Assessing Speech Perception Skills in Pediatric Cochlear Implant Users via the Split-Screen Preferential Looking Procedure

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7th International Cochlear Implant Conference, Manchester, England (September, 2002)

OBJECTIVE

Current regulation in the United States specifies that prior to a child receiving a cochlear implant, one must demonstrate that the candidate meets audiometric criteria and that little or no benefit is received from hearing aids. However, the current protocols available to assess such "benefit" in infants are limited. The primary objective of the current research was to evaluate the Split-Screen Preferential Looking Procedure (SPLP; Hollich, Hirsh-Pasek, & Golinkoff, 2001) as a viable means to assess the speech perception skills of hearing-impaired infants during their pre-implant hearing-aid trials and their post-implant experience.

The SPLP was validated using stimuli modeled after those items used in Patterson and Werker (1999; 2002). These particular stimuli were used to assess the intermodal perception skills of infants with a variety of hearing levels. More specifically, we were interested in determining the point in development at which infants who use hearing aids and/or cochlear implants are able to successfully match phonetic information from the lips and voice. Individuals' preliminary results from this on-going study are presented within.

METHOD

Participants

A total of 15 infants (10 males, 5 females) participated in this study. Six children had normal hearing and 9 children were deaf and became cochlear-implant users over the course of the study. Repeated measures were gathered on each child, thus the children were tested at various ages. Normal-hearing infants' were assessed between 3- and 5-months-old and cochlear-implant users were assessed at least once preceding cochlear implantation and succeeding stimulation (ages ranged from 5 to 24 months). All infants' cognitive abilities were "within the normal limits" in accordance with the *Bayley Scale of Infant Development-II*'s "Mental" subscale (Bayley, 1993). Infants had no known visual abnormalities.

Split-screen Preferential Looking Procedure

SPLP is designed to determine if infants show a consistent preference for a video event that is related to an acoustic stimulus. The index of preference is the difference in the length of the infant's looking time to the two different kinds of visual stimuli over the test-trial series. The resulting data are utilized to make inferences about various aspects of infants' speech perception and language development.

Stimuli

Video stimuli. A female model was filmed articulating /a/ and then /i/. The final edited stimuli yielded two videos in which the model's articulations were matched in duration.

Audio stimuli. A second female, native speaker of American English recorded the audio stimuli. The final audio stimuli set consisted of 3 articulations of /a/ and 3 articulations of /i/ spoken in infant-directed speech.

Bimodal stimuli. *Cinestream 3.1* software was used to ultimately combine the video tracks to form two, 27-s-long loops of 9 articulations. These videos were then synchronized and combined with each of the audio tracks. Finally, the /a/ and /i/ video loops were edited onto one screen, enabling a simultaneous, side-by-side display of the video loops (Figure 1).

Figure 1. *SPLP video stimuli for the present experiment.*

Apparatus. The set-up for the SPLP was housed in a double-walled soundbooth. A 52" television monitor was located in the front of the booth and a video camera was mounted above the monitor. On each trial, the orientation of the infant's eyes was recorded via this video camera. The booth was lined with curtains, thus only the monitor-screen and the video camera's lens were visible (see Figure 2).

Procedure. The infant was seated on the caregiver's lap in front of the montior; the experimenter was seated outside of the booth. The caregiver wore a pair of glasses with opaque lens. All trials began with a flashing, red square in the middle of the monitor to capture the infant's attention. Experimental sessions consisted of a *Familiarization Phase* and a *Test Phase*.

The *Familiarization Phase* consisted of silent trials in which the infant was introduced to the video images and their respective locations. The *Test Phase* consisted of the same video images presented in the *Familiarization Phase*, however the infant was now presented with speech stimuli played over the television's central loudspeakers and the two video images were presented simultaneously. The stimuli for each trial continued to played until its completion. Sound presented, left-right positioning of the two videos, and order of familiarization were counterbalanced.

Coding

Coding was performed in accordance with Hollich's (2001) coding-method for the SPLP. Using the video footage recorded of each infant during his or her test session, *cinestream 3.1* was utilized to conduct a frame-by-frame analysis of each infant's gaze direction and duration. Gaze duration was summed for each video image (i.e., the /a/ articulation and the /i/ articulation) and averaged across stimulus conditions. This yielded the mean total looking time (in seconds) for each image during the *Test Phase*.

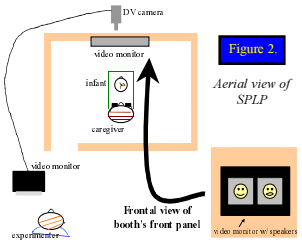

Figure 2. *Aerial view of SPLP*

RESULTS

Viability of the SPLP

A total of 36 experimental sessions have been conducted to date. Eighty-nine percent of the sessions were successfully completed and provided employable data. Given that the attrition rate for similar experiments conducted with normal-hearing infants is typically 20% (Jusczyk,1997), the present results suggest that the SPLP is a viable experimental method to implement with pediatric, hearing-aid and cochlear-implant users.

Bimodal Perception

In the present experiment a proper matching of the auditory and visual stimuli was assumed if the infant spent significantly more time looking at the woman articulating the same vowel sound presented via a loudspeaker. Preliminary data from a normal-hearing participant and a cochlear-implant user are presented below.

Figure 3. *Data from a normal-hearing participant.*

Figure 3 displays data from a normal-hearing participant aged 4.5 months. In concurrence with the previous literature exploring bimodal perception (Patterson & Werker, 1999) this participant looked significantly longer at the target, matching face [t (7) = 2.56, $p < .05$], thus further supporting the robust phenomenon that 4.5-month-old infants can accurately match phonetic information in the lips and voice.

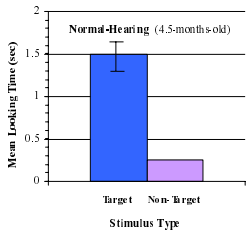

Figure 4. *Longitudinal data from a deaf participant.*

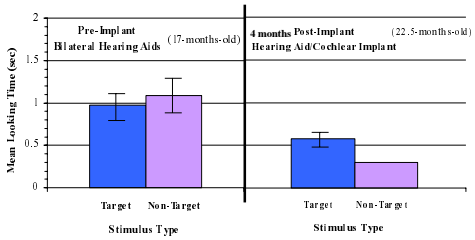

Figure 4 displays longitudinal data from a child who ultimately received a cochlear implant. The first graph in this figure shows data from her pre-operative, bilateral hearing-aid trial test session. There was no significant difference in looking times during the pre-operative test session [t (7) = -.15, $p > .05$], suggesting that the 17-month-old, bilateral hearing-aid user was not able to accurately match phonetic information in the lips and voice. The second graph in this figure shows data from her 4-month, post-implant test session (note that this participant wore a hearing aid in her opposite ear). The participant showed a nonsignificant trend [t (7) = 1.10, $p > .05$] of looking longer at the target, matching face during this post-implant test session.

CONCLUSIONS

Viability of the SPLP

The primary objective of the present study was met. The low attrition rate documented to date provides evidence that the SPLP is a capable paradigm, specifically in regards to assessing the speech perception skills of both hearing-aid and cochlear-implant users. These results give promise that such research may ultimately contribute to the development of an empirically valid, clinical protocol that can be used to assess the auditory benefit gained by children with hearing impairment.

Bimodal Perception

The preliminary results from the bimodal perception experiment are promising. The data presented here from a normal-hearing infant corroborate previous results in the field. When simultaneously presented with videos of a woman articulating /a/ and a woman articulating /i/, the participant looked significantly longer at the face that corresponded with the vowel sound he heard via a loudspeaker, thus suggesting that speech is represented intermodally in normal-hearing infants as young as 4.5-months-old.

The present exploratory data from the cochlear-implant user are equivocal. During her pre-operative bimodal test session she had 7 months of bilateral, hearing-aid experience. However, despite her ideal hearing aid fit, when the child was presented with the simultaneous video images she did not look significantly longer at the matching face that corresponded with the vowel sound presented over the loudspeaker. These results contradict the data gathered on normal-hearing infants. During her post-operative bimodal test session the participant had 4 months of cochlear-implant experience and she continued to wear a hearing aid in her opposite ear. Her mean looking times, again, did not differ significantly during this test session. Nonetheless, when this data is compared to that of the normal-hearing participant a trend is noted.

There are a number of factors that could be affecting these differences in performance across individuals and test sessions:

1) *More participants are needed.* There is no documentation that indicates SPLP is capable of evaluating individual differences across participants. Thus before conclusions can be drawn regarding the bimodal perception skills of hearing-aid and/or cochlear-implant users, the remaining data from all of the participants needs to be analyzed.

2) *Complete, longitudinal data sets are needed.* Speech perception phenomena, to date, have been evaluated using cross-sectional designs and these data have been combined to form a "complete" picture of cognitive development. This lack of longitudinal data in normal-hearing infants makes it unclear as to how infants continue to perform on these experimental tasks after there is evidence of reaching particular performance levels. Collection of longitudinal data (for both normal-hearing infants and cochlear-implant users) will ultimately reveal the shape of the function. If the function is not linear (as it is often assumed to be), but rather an inverted U-shaped function, we may actually be missing the developmental zenith of performance in the older participants (e.g., the cochlear-implant users).

3) *There are differences in the children's auditory systems.* The auditory input provided to infants via a cochlear implant is not the same auditory input provided to infants via a normally hearing auditory system. Furthermore the auditory input provided via a cochlear implant may be less than optimal, given the challenges associated with creating an ideal MAP for an infant or toddler.

4) *The cochlear-implant user's auditory experience via her hearing aids was different from her auditory experience via her cochlear implant and hearing aid.* This difference in performance across her test sessions may be a result of her cochlear implantation. Specifically, the 4 months of auditory experienc provided to this 22.5-month-old via her cochlear implant may have improved her levels of audibility. These improved levels of audibility subsequently may have contributed to her ability to begin to match phonetic information in the lips and voice.

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Acknowledgements

This work was supported in part by research grant 2 P50 DC00242 from the National Institutes on Deafness and Other Communication Disorders, National Institutes of Health; grant RR00059 from the General Clinical Research Centers Program, NCRR, National Institutes of Health; and the Iowa Lions Sight and Hearing Foundation.
Special thanks to Linda Spencer, Sandie Bass-Ringdahl, Courtney Burke, Michelle Hughes, and the infants and their families who volunteered their time for these studies.

Additional Information...

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