SUB-SEGMENTAL DETAILS IN EARLY LEXICAL REPRESENTATION OF CONSONANTS

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ABSTRACT

White & Morgan [8] showed that 19-month-olds have detailed representations of consonantal onsets. Here, we examine whether infants also have detailed representations of consonantal codas and whether infants' representations are underspecified for unmarked segments. Our results show that infants' lexical representations are as detailed as those of adults.

Keywords: early lexical representation, infant word recognition, phonetic features, specification, mispronunciation

1. INTRODUCTION

As adults, we are able to efficiently process the phonology of our native language, and are thus able to focus on the linguistic dimensions that are critical for distinguishing among potential word candidates in the lexicon (e.g. /t/ and /p/ in "cat" and "cap"). Moreover, we can easily apply our phonological knowledge to identify new lexical entries when tokens differ sufficiently along phonological dimensions and fail to be attested as existing words in the lexicon. To infant learners, phonological knowledge is of equal importance. To build a lexicon of the language they are learning, infants need to create stable word representations in memory, learn the mappings between words and their referents, and differentiate words from one another. Previous research has sometimes suggested that early lexical representations are much less detailed than mature representations (e.g. [5]). However, recent findings indicated that infants are not only sensitive to one-feature mispronunciations of familiar words (e.g. [7]) but also display graded sensitivity to varying degrees of onset mispronunciations of familiar words. White & Morgan [8] found that as mispronunciations increasingly deviated by one (/gog/), two (/kog/), or three features (/sog/) from the correct forms (/dog/), infants' proportional looking to a referent of the familiar target word (e.g. the dog) decreased in a graded fashion. In this paper, we present three studies showing from different perspectives that infants' early lexical representations are as specific as those of adults.

2. EXPERIMENTS

2.1. Experiment 1

This experiment used White & Morgan's procedure to test whether their findings applied to coda as well as onset mispronunciations.

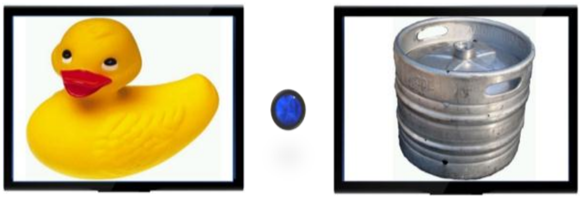
2.1.1. Subjects

Thirty-two 19-month-olds (mean age = 586.5 days) subjects were tested.

2.1.2. Stimuli

The familiar stimuli comprised a set of words that are comprehended by at least 50% of infants by 14 months, according to the MacArthur CDI norms [2]. In each trial, infants saw two images, one depicting a referent of a familiar word, the other depicting a referent of an unfamiliar (to 19-month-olds) word. An example stimulus pair is depicted in Fig. 1.

Figure 1: Sample visual stimulus pair.



Of 18 total trials, five had the familiar object's label pronounced correctly (e.g. duck), three had familiar object's label pronounced with a one-feature change (place) in the coda consonant (e.g. dut), three had two-feature changes (place + voicing) in the coda consonant (e.g. dud), three had three-feature changes (place + voicing + manner) in the coda consonant (e.g. duz), and four novel trials in which the unfamiliar object was named (e.g. keg). Novel trials were included to provide a baseline to measure looking behavior in the context of a completely unfamiliar word. Each of the 18 trials involved a unique item. Degree of mispronunciation of items was counterbalanced across four groups of infants. Examples of mispronunciations are given in Table 1.

Table1: Sample audio conditions of Experiment 1.

Correct	Example Target
Correct	"duck"
1 feature (Place)	"dut"
2 feature (Place + Voicing)	"dud"
3 feature (Place + Voicing + Manner)	"duz"

All mispronunciations resulted in non-words or in words judged unlikely to be familiar to toddlers at this age.

2.1.3. Procedure

An intermodal preferential looking procedure (IPLP) was used, in which one object with a known label and a second object with unknown label were displayed on two horizontally opposed screens (See Figure 1). Each trial began with a salience phase, during which two objects were displayed silently for 4 seconds. The infants' attention was attracted to midline to avoid contingencies between side of fixation at the end of the salience period and at the beginning of the test period. After recentralization, the experimenter initiated the test phase. During the test phase, the audio stimulus (Where's the X?) was played, then immediately after the coda of the target word, the same two visual stimuli were presented simultaneously for 8 seconds. Infants' looking was recorded and then coded off-line frame by frame.

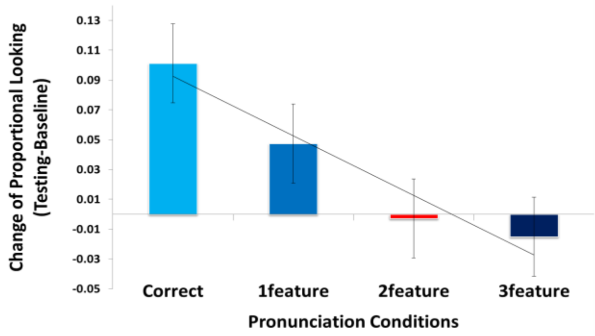
2.1.4. Results and discussion

The dependent measure was the change in subjects' looking proportions to the familiar object between the (silent) salience phase and the test phase, which was calculated using the formula:

(1) %LookFamiliar(Test) - %LookFamiliar(Salience)

Comparison across test and salience phases allowed us to use each stimulus pair as its own control, thereby controlling for any inherent preference for a particular stimulus in each pairing. As expected, there was significant linear trend of decreased looking to familiar objects with increasing severity of coda mispronunciation: F_s (1,124) =4.083, p<.05, F_i (1, 44) =4.109, p<.05, replicating White & Morgan (2008)'s findings for onsets. Test-minus-salience difference scores are depicted in Fig. 2.

Figure 2: Mean Differences of Looking Proportions. Condition is represented on the x-axis. The y-axis represents the difference between proportion looking at the familiar object in the test phase and proportion looking at the familiar object in the salience phase.



The pattern of results shows that 19-month-olds have graded sensitivity to varying degrees of word coda mispronunciations. Since both 14-month-olds [7] and 22-month-olds [1] are sensitive to one-feature mispronunciations of familiar words, together with these findings and those of White & Morgan [8], we may infer that degree of detail of early lexical representation is consistent over age.

2.2. Experiments 2 & 3

As claimed by phonology theories and supported by some psycholinguistic research, adults' lexical representations may not always be fully specified. In particular, unmarked coronal consonants (e.g. [d] [t] [n] [l]) may be under-specified whereas non-coronal consonants (e.g. [b] [k] [m] [r]) are fully-specified. For instance Lahiri & Reetz [4] found less priming in adults from non-coronal→ coronal mispronunciation changes (e.g. dog-dod), than from coronal→non-coronal changes (e.g. cat-cak). If infants' representations are similarly underspecified, they should also show such asymmetrical patterns in mispronunciation tasks, depending on whether the mispronunciations are from underspecified to specified segments or from specified to underspecified segments. Experiments 2 and 3 address this question for consonantal onsets and codas, respectively.

2.2.1. Subjects

Twenty-two 19-month-olds were tested in Experiment 2; twenty-six were tested in Experiment 3.

2.2.2. Stimuli

Like in Experiment1, the visual stimuli of each trial are comprised of a familiar object and an unfamiliar object. Of the 18 trials, three were correct underspecified trials (e.g. duck), three were mispronounced underspecified (e.g. dut), three were correct specified pronunciations (e.g. cat) three mispronounced specified trials (e.g. cat →cak), and the remaining six were correct and novel fillers. Mispronunciations only involved changes in place of articulation.

2.2.3. Procedure

Same as Experiment 1.

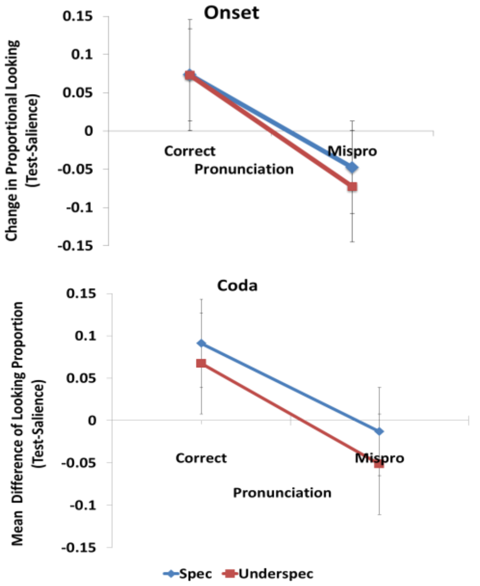
2.2.4. Results and discussion

As in Experiment 1, the dependent measure was the change of looking proportion to familiar objects between salience and test phases. To explore the effects of specification and mispronunciation, split-plot-ANOVAs were performed on the four conditions (correct-mispronounced*specified-underspecified) for both experiments. For both onsets (see Figure 3) and codas (see Figure 4), we found that there were significant effect of pronunciation (correct-mispronounced): Fo_s (1, 21) = 10.92, p < .005; Fo_i (1, 10) = 16.02, p < .005. Fc_s (1, 21) = 0.05, p = 0.82; Fc_i (1, 10) = 0.32, p = .58; however, the effect of interaction was not significant either for onsets Fo_s (1, 21) = 0.003, p = 0.96; Fo_i (1, 10) = 0.21, p = .65, or for coda Fc_s (1, 25) = 0.04, p = .84; Fc_i (1, 10) = 0.84, p = .85. Therefore, conflicting with the underspecification accounts for both infants [3] and adults [4], our findings indicated that 19-month-olds symmetrically specify both coronal and noncoronal consonants in their lexical representation. Possibly infants at this age have more detailed information in their lexical representation, and they need more experience to learn which segments can be safely under-specified. However, most previous studies on underspecification in adults used priming tasks to examine effects of mispronunciations. As we know, priming studies necessarily introduce some lag between primes and targets, and it is thus unclear whether the results reported by Lahiri and Reetz are perceptual or post-perceptual. To disentangle this, in experiment 4, we tested adults on their immediate responses to mispronunciations using an eyetracking procedure in a fashion comparable to our testing on infants.

2.3. Experiment 4

The purpose of this study is to test whether adults asymmetrically represent coronals and non-coronals in an on-line word recognition task.

Figures 3 & 4: Mean Differences of Looking Proportions for onsets and coda. Pronunciation is represented on the x-axis. The y-axis represents the difference between proportion looking at the familiar object in the test phase and proportion looking at the familiar object in the salience phase. The blue line represents words with specified consonants and the redline represents words with underspecified consonants.



2.3.1. Subjects

Twenty-four mono-lingual English speaking adults with the age range of 19-37 were tested.

2.3.2. Stimuli

The familiar stimuli comprised a set of highly frequent objects with their names highly familiar; while the distractors are comprised of a set of highly rare objects, with their names unlikely to know. An example stimulus pair is depicted in Fig. 5:

Figures 5: Sample visual stimulus pair.

There are 108 trials, in which 18 were correct underspecified trials (e.g. duck), 18 were mispronounced underspecified (e.g. dut), 18 were correct specified pronunciations (e.g. cat) 18 mispronounced specified trials (e.g. cat →cak), and the remaining 36 were correct and novel fillers. Like in Experiment 2 & 3, mispronunciations only involved changes in place of articulation. All mispronunciations resulted in non-words in English.

2.3.3. Procedure

Participants were looking at a screen in which one object with a known label and a second object with unknown label were horizontally displayed (See Figure 5). Like in experiment 1, each trial began with a salience phase, during which two objects were displayed silently for 4 seconds. Then the participants' attention was attracted to midline to be recentralized. After recapturing participants' attention to the midline, the test phase began, during which the audio stimulus for the target word (X?) was played, and immediately after the coda of the target word, the same two visual stimuli were presented simultaneously for 8 seconds. Participants' looking was recorded and online coded by the eye-tracker.

2.3.4. Results and discussion

The dependent measure was the difference in subjects' looking proportions to the target object and the distractor, which was calculated using the formula:

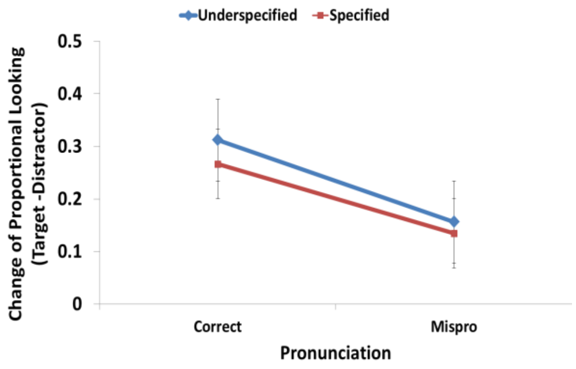
(2) %LookTarget - %LookDistractor

Like in Experiment 2&3, a 2*2 split-plot-ANOVAs showed a significant effect of mispronunciation: $F_s(1,23)=14.31$, $p<.005$, $F_i(1,70)=83.53$, $p<.001$, however, no significant pronunciation by specification interaction was found F_s (1, 23) = 0.754, p = 0.39; F_i (1, 70) = 0.120, p = 0.73 (See Figure 6). These results indicated that adults showed symmetrical sensitivity to both directions of mispronunciation changes during on-line word recognition, conflicting with the underspecification accounts, which might not tap the same level of representation as our task.

3. GENERAL DISCUSSION

Like adults, infants, at least by 19 months, have detailed phonological representations of both onset and coda consonants: in each case, increased severity of mispronunciations increasingly impairs recognition of familiar words in a graded fashion. Meanwhile, like adults. infants symmetrically specify both coronal and noncoronal phonemes in on-line word recognition. Therefore, the findings in our current study challenged the holistic hypothesis of lexical development by showing from different perspectives that infants' lexical details are of adult-like sophistication. Thus, we can conclude that there is a developmental continuity for the mechanism of lexical representation and word recognition.

Figure 6: Adults' Mean Differences of Looking Proportions. Pronunciation is represented on the x-axis. The y-axis represents the difference between proportion looking at the target object and distractor. The blue line represents words with specified consonants and the redline represents words with underspecified consonants.



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