

NOVEL FEATURE PROCESSING

BY CHILDREN AND ADULTS

by

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ABSTRACT

The common notion that “younger is better” for acquiring second language (L2) phonology is typically supported by empirical evidence. However, there is no clear explanation for this trend, and few direct comparisons of the process by which adults and children acquire L2 phonology. Research comparing adults’ and children’s native language (L1) processing has indicated that children exhibit greater sensitivity than do adults to L1 nonphonemic acoustic variation. The present study aims to determine if children’s sensitivity to nonphonemic L1 variation can extend to a novel L2 sound contrast. It was hypothesized that this L1 sensitivity may allow for greater sensitivity to a novel L2 contrast. Additionally, this study compared performance by children and adults on a perceptual as opposed to a lexical task, predicting an advantage for discrimination of a novel contrast in a purely perceptual task. Four and 5-year old children and adults were tested on their discrimination of Japanese nonwords differing minimally by the novel consonant feature [length]. Experiment 1 involved discrimination of auditory pairs and Experiment 2 involved picture-word matching of previously learned words. Results showed no awareness of the novel contrast in [length] in Experiment 1 by the children and near-chance performance for the adults. No effect of perceptual versus lexical task was found in adult performance. It is proposed that the children’s results stem in part from the difficulty of a task requiring them to express awareness of an L2 contrast that was nonmeaningful in the L1. These results support research showing that adults

outperform children in L2 learning environments where adults' learning strategies present an advantage. Additionally, although the lexical task was not significantly more difficult for adult subjects as a group, scores on the two tasks revealed individual variation. This variation in performance may be a topic for further investigation.

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INTRODUCTION

Evidence supports the common assumption that younger second language (L2) learners have an advantage over older learners in acquiring native-like phonological proficiency. Both anecdotal and scientific evidence support this advantage. For example, the L2 pronunciation of learners beginning L2 acquisition at an earlier age has been found to resemble that of native speakers as evaluated by native speakers (DeKeyser & Larson-Hall, 2005; Flege, Birdsong, Bialystok, Mack, Sung, & Tsukada, 2006; Flege, Yeni-Komshian & Liu, 1999), and under acoustic analysis (Baker & Trofimovich, 2005). As for perception, L2 speakers who began at an earlier age have also been shown to perceive and identify L2 phonemes more like native speakers than their older counterparts (Baker, Trofimovich, Mack & Flege, 2002).

The correlation between age of acquisition and L2 phonological proficiency is even more striking compared to the relation between age and other aspects of linguistic fluency. For example, DeKeyser and Larson-Hall (2005), in a review of recent research on the effects of age of acquisition (AOA) on L2 acquisition, pointed to differing results for grammaticality judgment tests and global phonological fluency ratings. They noted that “all the studies that have used global accent ratings on sentences or paragraphs that were read or spontaneous speech have found that degree of accent increases as AOA increases” (DeKeyser & Larson-Hall, 2005, p. 93), but most tests of grammatical competence reflect “a decline (of considerably varying degree) during childhood,

followed by a low to zero correlation through adulthood” (DeKeyser & Larson-Hall, 2005, p. 90). Thus it appears that L2 phonological acquisition is in some way more closely linked with age of learning than other aspects of language learning.

Measures of L2 learners’ performance in phonological tasks repeatedly attest to a negative correlation between age of acquisition and ultimate L2 performance; however, the reasons behind this phenomenon remain unclear. Specifically, how does phonological acquisition proceed differently at different ages, such that the end results are not the same? In order to shed light on this question it is useful to move from observation of ultimate phonological performance to exploration of the actual process of phonological acquisition for both adult and child L2 learners.

Research addressing L2 sound acquisition in adult speakers suggests a tendency for adults to categorize L2 sounds according to well-established native language (L1) categories (Best & Strange, 1992; Brown, 1998; Flege, 1999; Larson-Hall, 2004). Difficulties with L2 production and encoding of auditory input as abstract phonological representations would result from this sound categorization by adult speakers. However, a similar consensus concerning the influence of L1 categories on L2 sound acquisition does not exist for children.

Furthermore, although the end result of phonological acquisition for learners beginning at different ages has been a frequent subject of inquiry (e.g., Flege, Yeni-Komshian & Liu, 1999; Hakuta, Bialystok & Wiley, 2003; Oyama, 1976; Patkowski, 1980), direct comparisons of the process by which children and adults eventually achieve these divergent results are less common. There are relatively few studies directly comparing the phonological acquisition process of adults and children at different stages

of L2 development (examples to be discussed include Baker et al., 2002; Baker & Trofimovich, 2005; Heeren, 2006; Snow & Hoefnagel-Höhle, 1977; Walley & Flege, 1999).

The aim of the present study is to address one aspect of the process of L2 phonological acquisition: the initial processing of a non-native sound contrast in both perceptual and lexical representations. This was achieved by observing children's and adults' ability to identify the novel phoneme contrast [length], in order to compare how children and adults may initially perceive such contrasts, and subsequently store words containing these contrasts in similar or different ways. Specifically, this performance is taken to reflect the degree to which children and adults tend to perceive or lexically encode contrasting L2 sounds according to their L1 categories.

This study had the second aim of observing whether subjects' ability to identify a novel contrast differs in a purely perceptual as opposed to a lexical task. Past studies have shown that discrimination of acoustic differences may be more difficult for adults as well as children when lexical, meaning-based information is associated with the auditory stimuli presented (Curtin, Goad & Pater, 1998; Flege & Walley, 1999; Stager & Werker, 1997). In other words, subjects may be more aware of acoustic variation when no meaning-related information is available in memory. In order to compare sensitivity to a novel contrast in a purely perceptual or a lexical task, the present study included both discrimination of L2 nonwords encountered as simple auditory stimuli, as well as words associated with visual images.

BACKGROUND

L1 Phonological Processing

The current study proposes to compare how novel sound categories are initially perceived and subsequently stored during word learning by children and adults. Specifically, it seeks to identify the similarities or differences between child and adult L2 phonological representations. Although little research has directly compared how children and adults process L2 sounds, there is a large body of research comparing L1 processing by children and adults. A major focus of this research is the degree of similarity or difference between children's and adults' abstract phonological representations of their native L1 sound inventories.

Many theories of L1 word processing are based on successive access to various levels of mental representations, with distinct representations posited for abstract phonological form and meaning-based lexical representations. According to such theories, perception of acoustically detailed auditory input activates a more abstract, phonological form, thus extracting the meaningful, contrastive elements of a given language. This abstract form then allows for access to the lexical entry of a word, including meaning-associated features. Implied in such a system is the filtering of perceived acoustic details that are not meaningful for a speaker's native language, and a common inventory of abstract, contrastive segments shared by speakers of the same L1.

Significant differences in children's and adults' performance on L1 word recognition tasks have led some to propose that children do not yet extract the same level of detail as adults from perceived acoustic input, and have less detailed abstract phonological forms associated with words stored in memory. However, recent studies of young children's L1 perception has tended to support a high degree of similarity between the abstract phonological forms children and adults use to access lexical information (Gerken, Murphy & Aslin, 1995; Swingley, 2003; Swingley & Aslin, 2002).

Despite proposals that children do not attend to the same level of detail in processing acoustic input and subsequent lexical storage as adults (for example based on evidence of less awareness of word-initial segment noise (Walley, 1988), less awareness of feature position (Treiman & Breaux, 1982) or less awareness of the feature [place] (Storkel, 2002)), evidence now supports a similar sensitivity to detail in adults and children when appropriate methods are used. For example, children show detailed awareness of feature variation introduced by mispronunciations of real words (Gerken, Murphy & Aslin, 1995; Swingley, 2003; Swingley & Aslin, 2002). The research of Swingley and Aslin (2002) revealed that recognition and visual fixation by 14-month old children for items associated with familiar words was significantly affected by mispronunciations involving the substitution of even a single feature (*tog* for *dog*; or *pity* for *kitty*). Swingley (2003) showed similar differential recognition of correctly pronounced versus mispronounced familiar words with 19-month old children. These results seem to imply detailed phonological features in children's lexical representations of well-known words, even before the "word spurt" period of intense lexical acquisition, generally occurring around the age of 18 months. Concerning older children, Gerken,

Murphy and Aslin (1995) found 3- and 4-year old children to be sensitive to the number of feature substitutions in a familiar word. For example, children in their experiment were more likely to confuse a target word *little* and a test word /nitɫ/ (differing in [manner]) than *little* and /grɫɫ/ (differing in both [manner] and [place]).

Beyond a shared sensitivity to L1 feature substitutions in known words, adults and children appear to store some subphonemic acoustic details in memory in similar ways. A notable characteristic of segmental processing in both children and adults is the ability to abstract across subphonemic variation such as individual speaker differences or allophonic variants of the same segment, while at the same time retaining these details to some degree.

Since the earliest research on the phenomenon of categorical perception (Liberman et al., 1957), the idea that listeners systematically ignore uninformative acoustic variation when processing incoming acoustic data has become widespread. Clearly, attention to nonessential aspects of the sound signal, such as whether a speaker pronounces the word *later* with or without a flap (/letər/ or /lerər/), or the relative pitch produced by a certain speaker, would impede L1 speech processing efficiency. Similarly, attention to non-native feature distinctions with no contrastive value in a child's native language is not an efficient use of processing resources for the goal of L1 acquisition. It is expected that speakers would ignore non-native contrasts in an L2 in the same way they would ignore allophonic variation in their L1, because they are directing their attention to specific acoustic details signaling contrastive categories of their L1. Research on infant perception supports the claim that over time children focus their awareness on native contrasts at the expense of non-native contrasts. For example, Kuhl et al. (2005)

have shown a correlation between an earlier decline in presumably inefficient attention to novel non-native contrasts (never before encountered by the child) and subsequent greater L1 proficiency.

It has recently become clear, however, that although both adults and children effectively “filter” incoming speech for the most meaningful aspects of their native language, nonessential acoustic details are retained in some form. This sensitivity has been illustrated in L1 word priming studies such as those carried out by Church and Schacter (1994) with adults and Fisher and Church (2001) involving 2- and 3-year old children. Priming refers to the phenomenon whereby a subject more quickly recognizes a word recently encountered in a priming phase than a new word. Church and Schacter (1994) showed priming to be sensitive to not only segment level details, but also to subphonemic acoustic variation. In a study with adult English speakers, the authors showed significantly decreased priming effects with changes in speaker voice on a degraded identification task, and with changes in overall fundamental frequency on both a degraded identification and a stem-completion task. According to the authors, these results reflect perceptual representations including both abstract phonological and subphonemic acoustic detail.

Sensitivity to subphonemic detail in adults’ L1 has also been found through both auditory discrimination tasks (Pegg & Werker, 1997) and “category goodness” judgment tasks (Miller, 1994). Using a stop consonant voicing discrimination task, Pegg and Werker presented adult subjects with voiced and voiceless unaspirated alveolar stops, which are both found in English, but do not represent a phonemic contrast in syllable-initial position. Results showed that adults performed above chance in distinguishing the

subphonemic L1 variants. Similarly, Miller reported that adults' sensitivity to L1 within-category differences is reflected in the "systematic variation" in their ratings of acoustically varying tokens of a single L1 phoneme category as better or worse examples of that category. For example, adult English speakers systematically rated the category goodness of /p/ tokens varying along a VOT continuum, with a limited range of VOT values being identified as the best exemplars of /p/. (Miller, 1994, p. 273)

As for children's sensitivity to L1 within-category contrasts, Fisher and Church (2001) showed similar sensitivity by 2- and 3-year old children to nonessential acoustic details. In their study, information about "allophonic" variation such as alternations between [t] and a flap [ɾ] in unstressed English syllables influenced toddlers' recognition of subsequent tokens of the same word. For example, a child primed with the word "potato" with a flap in the final syllable [pətɛɾo] more accurately identified and repeated a subsequent token of the same word with a flap in the final syllable than a subsequent token with the [t] variation in the final syllable [pəteto]. Thus information that presumably has no contrastive value in English, [t]-[ɾ] allophonic alternation within the English category /t/, was nonetheless stored in memory by subjects in a way that influenced processing of the next instance of the same word. Importantly, however, the different token of the same word still had a weaker, but significant facilitative effect on subsequent recognition. This seems to indicate that although the 2- and 3-year old children maintained a detailed representation in memory, they were also aware of the shared abstract categories between the acoustically different tokens, similar to adults.

Increasingly sophisticated methods of inquiry have produced an emerging picture of children's L1 processing that bears a striking resemblance to their adult counterparts.

However, differences have also been identified between the ways in which children and adults categorize perceived auditory input as abstract, L1 phonological representations. Recent research has shown that in some tasks, children may exhibit greater awareness of acoustic variation than adults (Hazan & Barrett, 2000; Heeren, 2006; Pursell, Swanson, Hedrick & Nabelek, 2002).

In a cross-linguistic comparison of age-related phoneme category differences, Flege and Eefting (1986) found differences in category boundary locations between English-speaking 9-year-olds and English-speaking adults, as well as between Spanish-speaking 9-year-olds and Spanish-speaking adults. Subjects categorized tokens along a VOT continuum varying from /d/ to /t/. In both language groups, adults identified a boundary between the two at a significantly longer VOT value than the children. Heeren (2006) also found significant differences in the placement of category boundaries for Dutch 5-year old and 7-year old children and adults. He taught subjects novel picture-word associations for the minimal pair /fa/ and /sa/, and used a picture classification task to evaluate children's perception of tokens on a /f-s/ continuum. Heeren found that the 5- and 7-year old groups differed from adults and each other, with the 5-year-olds placing their boundary nearer to /s/ and the 7-year-olds' boundary closer to /f/. Thus, both studies show age-related variation in category boundary placement for selected phonemes.

Studies have also found significant differences in the consistency with which children and adults identify auditory tokens as L1 sound categories. As mentioned earlier, speakers of the same L1 tend to pay less attention to within-category acoustic variation than variation between sound tokens on either side of a category boundary. As a result, when asked to label tokens spanning different sound categories, adults generally label

acoustically varying tokens together when they fall within the same category, but show an abrupt shift in response at the category boundary (Liberman et al., 1957). Figure 1 represents the results of such a labeling task by Liberman et al. (1957) using tokens varying in a three-way place distinction from /b/ to /d/ to /g/. The authors cited the steepness of these identification slopes as evidence of “sharp and stable” category boundaries.

Hazan and Barrett (2000) analyzed the identification of phonemic categories by English-speaking adults and 6- to 12-year old children to determine the degree of similarity or differences produced in such a task. Subjects heard a series of acoustic tokens along a continuum of contrasting sounds (/g-k/; /d-g/; /s-z/; and /s-f/) and labeled each token. The authors found that although the location of the category boundaries did not differ significantly by age on these tasks, adult responses produced a steeper

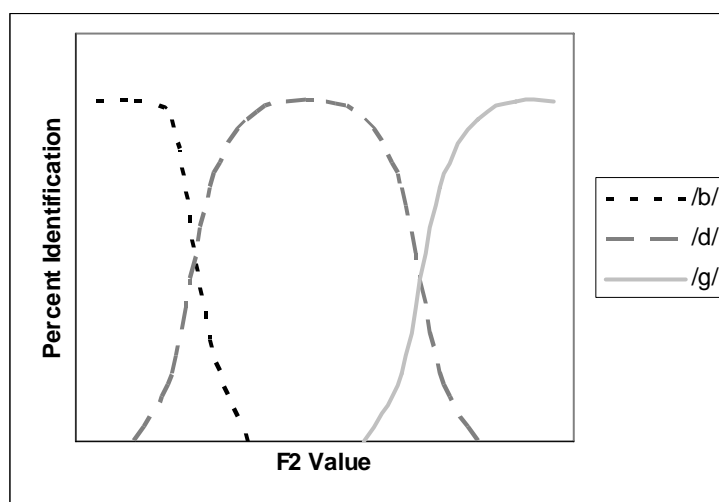


Figure 1. Stylized representation of L1 phoneme labeling data from Liberman et al. (1957). Percent identification of stimuli along a 14-point continuum, varying in F2 transition from /b/ to /d/ to /g/.

identification function gradient at phoneme boundaries and their responses were more consistent despite acoustic cue manipulation compared with children. Whereas the adults more systematically categorized ambiguous tokens according to an established L1 category, the children showed greater variation in their response for the less typical tokens. Figure 2 represents labeling data from the study of Hazan and Barrett along a /d-g/ continuum by age group.

Similar results have been found by Pursell, Swanson, Hedrick and Nabelek (2002) for English children's perception of a /I-ε/ vowel continuum as well as by Heeren (2006) for Dutch children's perception of a Dutch vowel length contrast. These results seem to indicate children's greater awareness of differences which, for adults, constituted irrelevant, within-category variation.

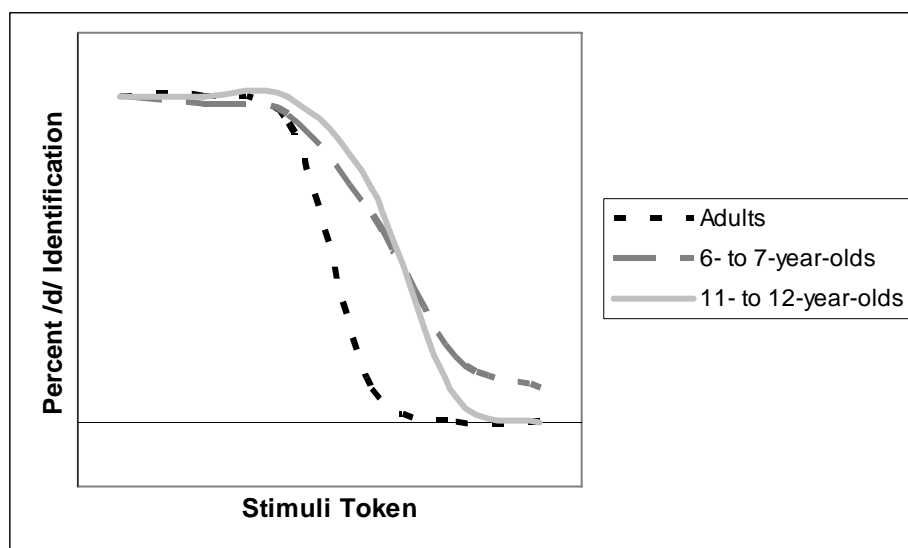


Figure 2. Stylized representation of labeling task data from Hazan and Barrett (2000). Percent identification of /d/ for stimuli varying in burst frequency and F2 and F3 transitions along a 6-point continuum from “date” to “gate”. Results given by age group.

Hazan and Barrett (2000) pointed to their findings as evidence that segmental representations continue to evolve beyond the early years of language learning. The conclusion that L1 phonology does not remain “frozen” past an early point in development and is less stable in young children is further supported by analyses of the L1 productions of speakers of two languages. Research has shown L2 influence on the L1 phoneme categories in such speakers. For example, Flege (1987) found that the L1 /t/ productions of native English and native French bilingual French-English speakers who had learned their L2 as adults differed significantly from the /t/ productions of monolingual English and French speakers. The influence of L2 sound categories on an L1 has been found to be even greater in younger learners, however. Baker and Trofimovich (2005) found greater “phonetic restructuring” in the L1 vowel productions of Korean-English early bilinguals (10- to 17-year-old native Korean speakers who had arrived in the US at an average age of 9 years) compared to adults. In other words, as a result of their new L2 linguistic environment, the native L1 Korean vowel categories of 9-year-olds were altered to a greater extent than those of adults.

Less direct evidence of age-related variation in L1 processing can be found in list-recall studies investigating the types of false recall produced by subjects at different ages. Dewhurst and Robinson (2004) presented 5-, 8- and 11-year old subjects with semantically related lists of English words, and analyzed the types of errors produced by each age group. The number of falsely recalled words decreased with age, but interestingly the relation between the falsely recalled words and the list words also changed. The 11-year-olds were more likely to produce errors semantically-related to the list words, and rarely substituted a phonologically-related word, however, the 5-year-

olds' errors were predominantly rhymes of the list words. In other words, the 5-year-olds were more likely to produce an error based on phonological association when trying to recall the list words than the older group. Although the results were based on memory errors, they seem to suggest a greater reliance on phonological form in memory recall of L1 words for younger children.

The results of Dewhurst and Robinson (2004) also support studies pointing to young children's overall greater attention to auditory over other types of sensory input in their environment. Robinson and Sloutsky (2004) for example, found that when auditory and visual clues conflicted in indicating the answer to a problem, children tended to focus on the auditory clue in contrast with adults.

Evidence of greater sensitivity to subphonemic detail by younger L1 speakers appears to reflect less efficient processing on the part of young listeners, who somehow lend greater attention to nonmeaningful differences than adults. Similarly, greater awareness of phonological associations between words would seem to be less useful than awareness of semantic associations for effective communication. An interesting question, however, is whether an immature focus on phonological input may offer some advantage for the acquisition of native-like phonology in a second language.

The idea that an undeveloped state of L1 language processing may represent an advantage for L2 acquisition has been considered by many researchers. Newport (1990) proposed that memory limitations in children may actually facilitate the learning of morphology in children, whereas adults' ability to store larger and more complex information in memory would in fact be a "counterproductive skill" for some aspects of linguistic acquisition (Newport, 1990, p. 26). Cochran, McDonald and Parault (1999)

tested the hypothesis that a child-like reduced processing capacity may aid the acquisition of verb agreement in a novel language (in this case, a signed language). The researchers found that adults who were exposed to this system under conditions in which their attention was reduced later performed better than other adults on tasks requiring them to adapt the learned signs to new contexts, similar to child learners of sign language. They concluded that limitations on processing capacity, similar to children's, could in fact help L2 syntactic acquisition.

As for phonological acquisition, Flege, Yemi-Komshian and Liu (1999) suggested that the still-fluctuating state of a child's L1 phonetic system may be responsible for child learners' eventual advantage over adults in acquiring L2 phonology. However, the process by which children acquire an L2 phonological system has not been thoroughly explored. The present study aims to address one aspect of this process by focusing specifically on how L1 category influences may differentially affect children's and adults' auditory perception and lexical encoding of a novel contrast encountered for the first time. Studies of this kind already offer insights into the L2 processing of adults.

L2 Phonological Processing

In contrast with the large literature comparing L1 processing by children and adults, relatively little can be found directly comparing L2 processing by these two groups. Adult L2 processing, however, has been the subject of many studies.

Much research on adult L2 phonological acquisition has focused on learners' auditory perception and abstract, phonological representations of non-native sound categories as a foundation for L2 phonological performance. This research has resulted in theories claiming the source of L2 speakers' phonological deviance from L1 norms can

be found in the interaction between L1 and L2 sound categories during acquisition (Brown, 1998; Flege, 1999; Kuhl et al., 2005; Larson-Hall, 2004). Among the factors considered to create the impression of “foreign accent” are non-native productions at the segmental level, where adults’ well-established L1 phonological representations may have a debilitating effect on the acquisition of L2 sound categories.

Brown (1998) proposed that the absence of specific L2 features in a learner’s L1 leads to difficulties in perceiving and acquiring L2 segments with the novel feature. Flege’s Speech Learning Model (1999) maintains more generally that successful L2 phonological acquisition depends crucially on the degree of L1 and L2 sound similarity, the learner’s ability to perceive slight phonetic differences between similar L1 and L2 sounds, and the learner’s ability to form distinct L2 categories. Specifically, L1/L2 interaction may lead to an L2 sound being assigned to the closest L1 sound category.

Best and Strange (1992) offered a more detailed scenario of the possible ways an L2 sound may be processed by a learner, within the framework of Best’s Perceptual Assimilation Model. They proposed that although two L2 phonemes may be assimilated to a single L1 phoneme, the learner may still distinguish between a “better” and a “worse” fit, similar to L1 speakers’ sensitivity to “category goodness” in their native language as mentioned earlier (Miller, 1994). According to Best and Strange, the L2 learner is sensitive to the degree to which an L2 phoneme resembles an L1 phoneme as a good or poor exemplar of that phoneme. They suggested this judgment may both inform the learner’s discrimination of a novel L2 contrast and aid in eventual formation of separate L2 categories. Furthermore, the authors noted that this perception is influenced by individual variation in attention to specific cues in the auditory stimuli. This suggests

a possible relevance of age-related variation in the use of cues to identify L1 phonemes, discussed earlier (Flege & Eefting, 1986; Heeren, 2006; Hazan & Barret, 2000; Pursell, Swanson, Hedrick & Nabelek, 2002). A greater awareness of within category acoustic differences in a learner's L1 may offer an advantage in detecting novel contrasts in an L2.

As previously mentioned, relatively little research has thus far been dedicated to the way children process novel sounds in a novel language and comparing this directly to adult processing. This may be largely due to practical limitations in the use of laboratory tasks, such as those mentioned above, with children. Existing studies mostly evaluate the speech of children living in an L2 environment for varying lengths of time.

For example, in a study of British speakers aged 3-60 years, living in a Dutch-speaking L2 environment in Holland, Snow and Hoefnagel-Höhle (1977) found that adults outperformed children on L2 phonological production tasks (imitation and spontaneous production) 6 weeks after subjects' arrival in their L2 environment. However, after 10 months, the younger subjects began outperforming the older subjects on measures of phonological accuracy of pronunciation.

Baker et al. (2002) and Baker and Trofimovich (2005) also focused on L2 speakers living in an L2 environment, evaluating the English vowel perception and production of Korean immigrants in the US. Baker et al. compared native Korean adults' and children's perception of English vowel contrasts that are not present in Korean. In one experiment, the researchers asked children and adults with 1 year's residency in the US to classify English vowels into Korean vowel categories (assign a Korean vowel equivalent to a spoken English vowel). They found that children were less likely than adults to assign an English vowel to the same Korean category each time. Furthermore

with just 1 year of residency, children outperformed adults in discriminating English minimal pairs *heed-hid* and *hot-hut*.

Concerning production, Baker and Trofimovich (2005) compared overlap of Korean and English vowel productions by Korean immigrants to the US, categorized as either early learners (arriving in the US on average at 9 years of age) or late learners (arriving on average at 25 years). Results showed that early bilinguals produced more acoustically distinct categories for their L1 and L2 vowels, but late bilinguals tended to “merge” L1 and L2 categories. According to the researchers, whereas early bilinguals appeared to exhibit a “phonetic restructuring” of both L1 and L2 vowel categories, late bilinguals did not show the same degree of bi-directional interaction.

Thus, studies of adults and children living in an L2 environment appear to support an advantage for children over adults in discriminating and producing L2 vowel contrasts after 10 to 12 months of L2 exposure, as well as the notion that children’s L1 categories are less stable than those of adults. Only a small number of experiments, however, have attempted to evaluate first-time exposure to an L2 in a laboratory environment.

In a laboratory task involving British speakers ranging from 5-31 years of age, Snow and Hoefnagel-Höhle (1977) found a linear increase with age in the subjects’ ability to produce novel Dutch sounds in an imitation task. The study involved no assessment of perceptual awareness of the sounds, though, only production.

In a perceptual experiment, Walley and Flege (1999) used a categorization task to evaluate English-speaking adult’s and 5- and 9-year old children’s perception of vowel tokens on a continuum ranging from a familiar /ɪ/ to a non-native front rounded /y/. Subjects were told they would either hear the made-up word /hɪb/ or another, unidentified,

made-up word (/hyb/), and were asked to press a button based on the word they heard. They found that 5-year old children had more difficulty accurately identifying the endpoint tokens, less consistently identified tokens as reflected in a less steep identification function, and tended to label more tokens as /hrb/ than the older subjects. From these results the authors concluded “considerable uncertainty or openness as to the status of the foreign vowel” on the part of children (Walley & Flege, 1999, p. 327).

More recently, Heeren (2006) attempted to evaluate 6-year old, 12-year old and adult Dutch subjects’ perception of a British English /θ-s/ contrast in a pretest-training-post-test design. However, the 6-year-olds were unable to complete the demands of the discrimination and classification tasks in pilot experiments and were not included in the final experiment. Heeren found no significant differences in the performance of adults and 12-year-olds, who both showed small improvements in perception of the English fricative contrast. This study highlights the difficulty of designing sufficiently comparable measures of L2 perception for children and adults within the limits of a laboratory experiment, where a balance must be achieved between a task that is overly difficult for the children and one that is overly simple for the adults.

Perceptual and Lexical Processing

As can be seen, research investigating L2 sound processing varies in both the type of subject involved (ranging from monolingual subjects exposed to L2 sounds for the first time in a laboratory setting to L2 speakers living in an L2 environment for 10 or more years), and the nature of the task used to evaluate the subjects’ abilities (perception of sounds, word recognition, production). The significance of this variation, and the variation in performance resulting from different types of tasks, has recently been

examined. It appears that a task involving recognition of both the phonological form and the meaning, or lexical retrieval, of a word may be more difficult than a task based solely on distinguishing or classifying phonological segments. Variation of this type has been found in both L1 and L2 processing.

Concerning children, Stager and Werker (1997) found a disconnect in the ability of 14-month-olds to distinguish feature contrasts in native-language minimal pairs in a purely perceptual context (no meaning involved) as opposed to a lexical task where each member of the pair was associated with meaning. Infants who were habituated to the sound *bih*, with no explicit referent, exhibited awareness of the distinction with its minimal pair *dih*. However, when infants were habituated to the sound *bih* associated with a picture of an object, and when the object was then shown with the minimal pair *dih*, they showed no awareness of the distinction. Stager and Werker attributed these results to the increased “computational” demands of both perceiving the phonological form of a word and associating this with meaning. They suggested that reduced attention to phonetic detail may be an efficient strategy young children adopt to more successfully associate word-meaning pairs.

Effects of L1 lexical representations on perceptual sensitivity have also been found in a study with both adults and young children (5- and 9-year-olds). Flege and Walley (1999) looked at the effect of lexical representation on vowel categorization performance. Subjects in their study were presented with CVC words varying in vowel quality along a continuum from a familiar /ɪ/ to a foreign /y/ sound. In one condition, the native /ɪ/ endpoint was in the form of a real English word (*bib*), but the foreign endpoint was not a real word (/byb/). In the other condition both the native and foreign vowel

endpoints were made-up words (/bɪp/ and /bɪp/). Results showed an effect of lexical condition on the vowel boundary, with both children and adults labeling more tokens as /ɪ/ when the endpoint was a real English word. It appears that the presence of an established, meaning-related representation affected both young children's and adults' sensitivity to the sound contrast.

Looking at the effect of L2 lexical representations for adults alone, Curtin, Goad and Pater (1998) found differential perception of Thai stop consonant categories (aspirated, unaspirated voiceless, unaspirated voiced) in a task involving lexical retrieval, as opposed to past experiments assessing purely perceptual distinctions. The authors found that English speakers had more difficulty perceiving aspiration, which is not contrastive in their L1, than voicing, which is contrastive in their L1 on lexical tasks with Thai minimal pairs. This result contrasted with previous studies requiring purely perceptual discrimination, in which aspiration contrasts were more easily recognized by English-speaking subjects. The authors concluded that L1 phonological contrasts have a greater influence on learners' abstract, lexical storage of L2 word representations associated with meaning than on nonlexical, auditory perception.

The conclusion that perception of some L2 contrasts is inherently more difficult for adults in lexical tasks than perceptual tasks has been called into question by Pater (2003), however, who found no such discrepancies when lexical and perceptual tasks were made to be more similar. Pater compared listeners' performance on a lexical and nonlexical version of the XAB task. In the nonlexical version, subjects matched a target sound with one of two subsequent sounds. In contrast, the lexical version required a subject to match a target picture with one of two sounds. The results of these parallel

tasks showed no effect of lexical as opposed to nonlexical task. Pater's research points to the importance of controlling not only for the type of recognition being tested (purely perceptual or lexical) but also for the actual nature of the task itself if comparisons are to be drawn.

Furthermore, there is evidence that in some cases, an L2 learner may lexically encode an L2 sound contrast in minimal pair L2 words, but show difficulty perceiving the same contrast in L2 auditory input. Weber and Cutler (2004) used eye-tracking to monitor Dutch speakers' response to an English /æ-ε/ contrast that does not exist in Dutch. For example, subjects heard a target word ("panda") and saw a picture of the target (panda) and a distracter (pencil) whose first syllables differed minimally in the non-native contrast. Looking times showed that when the target contained /æ/, Dutch subjects fixated on the distracter with /ε/, before the rest of the word context became apparent and they looked at the target picture. This was not the case when the target was /ε/ and the distracter was /æ/. According to Weber and Cutler, these results represent Dutch speaker's mapping of the auditory /æ-ε/ contrast in perception onto a single category /ε/, which is more similar to a Dutch category. However, the listeners' ability to recover from this distraction given the rest of the word shows that the contrast appears to be lexically encoded.

The present experiment aimed to evaluate both age-related and task-related differences in awareness of a novel feature, Japanese [length], by English speakers with no experience with such a contrast. In Japanese, unlike in English, the feature [length] can be used contrastively to distinguish two separate lexical items. For example, in

Japanese the long (or geminate) /tt/ in *otto* “husband” distinguishes it from *oto* “sound” with a singleton /t/.

Perception of the feature [length] was chosen as an appropriate measure due to its relative perceptibility by speakers whose L1 does not use this feature contrastively, as shown in Hayes-Harb (2005). In this study, monolingual English speakers were shown to be sensitive to manipulations in acoustic stimuli varying along a [length] continuum, although they did not label them categorically in the way that Japanese speakers did. Furthermore Hayes-Harb and Masuda (to appear) found monolingual English speakers to be sensitive to a [length] contrast in lexically stored items. In their experiment, monolingual English speakers were taught novel Japanese picture-word pairings, with four pairs of words minimally contrasted by the feature [length] (for example [ketto] with a picture of a dresser contrasted with [keto] and a picture of a lemon). Following word learning, subjects were asked to indicate whether pictures matched spoken words in a listening task. Of critical importance was subjects’ ability to correctly identify a picture-word mismatch depending only on a [length] contrast. Although the monolingual English speakers’ results revealed an inability to consistently identify a [length] contrast, their performance did not indicate a complete neutralization of the non-native contrast in their lexical representation. Rather, results showed an ability to perceive and lexically encode the [length] contrast to some degree. The authors suggest that as the subjects became aware of the importance of the [length] contrast, because they were presented with lexical items distinguished by this contrast, they may have retained some trace of this difference. For instance, an L1-like /t/ may have contrasted in the learner’s lexical representation

with a separate, non-native /t/, allowing for some distinction, but not enough to identify the nature of the novel feature (Hayes-Harb & Masuda, to appear, 35).

Experiment 1 of the present experiment had the goal of comparing children's and adults' awareness of the feature [length] in a purely perceptual task, involving no association of the auditory stimuli with meaning. Experiment 2 was designed to compare children's and adults' awareness of the same contrast following a word-learning phase, thereby requiring retrieval of a recently encoded, lexical form.

The first measure of this awareness was accurate recognition of a test word differing from a target only by the feature [length]. An additional measure of sensitivity to the novel feature, however, was a comparison of the type of errors made by the subjects. Research has shown that both adults (Goldinger, Luce & Pisoni, 1989) and children (Gerken, Murphy & Aslin, 1995) are sensitive to feature-sharing among similar words, being more likely to confuse words sharing a greater number of features than words with fewer overlapping features. For this reason, test words were included that differed from the target by one feature [place] (/tt/ and /pp/) or two features [place + length] (/tt/ and /p/), in an effort to further evaluate awareness of the contrast [length]. As mentioned, Hayes-Harb and Masuda (to appear) found that monolingual English speakers have some ability to lexically encode a distinction determined by the novel feature [length]. However, it is unclear how detailed a novel feature representation may be in the learner's memory, with the possibility that the learner simply retains that the sound is "different" from a corresponding L1 /t/. It is proposed here that a learner's greater confusion in a lexical task of a long /tt/ with a long /pp/ than with a /p/ will indicate a

lexical representation of the novel feature [length] with enough detail to be activated by another sound sharing this feature.

The following predictions were made based on past evidence of age-related L1 perceptual performance and task-related L2 perceptual performance:

1. Children will be more likely than adults to show sensitivity to a novel feature contrast [length] through:
 - a. Perception of the contrast in minimal pairs differing only by the feature [length]
 - b. Less accurate perception of a contrast in a minimal pair differing only by a familiar feature [place] than a pair differing by both a familiar and a novel feature [place + length]
2. Both groups will show greater sensitivity to a novel feature contrast [length] on a purely perceptual task than on a task requiring lexical retrieval

EXPERIMENT 1: PERCEPTUAL TEST

Subjects

Sixteen monolingual adult native speakers of English were recruited from University of Utah classes and received course credit for their participation. Three additional subjects who were not monolingual English speakers completed the experiments but were not included in the data analysis. Four 4- and 5-year old native speakers of English (average age = 4 years, 9 months) were recruited through local pre-school centers or personal acquaintance and completed Experiment 1. Three additional children did not successfully pass criterion as described below for inclusion in the test phase of Experiment 1. Only 2 children successfully met the criterion for inclusion in the test phase of Experiment 2. Three native speakers of Japanese were additionally recruited and were each paid or received course credit for their participation. However, 1 of the Japanese speakers had spent an extensive period of his childhood in English-speaking schools in the US and had lived and worked for 15 years in the US. This speaker's results differed significantly from the other native Japanese speakers and were not included in the data reported.

Stimuli for Child Experiments

Stimuli consisted of two Japanese nonword targets and one filler of the form VCV, and three sets of related test words. Test words consisted of three VCV words sharing all but one or two features with the target/filler. In the contrastive length *target* sets, test

words differed from the target by the features [length], and/ or [place]. In the *filler* sets, test words differed by the features [manner], and/ or [place]. The fillers were intended to verify that native English speakers would identify presumably familiar contrasts from their native language on the tasks of this experiment, and to serve as a comparison for subjects' performance on the novel contrast [length]. The conditions are summarized and illustrated in Table 1 .

Stimuli for Adult Experiments

Adult stimuli conditions were identical to the child experiments, but differed in number, with a total of six target and three filler Japanese nonwords, as shown in Table 2.

Table 1. Stimuli used for child experiments.

| | Contrastive Length Target | | Filler |
|----|----------------------------------|------------|---------------|
| | /kk/ | /t/ | /n/ |
| | okka | uto | ine |
| A. | oka | utto | ide |
| B. | otta | uko | ime |
| C. | ota | ukko | ibe |

A. target-unmatched: differs in [length] (filler = [manner])

B. target-unmatched: differs in [place]

C. target-unmatched: differs in [length + place] (filler = [manner + place])

Table 2. Stimuli used for adult experiments.

| | Contrastive Length Target | | | | | | Fillers | | |
|----|----------------------------------|------------|-------------|------------|-------------|------------|----------------|------------|------------|
| | /kk/ | /k/ | /pp/ | /p/ | /tt/ | /t/ | /n/ | /d/ | /b/ |
| | okka | uke | eppo | opi | etta | uto | ine | uda | ebe |
| A. | oka | ukke | epo | oppi | eta | utto | ide | una | eme |
| B. | otta | ute | ekko | oki | eppa | upo | ime | uba | ede |
| C. | ota | utte | eko | okki | epa | uppo | ibe | uma | ene |

All stimuli were recorded by a native speaker of Japanese in a sound-controlled booth.

Procedures

In both experiments presented here every effort was made to ensure that children's and adults' tasks were as similar as possible. However, pilot tests revealed practical limitations on not only the number of target/filler words that could be presented, but also the session durations for preschool children. Furthermore, different methods of response were designed to maintain children's interest in the experiment. Descriptions first describe the stimuli and procedures used with children, before noting any differences in adult procedures.

Procedures for Child Experiment 1

The procedures used with children were similar to the modified, two-stimulus comparison task developed for preschool-aged children by Gerken, Murphy and Aslin (1995). Their procedure was designed to minimize the memory and attention demands of a typical two-stimulus comparison, in which the target word changes on each trial. In the task used here, each target/filler is followed by all instances of related test words before a new target/filler is presented.

In the present experiment, subjects heard a Japanese nonword, which they were told was the favorite word of a stuffed animal. They were asked to put a cookie in a "cookie jar" when they heard the favorite word. If the test word was different, they were instructed to put a cookie in a "trash can." The containers were of equal size, one blue and one silver, and were attached to the table in front of the child.

Practice trials. The number of practice trials was determined necessary for child participants to ensure understanding of the test procedure. Practice trials were preceded by a video presentation with the purpose of introducing child subjects to the nature of the task. Before the practice trials, subjects were led through a video sample of the experiment where they were reminded to feed the animal a cookie or put a cookie in the trash after each test word. Practice trials consisted of Japanese CVC nonwords unrelated to the target and fillers used in the test trials.

During practice trials, subjects saw a stuffed animal on a screen and heard the following dialogue: “This friend’s favorite word is *opi*. He eats cookies only when he hears the word *opi*. Give him a cookie if you hear the word *opi*. If you hear a different word, put a cookie in the trash. Only give him a cookie if you hear the word *opi*.” A plastic cookie was then placed in the middle of the table in front of the child (pilot tests showed that making all cookies available at once proved to be a distraction), and a test word was presented. Each target in the practice trial was followed by three nonsimilar test words and one identical condition, each presented twice for total of eight test words. Subjects were reminded of the target word once in the middle of each block of test words (after four test words). Subjects who scored less than 80% on the practice trials were not included in the test trials.

Test trials. Test trial procedures were nearly identical to practice trials, except that presentation of each target or filler described above was followed by the three target/filler-unmatched and one target/filler-matched conditions, each presented three times, for a total of 12 test words per block, presented in random order. Subjects were

reminded of the target/filler twice in the middle of each block of test words (after every four test words). Thus in total each child was presented with three blocks of 12 test words.

Procedures for Adult Experiment 1

The procedure for adults was similar to children's in that subjects were presented with a target/filler word and asked to identify subsequent test words as either "same" or "different". The procedure differed in that adults responded using a keyboard with keys labeled "same" and "different".

Test trial. Each target or filler word was followed by three target/filler-unmatched and one target/filler-matched condition, each presented three times, for a total of 12 test words per block, presented in random order. In contrast with the child subjects, adults were reminded of the target/filler word only once during each block of test words (after six test words). Adult test trials also differed from children's in presenting six targets and three fillers, three times each for a total of 27 blocks of 12 test words altogether.

EXPERIMENT 2: LEXICAL LISTENING TEST

The purpose of this experiment was to compare children's and adults' awareness of a novel feature contrast [length] in newly learned words by observing their ability to distinguish target words from test words differing by the feature [length]. Whereas the previous experiment was intended to assess subjects' initial auditory perception of non-native words, the test trials in Experiment 2 were designed to require access of a recently-stored representation associated with meaning.

Subjects

Adult subjects were the same as in Experiment 1, and completed Experiment 2 in the same session. Child subjects completed Experiment 2 on a subsequent day, as deemed necessary by limited attention and tiredness in pilot experiments. Only 2 of the child subjects successfully met criterion for participation in the test phase as described .

Stimuli

Stimuli were identical to those used in Experiment 1. Word learning involved the words presented as target/filler words in the test trials of Experiment 1.

Procedures for Child Experiment 2

Word learning. Subjects were taught picture-word pairings for the two target and one filler word encountered in Experiment 1. Cartoon animal characters were displayed

on a computer screen in succession as the recorded name of each picture was presented over headphones. Pictures were displayed for 2 seconds, with a 500 ms break between pictures. Each of the three picture-word pairs was presented three times in random order. Because pilot tests showed that picture matching with feedback and interaction was useful to hold the subjects' interest in the word learning task, three additional interactive activities were included. First, the subject was asked to match a printed picture with a picture-name pair presented on the screen once for each word. The subject was then asked to choose the correct cut-out pictures based on the spoken words alone, each presented twice, with feedback given via the correct picture appearing on the screen afterwards. Finally subjects were asked to choose one of three pictures based on a spoken name, each presented twice, with feedback given by animation on the screen. In all, each child subject was exposed to eight tokens of each picture-name pair during word learning.

Practice trials. The procedure for the practice and test trials of Experiment 2 was nearly identical to the procedure for Experiment 1, the only difference being that the target in the lexical test was in the form of a cartoon picture on a container, rather than an auditory stimulus. Subjects saw a picture and heard the following phrase: "Here is the first hungry friend. If you hear his name, feed him a cookie. If you hear a different name, put a cookie in the trash." In the practice trials, each of the three pictures was presented once, followed by six nonsimilar test words and two target/filler-matched conditions. The practice trial was intended to assess both the subject's successful completion of word learning and understanding of the procedure. Subjects who scored less than 80% on the practice trials were not included in the test trial of Experiment 2.

Test trials. The procedure for test trials was identical to that used in the practice trials, except that each picture was followed by three target/filler-unmatched and one target/filler-matched condition, each presented three times, for a total of 12 test words per block, presented in random order as in Experiment 1. Thus in total each child was presented with three blocks of 12 test words.

Procedures for Adult Experiment 2

Word learning. Adults were exposed to picture-word pairs for the six target and three filler Japanese nonwords used in the test trial of Experiment 1. The procedure differed from the children's word learning in that line drawings of common objects were used in place of cartoon character images. Adult subjects were told that they would be learning the names of objects in a foreign language. Each of the nine picture-word pairings was presented three times in random order. Following this presentation, adults were asked to circle pictures presented on an answer sheet that matched spoken names, with feedback in the form of the correct picture being shown on the screen. This type of training with feedback was intended to maintain a close similarity with the children's procedure, in which feedback was found necessary for effective word learning. In all, adult subjects were exposed to each picture-name pair four times during word learning.

Practice trials. The procedures for adult practice and test trials of Experiment 2 were nearly identical to the test trial procedure for Experiment 1, the only difference being that the target/filler in the lexical test was in the form of a picture rather than an auditory stimulus. Subjects saw a picture and were instructed to identify whether subsequent test words matched the image by pressing buttons labeled "same" or "different" on a keyboard. In the practice trials, each of the nine pictures was presented

once, followed by six nonsimilar test words and two target/filler-matched conditions. The practice trial was intended to assess both the subject's successful completion of word learning and understanding of the procedure. Subjects who scored less than 80% on the practice trials repeated the word learning.

Test trials. The procedure for test trials was identical to that used in the practice trials, except that each of nine pictures was presented three times followed by the three target/filler-unmatched and one target/filler-matched condition, each presented three times, for a total of 12 test words per target/filler, presented in random order as in Experiment 1. Adult test trials again differed from children's in presenting six targets and three fillers, three times each for a total of 27 blocks of 12 test words.

RESULTS

Experiment 1

Responses on the perceptual task were encoded as correct (“same” response to a target-matched or filler-matched item, or “different” response to a target-unmatched or filler-unmatched item) or incorrect (“different” response to a target-matched or filler-matched item, or “same” response to a target-unmatched or filler-unmatched item). Table 3 represents the percent correct data for each adult speaker group and each condition in the target and filler sets.

As indicated earlier, 1 Japanese subject’s performance appeared to reflect extensive experience in an English L2 environment beginning in early childhood. For this reason the subject’s data was not included in the following language group comparison. A three-way ANOVA with language group (two levels: English and Japanese adults) as a

Table 3. Percent correct data, Experiment 1 by condition and subject group.

| Subject Group | target-unmatched [length] | target-matched | target-unmatched [place] | target-unmatched [length + place] |
|----------------------|--------------------------------------|-----------------------|-------------------------------------|--|
| English Adults | 44.0 | 89.7 | 98.0 | 98.8 |
| Japanese Adults | 94.4 | 92.6 | 98.1 | 100.0 |

| Subject Group | filler-unmatched [manner] | filler-matched | filler-unmatched [place] | filler-unmatched [manner + place] |
|----------------------|--------------------------------------|-----------------------|-------------------------------------|--|
| English Adults | 98.8 | 63.9 | 81.9 | 99.5 |
| Japanese Adults | 100.0 | 81.5 | 87.0 | 100.0 |

between-subjects variable, and target versus filler (two levels: target, filler) and condition (4 levels: A, B, C, D) as within-subject factors, revealed a significant main effect of language group ($F(1,16) = 9.920, p < .05, \text{partial } \eta^2 = .383$)¹. This indicates that Japanese subjects (averaging 94% correct across conditions) outperformed English subjects (averaging 84% correct across conditions) as predicted. There was also a significant main effect of test condition ($F(3,48) = 4.598, p < .05, \text{partial } \eta^2 = .223$), but no main effect of target versus filler items ($F(1, 16) < 1, \text{partial } \eta^2 = .001$). No interaction was found between target versus filler items and language group ($F(1,16) = 1.125, p = .305, \text{partial } \eta^2 = .066$) or item condition and language group ($F(3,48) = 2.362, p = .083, \text{partial } \eta^2 = .129$). An interaction was significant between target versus filler items and test condition ($F(3,48) = 12.447, p < .005, \text{partial } \eta^2 = .438$) as well as the three-way interaction between target versus filler items, test condition and language group ($F(3,48) = 5.286, p = .003, \text{partial } \eta^2 = .248$).

Next, the English speakers' ability to perform on the filler items (familiar contrasts) as opposed to the target items (novel contrasts) was analyzed through an ANOVA on the percent correct data of the English speakers alone with test condition (two levels: target and filler) as a within-subjects variable. No significant effect was found ($F(1,63) < 1, \text{partial } \eta^2 = .009$), in contrast with the predictions of this experiment. Upon closer examination of the data, it was found that many of the English-speaking subjects experienced difficulty with the filler *ebe*, perhaps struggling to distinguish it from the minimal pair *ede*, as revealed by the proportion correct data on this item reported in Table 4.

¹ Partial η^2 values indicate the size of the effect attributable to a particular factor. According to Cohen (1988), a partial η^2 value of 0.01 represents a small effect, 0.06 a moderate effect, and 0.14 a large effect.

Table 4. Percent correct data Experiment 1 for English adults on the filler *ebe* by condition.

| filler-unmatched [manner]: <i>eme</i> | filler-matched: <i>ebe</i> | filler-unmatched [place]: <i>ede</i> | filler-unmatched [manner + place]: <i>ene</i> |
|--|---------------------------------------|---|--|
| 98.0 | 33.3 | 64.6 | 100.0 |

It is unclear why the familiar [place] contrast (between bilabials and alveolars) should prove difficult in this filler item. A possible explanation may lie in the fact that the intervocalic consonant /b/ here is flanked by two identical vowels, whereas all other CVC items in this experiment consisted of a consonant and two distinct vowels. This may have contributed to greater difficulty in holding the filler *ebe* in memory and differentiating *ebe* from highly similar test items. Additionally, the Japanese alveolar /d/ is articulated differently than the English /d/, with Japanese speakers using the blade of the tongue to make the closure with the alveolar ridge. English speakers, in contrast, use the tongue tip (Tsuji-mura, 1996). Thus the Japanese /b/ versus /d/ distinction may not have been as familiar to the English listeners as expected.

In order to evaluate the English speakers' performance on the remaining two fillers, a second ANOVA was performed on the percent correct data of the English speakers with the two other fillers *ine* and *uda*, excluding the filler item *ebe*, with the same within-subjects variable (two levels: test and filler) as before. This second measure revealed a significant effect of test condition ($F(1,63) = 5.649, p < .05, \text{partial } \eta^2 = .082$).

In view of the lack of significance between the filler group as a whole and the target group, and in order to provide another measure of the English speakers' ability to distinguish a familiar contrast in this task, a comparison of the conditions target-unmatched [length] (novel contrast for English speakers) and target-unmatched [place]

(familiar contrast for English speakers) was carried out. An ANOVA on the percent correct data with a two-level within-subject variable (target-unmatched [length] and target-unmatched [place]) showed a significant effect of condition ($F(1,15) = 62.289$, $p < .001$, partial $\eta^2 = .806$) on the percent correct, indicating that English speakers were able to successfully identify the [place] contrast despite their difficulty with the unfamiliar [length] contrast.

Next, in order to address the hypothesis that English-speaking adults would not exhibit awareness of the novel [length] contrast, their response to the target-unmatched [length] items was considered. Recall that an accurate rejection of this item (“different” response) would reflect the subject’s awareness that it is different from the target. As seen in the chart above, English adults correctly rejected this item less than half of the time (44% of responses), performing near chance, indicating an inability to consistently identify a [length] contrast on these items.

As the task in this experiment involved a forced-choice “same” or “different” response, there is the possibility of bias towards one or the other response, which may not be reflected in the percent correct data (for example, an overall bias towards “same” may result in greater proportion correct for the target-matched condition than in the target-unmatched [length] condition without indicating any real distinction between the two). An ANOVA was therefore carried out on the proportion of “same” responses with item condition (two levels: target-matched and target-unmatched [length]) as a within subjects factor, in order to determine the degree to which subjects differentiated the two. This revealed a significant effect of item condition ($F(1,17) = 30.860$, $p < .001$, partial $\eta^2 = .645$). The result indicates that, despite their inability to consistently categorize the

[length] contrast, adult subjects did show some sensitivity to the contrast between the target-matched and target-unmatched [length] conditions.

As for the second measure of awareness of the feature [length], it was predicted that this would be reflected in a greater tendency to confuse an item differing in [place] with the target, than to confuse an item differing in both [place] and [length]. However, confusion can only be measured by analyzing incorrect responses, and the English-speaking adults' performance on these items was at ceiling (98% correct for target-unmatched [place] and 98.8% for target-unmatched [place + length]), with no significant difference between the two ($F(1,15) = 2.561, p = .130, \text{partial } \eta^2 = .146$).

As previously mentioned, the children's tasks included a reduced number of items (two targets and one filler); thus direct comparison with the adult data is not appropriate. Furthermore, only four of the children tested reached criterion on the practice trials of Experiment 1 for inclusion in the study. Adult and child test conditions were the same, however, and responses were encoded in the same way. Two responses were not included due to experimenter error (the experimenter placed a cookie in front of one bin instead of between the two) and one ambiguous response (the child put the cookie completely in one container then retrieved it to put in the other container). Proportion correct results for the child subjects' perceptual tests are reported in Table 5 .

Table 5. Percent correct data Experiment 1 for English child subjects by condition.

| | | | |
|-------------------------------------|-----------------------|------------------------------------|---|
| target-unmatched [length] | target-matched | target-unmatched [place] | target-unmatched [length + place] |
| 0.0 | 95.8 | 87.5 | 91.7 |
| filler-unmatched [manner] | filler-matched | filler-unmatched [place] | filler-unmatched [manner + place] |
| 100 | 91.7 | 41.7 | 100 |

As with the adult subjects, children's performance on the filler item, this time *ine*, was unexpectedly low, with a near chance proportion correct on the condition *ime* (41.7%). A possible explanation for this failure may be the inherent difficulty of distinguishing the nasal [place] distinction. Maddieson (1984) points to evidence that although nasals are distinct from non-nasals (such as the manner contrasts in the other two unmatched conditions above), nasal place contrasts are more difficult to perceive than oral place contrasts (Maddieson, 1984, 70). Furthermore, whereas the children were unsuccessful on the [place] distinction for the nasal in the filler item, their performance on the target-items' [place] distinction (87.5%) offers some support for their ability to identify this familiar distinction in a stop consonant.

Of primary interest concerning the hypothesis that children would show greater awareness of the contrast [length] than their adult counterparts is their performance on the condition target-unmatched [length]. As revealed in Figure 3, children consistently failed to show the slightest awareness of this distinction, incorrectly responding "same" to this condition on each presentation.

This result does not support hypothesis 1a, and in fact seems to reveal no awareness of the [length] feature on the part of the children. However, considering the small number of subjects completing the task, these data should be interpreted with caution.

Performance on the conditions target-unmatched [place] and target-unmatched [place + length] also does not reflect any sensitivity to the contrast [length], as there was little difference between the two.

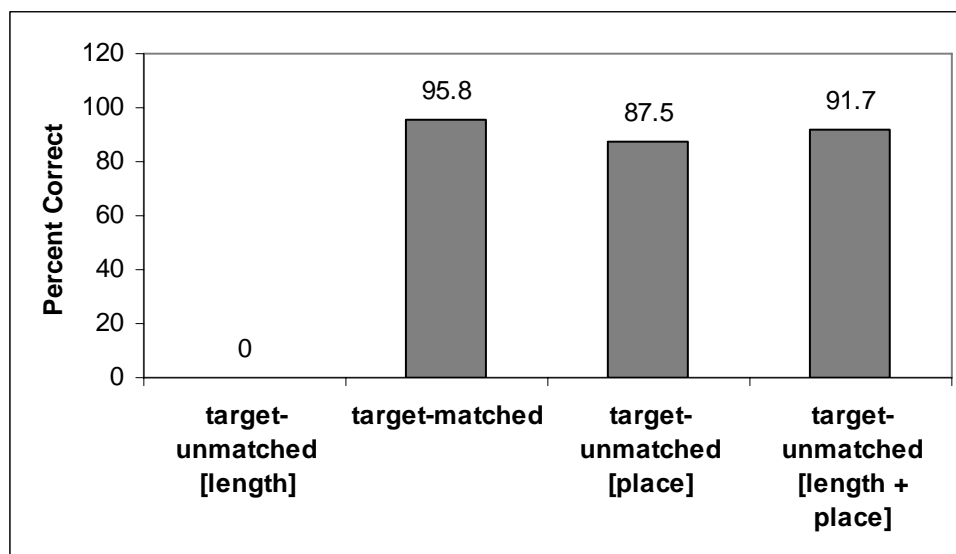


Figure 3. Percent correct data for child subjects, Experiment 1, by condition.

Experiment 2

Responses on the lexical task were encoded in the same manner as the perceptual responses: correct (“same” response to a target-matched or filler-matched item, or “different” response to a target-unmatched or filler-unmatched item) or incorrect (“different” response to a target-matched or filler-matched item, or “same” response to a target-unmatched or filler-unmatched item). Table 6 represents the percent correct data for each speaker group and each condition in the target and filler sets.

Table 6. Percent correct data Experiment 2 by subject group and condition.

| Subject Group | target-unmatched [length] | target-matched | target-unmatched [place] | target-unmatched [length + place] |
|----------------------|----------------------------------|-----------------------|---------------------------------|--|
| English Adults | 46.0 | 77.6 | 91.0 | 94.4 |
| Japanese Adults | 99.0 | 89.8 | 95.3 | 100.0 |

| Subject Group | filler-unmatched [manner] | filler-matched | filler-unmatched [place] | filler-unmatched [manner + place] |
|----------------------|----------------------------------|-----------------------|---------------------------------|--|
| English Adults | 98.6 | 70.1 | 76.3 | 92.8 |
| Japanese Adults | 100.0 | 83.3 | 79.6 | 100.0 |

As with Experiment 1, only 2 of the 3 Japanese speakers' data were included in the language group comparison. A three-way ANOVA with language group (two levels: English and Japanese adults) as a between-subjects variable and target versus filler (two levels: target, filler) and condition (four levels: A, B, C, D) as within-subject factors, revealed a significant main effect of language group ($F(1,16) = 7.005, p < .05, \text{partial } \eta^2 = .304$). This indicates that the native Japanese speakers performed significantly better (averaging 93% correct across conditions) than the English speakers (averaging 81% correct across conditions), as predicted. There was no significant main effect of target versus filler condition ($F(1,16) < 1, \text{partial } \eta^2 = .004$) or item condition ($F(3,48) = 2.241, p = .096, \text{partial } \eta^2 = .123$). Interactions were not significant between target versus filler and language group ($F(1,16) = 3.016, p = .102, \text{partial } \eta^2 = .159$), item condition and language group ($F(3,48) = 1.267, p = .296, \text{partial } \eta^2 = .073$), or the three-way interaction between target versus filler, condition and language group ($F(3,48) = 2.382, p = .081, \text{partial } \eta^2 = .130$). However, there was a significant interaction of target versus filler and item condition ($F(3,48) = 4.626, p < .05, \text{partial } \eta^2 = .224$).

In order to evaluate the English speakers' performance on target and filler items, an ANOVA with test condition (two levels: target and filler) as a within-subjects variable was performed on the proportion correct data of the English speakers alone. As with the perceptual data, no significant effect was found ($F(1,63) = 2.831, p = .097, \text{partial } \eta^2 = .043$). This may again be due to the unexpected difficulty with the filler *ebe*. A comparison of the target-unmatched [length] and target-unmatched [place] conditions was therefore carried out as an additional measure of subjects' ability to distinguish a familiar contrast on this task. An ANOVA on the percent correct data with a within-

subjects variable of item condition (two levels: target-unmatched [length] and target-unmatched [place]) revealed a significant effect of item condition ($F(1,15) = 21.284, p < .001, \text{partial } \eta^2 = .587$)

As in the perceptual task, responses to target-unmatched [length] items were used as an indicator of adult English-speakers' awareness of the [length] contrast. Once again, these subjects accurately rejected the item in less than half of presentations (46% of the time) suggesting a failure to accurately identify the [length] contrast of the test item. In order to further evaluate the English speakers' possible sensitivity to the contrast, an ANOVA was performed on the proportion "same" responses with a two-way within-subjects variable of target-matched and target-unmatched [length] conditions. This analysis revealed a significant effect of item condition ($F(1,15) = 12.509, p < .005, \text{partial } \eta^2 = .455$) suggesting that the subjects were aware of some difference between the two conditions, despite their inability to consistently reject the target-unmatched [length] condition.

Similar to the perceptual task, there was no significant difference between subjects' response to the conditions target-unmatched [place] and target-unmatched [place + length] ($F(1,15) = 3.985, p = .064, \text{partial } \eta^2 = .210$).

Only 2 of the child subjects successfully reached criterion on the practice trials of Experiment 2. As a result, these 2 subjects' data will be considered separately. The children's responses were coded in the same way as the adults and the proportion correct data by child and by condition is presented in Table 7 .

Table 7. Percent correct data Experiment 2 by child subject by condition.

| Subject Number | target-unmatched [length] | target-matched | target-unmatched [place] | target-unmatched [length + place] |
|----------------|------------------------------|----------------|-----------------------------|--------------------------------------|
| Child S3 | 66.7 | 100.0 | 100.0 | 100.0 |
| Child S6 | 66.7 | 50.0 | 100.0 | 100.0 |

| Subject Number | filler-unmatched [manner] | filler-matched | filler-unmatched [place] | filler-unmatched [manner + place] |
|----------------|------------------------------|----------------|-----------------------------|--------------------------------------|
| Child S3 | 100.0 | 100.0 | 0.0 | 100.0 |
| Child S6 | 100.0 | 0.0 | 100.0 | 100.0 |

Concerning both children's data, performance on the filler was once again low, with S3 failing to distinguish the filler-unmatched [place] condition in each presentation, and S6 failing to correctly identify the filler-matched condition. This may also reflect an unforeseen difficulty in distinguishing the nasal [place] contrast as mentioned above. However, S6's inability to identify the filler-matched condition (0% correct) suggests a bias for "different" responses (all of the filler block responses were "different") or a failure to truly learn the picture-word pair.

As for performance on the target items, S6 performed at chance in correctly identifying the target-matched condition (50%), again suggesting a failure to successfully retain the picture-word pairs in memory. It seems that the lexical task of Experiment 2 was overwhelmingly difficult for the child subjects, and possible reasons for this will be discussed.

However, 1 of the subjects, S3, appears to correctly identify the target-matched condition on all presentations. Of interest is an increased tendency to correctly reject target-unmatched [length] conditions (66.7%), in contrast with the perceptual test of Experiment 1, in which this subject consistently failed to identify the [length] contrast

(0% correct on the same condition). For this particular child the lexical task appeared to reveal greater sensitivity to the contrast [length].

Despite the small number of child participants, the data presented above clearly do not support Hypothesis 1, which predicted an advantage for children in performance on a task assessing awareness of a novel contrast [length]. Possible explanations for this result will be addressed in the discussion .

Hypothesis 2 predicted a task-related difference in performance for purely perceptual (Experiment 1) as opposed lexical (Experiment 2) discrimination tasks. The small number of child participants in Experiment 2 does not allow for a meaningful comparison and the analysis will remain limited to the adult subjects.

In order to address Hypothesis 2, it is necessary to compare the degree to which subjects differentiated the members of minimal pairs distinguished by the novel feature [length] in each of the two experiments. As the tasks used in these experiments involved a forced-choice between a “same” response and a “different” response, possible bias toward one type of response may dissimulate this awareness as discussed above. For this reason, signal detection was used to analyze each English adult subject’s scores separately, where “same” responses to target-matched items were hits and “same” responses to all other conditions were false positives. Separate d-prime scores were calculated for the perceptual (Experiment 1) and lexical (Experiment 2) tasks for each subject. An ANOVA with task (perceptual or lexical) as a within subjects factor revealed no effect of task on the d-prime scores ($F(1,15) = 3.946, p = .066, \text{partial } \eta^2 = .208$).

DISCUSSION

The small number of child subjects makes the predictions of Hypothesis 1 difficult to address through detailed comparison of adult and child performance in Experiment 1 and impossible in Experiment 2. However, the results that were obtained with the four children in Experiment 1 clearly did not provide support for Hypothesis 1, which predicted greater awareness of the novel feature [length] on the part of the child participants. On the contrary, whereas adults' performance on the target-unmatched [length] condition appeared to be roughly at chance, the children consistently accepted the target-unmatched [length] condition as the "same" as the target. Furthermore the significant difference in the proportion "same" data for the adults between the target-matched and the target-unmatched [length] condition indicates that adults were able to detect some difference between the two conditions. This sensitivity is in line with the results of Hayes-Harb and Masuda (to appear) who found that monolingual English speakers were able to distinguish Japanese [length] contrasts to some extent in a lexical task with some similarities to the present experiment. The performance of the adults here contrasts with the children who incorrectly responded "yes" to the target-unmatched [length] condition in every case. There are two possible explanations for this result. First of all, it may be that the children were sensitive to the [length] contrast, but the tasks were inappropriate for gaining a reliable measure of this awareness. Secondly, the children may simply have lacked any awareness of the contrast being tested.

Concerning the first explanation, the inability of the majority of child participants to complete the tasks suggests that the activities may have been inappropriate for assessing preschool-aged children's perceptual representations. Specifically, the tasks here involved a forced-choice, explicit "same" or "different" response on the part of the subject. Such a task would well have been familiar to the undergraduate adult participants, who may have approached it with a greater understanding of their expected performance and the purpose of the experiment. Comments recorded by several participants upon leaving the experiment revealed a general awareness that perception of a sound contrast was being tested. The performance of the preschool children, on the other hand, may reflect difficulty in making an association between small perceived sound differences and a "different" response.

Gerken et al. (1995) point to the possibility of adults and children employing different strategies on laboratory-style phonological tasks, reflecting their stage of cognitive development as much as phonological perception. Use of more efficient strategies in learning environments has also been cited as a reason that adults may appear to outperform children in language acquisition in the short-term, despite children's long-term advantage (DeKeyser & Larson-Hall, 2005; Marinova-Todd, Marshall & Snow, 2000). Furthermore, DeKeyser (2005) argues for adults' superior performance over children on explicit learning tasks, defined as those tasks involving awareness of what is being learned. He also notes adults' access to "analytical abilities to think at least to some extent about the structure of the L2 (and its differences with the L1)," (DeKeyser, 2005, p. 334). Adults' greater overall awareness of the general objectives of the task may have helped them identify a non-native sound contrast, and their more appropriate strategies

for dealing with the discrimination task in Experiment 1 may have enabled them to better express their sensitivity to sound differences in words. Finally, the adults may have more easily adapted to the notion of different-sounding “foreign” words in Experiment 1.

Although the present procedures were adapted from the those successfully used with preschool-aged children by Gerken et al. (1995), the stimuli here differed in presenting novel words distinguished by a novel contrast. The strangeness of trying to distinguish abstract foreign-sounding words may have distracted attention away from the actual discrimination task for the children.

Secondly, it may be that the children simply did not perceive any contrast between the members of the minimal pairs distinguished by [length] in the perceptual task. One possible explanation for this lies in the vastly unequal number of trials. Adult subjects were tested three times on each of the six targets, but the children were only tested once on two targets. As a result, adults had a much greater opportunity to observe small differences between words on multiple presentations of the same words, as well as to observe similar contrasts within other trials. This repetition may have given a disproportionate advantage to the adult subjects.

Alternately, it is possible that the children lacked awareness of the contrast due to less-detailed representations of these novel words encountered for the first time, with no access to a previously stored lexical representations. Despite ample evidence of preschool children’s sensitivity to detail in well-known, familiar-sounding words, such as those used in Gerken et al. (1995) and Swingley (2003), similar perceptual evidence does not exist for novel words in a non-native phonology.

The second explanation is possible; however, it seems that the methods used here and the small number of children tested did not allow for confirming or disproving it. The difficulty children experienced completing the experiment suggests that a less cognitively demanding method may yield more meaningful results with preschool aged children. Alternately, the present methodology may be better adapted for older, school-aged children, with greater experience and attention for this type of task.

The second prediction upon which this experiment was based, a task-related performance difference by both groups, was also not supported by the data. Specifically, the adult subjects' identification of the target-matched compared to target-unmatched [length] condition showed no significant effect of perceptual (Experiment 1) or lexical (Experiment 2) task. The English subjects did not find the [length] contrast significantly more difficult to identify on the lexical task.

This finding is in line with Pater's (2003) results concerning the learning of Thai aspiration and voicing contrasts in a laboratory experiment. As mentioned earlier, in an XAB task, Pater found no task-related differences in English speakers' ability to distinguish novel contrasts on a task involving sound-picture matching and a task involving sound matching alone, in contrast with earlier findings. It appears that the ability of English speakers in the present experiment to distinguish a novel [length] contrast was also not significantly affected by the nature of the task involved.

It is also possible that the low power (.460) of the results comparing individual d-prime scores for target-matched and target-unmatched [length] conditions on the perceptual and lexical task represents a less than robust finding, due to a low number of subjects. Furthermore, comparison of individual d-prime scores, represented in Figure 4 ,

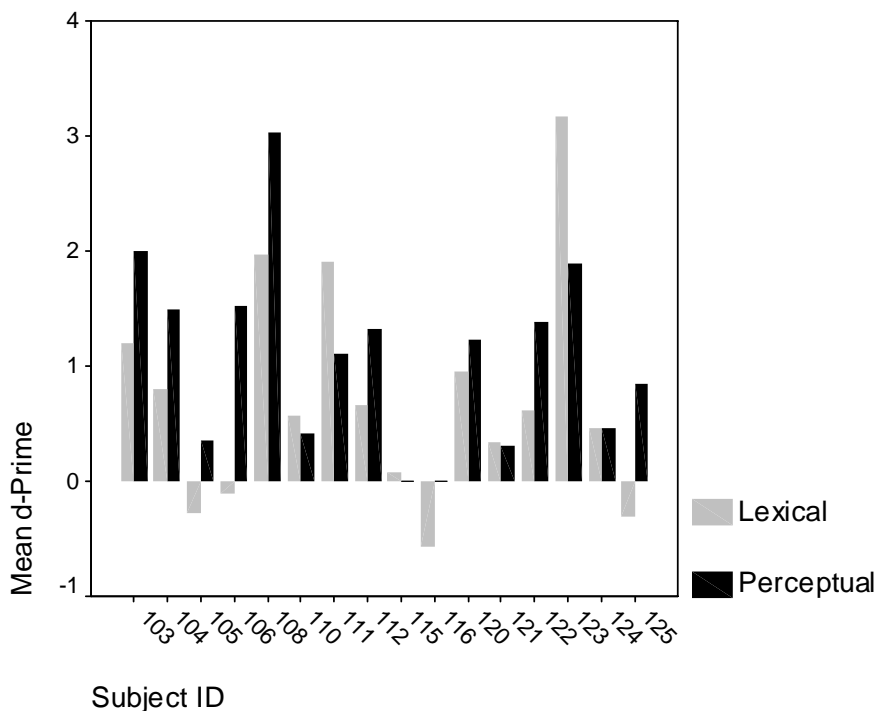


Figure 4. Individual d-prime scores for proportion “same” responses on target-matched and target-unmatched [length] items, lexical and perceptual tasks compared.

revealed a certain amount of individual variation in performance. The majority of individual subjects (10 out of 16) showed a tendency to better differentiate the items distinguished by [length] in the perceptual task of Experiment 1 than in the lexical task of Experiment 2. One subject performed equally on the two tasks and 5 subjects performed better in distinguishing the [length] contrast on the lexical task. Interestingly, 1 subject appears to have excelled on the lexical task, in comparison with the perceptual task.

The reasons behind such individual variation are unclear. It is possible that for some of the subjects, the cumulative exposure to targets in the perceptual tasks of Experiment 1, in addition to the word learning phase of Experiment 2, allowed for a heightened awareness of the significance of the [length] contrast and greater attention to this contrast in the test phase of Experiment 2. It also seems possible that for these few

subjects the learning of lexical items containing segments contrasting in [length] provided evidence for the need to attend to this feature, which was not provided in the more abstract perceptual task of Experiment 1. The individual variation observed here is, in any case, a topic for further investigation.

CONCLUSION

Although the current study has not been able to successfully address the question of age-related variation in sensitivity to a novel feature contrast [length], it has revealed an advantage for adults over children in expressing sensitivity to a novel contrast in the type of forced choice tasks used in this experiment. This study seems to support an advantage for adults in situations that measure awareness of what is being learned, such as an awareness of the potential importance of non-native sound differences in a foreign language here. The results may also reflect adults' use of cognitive strategies, unavailable to children, such as an ability to analyze differences between their L1 and an L2, as maintained by DeKeyser (2005).

The data here clearly does not support an advantage for children over adults in awareness of novel feature contrasts; however, past research overwhelmingly supports the fact that, over time, children acquire native-like L2 phonology to a greater degree than adults. It may be that this advantage does not result from an initially greater perceptual sensitivity to L2 contrasts due to less L1 category influence, as proposed here, but from a greater flexibility to create new, abstract phonological L2 sound categories based on repeated exposure to L2 contrasts. The potential benefits of children's less-stable L1 system for acquiring the contrast of L2 sounds may only become apparent with long-term exposure to these L2 sounds. Indeed, current studies have shown the role of acoustic statistical evidence, in the form of distributions of contrasting sound tokens

along a feature continuum, on perception of novel phonemic contrasts for both infants (Maye, Werker & Gerken, 2002) and adults (Maye & Gerken, 2000). This line of research, exploring the role of repeated exposure to sounds contrasting along a novel feature dimension on the long-term abilities of adults and young children of different ages to distinguish minimal pairs based on these contrasts, may reveal greater age-related differences over time than initial exposure to a limited number of words.

Finally, the question of task-related difficulty with regard to awareness of a novel feature remains a subject for further examination. Perception of the novel contrast [length] in this study was not significantly more difficult for subjects in a task involving lexical access than in a task involving pure perception, and scores comparing the two tasks revealed a certain amount of individual variation. Further research may attempt to analyze this individual variation in ease of contrast perception in the presence or absence of meaning.

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