or B) was presented first and subsequently tested; $F(1,23) = .034$, $p=.86$. An item analysis revealed no differences in looking time to either word or non-words regardless of which language was tested (all ps > .05).

Results from this experiment suggest that infant learners were not able to maintain learning of the first presented language after receiving exposure to the second language. Since the only difference between Experiments 1 and 2 was the addition of exposure to the second language during familiarization, we surmised infants' failure to demonstrate learning of the first presented language was due to one of three factors. First, infants may have been unable to remember the statistics of the first language over the 90 second delay (during second language exposure) between the familiarization to the first language and test. Second, it is possible that they learned the second language and did not maintain learning of the first. Finally, perhaps they combined the statistics of the two languages during exposure, resulting in weaker evidence for word boundaries. To begin to adjudicate between these hypotheses, Experiment 3 tested the L2 immediately after exposure.

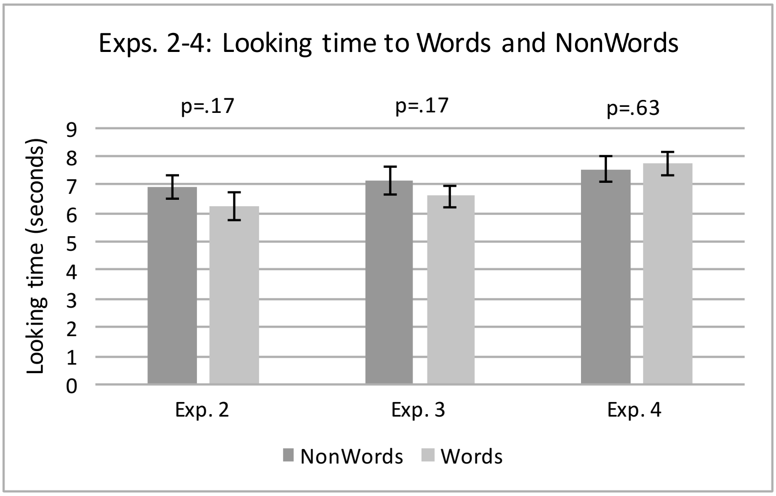

Figure 2: Experiments 2-4 results

4. Experiment 3

4.1. Participants

Twenty-four typically developing infants (Mean age: 8.08 months, range: 7.43-8.7 months; 12 males) from monolingual English homes participated in Experiment 2. Half of the participants heard Language A first, and the other half heard Language B first. Fifteen additional infants were excluded from the experiment (12 for fussing out, 1 due to experimenter error, and 2 due to computer error).

4.2. Stimuli

The stimuli were the same as those used in Experiment 2.

4.3. Procedure

The procedure was the same as that used in Experiment 2, except that the test items were drawn from L2 as opposed to L1.

4.4. Results and discussion

Infants listened to the positionally-sensitive non-words for 7.12 seconds (sd =2.35) and to the words for 6.59 seconds (sd = 1.87), see Figure 2. A t-test revealed no significant difference between these looking times; $t(23) = -1.41$, $p=0.17$, 95% *CI* [-1.30, 0.25]. An ANOVA with the difference score (looking time to non-words – looking time to words) and language tested as a fixed factor showed that, unlike previous experiments, there was an effect of which language was tested, such that when Language B was tested, participants exhibited a familiarity preference ($F(1.23) = 4.43$, p=.047), but no such effect was present for Language A ($p > .05$). This difference is difficult to interpret, as it was not present in any other experiments. An item analysis revealed no differences in looking time to either word or non-words regardless of which language was tested (all ps > .05).

Results from Experiment 3 suggest that participants did not acquire L2. Since participants were tested immediately after exposure to the L2, and thus there was no delay between exposure and test, their failure to exhibit learning may be due to combining statistical information across the two languages or lack of attention to the structure. In experiments with adult participants, when two languages were presented successively, the second language was not learned (albeit, the first language was, see Gebhart, Aslin, & Newport, 2009). One factor that helped learners acquire both languages was providing an adequate contextual cue (see also Weiss, Gerfen, & Mitchel, 2009; Mitchel & Weiss, 2010). Given those findings, in Experiment 4 we provided infants with a contextual cue corresponding to the change in language.

5. Experiment 4

In this experiment, we provided infants with two contextual cues to mark the language change: the first presented language (counterbalanced for order) was pitch shifted down by 60 Hz to sound like a different speaker, and a 5 second pause was also added between the two languages. Infants were once again tested on the L2 to remove any time lapse between familiarization and test.

5.1. Participants

Twenty-four typically developing infants (Mean age: 8.08 months, range: 7.66-8.7 months; 12 males) from monolingual English homes participated in Experiment 4. Half of the participants heard Language A first, and the other half heard Language B first. Ten additional infants were excluded from the experiment (9 for fussing out, 1 for facing the caregiver the entire experiment).

5.2. Stimuli

The stimuli were the same as those used in previous experiments, except that the first presented language was pitch shifted down by 60 Hz in Audacity in an effort to provide a cue akin to a change in talker voice. A 5 second pause was also inserted in between the end of the L1 stream and the start of the L2 stream.

5.3. Procedure

The procedure was identical to Experiment 3.

5.4. Results and discussion

Infants listened to the positionally-sensitive non-words for 7.52 seconds (sd =2.21) and to the words for 7.74 seconds (sd = 2.12), see Figure 2. A t-test revealed no significant difference between these looking times; $t(23) = 0.63$, $p=0.53$, 95% CI [-0.49, 0.92]. There was no effect of which language was tested (A or B); $F(1.23) = .62$, $p=.44$.

Despite adding two different contextual cues, infants were not able to learn the L2. However, it is possible that this result is specific to the particular contextual cues that we used in this design. There is some evidence that pitch-shifting was not an effective contextual cue for adults. Notably, in the Gebhart et al., (2009) study, pitch shifting one language was insufficient to overcome the primacy effect (though in Weiss, Gerfen, & Mitchel, 2009 a voice change was sufficient, albeit with multiple exposures to each language during familiarization). Similarly, the 5-second pause introduced between the two speech streams may not have sufficient for highlighting the switch to a novel speech stream. Our results leave open the possibilities that infants may have been able to demonstrate learning given other types of contextual cues.

6. General discussion

In a series of 4 experiments, we sought to investigate whether 8-month-old monolingual infants can segment two artificial languages. We designed two languages with partial overlap in their syllable inventory, and presented them successively. Experiment 1 tested the two artificial languages in isolation and found that each of the languages could be learned with 90 seconds of exposure. Experiment 2 exposed participants to both languages, and tested only the L1. In contrast to the isolated presentation, infants did not exhibit learning. Experiment 3 exposed participants to both languages and then tested the L2. Like Experiment 2, infants did not exhibit learning. Finally, in Experiment 4 we tested infants' learning of L2 after providing them with additional contextual cues that corresponded with the change in structure: a lowering in pitch of one of the languages, and a 5 second pause between the languages. However, these contextual cues did not facilitate learning of the L2 for infants.

Overall, this set of findings indicates that infants raised in monolingual homes have difficulty acquiring multiple structures in the context of the standard statistical learning speech segmentation paradigm. The lack of learning in Experiments 2-4 may be due to several causes. Certainly, the overlap between the languages could have contributed to the lack of learning, as learners may have collapsed statistics across both structures and thereby reduced the transitional probability cues that marked word boundaries. Alternatively, it is possible that 90 seconds of exposure may be sufficient for learning in isolation, but insufficient when there is increased variance in the input due to the presence of two languages. Given that adult learners struggle to learn two languages with overlap in their syllable inventory, exhibiting either a primacy effect (e.g., Gehbart et al., 2009) or no learning (e.g., Weiss et al., 2009), the results of Experiments 2 and 3 demonstrate that infants also struggle in this task. While adult performance is sometimes more robust when contextual cues are added, Experiment 4 suggests that this is not necessarily the case for infants, at least with the tested cues of pitch and the insertion of a brief pause.

Given the nature of our task, it is possible that bilingual infants might fare better than our monolingual infants. As noted in the Introduction, Kovacs and Mehler (2009a) found 7-month-old bilingual infants better able to inhibit a prepotent response in order to learn a new contingency. Likewise, the finding that bilingual infants may be better equipped to learn multiple rules in the absence of contextual cues (Kovacs & Mehler, 2009b) suggests they may be better able to acquire multiple sets of statistics. Given that monolingual 12-month-old infants were able to learn both rules when a contextual cue (speaker voice) was added suggests that slightly older infants might perform better on our task as well.

Yet, other evidence suggests that even bilinguals may not necessarily show an advantage relative to monolinguals in segmenting multiple inputs on the basis of short exposure. For example, using a natural language segmentation paradigm, Polka and colleagues (2016) recently reported that 8-month-old French-English bilingual infants had difficulty segmenting words from both of their native languages. Likewise, the few studies to look at multi-language segmentation in adult bilinguals has failed to find an advantage relative to monolinguals (e.g., Bogulski, 2013; Bulgarelli & Weiss, 2016), though statistical word learning paradigms have reported differences for acquiring multiple mappings between labels and referents (Poepsel & Weiss, 2016). Our future work will test older bilingual infants on this paradigm in order to determine whether they fare better than monolinguals (as one might predict based on Kovacs & Mehler, 2009) or whether they will also struggle acquiring more than one language in this experimental paradigm (akin to Polka et al., 2016).

Future research may also explore the use of different contextual cues, which may be more ecologically valid. For example, rather than using a pitch shift to simulate a change in speaker, it may be more effective to present learners with stimuli spoken by different individuals. Notably, pitch-shifting one of the two languages did not lead participants in the Gebhart et al., (2009) study to exhibit learning of both languages, while a change in speaker did help adults acquire two artificial languages in the context of a slightly different learning paradigm (Weiss et al., 2009). This type of change may be done in concert with providing additional cues that covary with different real-world languages, for example varying phonological features such as changing the voice onset times or vowel lengths for one of the languages. Since infants growing up in bilingual environments ultimately become bilingual adults, and thus must have tracked and acquired multiple languages, future research will hope to determine the mechanisms that allow learners to successfully track multiple underlying structures in the environment.

References

Boersma, Paulus. P. G. (2002). Praat, a system for doing phonetics by computer. *Glot international*, *5*.

Bogulski, Cari. (2013). Are bilinguals better learners?: A neurocognitive investigation of the bilingual advantage (Unpublished dissertation) Pennsylvania State University

Bulgarelli, Federica, & Weiss, Daniel J. (2016). Anchors Aweigh: The Impact of Overlearning on Entrenchment Effects in Statistical Learning.

Gebhart, Andrea. L., Aslin, Richard N., & Newport, Elissa L. (2009). Changing structures in midstream: Learning along the statistical garden path. *Cognitive science*, *33*(6), 1087-1116.

Gonzales, Kalim, Gerken, LouAnn, & Gómez, Rebecca L. (2015). Does hearing two dialects at different times help infants learn dialect-specific rules?. *Cognition*, *140*, 60-71.

Karuza, Elisabeth A., Li, Ping, Weiss, Daniel J., Bulgarelli, Federica, Zinszer, Benjamin D., & Aslin, Richard N. (2016). Sampling over nonuniform distributions: a neural efficiency account of the primacy effect in statistical learning. *Journal of cognitive neuroscience*.

Kovács, Ágnes M., & Mehler, Jacques. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences*, *106*(16), 6556-6560.

Kovács, Ágnes. M., & Mehler, Jacques. (2009). Flexible learning of multiple speech structures in bilingual infants. *Science*, *325*(5940), 611-612.

Kroll, Judith F., Dussias, Paola E., Bice, Kinsey, & Perrotti, Lauren. (2015). Bilingualism, mind, and brain. *Annu. Rev. Linguist.*, *1*(1), 377-394.

Marcus, Gary F., Vijayan, Sugumaran, Rao, S. B., & Vishton, Peter M. (1999). Rule learning by seven-month-old infants. *Science*, *283*(5398), 77-80.

Maye, Jessica, Werker, Janet F., & Gerken, LouAnn. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, *82*(3), B101-B111.

Mitchel, Aaron & Weiss, Daniel J. (2010) What's in a face? Visual contributions to speech segmentation. *Language and Cognitive Processes, 25(4),* 456-482

Poepsel, Timothy J., & Weiss, Daniel J. (2016). The influence of bilingualism on statistical word learning. *Cognition*, *152*, 9-19.

Polka, Linda, Orena, Adriel J., Sundara, Megha, & Worrall, Jennifer. (2016). Segmenting words from fluent speech during infancy–challenges and opportunities in a bilingual context. *Developmental science*.

Reeder, Patricia A., Newport, Elissa L., & Aslin, Richard N. (2013). From shared contexts to syntactic categories: The role of distributional information in learning linguistic form-classes. *Cognitive psychology*, *66*(1), 30-54.

Saffran, Jenny R., Aslin, Richard N., & Newport, Elissa L. (1996). Statistical learning by 8-month-old infants. *Science, 274*, 1926-1928.

Smith, Linda, & Yu, Chen. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, *106*(3), 1558-1568.

Weiss, Daniel J., Gerfen, Chip, & Mitchel, Aaron D. (2009). Speech segmentation in a simulated bilingual environment: A challenge for statistical learning?. *Language Learning and Development*, *5*(1), 30-49.

Weiss, Daniel J., Gerfen, Chip, & Mitchel, Aaron D. (2010). Colliding cues in word segmentation: The role of cue strength and general cognitive processes. *Language and Cognitive Processes*, *25*(3), 402-422.

Weiss, Daniel J., Poepsel, Timothy, & Gerfen, Chip. (2015). Tracking multiple inputs. *Implicit and Explicit Learning of Languages*, *48*, 167.

Proceedings of the 41st annual Boston University Conference on Language Development

edited by Maria LaMendola
and Jennifer Scott

Cascadilla Press Somerville, MA 2017

Copyright information

ISSN 1080-692X
ISBN 978-1-57473-076-0 (2 volume set, paperback)
ISBN 978-1-57473-176-7 (2 volume set, library binding)

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