SPEECH PRODUCTION CHARACTERISTICS OF CHILDREN FOLLOWING TRAUMATIC BRAIN INJURY

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ABSTRACT

The purpose of the present investigation was to provide a comprehensive analysis of the speech production abilities of nine children with severe traumatic brain injury. Results revealed comparable phonemic-level skills in normal subjects and subjects who had suffered severe TBI approximately 13 months earlier. However, precision of articulation and suprasegmental aspects of speech production remained compromised in the majority of these TBI subjects.

INTRODUCTION

Despite considerable interest in the sequelae of pediatric brain injury, little information exists concerning these children's speech production skills. In previous investigations, few children have received comprehensive speech evaluations, and information on these children's speech production abilities, if mentioned at all, has been reported in general and anecdotal form. In addition, there are few published accounts of the changes in speech abilities during the recovery process.

The anecdotal reports that have appeared in recent years do suggest the presence of speech production deficits following TBI. One of the most commonly mentioned deficits is decreased speech intelligibility, generally presumed to result from motor planning and motor speech problems including dysarthria and apraxia of speech [1]. Prosodic and voice deficits also have been reported, with abnormalities in verbal fluency, speech rate, word and sentence stress, loudness, pitch and resonance among those mentioned [2].

Campbell & Dollaghan [3] examined the expressive language and speech skills of children and adolescents with TBI in a more comprehensive fashion than previous studies. Using developmentally appropriate measures of speech and language functioning in reasonably naturalistic tasks, language samples were obtained from these survivors seven times during a one-year period following the injury. The first sampling session occurred after the children and adolescents were discharged to a rehabilitation hospital and showed some evidence of intentional communication. The final session occurred 13 months later. Each brain-injured subject was age-matched with a normally developing non-injured child whose speech and language were sampled on the same schedule and with the same procedures. All of the children with TBI received less than 38 hours of speech and language treatment over the year following their injury.

The subjects in the Campbell & Dollaghan [3] investigation were nine children and adolescents ranging in age from 5:8 to 16:2 (years:months) at the time of injury. Four of the subjects were male and five were female. Each subject had English as a first language, and none had received speech, language, or psychological treatment prior to injury. In addition, all subjects had been functioning in normal classrooms prior to injury. Eight of the brain-injured subjects sustained closed head injuries from motor vehicle accidents, and the remaining child experienced an open head injury. All subjects were judged to be severely head-injured, meaning that they were unconscious for a minimum of 72 hours and received Glasgow Coma Scores of less than 11 (on a 15-point scale) for this time interval.

In Campbell and Dollaghan's initial report [3], data were presented on seven global measures of expressive speech and language output (including total number of utterances, total number of words, mean length of utterance in morphemes, percentage of complex utterances, percentage of utterances with mazes, and percentage of consonants correct). Not surprisingly, significant differences were found between the head-injured and non-injured groups on every one of the seven indices at the first sampling session, which occurred approximately one month post-injury. However, by the final sampling session, from 13-17 months post-injury, the groups differed on only one of these measures, with the brain-injured children producing significantly fewer utterances than their matched controls.

Results also showed changes in these subjects' speech production abilities over this 13-month period. There was a significant difference in the mean Percentage of Consonants Correct (PCC) [4] for the brain-injured (87%) and normal (98%) groups at the first sampling session. By the final session, there was no significant difference in the mean performance of TBI (95%) and normal (98%) groups. The PCCs of the individual normal subjects were quite stable across the sampling sessions, with performance generally above 90% correct. For the individual brain-injured subjects, there were measurable increases in PCC across the sampling sessions, with 7 of the 9 subjects producing at least 95% of their consonants correct at the final session. This result was somewhat surprising given the severity of these subjects' head injuries and suggests that their ability to correctly produce consonant phonemes in naturalistic conversation was reasonably close to that of their normal controls by 13-17 months following injury.

To further examine whether all brain-injured subjects actually reached the level of consonant articulation accuracy of their matched control subjects during the 13-month sampling period, a "normal performance quotient"[5] was calculated for each subject pair. The normal performance quotient was computed by dividing each brain-injured subject's PCC by the PCC of his or her matched control subject. A quotient of 1.0 would indicate that performance was equal to that of the uninjured subject. Results showed that six TBI subjects had performance quotients of 1.0 by the final session; all TBI subjects had performance quotients of at least .8 by sampling session 5, approximately three months post injury.

Based on these PCC results, it is tempting to conclude that the speech production deficits of most of these TBI children had resolved approximately one year after injury. However, PCC is a general index of consonant production and does not capture differences in articulatory precision or prosodic aspects of speech production. Clinical experience with these subjects suggested the need to examine articulation in more detail, as well as to consider other components of their speech production systems. Therefore, the purpose of the present investigation was to provide a more comprehensive analysis of the speech production abilities of these nine children with TBI and their age-matched normal control subjects approximately 1 year post injury.

METHODS

Subjects

The subjects for this investigation were the same 9 children with TBI and their age-matched normal control subjects described previously [3].

Speech Samples

A 12-minute conversational speech sample was obtained from each subject. For the subjects with TBI, the conversational samples were obtained from 13-17 months post injury. The conversational sample was the data set for the phonemic, phonetic, and

voice-prosody analyses. As described below, the subject's on-line narration of a 108-second video cartoon [6] was the corpus used for perceptual ratings of speech clarity and speaking rate.

Phonetic Transcription

The first 225 non-questionable words produced by each subject were transcribed phonetically into a microcomputer for analysis with the computer software programs entitled *Programs to Examine Phonetic and Phonological Evaluation Records (PEPPER)* [7]. Point-by-point agreement for phonemic transcription was above 90%.

Speech Analyses

To document the segmental and non-segmental characteristics of these subject's speech, a series of analyses were performed on the conversational samples. Segmental analyses included classification of phonemic and phonetic error types. Non-segmental analyses included ratings of prosodic and voice characteristics (e.g., phrasing, rate, word and sentence stress, loudness, pitch and vocal quality) using the Prosody-Voice Screening Profile [8] [9].

Finally, independent subjective ratings of speech clarity and speaking rate were obtained from naive listeners. This was accomplished by asking naive listeners to rate the 108-second video narration samples using direct magnitude estimation procedures [10]. Briefly, on two different occasions listeners judged a set of randomly ordered samples from brain-injured and control subjects with respect to speech clarity and speaking rate.

RESULTS

Results revealed comparable phonemic-level skills in normal subjects and subjects who had suffered TBI from 13-17 months earlier. As mentioned previously, the mean PCC value for the group with TBI was 93% while the mean PCC value for the normal group was 95%. Nearly all subjects with TBI produced more than 90% of consonants correctly, with only 1 subject's PCC falling below 85% correct. For the subjects with TBI, deletions of word-final consonants (typically fricatives and affricates) were the most common phonemic-level error; substitutions were noted in only two of the nine subjects. As indicated in Table 1, only one subject, whose PCC was 82%, was considered to have a phonemic-level deficit.

Phonetic-level errors were much more common and occurred in eight of the nine subjects with TBI. Inappropriate nasalization and lateralization of sibilants [s, z, ʃ] were common, and weak articulation and devoicing errors were also observed in approximately half of these subjects.

Table 1. Number and percentage of children with TBI displaying deficits in each component of speech production.

Speech Component	Number and % of Children Involved
Phonemic	1/9 (11%)
Phonetic	8/9 (89%)
Prosody-Voice	8/9 (89%)
Speech Clarity	5/9 (56%)
Speaking Rate	5/9 (56%)

Clinically significant deficits on the Prosody-Voice Screening Profile were found in all subjects but one at the final sampling session. Deficits in phrasing (word repetitions) were observed in seven of these subjects; six exhibited deficits in speaking rate and word/sentence stress. Four of the subjects displayed deficits in voice quality.

Finally, as described previously, naive listeners rated 108 second spontaneous samples obtained in a video narration condition with respect to speech clarity and speaking rate. Results revealed that the spontaneous speech of 5 of 9 BI subjects was rated significantly less clear than that of their normal control subjects; these same 5 BI subjects were rated as having significantly slower speaking rates than their control subjects.

CONCLUSION

The results of these analyses suggest that these TBI subjects experienced a significant recovery of phonemic-level skills over a period of approximately 13-17 months. However, precision of articulation and suprasegmental aspects of speech production remained compromised in the majority of these subjects such that naive listeners judged their communication skills to be significantly poorer than those of matched controls.

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