Generalization of Statistical Word Learning Across Speakers of Different Genders

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Abstract

Infants typically learn their native language at an impressive rate. Research suggests that infants may solve one of the most fundamental aspects of language acquisition, namely finding words in continuous speech, by tracking patterns in sounds and assessing which sounds likely go together to form words. This mechanism for early language acquisition is referred to as statistical word-learning. Two syllables/sounds that tend to occur frequently together are said to have high transitional probability (HTP) while those that do not have low transitional probability (LTP). Previous studies have shown that infants are able to differentiate between HTP and LTP words in artificial and natural speech. However, there have been very limited studies on the specificity of infants' indexical representations (speaker characteristics) of statistically-defined words and none of them have used a natural language. For this study, we will be testing infants' word learning in natural speech (Italian) across speakers of different genders. Monolingual English-learning 22- to 24-month-old infants (planned sample size=32) will be tested using a statistical learning task which consists of familiarization, training (label-learning), and testing (Looking-While-Listening Procedure) phases. The infants will be presented with a stream of continuous Italian speech produced by a native Italian-speaking woman; the statistics which must be tracked will be presented in this phase. Then, they are trained to learn labels for novel objects and tested by a native Italian-speaking man. We will be observing their eye movements during the testing phase for accuracy and reaction time. We predict that infants will generalize and successfully continue to learn HTP and possibly LTP words.

Introduction

Infants are able to learn a lot about their native language at an impressive rate considering the complexities involved. A challenge they typically face is finding words in continuous speech when there are limited cues for word boundaries (Cole & Jakimik, 1980). Previous research has identified many mechanisms for overcoming this challenge. One mechanism for tracking patterns in continuous speech which is not language-specific is statistical learning. In statistical learning, infants track the transitional probability (TP) that two syllables will co-occur.

The TP of co-occurring syllables is much lower between words than within words. For example, in the phrase "pretty baby", the TP of pre/ty and ba/by (within word) is much higher than the TP of ty/ba (between words). It has been found that infants as young as 8-months of age can use TP to track speech regularities and find word boundaries in continuous speech for both artificial and natural language (Saffran, Aslin, Newport, 1996; Pelucchi, Hay, and Saffran, 2009). Additional research has demonstrated that when 17-month-old infants were given target words with high TP (HTP) and low TP (LTP), they could learn novel object labels only in the HTP condition (Hay, Pelucchi, Graf Estes, & Saffran, 2011). These results indicate that statistical regularities influence word learning.

Despite the progress being made to further the understanding of statistical word-learning, little is still known about how infants represent statistically-defined words. Infants typically receive language input from multiple speakers. Speakers may differ in characteristics such as age or gender, and these characteristics are referred to as indexical features of speech. As these indexical features do not convey the meaning of words, infants would benefit from ignoring them. Houston and Juscyzk (2000) demonstrated that 7.5-month-old infants could not generalize

words across speakers of a different gender in their native language, but 10.5-month-olds could. Also, it has been shown that 11- and 17-month-olds can generalize statistical word learning when the speaker gender is changed between familiarization and test in an artificial language (Graf Estes, 2012).

In this current study, we seek to test the ability of 22- to 24-month-old infants to generalize across indexical representations (i.e. speaker gender) of statistically-defined words in natural Italian speech. As stated before, it is advantageous for infants to disregard indexical features of speech, so we predict that infants will generalize and successfully learn HTP and possibly LTP words. Infants should be able to pull HTP words out of the speech stream produced by a female speaker and use them as object labels when produced by a male speaker. Word learning would be measured with reaction time and accuracy of looking at objects labelled in each condition.

Method

Participants

This study planned to test thirty-two 22- to 24-month-old infants. These infants were all monolingual English-learning. They were born full-term with no known hearing or vision problems and fewer than four ear infections in the last 12 months. Participants were recruited from the Knoxville area using the Child Development Research Group database maintained by the Department of Psychology at the University of Tennessee.

Stimuli

A native female Italian speaker produced the stream of speech used as the familiarization corpus. This corpus included 4 target words (*bici*, *casa*, *fuga*, and *melo*), two of which were HTP (TP=1.0) and two of which were LTP (TP=0.33). HTP words were those in which the syllables only occurred within those words, whereas the syllables in LTP words occurred in other words as well, thus lowering the TP. The speaker produced 2 counterbalanced languages in which the HTP and LTP words were switched to control for listening preferences. The corpus, consisting of 12 sentences, was repeated three times during familiarization and lasted for about 2 min and 15 sec. The stimuli for the remaining phases (training and test) were produced by a native male Italian speaker. This includes the target words (*bici*, *casa*, *fuga*, and *melo*), familiar English words (*baby*, *doggy*, *book*, and *shoe*), and English carrier phrases (*Look at the*, *Where's the*, *Find the*, etc.). All stimuli were normalized to the same sound intensity in sound editing software.

Procedure

To begin, infants were familiarized with one of the language samples (Italian female) while a silent cartoon played on the monitor. After this, a pinwheel acting as an attention getter appeared on the monitor, and when the infant directed its gaze toward it, the experimenter began the training phase. The training phase consisted of a label-learning task. The 2 HTP and 2 LTP target words were paired (produced by a male Italian speaker) with a picture of a novel object presented on the screen. This phase had 20 trials, 16 of which were novel object-labelling (8 HTP, 8 LTP) and 4 which were familiar object-labelling. The phase was presented in the following way (example using *bici*): "Bici! See the/There is a Bici. It's a/Look at the Bici, Bici!" At the end of training, a pinwheel is again presented.

Once the infant regained attention, the testing phase, which used the Look-While-Listening paradigm, began. In this phase, two pictures appeared on the screen simultaneously while the target or familiar words were repeated (produced by a male Italian speaker). The pictures were either two familiar objects or two novel objects. There were a total of 32 trials with 24 novel (12 HTP, 12 LTP) and 8 familiar. There was one additional trial halfway through to regain attention. The phase was presented in the following way (example using *bici*): "Find the/Where's the Bici. Bici! Do you like it?/Do you see it?"

The entire study occurred in a soundproof booth and lasted about 10 minutes. Infants were seated on their caregiver's lap in front of a monitor. The caregiver wore a pair of headphones to prevent any influence on the infant's behavior. Looking behavior was recorded by a camera underneath the monitor and the videos were coded using iCoder software. Looking accuracy and time were used as measurements of learning.

Results

Twelve 22- to 24-month-old infants participated. However, the data from these trials has not been coded.

Discussion

This study served to further the understanding of statistical word learning and its role in early language acquisition. It could provide more knowledge about how veridically infants are representing statistically-defined words. If our predictions were supported, then 22- to 24-month-old infants would be able to generalize across speaker gender from familiarization to test and learn HTP words even when the labels were produced by a male speaker. If infants pulled out LTP words from the fluent speech stream, they may also be able to generalize LTP words across speakers and show successful LTP word learning. However, if LTP words are not pulled out of

the speech stream or if they are not represented as strongly as HTP words, infants might fail to treat LTP labels produced by a male speaker as good object labels. These findings would suggest that infants of this age can ignore indexical properties of speech when word-learning in a non-native language; this would support previous studies on indexical features done using native and artificial languages. These findings would also suggest that these infants are successfully learning the words because of the TP and statistical learning, not due to acoustic characteristics of the speaker. Gaining a better understanding of early language development will aid in providing support for those populations who experience disruptions in language.

However, if our predictions were not supported by the results, then this would suggest that indexical characteristics of speech do influence word-learning in infants of this age. This would not be consistent with previous studies and would indicate that there are differences in representations of statistics between a non-native natural language and a native or artificial language. This result would also suggest that in previous studies testing statistical word-learning in a natural language the infants may have been able to distinguish between HTP and LTP words more so due to acoustic familiarity rather than tracking TP. If this had occurred, the next step would be to ensure that the infants were tracking TP by replicating previous studies. After that, it may be beneficial to include an older age group to see if they can successfully generalize.

Future research should include other types of indexical features besides gender. One direction could be testing the effect of acoustic variations of speakers of the same gender. Graf Estes and Lew-Williams (2015) demonstrated that low acoustic variation seems to impede 8-month-old infants' ability to segment words in an artificial language. A similar study could be done using a natural language (Italian). Another indexical feature to test could be the age of the speaker. A similar procedure to this study could apply but, instead of a male speaker, an elderly

woman could be used. Exploring various indexical features supplies further knowledge about statistical word-learning and infant language acquisition.

Appendix

Language A-- HTP-words: *fuga*, *melo*; LTP-words: *bici*, *casa*

Spesso Lisa capita in fuga nella casa dove giaci gracile e tesa. Se cadi con la bici prima del bivio del melo cavo ti do dieci bigoli e una biro. Gli amici della cavia Bida poggiano le bici in bilico presso il melo per difesa dalla biscia. Sovente carico la spesa nel vicinato dopo una fuga con la bici nuova. Carola si è esibita in una fuga verso il melo perché offesa dagli amici scortesi. Se vai a casa in bici ti debiliti ma cali e non sei più obesa. Dietro la casa del capo ho sprecato i ceci sotto al melo ombroso. Se cuci subito sulla divisa bigia il distintivo col melo vado in casa a dormire. Teresa si abitua alla fuga da casa con la vecchia bici senza luci posteriori. Taci sulla fuga di Marisa con il caro lattaio. Il bel melo sta tra la casa dei Greci e la chiesa arcana dove hai giocato con le bilie. I soci della ditta Musa si danno alla fuga con la bici della maglia rosa.

Language B-- HTP-words: *bici*, *casa*; LTP-words: *fuga*, *melo*

Roméro fu coinvolto in una futile fuga in bici verso il profumo del mélo ombroso.

Il collega di Paolo Fusi trovò la bici per la fuga presso la casa del molo. La maga tiene in casa almeno un fuco, uno squalo e una tartaruga del Nilo. Il fuco procede parallelo alla casa sulla riga tracciata dalla cometa. Il gattone Refuso medita sul mélo presso casa ascoltando una fuga di Verdi. Il fu Medo Rossi ruppe la braga nella bici il mese scorso durante la gara. Giga ogni mese paga con zelo l'affitto per la casa con il melo in fiore. meco prega il cielo che ogni fuga da casa termini sotto melo ombroso. Il delfino beluga si dimena tutto solo nella fuga verso il Nilo azzurro. Un pezzo di filo si è infilato nella bici appoggiata al melo dietro la méscita. Vi fu un

tempo in cui la bici in lega non temeva il gelo del rifugio della Futa. La strega del melo fu vista in fuga sulla bici con un chilo di rametti.

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