Early sensitivity to linguistic form*

LouAnn Gerken
University of Arizona

1. Overview

Human infants have always been impressive creatures in the eyes of their parents. During the last two decades of the 20th century, however, infants became the darlings of science and the media as well. Thanks to a collection of techniques that allow us to infer how infants perceive, process and remember the world, we have become collectively awed by their early abilities. In the domain of language alone, infants have racked up an inspiring list of accomplishments. They are able to discriminate nearly every speech sound used in adult linguistic systems (e.g., Eimas, 1975; Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Moffitt, 1971; Bertoncini, Bijeljac-Babic, Blumstein & Mehler, 1987). They can discriminate stimuli based on number of syllables (van Ooijen, Bertoncini, Sansavini, & Mehler, 1997). They recognize their mother's language, their mother's voice, and particular stories she read to them while pregnant (DeCasper & Fifer, 1980; DeCasper & Spence, 1986; Mehler, Jusczyk, Lambertz, Halsted, Bertoncini, and Amiel-Tison, 1988). The list goes on.

The past 20 or so years of research on infant language perception have shown us that infants have a remarkable aptitude for discriminating among some basic linguistic forms. We are now at a point where we can more fully devote our attention to the question of whether and how infants apply this aptitude to the daunting task of acquiring the particular language(s) used in the community into which they were born. The task of infant language researchers is no less daunting. We must now ask, in a way that yields testable predictions for infant research, what acquiring a language entails, and how early discrimination abilities relate to the mature linguistic system. To some extent, these research questions reflect a shift in the field of infant language perception.

To grasp the shift, consider some earlier work on speech sound discrimination by infants. This work derived its questions in a fairly straightforward way

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from adult speech perception research. For example, we know from categorical perception experiments that English-speaking adults perceive all bilabial stop consonants produced within a certain range of voice onset time (VOT) values as /ba/ and all bilabial stops with longer VOT's as /pa/. We also know that adults are poorer at discriminating a pair of consonants with VOT's in the /ba/ range than between a pair with the same size VOT difference that crosses the /ba/~/pa/ boundary. Such adult discrimination research translates well into studies of infant discrimination (e.g., Eimas et al., 1971).

Although phonetic discrimination is an important part of the adult language faculty, it by no means constitutes the majority of adult language ability. Rather, a mature language system works in service of conveying meaning. Thus, much of our understanding of adult spoken language perception and comprehension comes from asking how listeners discern meaning in various linguistic contexts. For example, we ask whether it is more difficult to recognize a word that is phonetically similar to many other words in the mental lexicon than a word that is phonetically unlike other words (e.g., Vitevitch, Luce, Pisoni & Auer, 1999). Or we ask the conditions under which passive sentences are more difficult to interpret than active sentences (e.g., Ferreira, Bailey & Ferraro, 2002). Given the disparity between such research questions and the types of tasks at which infants have been shown to excel, the link between adult and infant language research is different than it was 20 years ago.

How can we study in infants the precursors of abilities that we believe are important in adult language? It is possible to construe the current point of contact between what we know about adult language perception/comprehension and infant research as "linguistic generalization." The ability to generalize beyond the utterances to which we have been exposed is arguably the hallmark of mature human language ability. Our ability to generalize is perhaps most obvious at the level of syntax, through which we can comprehend or produce a novel utterance. We are also capable of creating language games, such as Pig Latin[1], where we can generate new phonological strings based on a set of abstract principles. Even at the level of the lexicon, we must be able to recognize words under a variety of conditions that greatly distort the acoustic and phonetic properties (e.g., in noisy telecommunications, spoken by talkers whose dialects differ from our own, etc.).

Consistent with this very basic property of human language, much of current infant language research constitutes an exploration of infants' ability to make generalizations across language-like stimuli, a topic about which we have known relatively little until recently. Because, as noted above, infants in earlier work were shown to excel at discriminating among linguistic forms, the current generation of infant language perception researchers has sought to identify aspects of language in which generalization can be based on form alone. This focus on form, largely to the exclusion of meaning, may ultimately cause some difficulty in our ability to link the new wave of infant studies with adult abilities, a point which will be discussed below (also see Gerken, 2000; Naigles, in press). Nevertheless, in keeping with the state of play in the field, this article will focus on infants' early capacity to generalize aspects of language form.

I begin by presenting some of the methods used by researchers to make inferences about infants' ability to make linguistic generalizations. Next, I present three areas in which it appears that adults can engage in linguistic generalization based on form alone. Based on the three areas of adult ability, I outline three tasks for the infant language learner. I then provide an overview of what we do and do not know about how infants approach each of these tasks. Finally, I identify four overarching questions raised by the studies outlined here. These questions are: How should we characterize development? Should we focus on general or specific properties of the data? Is discrimination enough? and How are the abilities we see in infants related adult language?

2. Methods used to test infants' sensitivity to language

Four general types of methods are frequently used to assess infants' language ability. All four methods are used to determine whether an infant discriminates among auditory stimuli by determining if she responds differently to stimuli of different types. Generally, the response measures are not sufficiently robust to compare infants' responses to more than two, or perhaps three, stimulus types. The fourth method is also beginning to be used to yield reaction time data, which may allow for more complex comparisons.

2.1 Habituation Techniques

The first method comprises variants of habituation approaches. In High Amplitude Sucking (HAS), infants suck on a non-nutritive nipple connected to a pressure transducer. As long as an infant maintains a sucking rate above a predetermined criterion, she continues to hear a stimulus of a particular type. When sucking falls below that rate for a period of time, the infant is said to have habituated to the stimulus. Recovery from habituation is defined as an increase in the sucking rate over habituation levels. When a new stimulus gives rise to recovery, the effect is taken to indicate that the infant discriminates the old, habituated, stimulus from the new stimulus. For example, an infant might be habituated to a stimulus that would be perceived as /ba/ by an adult English-speaker. The dishabituation stimuli (presented to different groups of infants) might be an acoustically different stimulus that would also be perceived as /ba/ by an adult and a stimulus that would be perceived as /pa/ by an adult. If infants dishabituate only to the latter stimulus, we might conclude that all acoustic differences are not perceived equally by infants (e.g., Eimas et al., 1971).

Visual habituation paradigms are also possible, in which an infant hears an auditory stimulus as long as she fixates a visual stimulus (e.g., a checkerboard). When the infant stops fixating the visual stimulus for a pre-determined amount of time, she is said to have habituated to the auditory stimulus. Recovery from habituation occurs when the infant re-fixates the visual stimulus upon presentation of a new auditory stimulus (e.g., Stager & Werker, 1997). Recently, the visual habituation paradigm has been used to measure infants' ability to associate an auditory stimulus with a visual one (e.g., Gogate & Bahrick, 2001; Stager & Werker, 1997). An example of this use of the paradigm will be discussed under the section on building a lexicon, below.

2.2 Reinforced Headturn Technique

The reinforced headturn procedure (also called "operant headturn") rewards infants for detecting a change in an ongoing stimulus (e.g., a string of /ba/'s interrupted by /da/, Werker & Tees, 1984). Infants are trained that, if they turn their head to the source of sound when a change in the stimulus stream occurs, they will be allowed to see a smoked plexiglass box illuminate to reveal a moving toy inside. This is the only technique of the four in which a separate reinforcer motivates the infant to respond. The other methods rely on the internal motivation of the infant to indicate greater interest in one stimulus over another. Therefore, if an infant tested with the other techniques fails to show differential interest, it does not necessarily mean that the infant fails to discriminate the stimuli presented.

2.3 Preferential Listening

In variants of the preferential listening procedure, an infant's preference for one type of stimulus over another is measured by how much time she looks either toward flashing lights on either side of where they are seated (Headturn Preference Procedure, Kemler Nelson et al., 1995) or by how much time they look at a central visual target (like a bull's eye). The preference measured can either be one with which the infant enters the laboratory (e.g., mother's voice vs. another woman's voice; e.g., Mehler et al., 1988), or one resulting from a brief familiarization period. For example, infants might be tested on words presented during familiarization vs. words not presented during familiarization (Jusczyk & Aslin, 1995).

2.4 Preferential Looking

Finally, the preferential looking technique measures an infant's ability to choose which of two visual stimuli "goes with" an auditory stimulus (e.g., Golinkoff, Hirsh-Pasek, Cauley & Gordon, 1987). In this procedure, an infant is seated in front of two video displays and hears a word or a phrase that describes one of the displays. For example, an infant might hear "mommy" when shown displays of her mother and father (Tincoff & Jusczyk, 1999). Although this technique is used to test infants' referential/semantic interpretations of auditory stimuli, it has also been used to tap their form-based lexical generalizations (e.g., Swingley & Aslin, 2000). I will describe studies using the technique in this way.

3. What does acquiring a language entail?

As noted in the introduction, infant language researchers have attempted to identify domains of adult language ability in which generalizations can be made based on form alone. This article will focus on three types of generalization: phonological, syntactic and lexical.

At the level of phonology, speakers of a particular language divide the continuously varying acoustic signal into a small set of language-relevant phonetic features and combine features in principled ways to define both a segment inventory and legal combinations of segments. Thus, adult English speakers know that [pit^h] and [pit] with aspirated and unaspirated t's, respectively, are equivalent in terms of the phonetic features that are distinctive in English (i.e., aspiration is not distinctive in English). That is, [t^h] and [t] are treated as belonging to a single category. In terms of segment combinations, adult English-speakers know that [kto] is not a possible English word and that the plural of the nonsense word "snerg" is /snəɹgz/.

At the level of syntax, we treat semantically varying words as belonging to particular syntactic categories (e.g., noun, noun phrase, etc.) and combine these categories to create phrases and clauses. Thus, upon hearing "I saw a snerg yesterday," an adult English speaker would be able to say "What did the snerg look like?". That is, he would give "snerg" the privileges of occurrence of English nouns, without necessarily knowing what the word meant.

Whether humans actually represent discrete phonological and syntactic categories and formally encoded principles for combining them, or whether our linguistic representations are better thought of as points of stability in a multi-dimensional linguistic space, is a topic of debate (e.g., Elman et al., 1996; Pinker & Prince, 1988; Rumelhart & McClelland, 1987). Nevertheless, all approaches to language that attempt to account for generalization refer to something like categories and combinatorial principles. Therefore, any theory of language development must explain how language learners come to behave in ways consistent with having formed phonological and syntactic categories and combinatorial principles.

Although the discussion of generalization in language tends to focus on phonology and syntax, building a lexicon also requires a good deal of generalization beyond the stimuli to which one has been exposed. As noted in the introduction, listeners must entertain sufficiently general representations of word forms to know that different renditions of the same word, e.g., by different talkers, map onto the same lexical item in memory. Indeed, before the current cornucopia of studies demonstrating infants' early sensitivity to various aspects of language, parents and researchers alike marked the beginning of language development as recognition or production of first words. Note that this intuitive starting point for language involves two potentially separable abilities: finding and storing word forms, and associating forms with meanings. Because this article focuses on infants' ability to generalize based on language form, I will discuss only research on finding and storing word forms.

Based on the foregoing discussion, we can divide the infant's task of acquiring a language into three parts: (1) acquiring phonetic categories[2] and combinatorial principles, (2) storing word forms and their meanings, and (3) acquiring syntactic categories and combinatorial principles. The next sections provide an overview of the research in these three areas.

4. Some recent studies on infants' sensitivity to language form

Below I will review a handful of the many recent studies on infants' sensitivity to the form of their language. The studies were selected to reflect some of the current questions in the field, as well as to illustrate how researchers go about asking questions about infants' knowledge of language.

4.1 Acquiring phonetic categories and combinatorial principles

Although infants in the first months of life appear to be able to discriminate most speech sounds used in the world's languages, adults are not. The ground-breaking research of Werker and colleagues using the reinforced headturn technique has shown that infants lose their ability to discriminate non-native consonant contrasts, and therefore become more like adults, some time between 8 and 10 months of age (Werker & Tees, 1984). These results are generally taken to indicate that infants have begun to form categories of those speech contrasts that are relevant in their language. What causes infants to form phonetic categories has been a puzzle. We might naïvely assume that infants lose their ability to discriminate sounds that are not in the input. However, such an assumption misses the point that many acoustic differences that are phonemic in one language appear in another language as allophones of a single phoneme. For example, English-speakers have the option of releasing or not releasing and aspirating word final stops. Thus, English-learning infants may be exposed to both released and unreleased stops, but this phonetic difference does not affect meaning in English. The same acoustic difference does affect meaning in Hindi. What causes the English-learning infant and the Hindi-learning infant, both of whom hear variation in aspiration in their input, to treat aspiration differently?

One class of hypotheses is based on the observation that infants show a decline in non-native consonant discrimination at roughly the period of development that they begin to recognize and produce first words (MacKain, 1982; Jusczyk, 1985; Werker & Pegg, 1992; Best, 1995; Lalonde & Werker, 1995). Perhaps associating word forms with meanings as part of building a lexicon causes learners to focus on which aspects of form are relevant to meaning and which are not. Or, perhaps associating spoken word forms with the articulatory gestures needed to reproduce them causes a change in how learners attend to speech sounds. A potential problem with these views is that it is not clear how learning words might focus infants' attention on relevant phonetic properties if they did not already have a tacit list of potential properties in mind to begin with. Another problem is that infants' ability to discriminate non-native vowel sounds declines at about six months, a time at which word learning is not obviously underway (Kuhl, Williams, Lacerda, Stevens & Lindblom, 1992; Polka & Werker, 1994). If a non-lexical mechanism for perceptual change exists for vowels, the same mechanism may explain developmental change in consonant perception as well.

A third, and potentially more serious, problem with views that depend on word learning for change in speech sound discrimination is that infants appear to have difficulty discriminating minimal word pairs at the early stage of word learning (Stager & Werker, 1997; Werker, Fennell, Corcoran & Stager, 2002; see discussion of lexical development, below). For example, an infant who easily discriminates "ba" from "pa" might have difficulty discriminating "bear" from "pear" in the early stages of word learning. It is difficult to see how such an infant could use word-meaning pairs to focus on voicing as an important feature of English words.

Another hypothesis about the mechanism that underlies infants' focus on the phonetic features that are relevant in the target language concerns their attention to the statistical properties of their input (Guenther & Gjaja, 1996; Jusczyk, Bertoncini, Bijeljac-Babic, Kennedy, & Mehler, 1990; Kuhl, 1993; Maye, Werker & Gerken, 2002). On this view, an English-learning infant might hear a continuum of different degrees of aspiration on word-final stops, with most of the values clustering around a particular point in the acoustic distribution. That is, English-learning infants are likely to hear a monomodal distribution of aspiration. Hindi-learning infants are also likely to hear a range of aspiration values; however, the values should cluster around two points in the distribution — one for segments in which the speaker intends aspiration and the other for intentionally unaspirated segments. Thus, the Hindi-learner is exposed to a bimodal distribution of this acoustic variable.

Recent research by Maye and colleagues using the preferential listening technique suggests that even 6-month-olds respond differently to mono- vs. bimodal distributions of speech sounds (Maye et al., 2002). Six- and 8-month-old infants were exposed for about two minutes to syllables that varied along the acoustic dimension represented by the endpoints of [d] as in "day" and the unaspirated [t] in "stay" along with filler stimuli.[3] All infants heard all of the stimuli from an eight-token continuum. However, half of the infants heard a stimulus set in which most tokens came from the middle of the continuum (tokens 4 & 5, monomodal group), while the other half heard a set in which most tokens came from near the endpoints (tokens 2 & 7, bimodal group). During test, infants' listening times were measured as they were exposed to trials comprising either an ongoing alternation between the two endpoints (tokens 1 & 8, alternating trials) or a single stimulus from the continuum repeated (non-alternating trials). Each trial ended when the infant stopped fixating the visual target for a predetermined time. Only infants from the bimodal group responded differentially to the alternating vs. non-alternating trials.

One interpretation of these findings is that exposure to a bimodal distribution helped infants determine that the acoustic dimension in question was potentially relevant. In contrast, exposure to a monomodal distribution made it more likely that infants would ignore the same acoustic difference. These results suggest that infants are able to perform some sort of tacit descriptive statistics on acoustic input. Such "statistical learning" is a current theme in research on infant language development (e.g., Saffran, Aslin & Newport, 1996; Gómez & Gerken, 1999), and additional studies in this vein will be presented below. The fact that 6-month-olds showed an effect of the distribution with which they were familiarized suggests an additional advantage to the statistical learning hypothesis. It may explain why infants lose their ability to discriminate non-native vowel contrasts earlier than consonant contrasts, because languages generally include in their segment inventories many fewer vowels than consonants. Therefore, infants are exposed to many more vowel tokens than consonant tokens by 6 months of age and may have a better chance to statistically analyze vowel distributions.

Turning now to combinatorial principles in phonology, Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk (1993) demonstrated that English-learning 9-month-olds preferred listening to English over Dutch word lists that differed only in the phoneme combinations they contained (e.g., [kn], [vl], and [zw] are legal in Dutch but not English). Similarly, Sebastián-Gallés and Bosch (in press), also using the preferential listening technique, presented 10-month-olds with lists of CVCC non-words that were either phonotactically legal or illegal in Catalan. Spanish does not allow word-final clusters, so both types of stimuli were illegal in Spanish. Catalan monolingual infants and Catalan-Spanish bilingual infants exhibited significantly different listening times for legal vs. illegal sequences, but Spanish monolinguals did not.

Such results can be taken either to indicate that infants have tacit knowledge of the segment combinations that are legal in their language, or to indicate that they are sensitive to what is *likely* in their particular language, with illegal sequences having a likelihood of zero. Jusczyk, Luce and Charles-Luce (1994) explored these alternatives by presenting English-learning 6- and 9-month-olds with words containing legal phonotactic sequences that are either frequent or infrequent in English. The 9-month-olds, but not the 6-month-olds, showed a listening preference for the frequent sequences, further supporting the view that infants keep track of the descriptive statistics of their language. Using the preferential listening technique, Zamuner (2001) showed that even 7.5-month-old girls are able to discriminate CVC nonwords composed of frequent versus infrequent diphones.[4] It is important to note that the studies examining the effects of phonotactic frequency have not controlled for phone frequency. That is, segments in the low frequency items tend to occur in English with lower frequency than those in high frequency items. Therefore, both types of frequency may have contributed to infants' discrimination.

The studies reported above are consistent with a growing body of data suggesting that infants are able to keep track of various statistical properties of their input during the first year of life (e.g., Saffran, Aslin & Newport, 1996). Other studies in this vein will be presented below. We need to ask, however, whether infants are also able to go beyond the specifics of their input to more abstract generalizations. Consider first the level of abstraction called the "phoneme." None of the mechanisms described above, by which infants focus on the speech contrasts relevant in the target language, is well suited to the acquisition of abstract phonemes. Rather, all of the approaches focus more on what Maye (2000) calls "phonetic categories" and what others have called "position-specific phonemes" (see footnote 2). That is, all of the approaches discussed above focus on how infants come to treat English [pɪt] and [pɪt^h] as the same and discriminate these from [pɪk]. None is concerned with how infants might come to treat the /p/ in [pɪt] as a member of the same phoneme category as the /p/ in [spɪt]. Indeed, several researchers have argued that there is little evidence, except for our ability to learn an alphabetic writing system, for abstract phonemes at this level (see Maye, 2000, for an excellent review). Thus, infant research may help us to determine whether the levels of abstraction posited in linguistic theory are indeed part of our ability in a particular language.

However, there *is* evidence for the psychological reality of phonetic features. For example, the accessibility of the voicing feature can be seen in the morphological alternation of the plural marker on "dogs" surfacing as /z/ and the plural marker on "cats" surfacing as /s/. Thus, we must ultimately explain how language learners are able to abstract such featural information from the speech signal. For example, we might ask, if an infant is trained on a "day" ~ "stay" continuum such as the one used by Maye et al. (2002), is she able to infer the categorical nature of the stops in a "bay" ~ "spay" continuum? Data from adults suggest that the answer is *no* (Maye, 2000; Maye & Gerken, 2001). Adults trained on a bimodally distributed "day" ~ "stay" continuum discriminated the endpoints better than those trained on a monomodal distribution. However, neither group of adults was able to discriminate the endpoints of a "bay" ~ "spay" continuum. Nor were adults trained on a "bay" ~ "spay" continuum able to discriminate the endpoints of a "day" ~ "stay" continuum.

It may seem unsurprising that adults fail to transfer to new contrasts exhibiting the same acoustic/phonetic differences as training stimuli. After all, listeners can afford to be conservative in phonological generalization, because they are likely to hear all segments from their language's inventory within a short time. That is, they can wait to hear a pair of phonemes used in different words before concluding that those segments are different from each other. However, cross-linguistic data suggest that some phonetic contrasts in fact predict others. For example, languages with a voicing distinction in a velar place of articulation generally also have a voicing distinction in a coronal place of articulation (but not the reverse, Maddieson, 1984). Such cross-linguistic implicational relations might suggest that listeners will generalize to as yet unheard contrasts of certain types. Finding unidirectional phonological generalization in training studies of the sort employed by Maye and colleagues would provide an important empirical tie between what an infant learns about her particular language and cross-linguistic data. Therefore, it would be useful for future research to explore whether there are conditions under which adults and infants will generalize from a familiarized acoustic contrast to a new contrast that reflects the same phonetic feature.

The question of generalizability is also raised by studies on infants' sensitivity to the frequent combinations in their language. So far, we know only that infants are sensitive to frequently vs. infrequently occurring segments and combinations. We do not know whether they also have tacit knowledge of the underlying basis for possible combinations. Nor can we easily determine the nature of infants' phonotactic knowledge by testing them on combinations from the target language, because every legal segment combination has already been heard by an infant who enters the laboratory. Learning studies might help address this question. For example, it might be possible to expose English-learning infants to a set of CV and CVC words from a language that allows only codas of a certain level of sonority (e.g., Selkirk, 1984). Some examples of legal codas could be withheld during training, and the withheld codas could be pitted against illegal codas during test. If infants discriminate the legal and illegal items, we might conclude that they have tacitly abstracted the phonological property that allows some codas and not others.[5]

Clearly more research might be done to determine if and when learners generalize in the domain of phonology. However, as noted above, the ability to generalize far beyond specific input may not be critical in this domain: Each phoneme and phoneme combination will certainly appear many times in the input, allowing listeners to refer to stored representations in judging the distinctiveness of segments or the goodness of segment combinations. This is not the case in syntax, a point that will be addressed in the relevant section, below.

4.2 Building a lexicon

As noted earlier, building a lexicon entails at least two potentially separable tasks: finding and storing potential word forms and associating those forms with appropriate meanings. A great deal of research over the past decade has focused on the cues that infants might use to identify potential word forms, and in particular, to segment words from the speech stream. Perhaps the simplest cue comes in utterances comprising a single word, in which both initial and final word boundaries are supplied for the learner (Brent & Siskind, 2001). Learners who first encounter words in this form might later be able to extract them from continuous speech (Dahan & Brent, 1999). Other research has shown that infants are better able to identify words at the ends of utterances and utterance-internal phrases, where they tend to be lengthened and where the final boundary is relatively clear (e.g., Fernald, McRoberts & Swingley, 2001; Saffran, Newport & Aslin, 1996). Still other cues that infants have been found to employ include language-specific canonical stress patterns (e.g., Echols, Crowhurst & Childers, 1997; Johnson & Jusczyk, 2001; Morgan & Saffran, 1995) and phonotactic information (Christophe, Dupoux, Bertoncini, & Mehler, 1994; Hohne & Jusczyk, 1994; Johnson & Jusczyk, 2001). Finally, it appears that the probability with which one syllable is followed by another can be used by infants to locate words that appear multiple times in running speech (Morgan & Saffran, 1995; Jusczyk, Houston & Newsome, 1999; Saffran, Aslin & Newport, 1996).

Demonstrating the usefulness of a particular cue typically entails presenting infants with familiarization stimuli in which words are embedded. Whether or not infants extracted those words is assessed in a subsequent test phase (Jusczyk & Aslin, 1995). For example, Saffran, Aslin and Newport (1996) familiarized 7.5-month-olds for about two minutes with four trisyllabic nonsense words (e.g., bidaku) strung together in random order (the same word could not occur twice in sequence) and with no breaks between words (e.g., bidakupadoti-golabubidakutupiro…). Infants were then tested to see whether they would discriminate two of the familiarized words (e.g., bidaku) from two "part words" made up of one syllable of one familiarized word and two syllables from another (e.g., kupado). They listened longer to part word stimuli than to familiarized words, indicating that they could discriminate the two word types.

Saffran and colleagues propose that infants were able to use the statistical likelihood of one syllable following another to extract the actual trisyllabic words from the training stimuli. For example, in the training word "bidaku" the syllable "bi" is followed by "da" and "da" is followed by "ku" with a probability of 100%. The syllable "pa" follows "ku" only about 33% of the time. A subsequent study ruled out the possibility that effect was due only to the fact that words occurred more frequently in the training stimuli than part words (Aslin, Saffran & Newport, 1998). Therefore, it appears that infants were able to compute transitional probabilities in order to determine what syllables "went together" as words. Similar studies using either tone or visual sequences as stimuli revealed that infants' ability to track transitional probabilities is not limited to linguistic stimuli (Aslin, Slemmer, Kirkham, and Johnson, 2001; Saffran, Johnson, Aslin & Newport, 1999).

The studies on word segmentation make it clear that infants, like adults, are able to use a variety of cues to accurately locate word-sized units. The ability to use multiple cues is important, because the cues that are most frequently used by adults (e.g., stress patterns and phonotactics), rely on language-specific regularities, which the learner must first discover by identifying at least some words by other means (e.g., hearing words in isolation and using statistical sensitivity).

Johnson and Jusczyk (2001) began to take on the question of what cue infants use when more than one is available. They replicated the results of Saffran and colleagues, showing that 8-month-old infants can use statistical cues to isolate words from an uninterrupted string by listening longer to part words than words. They then pitted statistical cues against stress in one experiment and against coarticulatory cues in another. In the stress vs. statistics experiment, new stimuli were created by placing stress on the last syllable of words. Stressed and unstressed versions of the words were presented during familization. For example, if "tudaro," "pigola," "bikuti," and "budopa" were the four words in the study, the familarization stimulus might be "bikuTIbudo-patudarobudoPAbikuti …" (syllables in capitals are stressed). During test, infants heard words and part words that were all unstressed, just as in Saffran, Aslin and Newport and the first experiment of Johnson and Jusczyk. The results showed that infants' preference from the first experiment reversed. That is, they listened longer to statistical words than to part words. Because stress typically occurs on the first syllable of English words, the statistical part words were good English word candidates, as marked by stress. The third experiment followed a similar logic, with a familiarization string like the following: "pigolabikutibudo-patudarobudopadikuti..." (underlined syllable triplets are coarticulated).[6] Again, infants were tested on statistical words and part words with no coarticulation on either, and as in the second study, they showed a preference for statistical words.

Johnson and Jusczyk take their findings to indicate that the infants in their studies used stress and coarticulatory cues, and not statistical cues, to isolate words during familiarization. This claim seems plausible, in the sense that stress and coarticulation information are immediately available to the infant for segmentation (assuming they are familiar with the cues from their experience with English), whereas statistics must be calculated over many words and therefore may be more demanding on processing resources. Nevertheless, it is important to note that the evidence Johnson and Jusczyk use to make their claim is simply a reversal in preference from what has been found with statistical cues alone. In a fourth study, they demonstrated that when coarticulatory cues and statistical cues coincide, infants show a continued preference for words over part words. Although the reversal in direction of preference is interesting, direction of preference on its own is difficult to interpret. This point will be discussed further in the last section.

Once word candidates have been segmented from the speech stream, they must be compared to existing words in the lexicon. The nature of stored lexical representations and the comparison process have become the focus of much of the work in lexical development in the past few years. One line of research has focused on the problem faced by learners when new tokens of a word are acoustically different from previously encountered tokens, and in particular, when the acoustic differences are due to differences in talker voice. We know from studies of adults that, although we are able to recognize words produced by any number of different talkers, we also encode talker information. When adults are presented with a list of words and later asked to determine whether words from a new list were also on the old list, they are more accurate when old and new words are spoken by the same talker (e.g., Nygaard, Sommers & Pisoni, 1994). In an infant study using a similar approach, Houston and Jusczyk

(2000) showed that 7.5-month-olds, who were familiarized with a passage produced by one female talker, were able to recognize particular words from the passage if they were produced by a different female talker, but not a male talker. In contrast, 10.5-month-olds recognized the words regardless of talker differences. One interpretation of these findings is that by 10.5 months, infants have begun to determine which acoustic differences are linguistically relevant and which are not. This notion is consistent with the finding reported above that infants begin to lose their ability to discriminate non-native consonant contrasts between 8 and 10 months of age.

Do the findings on infants' loss of non-native contrast discrimination and their ability to recognize words produced by different talkers mean that they have adult-like lexical form representations by the end of their first year of life? This question is currently under debate due to apparently conflicting results from Werker, Stager and colleagues (Stager & Werker, 1997; Werker et al., 2002) and recent articles by Swingley and Aslin (2000, 2002). In particular, the debate focuses on the nature of learners' phonetic representations for word forms that have been associated with referents.

In one line of research, Stager and Werker (1997) trained infants on novel labels for novel objects (e.g., /bɪ/ and /dɪ/ referring to different geometric shapes). Training consisted of presenting each object and the appropriate label until infants habituated (showed a decline in looking time). During test, infants were shown one of the objects, which was either given the appropriate label, or the label of the other trained object, and the amount of time looking at the object was measured. The rationale for the looking time measure was that infants should look longer when the label and object pairing failed to match the pairing presented during training, provided that they discriminate the two trained labels. Stager and Werker (1997) found that 14-month-olds did not look reliably longer in the mismatch condition, suggesting that they are not able to discriminate minimally different phonetic strings when the strings are used as labels.[7] Importantly, 14-month-olds were able to discriminate the same acoustic stimuli when they were associated with abstract checkerboard patterns, which presumably could not serve as referents. Werker et al. (2002) found that 17- and 20-month-olds *were* able to discriminate minimal pairs and that there was a relation between receptive vocabulary size and minimal pair discrimination. At both ages, infants whose receptive vocabularies were 200 words or more and whose productive vocabularies were 25 words or more were more likely to discriminate minimal pairs than infants with smaller vocabularies. Werker and her colleagues interpret these data to indicate that infants store phonetically underspecified representations of early words and begin to employ more detailed representations as the number of words in the lexicon makes it difficult to discriminate among phonetically similar items. Thus, children with larger vocabularies may be more likely to store more fully specified word representations.

Although this hypothesis is intriguing, such a reorganizational account does not explain *the source* of the new information used in the more mature representations (also see the final section, below). It simply explains *why* learners might begin to employ more fully specified lexical representations if they had access to them. (Note that a similar criticism was raised with respect to lexically-based accounts of infants' loss of discrimination for non-native contrasts.) Furthermore, the relation between vocabulary size and minimal pair discrimination can also be taken to mean that those children who are, for some reason, better at storing phonetically accurate word forms are faster at learning words.

The notion of an underspecified representation of early words also conflicts with other data. For example, Jusczyk and Aslin (1995) using a preferential listening procedure found that 7.5-month-old infants familiarized with passages containing the words "feet" and "cup" preferred word lists containing those words over lists containing the similar sounding foils "zeet" and "tup" (but see Hallé & de Boysson-Bardies, 1996). However, the study presented infants with only auditory words with no visual referents. It may be that it is only when infants treat word forms as labels for objects that they store the forms in coarser phonetic detail (Stager & Werker, 1997). Swingley and Aslin (2000) used the preferential looking technique and presented 18-month-olds with pairs of pictures of familiar objects and measured aspects of their looking behavior when presented with the label of one of the objects (e.g., "baby") or a phonetically similar foil ("vaby"). Infants looked longer at the relevant picture when the correct label was given, suggesting that they discriminated the labels from the foils. Swingley and Aslin (2002) demonstrated that even 14-month-olds look significantly longer at a picture matching a known word when the word itself is presented than when a minimally different foil is presented. Furthermore, the effect was not dependent on receptive or expressive vocabulary size. The results of Swingley and Aslin suggest that infants represent the words that they know in relatively fine phonetic detail.

Note that there are at least two differences between the studies of Werker and colleagues and those of Swingley and Aslin. First, the methods differ, with Werker and colleagues using a visual habituation paradigm and Swingley and Aslin using preferential looking. Thus, Swingley and Aslin compared infants' responses to a phonetic sequence that was associated with a referent ("baby") to a sequence that was not ("vaby"). In contrast, Werker and colleagues examined infants' ability to discriminate two phonetic sequences that were associated with referents. On the face of it, the second task seems more similar to minimal word pair discrimination.

A related difference between the two lines of research is that Werker and colleagues examined infants' responses to newly taught words, while Swingley and Aslin employed words infants knew when entering the laboratory. What differentiates newly learned words and known words? Is it merely the number of times that the infant has heard the word? Is it the length of time that the infant has associated the word with a referent? Or, are other factors, such as hearing the word produced by different talkers or in different environments, critical for phonetically detailed storage?

In an attempt to address these questions, Plunkett, Bailey, and Bryant (2000) tested 18- and 24-month-olds' ability to recognize words that they had learned recently vs. words they had known from early in the word learning process (based on parental report), using the preferential looking technique. Like Swingley and Aslin, they found that infants looked longer at referents of correctly pronounced words over pronunciations differing by one or two phonetic features. However, they found no consistent effects of how recently the words had been learned or of age. Given that 17-month-olds have been shown to discriminate minimal pairs in the studies of both Werker and colleagues and Swingley and Aslin, it might be worth replicating the Plunkett et al. study with younger infants (e.g., 14-month-olds).

At this point, the role of age, vocabulary size and amount of exposure to particular words in successful minimal pair discrimination is still not fully understood. However, one other change that has been observed during the second year of life may ultimately shed some light on how we might best characterize infants' developing lexical representations. This change has been observed in a set of studies by Swingley, Fernald, and their colleagues. For example, Fernald, Pinto, Swingley, Weinberg and McRoberts (1998) studied frame-by-frame the video tapes from a preferential looking paradigm to determine the time it took 15- to 24-month-olds to first look at a picture consistent with a spoken word. They found steady decreases in looking latencies, with the oldest group looking at the relevant picture 300 msec. earlier than the youngest group. They also showed that infants began looking at the correct picture before the offset of the spoken word, suggesting that, like adults, they are able to identify words from partial phonetic information (e.g., Fernald, Swingley, & Pinto, 2001). Perhaps future studies that examine the relation of vocabulary size, lexical access speed, and skill at minimal pair discrimination might help us to understand the developmental change observed by Werker and her colleagues.

4.3 Acquiring syntactic categories and combinatorial principles

Perhaps the most controversial area of research on early language abilities concerns syntax. Historically, language researchers focusing on production data have viewed the standard sequence of language acquisition as one in which learners first link word forms with meanings and only later attend to syntactic relations among words. What does it mean, therefore, to study the acquisition of syntax during a period when very few if any words are known? Although researchers studying lexical development have studied the discrimination of word forms that infants may or may not "know," the notion that we might be able to study infants' sensitivity to the forms of whole utterances without assessing their interpretations of these utterances is quite new.

The first studies examining infants' sensitivity to the syntactic forms of utterances involved making modifications to the language the infant was already learning. Shady, Gerken, and Jusczyk (1995) presented 10.5-month-olds with normal English sentences as well as sentences in which determiners and nouns were reversed, resulting in phrases like "kitten the." The stimuli were recorded using a speech synthesizer to avoid disruptions in prosody that are likely to occur when a human talker produces ungrammatical sentences. Using a preferential listening technique, the researchers demonstrated that infants listened longer to the unmodified sentences, suggesting that they were able to tell the difference between the two types of stimuli.

Other studies in this vein presented infants with normal English sentences versus sentences in which a subset of grammatical morphemes were replaced by nonsense syllables. These studies also show that infants could discriminate the grammatical and ungrammatical stimuli (Shady, 1996; Shafer, Shucard, Shucard & Gerken, 1998). Importantly, infants did not discriminate stimuli in which nonsense words replaced content words, suggesting that the information about language form carried by grammatical morphemes was more salient to infants than particular content words, which they may or may not have recognized (Shady, 1996).

Santelmann and Jusczyk (1998) showed that infants are able to detect violations in dependencies between English morphemes, such as auxiliary "is" and progressive suffix "-ing." Infants in their studies listened to sets of sentences like "Grandma is singing" vs. "Grandma can singing." Eighteen-month-olds, but not 15-month-olds, showed a preference for grammatical sentences, but only when the distance between the two morphemes was between one and three syllables.

Although these studies indicate that infants are sensitive to aspects of their input that might serve as "cues" to an aspect of adult syntax, we cannot take such cue sensitivity to indicate that these infants have knowledge of English phrase structure. Rather, cue sensitivity merely indicates that infants have encoded frequently occurring patterns in their native language. For example, in the Shady et al. (1995) study, many of the ungrammatical sentences contained two grammatical morphemes in sequence (e.g., "a that"). Such sequences are virtually nonexistent in English, and infants were probably responding to this and similar aspects of the stimuli, as opposed to any tacit expectation for determiners to precede nouns.

A similar issue may need consideration in the Santelmann and Jusczyk study, in which infants' preference for grammatical sentences containing "can" was not assessed. That is, infants were not tested on their ability to discriminate sentences like "Grandma can sing" vs. "Grandma can singing." Therefore, the preference for the "is/-ing" relation could simply reflect a preference for the more frequently occurring auxiliary "-is". This alternative interpretation of the Santelmann and Jusczyk data is weakened by the fact that the preference for grammatical sentences was no longer reliable when four or five syllables occurred between "is" and "-ing." However, sentence forms such as "Grandma is almost always singing" are probably relatively rare in English-learners' input (Santelmann, 2002). Therefore, infants' apparent sensitivity to the long distance dependency in this study may actually reflect sensitivity to some other frequency-based aspects of their native language.

Because it is difficult to separate sensitivity to syntactic structure and frequency of occurrence in the native language, researchers studying infants' generalizations over sentence-like stimuli have turned to familiarization studies. Like their counterparts in phonological and lexical development, these studies typically familiarize different groups of infants with stimuli from a natural or artificial language system for a brief period. The groups of infants are then tested on the same stimuli to determine if the groups respond differently. Differential responding during test is taken to indicate that infants learned during the familiarization phase of the study. Familiarization studies have focused on two aspects of syntactic learning: pattern abstraction and category induction.

With respect to pattern abstraction, Gómez and Gerken (1999) presented 12-month-olds with a subset of strings produced by one of two finite state grammars. The two grammars began and ended in the same CVC nonsense words, with the only difference being the string-internal sequences of words allowed. In one experiment using the preferential listening procedure, half of the infants were trained for about two minutes on strings from Grammar 1 and half on strings from Grammar 2. For example, VOT PEL was a legal sequence in strings of Grammar 1, but not grammar 2. During test, both groups of infants heard new strings from the two grammars. Infants showed a significant preference for the new strings generated by their training grammar. This study showed that infants learned about the sequential dependencies of the words in their training grammar and applied this knowledge to new strings during test.

A second, potentially more exciting, experiment examined infants' ability to abstract beyond sequential dependencies. Infants were familiarized as before, but they were now tested on strings from the two grammars instantiated in new vocabulary. This was done by pairing each word from one vocabulary with one from the other vocabulary (e.g., JED, FIM, TUP, DAK, SOG were matched with VOT, PEL, JIC, RUD, TAM, respectively). Thus, an infant who heard a string like JED-FIM-FIM-TUP in training might hear a string like VOT-PEL-PEL-JIC in test (both strings were generated by Grammar 1). Again, infants showed a preference for strings that were consistent with their training grammar, suggesting that they had abstracted some aspect of grammatical structure above and beyond pairs of specific elements.

In a similar series of studies, Marcus, Vijayan, Bandi Rao, Vishton (1999) exposed 7-month-olds to three minute speech samples of strings with ABA ("wi-di-wi" and "de-li-de") or ABB ("wi-di-di" and "de-li-li") patterns. During test, infants heard strings with the same pattern they had heard during training as well as the other pattern, both instantiated in new vocabulary (e.g., "ba-po-ba" vs. "ba-po-po"). Infants trained on ABA stimuli preferred ABB stimuli at test, while infants trained on ABB stimuli preferred ABA stimuli at test (i.e., a novelty preference). These results were important for demonstrating that younger infants can also abstract beyond specific word order.

In both the Gómez and Gerken and Marcus et al. studies, it is likely that infants were relying on a pattern of repeating and alternating syllables to determine whether what they heard during test was the same as or different from the training stimuli (Marcus et al, 1999). Indeed, additional studies by Gómez and Gerken (1998) revealed that, although infants showed sensitivity to sequential dependencies when exposed to grammars in which strings contained no repeating or alternating elements, they were unable to transfer from one vocabulary to another. Similar studies with adults suggest that what has been taken to be transfer of *grammatical* information across vocabularies does not in fact rely on a representation of a grammar at all (Gómez, Gerken, & Schvaneveldt, 2000). Rather, adults and infants appear to detect and remember local patterns of identical elements, and it is these local patterns that they recognize in longer strings in transfer studies. Infants' pattern detection ability is interesting and potentially important in human development. However, the syntax of natural languages rarely contains repetitions or alternations of the same word or morpheme. Therefore, it is not clear how these studies might relate to the acquisition of syntax in a real human language.

One aspect of pattern abstraction that does occur in real language concerns dependencies between non-adjacent elements. The relation between auxiliary verbs like "is" and the verb inflection "-ing" is such a dependency, as is the relation of negation markers "ne-pas" in French. As noted above, Santelmann and Jusczyk (1998) found that 18-month-old English-learners were sensitive to the dependency between "is" and "-ing." Gómez (in press) has found a similar effect in 18-month-olds who were familiarized with an artificial grammar of the form AXB and CXD, in which there is a dependency between the A and B elements and between the C and D elements. Importantly, Gómez found that it was only when the middle element was selected from a large pool (24) that infants could detect the relation between the first and third elements in the grammar. Because this was a familiarization study, it does not suffer from the same potential problems noted with regard to Santelmann and Jusczyk (1998). Gómez interprets her result to mean that infants attempt to process the strings in terms of sequential dependencies (A–X, X–B) until some point at which doing so becomes unfeasible (see discussion in the last section). Of course, in natural language, long distance dependencies encompass linguistic *constituents* (e.g., verb phrases). Thus, in order to fully link research on long distance dependencies to natural language, infants' sensitivity to constituent structure must ultimately be assessed.

Some studies have begun to test infants' sensitivity to constituent structure by examining their ability to induce syntactic categories. As noted earlier, a key component of the generativity of natural language syntax is the existence of formal categories such as noun, noun phrase, etc. One approach researchers have used has been one of paradigm completion, which can be demonstrated with a simple example from English. Imagine that a learner hears the phrases in (1a)–(1j), below. Note that the paradigm has two missing cells: "A boy" and

"Will eat." In a typical paradigm completion study, learners are familiarized with a subset of the paradigm and tested on both the missing cells, as well as incorrect combinations, like "A eat" and "Will boy." Learners' ability to accept the missing cells and reject the incorrect combinations is taken as evidence that they have tacitly understood the paradigm and treat "boy" as a member of the category containing "fish" and "dog" and "eat" as a member of the category containing "swim" and "sleep."

(1)	a.	The fish	b.	Can swim
	c.	A fish	d.	Will swim
	e.	The dog	f.	Can sleep
	g.	A dog	h.	Will sleep
	i.	The boy	j.	Can eat
	k.	???	l.	???

Demonstrating category induction by adults and children tested in a paradigm completion paradigm has proven to be a difficult undertaking (e.g., Braine, 1987). Research with adults suggests that they can only complete the paradigm when morphological markers to categories are supplemented with semantics, phonology or additional morphology (Braine, 1987; Frigo and McDonald, 1998; Mintz, in press; Wilson, 2000). Recent research in my laboratory suggests that infants are also able to induce new categories under these conditions (e.g., Wilson, Gerken & Nicol, 2000).

Other research suggests that, once some information about categories in the native language is in place, infants show sensitivity to paradigms like the one shown above. Höhle, Weissenborn and their colleagues (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz 2001, Höhle & Weissenborn, submitted) familiarized 10- to -12-month-old German learners with two syllable sequences comprising either a pronoun + monosyllabic noun, a determiner + a monosyllabic noun, or an iambic noun in which the strong syllable was also a monosyllabic noun. For example"Kahn" (boat) is the second syllable of the noun "Vulkan" (volcano). Four monosyllabic nouns (presumably unfamiliar to children) were used as the targets and always occurred as the second syllable in each sequence. Half of the infants heard two of the four nouns, and the other half heard the remaining nouns. During test, infants heard passages containing the monosyllabic nouns they heard during training, as well as passages containing the other two nouns. None of the passages contained words that had preceded the target nouns during training. Infants listened longer to passages containing the familiarized nouns, but only when they had been familiarized to determiner-noun sequences. That is, infants preferred familiar nouns, but only when the syntactic context of the training and test conditions matched. One way to interpret this "matching" effect is that German infants have learned that certain members of the set of determiners occur with the same words (like "the" and "a" precede a large number of words in English). Thus, infants were able to recognize the nouns they had heard during familiarization only when they were preceded by an element that they had learned to expect, based on their experience with German.

In a similar study, 14- to 16-month-old German learners were familiarized with two nonsense words in either a noun context (preceded by a determiner) or a verb context (preceded by a pronoun). They then heard passages in which the new words were used as nouns or verbs. This time, infants who were familiarized with phrases in which the novel word was used as a noun preferred passages in which it was used as a verb (the opposite of the finding from the one described above with younger infants). They showed no preference for either passage when they were familiarized with the novel word used as a verb.

In sum, a very small number of studies is beginning to suggest that infants may be able to use distributional information in the utterances that they hear to form lexical categories. However, this domain is clearly one that needs further research before we understand the circumstances under which category formation can and cannot occur. For example, we need to ask whether any category can be induced, or if only categories that critically resemble those found in natural languages can be acquired in this way. It is also important to note that, even if infants are able to create a category of familiar words that behave like nouns, they must still link this distributionally defined category with other complex properties of nouns (e.g., nouns can occur as arguments of verbs). That is, we may be left in the perhaps surprising position of finding that form properties of language are relatively easy for learners, while the link between form and meaning is difficult (see Gerken, 2000; Gómez & Gerken, 2000; Naigles, in press).

5. Four Questions

In the previous section, I reviewed some recent studies that examine infants' sensitivity to linguistic form. Below, I will consider four questions that are raised by these studies and others in the recent literature.

5.1 How should we characterize development?

Throughout the review in the previous section, the reader might have noted sentences like "X-month-olds, but not younger infants, showed a sensitivity to Y." Such sentences give the impression that infant studies reveal to us a developmental pattern, in which certain abilities appear at particular developmental stages. This impression is largely incorrect. Part of the reason that we cannot draw developmental conclusions from most infant studies is statistical. Many articles on infant language report that an effect is significant at one age but not significant at a younger age, hence sentences like the one I characterized above. However, most studies do not report whether or not the two age groups differ from each other. Statistically speaking, what is needed to establish an age effect is a significant interaction, such that age interacts with the variable of interest, say, grammaticality of the utterances infants heard. Given the great variability inherent in infant behavioral data, it is very rare that one is able to find a statistically significant interaction.

A second statistical problem is that we do not currently know whether discrimination effects in our studies are reliable within individual infants. That is, if 12 of 16 infants tested today show a particular effect, will the same 12 show the effect when tested a few days later? Or is 12 of 16 better thought of as an effect size and not a measure of particular infants' linguistic abilities? This point becomes especially important as techniques for testing normally developing infants are applied to atypical populations (e.g., Houston et al., 2002). These issues of statistical reliability suggest that we should be cautious about interpreting age effects from most of the studies of infant language.

In addition to the statistical problem, however, is a deeper problem, and that is that infant researchers typically have little to say about possible theories of development and the mechanisms that might cause an infant's behavior to change in one of our studies. The field's general lack of comment on developmental theory may stem from the fact that infant perception research began with the relatively simple question of "how early does a human perceive X?" The rationale behind such a question was often "if infants show this ability very early, it is unlikely that learning is involved." However, as our questions of infants become more sophisticated, so must our theories of development. Below, I outline four approaches to development explicitly taken or implied in the recent literature on language development.

One approach to development is consistent with the view that infants are performing statistics over large amounts of linguistic data in order to make a particular generalization. On this view, the source of change is simply the amount of data that infants encounter, which obviously increases with age. Many of the studies reporting age effects on discrimination appear to assume this framework (e.g., Houston & Jusczyk, 2000). The account offered earlier for why infants lose their ability to discriminate non-native vowels before consonants also is based on amount of input. On its own, this view predicts that if an infant is somehow deprived of linguistic input in the first months of life, she will show the same developmental pattern as a non-deprived infant, once she is exposed to normal input. Some of the research on the development of speech perception by infants who receive cochlear implants or amplification early in life may serve to test this prediction (e.g., Houston et al., 2002).

Another possibility is that exposure to more and more of the input allows infants to "try out" different ways of processing similar information. An interesting twist on this theme can be seen in the discontinuous dependency work of Gómez (in press), in which infants showed sensitivity to the A–B dependency in AXB string only when the set size from which X was drawn was large. If we view these data as having potential implications for language development, we might hypothesize that learners over time first try encoding sequential dependencies across strings. However, as they encounter sufficient variability in their input, this approach may become too resource intensive, causing them to try out a solution focusing on discontinuous dependencies. Such an approach entails that the learner is born with a set of possible ways of processing stimuli.

Yet another possibility is that infants reorganize the way in which they represent linguistic information when old representations are found to be inefficient. An example of this view is the proposal that infants change the way in which they represent the form of lexical items as they acquire larger vocabularies (Stager & Werker, 1997). As noted earlier, such an account needs to state the origin of the new representation. If it is available to the infant after reorganization, why was it not available earlier? And if the information was available to the infant earlier, why was it not used? Perhaps the answer is that the learner tries to create the most efficient language processing system possible, thereby ignoring stimulus information that does not add to efficiency. Indeed, this notion is the dominant one in hypotheses about why infants come to ignore non-native segment contrasts. Thus, reorganizational processes might best be seen as ones in which no new information is added, but that previously ignored information is refocused.

Finally, it is possible that the perceptual, encoding or access systems in the infant change as the infant matures, and these "peripheral" systems affect how the infant processes language. For example, Elman (1993) and Newport (1991) have proposed that younger learners encode information from a smaller perceptual window than older learners and that smaller window size yields different, and ultimately better, learning of morpho-syntactic relations (also see Santelmann & Jusczyk, 1998). A goal for future research in this domain might be to determine in computer models what happens to learning as small processing windows grow dynamically over development.

5.2 Should we focus on specific or general properties of the data?

The field of infant language perception has made major breakthroughs in the past decade in characterizing the nature of the infants we study. Most notably, we have been awed by infants' apparent sensitivity to the specifics of their input, including frequency of occurrence, transitional probabilities, and specific acoustic properties (e.g., talker voice). Indeed, it sometimes seems that infants store and analyze nearly every aspect of the world they perceive. Infants' ability to find order in the chaos of their input might appear to contradict claims by Chomsky (1965) that input is insufficient to account for the final linguistic state that humans achieve. Such "poverty of the stimulus" arguments are used to motivate modular, innate, species-specific, language acquisition mechanisms (e.g., Crain, 1991; Pinker, 1994). This view of language development is further challenged by studies in which non-human primates are able to perform similarly to human infants (e.g., Hauser, Newport & Aslin, 2001).

However, we must keep in mind two things when thinking about how infant perception data relate to mature language systems. Both points concern the weight that we give to specific vs. general types of information in our theories of language development. The first point is that poverty of the stimulus arguments concern our ability to generalize from old input to new utterances. It is truly exciting that infants can encode and remember so much of the specifics their input. The fact that they *do* approach their input with an ear toward detail almost certainly changes our understanding of the generalization mechanism (e.g., Gómez & Gerken, 2000). Further, the fact that the same sensitivity to input can be found for non-linguistic stimuli and in non-human animals may call into question aspects of modularity and species-specificity of the acquisition mechanism. Nevertheless, we must still provide an account of how learners are able to generalize. Alternatively, we must develop models of mature language ability that downplay the generative component (e.g., Elman, et al, 1999; see below).

One approach to the problem of generalization that some researchers are taking is to determine the circumstances under which learners do and do not generalize, keeping in mind the statistical issue raised with regard to development above (e.g., Gómez, in press). Within such frameworks, we can investigate both the amount of input needed to yield generalization, as well as the similarity of the input to real human languages. If input that deviates from known languages does not allow generalization, we will have evidence that our infant studies are tapping important properties of language (Hauser et al., 2001).

The point just made about patterns found and not found in human language brings us to a second point to keep in mind about specific vs. general information in language development. An important breakthrough in the study of language development in recent years has been the increase in fine-grained studies of specific children learning specific languages (e.g., Pine & Martindale, 1996; Tomasello, 2000). These studies come in contrast to the existing tradition of attempting to make generalizations across children or languages (e.g., Braine, 1963; Bowerman, 1973). Although the new focus on the particular in language development has certainly yielded an understanding that was not obtainable from work focusing on generalization, it risks losing some understanding as well. There is a long tradition in linguistics of identifying similarities across languages. Although this tradition has been used to support strongly nativist and modularist accounts of language, the observation of cross-linguistic similarities can be interpreted within many theoretical frameworks. In so far as cross-linguistic properties of language are well-documented, we must begin to think about how these properties can be reconciled with our focus on the particular in language development. It is likely that a theory that can account both for an individual infant's acquisition of her particular native language, and for the fact that languages of the world appear to share many properties, will take us many steps closer to a workable understanding of the problem. I will return to this point at the end of the article.

5.3 Is discrimination enough?

A third issue to which infant language researchers are turning their attention is the dependent measure we use in our studies, which is nearly always some form of discrimination. Let's consider preferential listening techniques, because these are generating most of the current discussion. In preferential listening studies, infants are exposed to between about 8 and 16 trials, usually with half of one type (e.g., familiar words) and half of another type (e.g., new words). Listening time data from the useable trials are averaged for each trial type, yielding two listening times per infant. Obviously, the robustness of these average scores depends on how many useable trials they reflect. The number of infants who show a preference for a particular stimulus type determines the direction of preference (e.g., more infants preferred familiar words than new words) as well as its statistical significance (12 of the 16 infants showed a familiarity preference). What can we say of the infants who did not show the typical pattern of responding? Sometimes, these infants show almost no difference in listening time to the two stimulus types. This situation is desirable, in the sense that it seems to reflect an absence of discrimination by these infants. But it is also possible that infants who do not follow the majority pattern show relatively large differences in the opposite direction. Are these infants failing to discriminate, or are they simply showing an opposite preference? Returning to the discussion of development, it is possible that what we see developing in our studies is not discrimination, but only consensus among infants as to what is preferable. The field would benefit greatly from either adopting a more robust behavioral measure or adding a concomitant measure that would allow us to better determine which differences in listening times are due to chance factors and which are due to the infant's interest in stimuli of one type or another.

Continuing the discussion of direction of preference, several recent studies have demonstrated that this measure can be changed in potentially interesting ways. Saffran (2001) trained infants on sequences of 3-syllable "words" for which the only cue to word boundaries was transitional probabilities (see discussion of Saffran, Aslin & Newport, 1996 in section on building a lexicon, above). During test, infants heard the words and part words in isolation (data from Saffran, Aslin & Newport, 1996), embedded in grammatical sentences or embedded in nonsense syllable frames. Training stimuli heard in isolation and in nonsense syllable frames showed a novelty preference (i.e., preference for part words), while training stimuli in grammatical sentence frames showed a familiarity preference. Johnson and Jusczyk (2001) used virtually the same stimuli as used by Saffran, Aslin and Newport (1996) and also found a novelty effect. However, when they used stress and coarticulatory cues to word boundaries, they found a familiarity effect. At this time, it is not clear how to interpret novelty vs. familiarity effects. However, age, complexity of the stimuli, and how frequently stimuli were heard during training, appear to be promising factors (Aslin, 1999). If what infants prefer to listen to is governed by their current knowledge of language structure, we must begin to attend not only to whether they discriminate between two stimuli, but which stimulus type they prefer.

5.4 How are the abilities we see in infants related to adult language?

In the introduction to this article, I suggested that there has recently been a shift in infant perception research, such that the link between infant and adult research is not as strong as it had been in the days of examining infants' ability to perceive phonetic contrasts. I further proposed that the current point of contact between infant studies and the adult language faculty concerns linguistic generalization. However, we clearly know much more about adult language abilities than that they can generalize. Therefore, I would now like to consider how the new approach to infants' sensitivity to linguistic form might ultimately be linked to what we know about adult language abilities.

Let me begin by pointing out that many of the infant studies reviewed above have adult counterparts. For example, both adults and infants are more likely to discriminate the endpoints of an acoustic continuum if exposed to a bimodal distribution of tokens (Maye, 2000; Maye et al., 2002). Both adults and infants encode information about talker voice when listening to words (Houston & Jusczyk, 2000). Both adults and infants are able to use statistical cues to segment 3-syllable nonsense words from continuous speech (Saffran, Aslin & Newport, 1996). Both adults and infants are able to identify a word before its offset (Fernald, Swingley & Pinto, 2001). Both adults and infants are better able to show sensitivity to a discontinuous dependency when the interrupting element is drawn from a large set (Gómez, in press). Both adults and infants are able to recognize new sentences from a finite-state grammar instantiated in new vocabulary only when the grammar has repeating or alternating words (Gómez & Gerken, 1998; Gómez et al., 2000). Such cross-age findings suggest that we are able to see in infants some rudiments of abilities they will employ throughout their lives.

Although the parallel studies in adults and infants are potentially important, they do not take us far enough in linking the majority of research on adult language to infant studies of the sort I have reviewed here. As noted in the introduction, most studies with adults assess participants' ability to access meaning from form, while the infant studies currently under consideration assess only infants' sensitivity to aspects of language form. Clearly we must ultimately understand how infants come to attach meaning to the forms they apprehend. As more studies address this problem, we may see that learners temporarily ignore form in favor of other meaning cues, such as those provided by social situations. That is, contrary to our earlier views of language development, we may see that language form is relatively easy to discern, while discovering the principles by which language attaches form and meaning may be difficult (see Gerken, 2000; Gómez & Gerken, 2000; Naigles, in press). We have already seen an apparent decrement in use of form as infants learn to associate phonetic strings with objects (Stager & Werker, 1997). On the view that form-meaning mapping is the difficult part of language development, it is likely that the entire field of infant language perception will face the issues currently being debated in the domain of infants' minimal pair discrimination (e.g., Stager & Werker, 1997; Swingley & Aslin, 2000).

Let me end by noting a potential similarity between studies of adults and infants that might ultimately allow us to create a stronger link between these two domains of research. I have already indicated that research on infants (and young children) must find a balance between whether we focus on learners' exquisite sensitivity to the details of their input or their ability to generalize beyond these details. A similar split in focus can be seen in recent approaches to adult language (e.g., Fereirra et al., 2001; MacDonald, Pearlmutter, & Seidenberg, 1996; Townsend & Bever, 2001). Adults appear to be much more influenced by the specifics of the stimuli with which we present them than many researchers had previously guessed. Nevertheless, as I have already discussed, adult language systems also allow for infinite creativity. As researchers in both domains now grapple with how to reconcile our human sensitivity to the particular and the general, we may gain a better insight into human language and how it develops.

Notes

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I dedicate this article to my friend and colleague, Peter Jusczyk, who facilitated my entry into the field of infant language perception, and whose research has been foundational in explorations of early sensitivity to linguistic form.

1. Pig Latin is a language game that has several dialects. In one, the first consonant(s) of a word is moved to the end and "ay" is added. A "y" is added to the beginning of words beginning with a vowel and to the end of words ending in a vowel. Thus, "I speak Pig Latin" becomes "yiyay eakspay igpay atinlay."

2. I will use the term "phonetic categories" to mean categories of speech segments that are distinctive from each other in a particular language. For example, the /b/ in "big" is a distinct phonetic category than the /p/ in "pig." I label these categories as phonetic, as opposed to phonological, because they are confined to a specific position in a syllable and are therefore not abstract phoneme categories of the sort discussed in linguistics. That is, I am not concerned here with learners ability to group together the /p/ in "pig" with the /p/'s in "spin" or "sip".

3. Adult English-speakers perceive both endpoints as /d/.

4. 7.5-month-old boys did not show the effect, although studies currently conducted in my laboratory indicate that 9-month-old infants of both sexes prefer less frequent phoneme combinations. Zamuner (2001) used the same CVC nonwords in a production study with older learners and found that they were better able to produce final consonants from nonwords with high diphone probability than lower probability.

5. Of course it must also be established that infants who do not receive training in the new language fail to discriminate the legal vs. illegal codas.

6. It is not clear how natural the familiarization stimuli might have sounded, with coarticulated syllables mixed with syllables that were not coarticulated.

7. The stimuli used by Stager and Werker (1997) are not possible words in English. Therefore, infants in their study may have failed to fully associate them with the novel objects. However, Pater, Stager & Werker (submitted) replicated the finding that 14-month-olds could not discriminate minimal word pairs with the possible words /bɪn/ and /dɪn/.

References

Aslin, R. N. (1999, June). *Interpretation of infant listening times using the headturn preference technique.* Talk presented at the meeting of the International Society on Infant Studies, Brighton, U. K.

Aslin, R. N., Slemmer, J. A., Kirkham, N. Z., & Johnson, S. P. (2001, April). Statistical learning of visual shape sequences. Paper presented at the meeting of the Society for Research in Child Development, Minneapolis, MN.

Aslin, R. N., Saffran, J. R., & Newport, E. L. (1998). Computation of conditional probability statistics by human infants. *Psychological Science, 9*, 321–324.

Bertoncini, J., Bijeljac-Babic, R., Blumstein, S., & Mehler, J. (1987). Discrimination in neonates of very short CVs. *Journal of the Acoustical Society of America, 82*: 31–37.

Best, C. T. (1995). Learning to perceive the sound pattern of English. In Rovee-Collier, C., & Lipsitt, L. (Eds.), *Advances in infancy research*, Ablex Publishing Co., Norwood, NJ, pp. 217–304.

Braine, M. D. S. (1963). The ontogeny of English phrase structure: The first phrase. *Language, 39*: 1–13.

Braine, M. D. S. (1987). What is learned in acquiring word classes — A step toward an acquisition theory. In B. MacWhinney (Ed.), *Mechanisms of language acquisition.* Hillsdale, NJ: Erlbaum.

Bowerman, M. (1973). *Early syntactic development.* Cambridge England: Cambridge University Press.

Brent, M. & Siskind, J. (2001). The role of exposure to isolated words in early vocabulary development. *Cognition, 81:* B33-B44.

Chomsky, N. (1965). *Aspects of a theory of syntax.* Cambridge, MA: MIT Press.

Christophe, A., Dupoux, E., Bertoncini, J., & Mehler, J. (1994). Do infants perceive word boundaries? An empirical approach to the bootstrapping problem for lexical acquisition. *Journal of the Acoustical Society of America, 95*: 1570–1580.

Crain, S. (1991). Language acquisition in the absence of experience. *Behavioral & Brain Sciences, 14*, 597–650.

Dahan, D. & Brent, M. (1999). On the discovery of novel wordlike units from utterances: An artificial-language study with implications for native-language acquisition. *Journal of Experimental Psychology: General, 128*, 165–185.

DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science, 208*, 1174–1176.

DeCasper, A. J., & Spence, M. J. (1986). Prenatal maternal speech influences newborns' perception of speech sounds. *Infant Behavior & Development, 9,* 133–150.

Echols, C., Crowhurst, M., & Childers, J. (1997). The perception of rhythmic units in speech by infants and adults. *Journal of Memory and Language, 36*: 202–225.

Eimas, P. (1975). Auditory and phonetic coding of the cues for speech: Discrimination of the (r-l) distinction by young infants. *Perception & Psychophysics, 18*: 341–347.

Eimas, P., Siqueland, E., Jusczyk, P., & Vigorito, J. (1971). Speech perception in infants. *Science, 171*: 303–306.

Elman, J. (1993). Implicit learning in neural networks: The importance of starting small. *Cognition, 46, 71–99.*

Elman, J., Bates, E., Johnson, M., Karmiloff-Smith, A., D. Parisi, & Plunkett, K. (1996). *Rethinking innateness: A connectionist perspective on development.* Cambridge, MA: MIT Press.

Fernald, A. , McRoberts, G. W., & Swingley, D. (2001). Infants' developing competence in understanding & recognizing words in fluent speech. In: J. Weissenborn & B. Höhle (eds.), *Approaches to bootstrapping in early language acquisition.* Benjamins: Amsterdam.

Fernald, A., Pinto, J. P., Swingley, D., Weinberg, A. & McRoberts, G. W. (1998). Rapid gains in speed of verbal processing by infants in the second year. *Psychological Science, 9,* 228–231.

Fernald, A., Swingley, D., & Pinto, J. (2001). When half a word is enough: Infants can recognize spoken words using partial phonetic information. *Child Development Special 72*, 1003–1015.

Ferreira, F., Bailey, K., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science, 11*, 11–15.

Frigo, L. & McDonald, J. L. (1998). Properties of phonological markers that affect the acquisition of gender-like subclasses. *Journal of Memory and Language, 39,* 218–245.

Gogate, L. & Bahrick, L. (2001). Intersensory redundancy and 7-month-old infants' memory for arbitary syllable-object relations. *Infancy Special Issue, 2*, 219–231.

Gerken, L. A. (2001). Signal to syntax: Building a bridge. In J. Weissenborn and S. Powers (eds.), *Signal to Syntax II.* Berlin: John Benjamins.

Golinkoff, R., Hirsh-Pasek, K., Cauley, K. & Gordon, L. (1987). The eyes have it: Lexical and syntactic comprehension in a new paradigm. *Journal of Child Language 14*, 23–45.

Gómez, R. (in press). Variability and detection of invariant structure. *Psychological Science.*

Gómez, R. & Gerken, L. A. (1998). Determining the basis of abstraction in artificial language acquisition. International Society on Infant Studies, Atlanta, April.

Gómez, R.L., & Gerken, L. (1999). Artificial grammar learning by 1-year- olds leads to specific and abstract knowledge. *Cognition, 70*, 109–135.

Gómez, R.L. & Gerken, L.A. (2000). Infant artificial language learning and language acquisition. *Trends in Cognitive Sciences, 4*,178–186.

Gómez, R.L., Gerken, L.A. & Schvaneveldt, R. (2000). The basis of transfer in artificial grammar learning. *Memory and Cognition, 28*, 253–263.

Guenther, F.H., Gjaja, M.N. (1996). The perceptual magnet effect as an emergent property of neural map formation. *Journal of the Acoustical Society of America, 100*, 1111–1121.

Hallé, P. & de Boysson-Bardies, B. (1996). The format of representation of recognized words in infants' early receptive lexicon. *Infant Behavior and Development, 19*, 463–481.

Hauser, M.D., Newport, E.L., & Aslin, R.N. (2001). Segmentation of the speech stream in a non-human primate: Statistical learning in cotton-top tamarins. *Cognition, 78*, B53-B64.

Höhle, B. & Weissenborn, J. (2001). The origins of syntactic categorization for lexical elements: the role of determiners, *Proceedings of the International Conference GALA* Palmela, Portugal.

Höhle, B. & Weissenborn, J. (submitted). Between rhythm and the lexicon: The role of determiners in speech segmentation in one-year-old German infants.

Hohne, E. & Jusczyk, P. (1994). Two-month-old infants' sensitivity to allophonic differences. *Perception and Psychophysics, 56*: 613–623.

Houston, D., Pisoni, D., Kirk, K., Ying, E. & Miyamoto, R. (2002, April). Assessing speech perception and language abilities of deaf infants before and after cochlear implantion. Talk presented at the meeting of the International Society on Infant Studies, Toronto, Canada.

Houston, D. & Jusczyk, P. (2000). The role of talker-specific information in word segmentation by infants. *Journal of Experimental Psychology: Human Perception & Performance, 26*: 1570–1582.

Johnson, E. & Jusczyk, P. (2001). Word segmentation by 8-month-olds: When speech cues count more than statistics. *Journal of Memory & Language, 44*: 548–567.

Jusczyk, P, Houston, D., & Newsome, M. (1999). The beginnings of word segmentation in English-learning infants. *Cognitive Psychology, 39*: 159–207.

Jusczyk, P.W. & Aslin, R.N. (1995). Infants' detection of sound patterns of words in fluent speech. *Cognitive Psychology, 29*, 1–23.

Jusczyk, P.W. (1985). On characterizing the development of speech perception. In Mehler, J., Fox, R. (Eds.), *Neonate cognition: Beyond the blooming, buzzing, confusion*. Erlbaum, Hillsdale, NJ, pp.199–229.

Jusczyk, P.W., Bertoncini, J., Bijeljac-Babic, R., Kennedy, L.J., Mehler, J. (1990). The role of attention in speech perception by young infants. *Cognitive Development, 5*, 265–286.

Jusczyk, P.W., Friederici, A.D., Wessels, J.M., Svenkerud, V.Y. & Jusczyk, A.M. (1993). Infants' sensitivity to the sound patterns of native language words. *Journal of Memory and Language, 32*, 402–420.

Jusczyk, P., Luce, P., & Charles-Luce, J. (1994). Infants' sensitivity to phonotactic patterns in the native language. *Journal of Memory & Language, 33*: 630–645.

Kemler Nelson, D.G., Jusczyk, P.W., Mandel, D.R., Myers, J., Turk, A., & Gerken, L.A. (1995). The headturn preference procedure for testing auditory perception. *Infant Behavior and Development, 18*, 111–116.

Kuhl, P.K. (1993). Early linguistic experience and phonetic perception: Implications for theories of developmental speech perception. *Journal of Phonetics, 21*, 125–139.

Kuhl, P.K., Williams, K.A., Lacerda, F., Stevens, K.N., Lindblom, B., (1992). Linguistic experience alters phonetic perception in infants by 6 months of age. *Science, 255*, 606–608.

Lalonde, C.E., Werker, J.F. (1995). Cognitive influences on cross-language speech perception in infancy. *Infant Behavior and Development, 18*, 459–475.

MacDonald, M., Pearlmutter, N., & Seidenberg, M. (1994).The lexical nature of syntactic ambiguity resolution. *Psychological Review, 101*, 676–703.

MacKain, K.S. (1982). Assessing the role of experience on infants' speech discrimination. *Journal of Child Language, 9*, 527–542.

Maddieson, I. (1984). *Patterns of sounds.* Cambridge England: Cambridge University Press.

Marcus, G.F., Vijayan, S., Bandi Rao, S., & Vishton, P.M. (1999). Rule learning by seven-month-old infants. *Science, 283*, 77–80.

Maye, J. (2000). The acquisition of speech sound categories on the basis of distributional information. Unpublished Ph.D. dissertation, University of Arizona.

Maye, J. & Gerken, L.A. (2001). Learning phonemes: How far can the input take us? *Proceedings of the 21st Boston University Conference on Language Development.* Boston, MA: Cascadilla Press.

Maye, J., Werker, J. & Gerken, L.A. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition, 82*: B101-B111.

Mehler, J., Jusczyk, P.W., Lambertz, G., Halsted, G., Bertoncini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition in young infants. *Cognition, 29*, 143–178.

Mintz, T. (in press). Category induction from distributional cues in an artificial language. *Memory and Cognition.*

Moffitt, A. (1971). Consonant cue perception by twenty- to twenty-four-week-old infants. *Child Development, 42*: 717–731.

Morgan, J. & Saffran, J. (1995). Emerging integration of sequential & suprasegmental information in preverbal speech segmentation. *Child Development, 66*: 911–936.

Naigles, L. (in press). Form is easy, meaning is hard: Resolving a paradox in early child language. *Cognition.*

Newport, E. (1991). Contrasting concepts of the critical period for language. In S. Carey and R. Gelman (eds.), *The epigenesis of mind: Essays on biology and cognition.* Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 111–130.

Nygaard, L., Sommers, M., & Pisoni, D. (1994). Speech perception as a talker-contingent process. *Psychological Science, 5*: 42–46.

Pater, J., Stager, C.L., & Werker, J.F. (submitted). Additive effects of phonetic distinctions in word learning.

Pine, J.M. & Martindale, H. (1996). Syntactic categories in the speech of young children: The case of the determiner. *Journal of Child Language 23*, 369–395.

Pinker, S. (1994). *The language instinct.* New York: William Morrow.

Pinker, S. & Prince, A. (1988). On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. *Cognition Special Issue: Connectionism and symbol systems, 28*, 73–193.

Plunkett, K., Bailey, T. & Bryant, P.E. (2000, July). Phonological representation and word recognition. In P.W. Jusczyk (Chair), *Learning to recognize words in fluent speech.*

Symposium conducted at the meeting of the International Society on Infant Studies, Brighton, U.K.

Polka, L., Werker, J.F. (1994). Developmental changes in perception of nonnative vowel contrasts. *Journal of Experimental Psychology: Human Perception and Performance, 20*, 421–435.

Rumelhart, D. & McClelland, J. (1987). Learning the past tenses of English verbs: Implicit rules or parallel distributed processing? In B. MacWhinney (ed.), Mechanisms of language acquisition. Mahwah, NJ: Lawrence Erlbaum Associates (pp. 195–248).

Saffran, J. (2001). Words in a sea of sounds: The output of infant statistical learning. *Cognition, 81*: 149–169.

Saffran, J. R, Johnson, E.K., Aslin, R.N., & Newport, E.L. (1999). Statistical learning of tone sequences by human infants & adults. *Cognition, 70*: 27–52.

Saffran, J., Newport, E, & Aslin, R. (1996). Word segmentation: The role of distributional cues. *Journal of Memory & Language, 35*: 606–621. 11

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

Santelmann, L. (2002). Cross-linguistic implications of studies on infants' sensitivity to syntax. Talk presented at the meeting of the International Society on Infant Studies, Toronto, Canada.

Santelmann, L. & Jusczyk, P. (1998). Sensitivity to discontinuous dependencies in language learners: Evidence for limitations in processing space. *Cognition, 69*: 105–134.

Sebastián Gallés, N. & Bosch, L. (in press). The building of phonotactic knowledge in bilinguals: The role of early exposure. *Perception and Psychophysics.*

Selkirk, E. (1984). *Phonology and syntax.* Cambridge, MA: MIT Press.

Shady, M. (1996). "Infants' sensitivity to function morphemes". Ph.D. dissertation, State University of New York at Buffalo, Buffalo, NY.

Shady, M., Gerken, L.A., & Jusczyk, P. (1995). "Some evidence of sensitivity to prosody and word order in ten-month-olds". In D. MacLaughlin & S. McEwan (eds.*), Proceedings of the 19th Boston University Conference on Language Development.* Sommerville, MA: Cascadilla Press (pp. 553–562).

Shafer, V. Shucard, J. Shucard, D. & Gerken, L.A. (1998). An electrophysiological study of infants' sensitivity to the sound patterns of English speech. *Journal of Speech and Hearing Research, 41,* 874–886.

Stager, C.L. & Werker, J.F. (1997). Infants listen for more phonetic detail in speech perception than in word-learning tasks. *Nature, 388*, 381–382.

Swingley, D. & Aslin, R.N. (2000). Spoken word recognition and lexical representation in very young children. *Cognition, 76,* pp. 147–166.

Swingley, D. & Aslin, R.N. (2002). Lexical neighborhoods and the word-form representations of 14-month-olds. *Psychological Science.*

Tincoff, R. & Jusczyk, P. (1999). Some beginnings of word comprehension in 6-month-olds. *Psychological Science, 10*, 172–175.

Tomasello, M. (2000). Do young children have adult syntactic competence? *Cognition 74*: 209–253.

Townsend, D. & Bever, T. (2001). Sentence comprehension: The integration of habits and rules. Cambridge, MA: MIT Press.

van Ooijen, B., Bertoncini, J., Sansavini, A. & Mehler, J. (1997). Do weak syllables count for newborns? *Journal of the Acoustical Society of America, 102*: 3735–3741.

Vitevitch, M., Luce, P., Pisoni, D., & Auer, E. (1999). Phonotactics, neighborhood activation, and lexical access for spoken words. *Brain & Language Special Issue: Mental lexicon, 68*, 306–311.

Werker, J. F. & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development, 7*, 49–63.

Werker, J. F., Pegg, J. E. (1992). Infant speech perception and phonological acquisition. In Ferguson, C. A., Menn, L., Stoel-Gammon, C. (Eds.), *Phonological development: Models, research, implications.* York Press, MD, pp. 285–311.

Werker, J., Fennell, C., Corcoran, K., & Stager C. (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. *Infancy, 3*, 1–30.

Wilson, R. (2000). Category induction in second language learning: What artificial grammars can tell us. Unpublished M. A. dissertation. University of Arizona.

Wilson, R., Gerken, L. A., & Nicol, J. (2000, November). Artificial Grammar Research Extends to Natural Language: Implicit Learning of Categories. Annual Meeting of the Psychonomics Society, New Orleans, LA.

Zamuner, T. (2001). Input-based phonological acquisition. Unpublished Ph.D. dissertation. University of Arizona.