Preliminary results from cross-language perception studies in early infancy

Dahl, Sofie

journal: Proceedings of Fonetik, TMH-QPSR
volume: 44
number: 1
year: 2002
pages: 037-040

http://www.speech.kth.se/qpsr
“Language Learning and Brain Plasticity”: project overview

Francisco Lacerda and Sofie Dahl
Stockholm University, Dept. of Linguistics

Abstract
This paper presents a general overview of the procedural aspects of speech perception studies conducted at the Department of Linguistics, Stockholm University, as part of the Swedish contribution to the international Human Frontiers project, “Language Learning and Brain Plasticity” (Kuhl et al., Seattle, Washington). The project’s goal is to assess changes in young infants’ representations of a native and a non-native speech contrasts. Behavioral and neurological data are being collected from infants living in monolingual and bilingual homes in the US, Sweden, Finland and Japan. The specific findings of this project cannot be reported at this time since there are still being processed and will be subsequently be compiled in a joint publication submitted by all the involved research teams.

Introduction
To become a competent speaker of an ambient language is necessary to develop the ability to discriminate between speech sounds that are used distinctively in the language, while treating as linguistically equivalent sounds that may in fact be acoustically different. This ability, as far as vowel sounds are concerned, is developed already by the end of the first six-months of life (Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992) whereas for consonants it seems to develop sometime during the second half of the first year of life (Polka & Werker, 1994). In general, infants tend to discriminate foreign contrasts at an early age, but their response to non-native contrasts diminishes greatly as they grow older, suggesting that there may be a shift in their focus of attention from a language-general to a language-specific perspective, during the first year of life.

Another way of expressing this type of shift in the young infant’s focus of attention is to view it as process of reorganization of the infant’s perceptual space, i.e., the acoustic to phonological mapping of the vowel space evolves during the infant’s first year of life. Areas of the acoustic space that were initially separated on purely auditory terms may start being treated as linguistically equivalent if the ambient language treats that acoustic variation as a linguistically irrelevant (allophonic). The impact of such reorganizations on the overall structure of the vowel space may, in principle, be appreciable. For instance, how does the discovery of a new linguistic contrast affect a previously established phonological organization? In particular, how is the acoustic-phonological mapping of a bilingual child affected by the simultaneous exposure to two languages?

The current project attempts to address this issue by studying the evolution of the ability to discriminate native and non-native speech contrasts, in two matched groups of infants being raised in mono- and bilingual homes.

The discrimination experiments were carried out using behavioral (head-turn technique) and electroencephalographic responses (Evoked Response Potentials). Although these techniques cannot be used simultaneously, it is assumed that they tap on two intimately related aspects of the infant’s speech processing capabilities since reliable behavioral discrimination performance requires an underlying neuronal flagging of differences in the representations of the input stimuli, as measured by the MMN (mismatch negativity) (Naatanen, 2001). It is thus expected that infants producing consistent head-turn responses also show reliably MMN responses for that contrast, although the reverse is not necessary true.
In line with this, the current project was designed to take a combined behavioral and electrophysiological approach to the reorganization of the infant’s perceptual space induced by the very exposure to the ambient language. Moreover, by studying matched groups of infants being raised in both monolingual and bilingual environments, the data may provide important insight on how the perceptual organization of the infant’s vowel space may be affected by competing linguistic information. The basic notion is that language exposure will tend to shift the infant’s attention focus from language-general contrasts to its ambient language’s specific contrasts. In this vein, the bilingual infant will be faced with two phonological systems competing for the attention focus. Thus, testing subjects having an ambient language common to both the monolingual and the bilingual group, it will be possible to investigate how the a contrast from this common language is affected by simultaneous exposure to another language.

Method

Subjects
The subjects for this project were selected from the Swedish population database, managed by the Swedish Board of Statistics. Using the services from the Board of Statistics was an important step in order to guarantee a random sample of subjects. Even more important was the possibility of targeting subjects from potentially bilingual environments by selecting parents with specific combinations of nationalities, the closest it was possible to come to a selection criterion based on true linguistic data. Parents fulfilling the nationality criteria and whose infants would be 6-8 months old at the time planned for the experiments received a letter from Stockholm University with an invitation to participate in the project. The procedures were explained and the parents were encouraged to enroll in the project by phoning to a specific number at Stockholm University or returning a filled form in a postage-free envelope that was sent with the letter.

The Swedish monolingual sample was easily selected from the database. In contrast, meeting the bilingual proved to be a difficult task. The criterion for “other language” for the bilingual subjects was a language that included the Swedish monolingual phonemic contrast plus another phonemic contrast that did not exist in Swedish. When only a language was selected, there were simply not enough subjects in the Stockholm area meeting the age and the bilingual environment. For this reason the bilingual criterion had to be relaxed to select subjects exposed to Swedish and as Croatian, Persian, French, Portuguese or Czech as “other” language.

Thirty-two monolingual and ten bilingual infants (six Persian-Swedish and four French-Swedish), 6-8 months old, participated in the first run of the experiments. Four months later, all the subjects were retested but complete data could only be obtained for sixteen of the monolinguals and seven of the bilinguals (four Persian and three French). Two additional subjects from the monolingual group and one from the bilingual (French-Swedish) had to be excluded because they could not participate in the ERP part of the data collection.

Stimuli
The stimuli were synthetic utterances produced with the HLSyn software. Because these stimuli are also used in the MMN procedure, the durations of the syllables in each contrast pair was strictly matched. The overall duration of the syllables as well as the duration of their respective consonantal and vowel portions was the same. The timing of the consonant-to-vowel transitions was also the same for the two elements of each contrast pair.

The infants were tested on two speech contrasts:
1) /pa/ versus /ta/ as the “native-language” contrast common to all the languages used in the study
2) /fa/ versus /ga/ as the native contrast only for the bilingual infants (Persian-Swedish, French-Swedish, Czech-Swedish, etc).

The testing order was counterbalanced at 6-8 months, with the same order at 10-12 months.

Procedure
The behavioral data on the infants’ discrimination ability was collected using the same Head-Turn procedure that had been used in earlier studies (e.g., Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). The procedure explores the infants’ interest for animated toys (reinforcers) that are displayed in show-boxes contingent with certain changes in the stimuli.
being played. The infant sits on the caregiver’s lap in front of a table on which an assistant displays toys to keep the infant looking forward. Both the parent and the assistant wear tight sealing headphones through which music is played so that they do not hear the stimuli that are being presented to the infant. In the background, a loudspeaker connected to the computer controlling the testing procedure, repeatedly plays, with a 2 s interval, one of the syllables from the contrast to be tested. This syllable functions as a reference against which the infant’s ability to discriminate the contrast will be tested.

When the infant’s gaze is focused on the toys being manipulated on the table, the assistant requires an observation trial by pushing a stepping on a switch hidden under the table. Outside the testing booth, an observer who watches the infant via a TV-monitor gets a message on the computer screen showing that an observation trial has been requested. The observer stands by to judge the infant’s response. An observation interval is then initiated. If the observation is a “test-trial” the background stimulus is replaced by the deviant, if it is a “control-trial”, the computer goes on playing the background stimulus during the observation interval.

The infants were tested on at least four consecutive sessions, two for the “native” contrast and two for the “bilingual” contrast. In case the infants did not condition in the first session, an additional conditioning session was provided. The order of the presentation of the contrasts was randomized and balanced across subjects to minimize the influence of systematic error factors. The first session for each contrast was a conditioning session during which the infant was familiarized with the stimuli to be used in the test proper.

The aim of the conditioning phase was to get the infant to discover the “hidden rules” of the procedure. In the beginning of the session all the observation intervals contain the deviant stimulus played with a 4 dB intensity cue relative to the level of the background stimulus and the experimenter outside the booth reinforces are always activated. The observer starts the reinforcers, which remain lit up throughout the presentation of the deviant stimulus. The infant typically looks towards the activated reinforcers. After a few forced presentations of the reinforcers in conjunction with the change in the stimuli, the infant tends to discover the contingency and anticipates the activation of the reinforcers when there is a change in the background stimulus. At this point, the observer does not start the reinforcers until the infant produces a head-turn towards them, in response to the presentation of the deviant stimulus. After two consecutive head-turns the intensity cue is removed and three more consecutive correct responses without the intensity cue are required to complete the conditioning phase. To provide the infant with ample exposure to the stimuli, the conditioning phase was continued until about 30 trials had been run.

In the next session, the infants who passed the criterion went on to the test phase. This phase was initiated with a “Refresh phase” essentially intended to remind the infant of the test procedure. Directly thereafter, the test phase was initiated. The procedure in this phase is similar to that of the conditioning phase, except that the observation trails consisted of 50% test-trials and 50% control-trials. The reinforcers were only activated when the infant produced positive correct discriminations (hits). In all the other cases (false-alarms, misses or correct-rejections) the reinforcers were not activated.

After the behavioral tests, ERP data was collected for the same stimuli pairs.

Acknowledgements

Project supported by Human Frontier Science Program Organization, European Union, grant RG0158/1999.

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