Some Issues in Infant Speech Perception: Do the Means Justify the Ends?

Raymond S. Weitzman, California State University, Fresno

A major focus of research on language acquisition in infancy involves experimental studies of the infant's ability to discriminate various kinds of speech or speech-like stimuli. This research has demonstrated that infants are sensitive to many fine-grained differences in the acoustic properties of speech utterances. Furthermore, these empirical findings have led investigators to theorize about how the infants internally process and represent speech stimuli. This paper examines one particular experimental protocol frequently used in these experiments: the Head-Turn Preference Procedure. It will be shown that this procedure is methodologically flawed and the theoretical conclusions drawn from its results are not adequately warranted.

Key words: infant speech perception, head-turn preference procedure, familiarization.

Ernst Moerk was not only a very close friend but also a colleague whose scholarship I greatly admired. Ernst's approach to investigating language acquisition was empirical and interactional, leading him to data-based conclusions. His microanalytical observations of the dynamics of child-parent interactions within and across time frames serve as models for conducting language acquisition studies. Only after he applied his methodological techniques did he look beyond them to what theories might best systematically encapsulate what he had found analytically. It was this data-driven pursuit to understand how children learn language that led him to the three-term contingency as an important principle in this process. While he did not carry out any investigations into infant speech perception, he inspired me to examine what research had been done in this area. And so I dedicate this paper to him and can only hope that it measures up to his standards.

Portions of this paper were presented at the 2005 annual meeting of the Association for Behavior Analysis in Chicago. I would like to thank Giri Hegde, David Palmer, Carolyn Rovee-Collier, Hank Schlinger, Gene Steinhauer, and Criss Wilhite for their comments on numerous versions that this paper went through. I am also grateful to Kyle Chambers for providing me with answers to specific questions I had about the experimental procedure he and his colleagues used in their research and for the individual infant data. Address correspondence to Raymond S. Weitzman, Professor Emeritus, Department of Linguistics, 5245 North Backer Ave., M/S PB92, Fresno, CA 93740-8001; e-mail: raymondw@csufresno.edu.

Research on the perceptual skills of infants with respect to speech stimuli has been proceeding at a fairly rapid pace for about 35 years now. Most of this research, as has been pointed out by Malcuit and Pomerleau (1996), has had and continues to have a cognitive orientation. Interestingly enough, this research requires behavioral techniques for carrying out its experimental investigations, but uses these results to make inferences about unobservable, and therefore unverifiable, internal mental processes and states.

A number of experimental procedures have been used in carrying out this research, including the High Amplitude Sucking Procedure for infants between birth and 3-4 months of age, the Conditioned or Operant Head-Turn Procedure for infants between 5.5 and 18 months of age, the Visual Habituation or Fixation Procedure, which has been used on infants, children, and even adults, and the Head-Turn Preference Procedure (HTPP), which has been used on infants between 4 and 18 months of age. (For details on these procedures, see Polka, Jusczyk, & Rvachew, 1995; Nelson, Jusczyk, Mandel, et al., 1995; Jusczyk, 1998).

It is this last procedure, the HTPP, that I will examine in this paper in order to point out some aspects of it that I consider to be highly problematic and which obscure functional relations between speech stimuli and the infant's behavior. Furthermore, I hope to show that results of studies using this procedure do not warrant the inferential conclusions of these studies. This will be done by describing and evaluating a study by Chambers, Onishi, and Fisher (2003),

hereafter referred to as Chambers, et al., which used the HTPP.

An aspect of infant speech perception that is being explored by researchers concerns the ability of infants to distinguish speech utterances that differ in their phonotactic patterns. Phonotactic patterns have to do with the way phonemes are arranged within a larger phonological unit, particularly the syllable. For example, the monosyllabic words "cæt," "tack," and "act" all share the same phonemes, /k/, /æ/, and /t/, but differ in the way these phonemes are arranged.

The Chambers, et al. study deals with the issue of the sensitivity of infants to such phonotactic differences among syllables. The authors present two experiments designed to determine whether infants can learn from listening practice alone a set of syllables with a certain phonotactic patterning, and to recognize that a new set of syllables has the same phonotactic patterning.

What they wanted to find out, essentially, was something like this: If you initially familiarize infants to syllables that have the canonical (generalized) form C_1VC_2 , where C_1 can only be one of a select group of consonants and C_2 is drawn from another select group of consonants, but not the same as C_1 , will infants then respond differently in a test phase to syllables with a C_2VC_1 canonical form compared to other syllables with a C_1VC_2 canonical form, but not the same as the ones with which they were familiarized?

Supposedly if they do respond differentially then it must mean that during the Familiarization Phase the infants have either internalized an abstract representation of the generic (canonical) form of the familiarized syllables or have internalized separate representations of each of the familiarized syllables. On the other hand, if the infants do not respond differentially, it suggests that infants in the age group being studied are unable to learn phonotactic differences just from listening practice.

EXPERIMENTAL MATERIALS AND PARTICIPANTS IN CHAMBERS, ET AL.

Stimuli

The speech stimuli of the study consisted of a total of 100 meaningful and nonsense CVC syllables recorded by an adult female speaker

of American English. Fifty of these syllables were structured so that the onset consonant could only be one of the five consonants /b, k, m, t, f/ followed by either the vowel /æ/ or /ɜ/, which was followed by one of five coda (final) consonants /p, g, n, tʃ, s/. Examples of such syllables in Standard English orthography are ban, kiss, fig, match, cag, and tin. The investigators designated these syllables *legal* syllables and used them as stimuli in the Familiarization Phase (see below). Another set of fifty stimulus syllables were created that were mirror images of the legal syllables, that is, the onset syllable consisted of one of the five consonants /p, g, n, tʃ, s/, followed by either the vowel /æ/ or /ɜ/, which was followed by one of the five coda consonants /b, k, m, t, f/. Examples of such syllables are nab, sick, giff, cham, gack, knit. These syllables were designated *illegal* syllables. The illegal syllables were only used in the Test Phase.

Twenty-five syllables were randomly drawn from each set, ensuring that each sublist contained as much as possible an equal number of the two vowels. Thus, a total of four sublists were created: two from the legal syllable set and two from the illegal syllable set. Infants were randomly assigned each of the four sublists.

Participants

Eight infants averaging 16.5 months of age (range: 15.8-16.9; four male, four female) from monolingual American-English-speaking homes. These infants were used in the two experiments that were carried out. Ten other infants were tested but eliminated from study because of being overly fussy or nonresponsive.

EXPERIMENTAL METHOD OF CHAMBERS, ET AL.

Experimental Setup for the HTPP

Figure 1 illustrates the typical setup for a HTPP experiment. Each infant sat on his/her mother's lap inside a dimly lit testing booth, facing the front of the booth. White curtains covered the side the infant faced, and the sides on the left and right. A green light protruded from the curtain on the side faced and red lights on the left and right sides. The parent wore a headset through which music was played. This

Figure 1. Layout of the testing booth for use in the Head-Turn Preference Procedure. (Source: Nelson, D. G. K., et al., 1995).

kept the parent from hearing what the infant heard from concealed loudspeakers beneath each side light. A video camera recorded the behavior of the infant. An experimenter, the primary coder, observed the infant on a silent monitor from outside the booth and registered the timing and direction of the head turns of an infant to a computer which controlled the presentation of stimuli.

Procedure

The HTPP consists of a Familiarization Phase followed by a Test Phase. There were two experiments reported on. The same procedure was carried out in the two experiments. In both experiments there was a brief break between the Familiarization Phase and the Test Phase in which an experimenter came into the booth and entertained the infant with a hand puppet. In Experiment 1 the break was 1 minute long and in Experiment 2 the break was 2 minutes long. Also, in the Familiarization Phase of Experiment 1 each syllable was presented six times at 1 s intervals, while in the Familiarization Phase of Experiment 2 each syllable was presented only five times. The duration of the Familiarization Phase in Experiment 1 was 3

min, 48 s, while the duration of the Familiarization Phase in Experiment 2 was 3 min, 10 s. The reason for the reduction in the number of repetitions of syllables and increase in the delay between the Familiarization Phase and Test Phase in Experiment 2 was to make the experimental conditions more similar for comparison purposes to an earlier phonotactic learning study (Onishi, Chambers, & Fisher, 2002) in which the subjects were adults.

Familiarization Phase. The Familiarization Phase began with the continuous, non-contingent and random playing of each of 25 syllables of a sublist drawn from the legal syllables at 1 s intervals. While the playing of the sublist goes on, the infant is trained to orient toward one of the flashing side lights. A trial started with the flashing of the green front light. Once the infant oriented his/her head to this light, it was turned off and one of the red side lights started flashing. The infant must turn his/her head at least 30° toward the light to meet the head-turn criterion. The light continued flashing until the infant looked away for at least 2 s. Then the front green light started flashing again, signaling the start of the next trial.

Test Phase. In the Test Phase there were 10 trials of which five trials consisted of a set of

Table 1
*Mean (SE) listening time in seconds
 by trial type for Experiments 1 and 2
 (Source: Chambers, et al.)*

Experiment 1		
<u>Syllables</u>		<u>Significance</u>
Legal	Illegal	
5.49 (0.92)	7.95 (0.86)	$t(7) = 2.65$, $p < 0.05$; Wilcoxon Z $= 2.10$, $p < 0.05$
Experiment 2		
<u>Syllables</u>		<u>Significance</u>
Legal	Illegal	
5.10 (0.97)	6.25 (0.93)	$t(7) = 2.37$; $p < 0.05$ Wilcoxon Z $= 2.10$; $p < 0.05$

five unfamiliar legal syllables and five trials of a set of five illegal syllables. In a particular trial the green light would start flashing to orient the infant toward the front. As soon as the infant did, it would be turned off and one of the red side lights would start flashing. As soon as the infant made a criterion turn, one of the sets of five unfamiliar legal syllables or five illegal syllables would start playing randomly only from the speaker on the same side as the flashing light. The trial ended when the infant turned away from the flashing side light or the five-syllable set had played three times, about 22.5 s. At the end of each trial the flashing side light would be turned off and the playing of the syllables would cease. The presentation of the trials were randomized with the constraint that the first two trials include a legal and illegal set and no more than two trials in a row of the same type.

Measurements were made of the duration of the head-turns for each trial. In Experiment 1 the reliability of the primary coder's off-line measurements of the infants' listening times was compared with those of another coder and found to be within .5 s of each other in 81% of

trials. In Experiment 2 the reliability of the two coders' times was found to be within .5 s of each other in 83% of trials. A few trials were excluded in both experiments either because the ratio of the two coders' listening time measurements was less than .6 or because an infant failed to make the criterion head-turn in that trial. However, at least four legal and four illegal trials were contributed by each infant in both experiments.

RESULTS OF CHAMBERS, ET AL.

On average the infants tended to listen longer to the novel illegal syllables than to the unfamiliar legal syllables in both experiments (see Table 1). This difference turned out to be statistically significant at the .05 level in both a t -test and a Wilcoxon Z test. On the basis of this the investigators concluded that (1) these two experiments demonstrated ("provide strong evidence") that infants can quickly learn new phonotactic restrictions through familiarization, and (2) that they responded in a similar way to new syllables that have the same canonical form, demonstrating stimulus generalization.

EVALUATION OF THE CHAMBERS, ET AL. STUDY

There are a number of specific questions about this study whose answers will reveal that the investigators' conclusions are unjustified.

1. What kind of effect were the stimuli having on the infants during the Familiarization Phase?

Many cognitivists seem to hold the view that infants acquire information about the phonetic properties of their native language by listening to adults speak (Kuhl, et al., 1997). Whether stated explicitly or implicitly, this seems to be the warrant for using familiarization as a key procedure in infant speech perception research. This may also explain why Chambers, et al. made little effort to observe the infants' behavior, other than that involved in the head-turning training, nor were any measurements made of the infants' behavior with respect to the stimuli being presented to them in order to determine what effect the stimuli might be having on them during the Familiarization Phase.

A familiar stimulus or stimulus class is one which an organism has been exposed to through past contingent interactions with the environment. Through these contingent interactions,

the familiar stimuli may have acquired some value for the organism. Among these possible values (Malcuit, Bastien, & Pomerleau, 1996) are (1) attention-getting (i.e., the stimulus has come to elicit an orienting response from the organism); (2) attention-holding (i.e., the stimulus has come to reinforce a response); (3) signaling or occasion setting (i.e., the stimulus functions discriminatively to evoke some type of behavior).

During the head-turning training in the Familiarization Phase of the Chambers, et al. study, the flashing lights functioned to elicit a head-turn orienting response, as well as perhaps to hold their attention after the head-turn (i.e., they acted as reinforcers). The infants were turning their heads toward the side lights anywhere from four to eight times during Familiarization Phase, depending on how long a flashing light held their attention each time (K. Chambers, personal communication, July 8, 2004). It is unknown, however, what effects this repeated flashing of the lights were having on the head-turning behavior of the infants, since no head-turning latency or head-turn duration measurements were taken.

The speech stimuli that the infants were exposed to in the Familiarization Phase seem to have established no eliciting, attention-holding, nor signaling value that can be discernible with respect to their behavior. At least there is no evidence that any functional relationship was established in the Familiarization Phase. Furthermore, since the stimuli were repeatedly presented, whatever response, if any, the infants were making with respect to the speech stimuli was likely to have been neutralized by repeated presentation. In other words, it is entirely plausible to view the infants as becoming habituated to the speech stimuli. No mention of this possibility is made by the investigators in their study.

2. What kind of effect were the stimuli having on the infants during the Test Phase?

Many infant speech perception studies, including the Chambers, et al. study, assume, based on previous investigations, that infants familiarized with one set of stimuli will respond differently to another set of stimuli that are topographically different from the familiarized stimuli, while they will respond similarly to another set of stimuli that bear a topographical resemblance to the familiarized set. As they sometimes put it, familiarization leads to "bi-

ases in stimulus preferences." (McMurray & Aslin, 2005).

Some investigators readily admit (McMurray & Aslin, 2005; C. Rovee-Collier, personal communication, December 21, 2004) that the bias in preference between familiarized and novel stimuli could go in either direction. That is, for example, in the case of auditory stimuli, subjects may show a greater tendency to listen longer to the novel stimuli or just the opposite and show a tendency to listen longer to the stimuli more closely resembling the familiarized stimuli! Apparently, there is no consensus among them as to the factors that might affect the direction of preference. This issue does not seem too troubling to them, as long as the infants as a group show some kind of bias with respect to the familiarized stimuli compared to the novel stimuli.

The direction of bias preference might be easily explained, however, if one takes into account the relation of the stimuli to the infant's behavior and the infant's recent history with such stimuli. In the Test Phase, unlike the Familiarization Phase, the relation of the presentation of the syllable sets to a response by an infant was very clear. It was contingent upon an infant turning his/her head toward the flashing light. Furthermore, the presentations were played only from the speaker on the same side as the light and were turned off as soon as the infant turned away. In studies presenting visual stimuli in a way analogous to the way the speech stimuli were presented in the Test Phase, but without any Familiarization Phase, it was found that visual fixation time was an index of the attention-holding effectiveness of the stimuli (Cohen, 1972 & 1976). In other words, the visual stimuli served as reinforcers for maintaining the head-turn. Thus, it is quite possible that the presentation of the syllable sets had a reinforcing effect. If the preference for the novel illegal syllables was valid, then a possible explanation for it was their greater reinforcing effect, compared to the unfamiliar legal syllables. Habituation in the Familiarization Phase could then explain why the unfamiliar legal syllables had a less reinforcing effect in the Test Phase, assuming that the infant's response habituated to the familiarized legal syllables and the habituation generalized to the unfamiliar legal syllables of the Test Phase. There are some further issues about this that will be discussed below in answer to Question 4.

3. What do the results of the Test Phase tell us?

Although the group results suggest that the infants were discriminating the legal syllables from the illegal syllables, we get a rather different picture when we look at the individual results. The mean listening time for each infant in Experiment 1 is shown in Table 2.

Table 2
Mean listening times in seconds for each infant in Experiments 1 & 2
(Source: K. Chamber, personal communication, July 8, 2004)

Experiment 1	Syllables	
	Legal	Illegal
Infant 1	8.8	9.5
Infant 2	1.8	3.3
Infant 3	8.5	7.1
Infant 4	7.6	7.8
Infant 5	3.1	6.2
Infant 6	5.5	11.0
Infant 7	5.0	9.1
Infant 8	3.6	9.6

Experiment 2	Syllables	
	Legal	Illegal
Infant 1	10.2	11.1
Infant 2	2.4	5.6
Infant 3	4.4	5.0
Infant 4	3.0	2.5
Infant 5	4.2	4.3
Infant 6	6.4	7.7
Infant 7	7.5	7.8
Infant 8	2.8	5.9

Based on these mean listening times for each infant, the ratio of the mean illegal syllable listening time to mean total listening time for each infant was calculated to get an idea of how close to chance the relative listening times were in the two experiments. If one considers the results of each infant as a replication of the experimental treatment, one can see what I think are important differences in the infant's responses. In Experiment 1 (Figure 2), the ratio of mean illegal listening time to mean total listening time seems well above chance for five infants (Infants 2, 5, 6, 7, and 8), but the ratios

for the other three infants seem close to chance. In Experiment 2 (Figure 3), where the infants were the same ones used in Experiment 1 but where the delay between the Familiarization Phase and the Test Phase was longer and the number of presentations of each syllable was one fewer, the results are even more striking. Only two infants (Infants 2 and 8) show a well above chance ratio of mean illegal listening time to mean total listening time. The other six infants have ratios much closer to chance. The problem in both experiments is that only five data points were used to calculate the means for each infant, so it is difficult to assess the significance of these ratios.

The relative contribution of each infant to the difference in listening times between the illegal syllables and the legal syllables was also calculated. The results of these calculations are perhaps even more troublesome than the illegal listening time ratios. In Experiment 1 (Figure 4) it turns out that just two of the seven infants (Infants 6 and 8) who listened longer to the illegal syllables contributed about 54% of the total difference in listening time. This raises questions as to the validity of considering the overall group results as sufficient evidence for a bias preference, given the small number of subjects.

Furthermore, in Experiment 2 (Figure 5) 66% of the total positive preference in listening time for the illegal syllables comes from just two infants (Infants 2 and 8) out of the seven that listened longer to the illegal syllables, pointing out once again a problem with considering the results for the group as a whole to be strong evidence for a bias preference.

These results strongly suggest that experimenters that rely on relatively small numbers of subjects should not base their conclusions and general inferences on the statistical significance of the average results for all infants, but should carefully examine the results on an individual subject basis.

4. Did the Test Phase demonstrate generalization of the unfamiliar legal syllables to the familiarized syllables?

From a structural point of view, the subsets of legal syllables used in the Familiarization Phase and the subsets of unfamiliar legal syllables in the Test Phase do share certain phonotactic properties: (1) their onsets can only be one of five of the same possible consonants; (2) the same two vowels form their nuclei; and

Figure 2. The ratio of mean illegal syllable listening time to mean total syllable listening time (illegal + legal) for each infant in the test phase of Experiment 1.

Figure 3. The ratio of mean illegal syllable listening time to mean total syllable listening time (illegal + legal) for each infant in the test phase of Experiment 2.

(3) their codas can only be one of five of the same possible consonants. The authors of the study seem to assume that because the unfamiliar legal syllables used in the Test Phase have the same structural form as familiarized

legal syllables, the infants will somehow generalize and categorize them together.

Being similar in structure or topography, however, isn't sufficient (nor even necessary) to declare them members of the same functional

Figure 4. Relative percentage contribution of each infant to the mean positive differences between illegal syllable listening time and legal syllable listening time in the test phase of Experiment 1.

stimulus class. The only empirical way we have to verify that both the familiarized legal syllables and the unfamiliar legal syllables constitute a single functional stimulus class is if we experimentally determine that they have a common effect on behavior. But since we have no clear idea what relationship was established between the familiarized legal syllables and the infants' behavior during the Familiarization Phase, we have no way of knowing whether they constituted a functional stimulus class or were established as such in the Familiarization Phase. Furthermore, we do not know whether the unfamiliar legal syllables used in the Test Phase were treated by the infants as members of the same stimulus class.

All we know based on the individual infants' listening time means in the Test Phase is that some of the infants showed a tendency to listen longer to the illegal syllables, suggesting that the illegal syllables may have been more effective reinforcers (attention holders) than the

unfamiliar legal syllables for them. Since there is no evidence that the illegal syllables are intrinsically more reinforcing or attention holding than the unfamiliar legal syllables, one might argue that this in itself suggests that the infants treated them as belonging to the same stimulus class as the familiarized legal syllables. But this still doesn't explain why the unfamiliar legal syllables were listened to less in some cases by the infants. Of course, a plausible explanation for some of the infants listening less to the unfamiliar legal syllables is that these infants did become habituated to the familiarized legal syllables and that the lower listening times of the unfamiliar legal syllables in the Test Phase is a reflection of the fact that the infants treated them as members of the same stimulus class. Unfortunately, there is no direct evidence that such was the case.

If some of the familiarized legal syllables had also been used in the Test Phase, where measurements were taken, we would have then

Figure 5. Relative percentage contribution of each infant to the mean positive differences between illegal syllable listening time and legal syllable listening time in the test phase of Experiment 2.

been able to compare the listening times for them to the listening times for the unfamiliar legal syllables, and of course, to the listening times of the novel illegal syllables. If the listening times for the familiarized and unfamiliar legal syllables had been found to be closer to each other than the listening times of the novel illegal syllables, we would then have had at least some evidence for including them in the same stimulus class. But without this evidence we are only guessing.

5. Did this study demonstrate that infants “learned the phonotactic regularities implicit in the familiarized syllables”?

This question relates to the issue of the stimulus properties that distinguish the legal syllables from the illegal syllables. The authors seem to assume that an infant during the Familiarization Phase is in some way processing the “information-content” of the stimuli and internalizing some kind of representation of the stimuli’s phonological structure. Whether such

an internal representation was established during the Familiarization Phase cannot be directly demonstrated by any known methods, it can only be inferred by how the infants respond to the stimuli.

But do the results of the two experiments really warrant such an inference? To warrant the statement that infants were sensitive to the stimulus properties of the syllables, it must be demonstrated (1) that the familiarized syllables constituted a functional stimulus class, (2) that the unfamiliar legal syllables also belong to the same class, and (3) that the novel illegal syllables belong to another stimulus class, which is differentially discriminated by the infants. As I have pointed out earlier, none of these relationships have been strongly demonstrated in this study.

Furthermore, while demonstration of these relationships would be necessary, they are still not sufficient. The problem is that the legal and illegal syllable sets differ in both their onsets

and codas. The question that arises then is whether both differences are salient for the infants or only one. If only one, which one? The onset or the coda? Some early studies (Shibamoto & Olmsted, 1978; Shvachkin, 1973) have suggested that infants may attend more to the onsets of syllables. In other words, the salience of the difference in initial consonants may have been greater for the infants than the salience of the final consonants.

For it to be confirmed that infants have learned to distinguish the onset and coda differences in the canonical patterns C_1VC_2 and C_2VC_1 , it must be also demonstrated that they can at least distinguish C_1VC_1 from C_1VC_2 and C_2VC_1 from C_2VC_2 . There is no evidence to support this in the Chambers, et al. study, especially since we have no clear idea just what the relationship was between the syllable sets and the infants' behavior.

CONCLUSION

Ultimately, when one talks about learning as far as language is concerned, it is usually not in terms of brief auditory experience with speech utterances as claimed by Chambers, et al., but over a fairly long period of time from myriads of interactions between members of the speech community and the child. I don't think learning phonotactic regularities are any exception to this. The infants in this study had already had an average of 16.5 months of learning to respond to speech stimuli. Of course, just what role this experience may have played in the experiments discussed here is totally unknown, as it usually is in such experiments.

It is more than likely that any differential listening effects that occurred among the individual infants during the Test Phase can be attributed to the difference in the reinforcing (attention holding) effectiveness between the novel illegal syllables and the unfamiliar legal syllables. And that difference can possibly be explained in terms of habituation-novelty effects, assuming the unfamiliar legal syllables were generalized to the (likely) habituated familiarized legal syllables. But since recovery from habituation can occur quickly, either spontaneously after a short period of time or to the original habituated stimulus following the presentation of a novel stimulus (dishabituation), whatever was learned in the Familiarization Phase was unlearned in a rela-

tively short time. In other words, there is no evidence that familiarization as carried out in these kinds of experiments is likely to lead to any long-term learning.

As Skinner (1989) has pointed out, the environment not only shapes and maintains behavior but also functions to occasion it as well. Looked at in this light, adult speech perception rests on a past history of years of shaping, maintenance, and stimulus control by the language community that begins at least from the moment of a child's birth. Linguistic units such as phonemes, syllables, and their phonotactic arrangements are probably best interpreted as discriminative stimuli in operant relationships. Schlinger (1995) suggested that in behavioral terms a phoneme is the smallest unit that exerts stimulus control over behavior. Other phonological units like syllables, as well as the phonotactic patterning of these units, can also be considered as units that exert stimulus control. However, in the Head-Turn Preference Procedure the speech stimuli are at best only functioning as attention holders (i.e., reinforcers) and never as discriminative stimuli. Thus it is questionable that this procedure is particularly useful in understanding the development of infant speech perception.

It has been suggested to me by C. Rovee-Collier (personal communication, December 21, 2004) that investigators that use the familiarization procedure intend only to demonstrate that infants can detect the difference between two stimuli and not to demonstrate stimulus control. If that is the case, then it seems to me that using this procedure is entirely inappropriate for investigating how infants learn categorical distinctions or phonotactic regularities.

Cognitivists look at adult and infant speech perception as a product of covert mental structures (representations) and covert inferential learning or memory processes, some of which are said to be built-in or innate. Experimental studies only seem to serve the purpose of occasioning the generation of confirmatory/disconfirmatory tests for theories about the structure of the mind, rather than establishing relations between environmental variables and speech behavior. Because of these predilections, many researchers have become unmindful of the kinds of functional relationships between stimuli and behavior that may be established in such experiments, unfortunately, to the detriment of research on infant speech perception.

REFERENCES

- Chambers, K. E., Onishi, K. H., & Fisher, C. (2003). Infants learn phonotactic regularities from brief auditory experience. *Cognition*, 87, B69–B77.
- Cohen, L. B. (1972). Attention-getting and attention-holding processing of infant visual preferences. *Child Development*, 43, 869–879.
- Cohen, L. B. (1976). Habituation of infant visual attention. In T. J. Tighe & R. N. Leaton (Eds.), *Habituation: Perspectives from child development, animal behavior, and neurophysiology* (pp. 207–238). New York: Lawrence Erlbaum Associates, Publishers.
- Jusczyk, P. W. (1998). *The Discovery of Language*. Cambridge: The MIT Press.
- Kuhl, P. K., Andruski, J. E., Chistovich, I. A., Kozhevnikova, E. V., Ryskina, V., Stolyarova, E. I., Sundberg, U., & Lacerda, F. (1997). Cross-language analysis of phonetic units in language addressed to infants, *Science*, 277, 684–686.
- Malcuit, G., Bastien, C., & Pomerleau, A. (1996). Habituation of the orienting response to stimuli of different functional values in 4-month-old infants. *Journal of Experimental Child Psychology*, 62, 271–291.
- Malcuit, G., & Pomerleau, A. (1996). Operant learning and habituation in infants. In S. W. Bijou and E. Ribes (Eds.), *New directions in behavior development* (pp. 47–72). Reno, NV: Context Press.
- McMurray, B., & Aslin, R. N. (2005). Infants are sensitive to within-category variation in speech perception. *Cognition*, 95, B15–B26.
- Nelson, D. G. K., Jusczyk, P., Mandel, D. R., Myers, J., Turk, A., & Gerken, L. (1995). The head-turn preference procedure for testing auditory perception, *Infant Behavior and Development*, 18, 111–116.
- Onishi, K. H., Chambers, K. E., & Fisher, C. (2002). Learning phonotactic constraints from brief auditory experience. *Cognition*, 83, B13–B23.
- Polka, L., P.W. Jusczyk, & S. Rvachew (1995). Methods for studying speech perception in infants and children. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 49–89). Timonium, MD: York Press.
- Schlenger, H. D. (1995). *A behavior analytic view of child development*. New York: Plenum Press.
- Shibamoto, J. S. & Olmsted, D. L. (1978). Lexical and syllabic patterns in phonological acquisition. *Journal of Child Language*, 5, 417–456.
- Shvachkin, N. K. H. (1973). The development of phonemic speech perception in early childhood. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development* (pp. 91–127). New York: Holt, Rinehart & Winston.
- Skinner, B. F. (1989). The listener. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 85–96). Reno, NV: Context Press.