Developmental Continuity in Infants’ Early Lexical Representations

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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. Stager & Werker, 1997). However, recent findings indicate that infants are not only sensitive to one-feature mispronunciations of familiar words (e.g. Swingley & Aslin, 2000) but also display graded sensitivity to varying degrees of onset mispronunciations of familiar words. White & Morgan (2008) 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) versus a referent with no known label decreased in a graded fashion.

In this chapter, we present four studies showing from different perspectives that infants’ early lexical representations are specified to the same degree and in the same manner 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 (Dale & Fenson, 1996). In each trial, infants saw two images, one depicting a referent of a familiar word, the other depicting a referent with no known label (to 19-month-
olds). An example stimulus pair is depicted in Figure 1.

![Sample visual stimulus pair.](image)

Figure 1: Sample visual stimulus pair.

Of 18 total trials, five had the familiar object’s label pronounced correctly, three had familiar object’s label pronounced with a one-feature change (place) in the coda consonant, three had two-feature changes (place + voicing) in the coda consonant, three had three-feature changes (place + voicing + manner) in the coda consonant, 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.

<table>
<thead>
<tr>
<th>Pronunciation Condition</th>
<th>Example Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>/d\k/</td>
</tr>
<tr>
<td>1 feature (Place)</td>
<td>/d\t/</td>
</tr>
<tr>
<td>2 feature (Place + Voicing)</td>
<td>/d\d/</td>
</tr>
<tr>
<td>3 feature (Place + Voicing + Manner)</td>
<td>/d\z/</td>
</tr>
</tbody>
</table>

Table 1: Sample audio conditions of Experiment 1.

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 no known 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 recalibration, 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. 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: $F_s (1,124) = 4.083, p<.05$, $F_t (1, 44) = 4.109, p<.05$, replicating White & Morgan (2008)’s findings for onsets. Test-minus-salience difference scores are depicted in Figure 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 after a label was heard and proportion looking at the familiar object in the silent salience phase.](image)

This pattern of results shows that 19-month-olds specify coda consonants in their lexical representations and have graded sensitivity to varying degrees of word coda mispronunciations. Since both 14-month-olds (Swingley and Aslin, 2002) and 22-month-olds (Bailey and Plunkett, 2002) are sensitive to one-feature mispronunciations of familiar words, together with these findings and those of White & Morgan (2008), we may infer that infants consistently have detailed lexical representation.

2.2 Experiments 2 & 3

As claimed by certain phonology theories and supported by some psycholinguistic research, adults’ lexical representations may not always be fully
specified. In particular, unmarked coronal consonants (/d/, /t/, /l/, /n/) may be underspecified whereas non-coronal consonants (/b/, /k/, /m/, /r/) are fully specified. For instance Lahiri & Reetz (2010) found less priming in adults from non-coronal→coronal mispronunciation changes (/dag/→/dad/), than from coronal→non-coronal changes (/kæt/→/kæk/). 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
As in Experiment 1, the visual stimuli in each trial comprised a familiar object and an unfamiliar object. Of the 18 trials, three were correct underspecified (/dæk/ or /kaet/), three were mispronounced underspecified (/gæk/ or /kaek/), three were correct specified (/kæt/ or /dæk/) three were mispronounced specified trials (/tæt/ or /dæt/), 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, ANOVAs were performed on the four conditions (correct-mispronounced*specified-underspecified) for each experiment. For both onsets and codas (see Figure 3), we found significant effects of pronunciation (correct-mispronounced): $\text{Fo}_s (1, 21) = 10.92, p < .005$; $\text{Fo}_i (1, 10) = 16.02, p < .005$. $\text{Fc}_s (1, 21) = 0.05, p = 0.82$; $\text{Fc}_i (1, 10) = 0.32, p = .58$. However, the pronunciation*specification interactions were not significant either for onsets $\text{Fo}_s (1, 21) = 0.003, p = 0.96$; $\text{Fo}_i (1, 10) = 0.21, p = .65$, or for codas $\text{Fc}_s (1, 25) = 0.04, p = .84$; $\text{Fc}_i (1, 10) = 0.84, p = .85$.

Contrary to underspecification accounts for both infants (Dijkstra & Fikkert, 2010) and adults (Lahiri & Reetz, 2010), 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 than needed in their lexical representation, and they need more experience to learn which segments can be safely underspecified. On the other hand, most previous studies on underspecification in adults used priming tasks to examine effects of
Figure 3: Representational salience represents the phase after a specified consonant. The y-axis during the test lines represents specified consonants and the silent red lines.
mispronunciations. Priming studies necessarily introduce lags between primes and targets, and it is thus unclear whether results such as those 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 eye-tracking procedure comparable to our testing of infants.

2.3 Experiment 4

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

2.3.1 Subjects

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

2.3.2 Stimuli

Familiar stimuli comprised a set of highly frequent objects with highly familiar names; the distractors comprised a set of unusual or nonce objects, whose names were unlikely to be known. An example stimulus pair is depicted in Figure 4.

![Figure 4: Sample visual stimulus pair.](image)

There were 108 trials, in which 18 were correct underspecified trials (/dæk/), 18 were mispronounced underspecified (/gæk/), 18 were correct specified pronunciations (/bæð/) 18 mispronounced specified trials (/dæθ/), and the remaining 36 were correct and novel fillers. As in Experiments 2 & 3, mispronunciations only involved changes in place of articulation. All mispronunciations resulted in non-words.

2.2.3 Procedures

Participants looked at a screen in which one object with a known label and a second object with unknown label were horizontally displayed (See Figure 4). As in Experiment 1, each trial began with a 4-second silent display of the two objects. A center fixation display then attracted participants’ attention to midline. After 1.5 seconds, the audio stimulus for the target word was played; immediately after the coda of the target word, the same two visual stimuli were presented for 8 seconds. Participants’ looking was recorded and coded online by the eye-tracker.
### 2.2.4 Results and discussion

The dependent measure was subjects’ looking proportions to target objects. As in Experiments 2 & 3, a 2*2 ANOVA showed a significant effect of mispronunciation: F_s(1,23)=31.14, p<.005, F_i(1,140)=24.41, p<.001. However, no significant pronunciation by specification interaction was found F_s (1, 23) = 1.52, p = 0.23; F_i (1, 140) = 0.17, p = 0.68 (See Figure 5). Adults showed symmetrical sensitivity to both directions of mispronunciation changes during on-line word recognition. This is contrary to the predictions of underspecification accounts and conflict with previous findings on underspecification, which may have tapped different levels of representation than did our tasks.

![Figure 5: Adults’ Mean Proportional Looking to the Target. Pronunciation is represented on the x-axis. The y-axis represents the proportional looking to the target object. The blue line represents words with underspecified consonants and the red line represents words with specified consonants.](image)

### 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. Meanwhile, like adults, infants symmetrically specify both coronal and
noncoronal phonemes in on-line word recognition. Therefore, the findings in our current study challenge holistic hypotheses of lexical development by showing that from different perspectives, infants’ lexical details are of adult-like sophistication. Rather than developmental discontinuity, there appears to be substantial developmental continuity in lexical representation.

References


