The Effects of Auditorally Augmented Feedback on the Eye-Hand Coordination of Students with Cerebral Palsy

(eye-motor coordination, tracing, fine motor tasks, Perceptuomotor Pen)

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To explore the question of whether auditorally augmented feedback can improve the eye-hand coordination of individuals with cerebral palsy, 59 (cerebral-palsied) students (mean chronological age 14 years, 3 months) were pretested with the Southern California Motor Accuracy Test and then randomly assigned to three groups. Group 1 performed training exercises—tracing line drawings—while simultaneously receiving auditorally augmented feedback about their efforts. Group 2 performed the same training exercises without the augmented feedback. Group 3 served as controls. All subjects were posttested with the Southern California Motor Accuracy Test, followed by a second post-test after a 3-month interval. At the first posttest, the performance of the feedback group was significantly superior to that of the other groups. At the second posttest, the performance patterns among the groups were essentially the same as at the time of the first post-test, but between-group differences were no longer significant. The results of this study are discussed in both empirical and theoretical terms.

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Many individuals with cerebral palsy have difficulty coordinating the visual and motor components of fine motor tasks and, as a result, manifest chronic problems with activities such as tracing accurately and writing legibly (1-4). Although this is only one of a number of motor-related difficulties encountered by these individuals, its importance to other, higher levels of functioning is clear (5, 6) and must be considered seriously by educators and therapists.

It is generally assumed that most tasks that require the coordinated use of eyes and hands generate visual, tactile, proprioceptive, and kinesthetic feedback to the individual attempting to perform them (7). These feedback systems allow the neurologically intact individual to monitor behavior and make modifications necessary to improve accuracy in a task. Feedback is thought to be the basis of eye-hand coordination and of fine muscle control in general. Some theorists explain the eye-hand coordination problems of individuals with cerebral palsy in terms of interference in the feedback process (6-9). Individuals with deficient or distorted feedback do not receive the kind of information that permits them to monitor and correct their own motor activities.

Recent research indicates that augmented feedback (feedback provided to the individual by an external signaling device) is potentially effective as a method of developing and enhancing some forms of motor functioning in individuals with cerebral palsy (10, 11). Most of the research on augmented feedback has been conducted within laboratory and clinical settings; its application in more natural settings has not been demonstrated. In this study the basic principles of augmented feedback were applied to training a functional skill—tracing—in a classroom setting. It was theorized that improving the feedback available to a child during the performance of a tracing task might lead to improved eye-hand coordination. Biofeedback research confirms the usefulness of several techniques for training control of motor functions. The basic principle, whether one speaks of biofeedback or augmented feedback, concerns supplementing or enhancing the information (feedback) that is intrinsic in a response or activity. Supplemental feedback is provided through auditory, visual, or haptic pathways or via combinations of these modalities. Feedback techniques have shown promise with a number of physical disabilities including those involving spasticity, such as wry neck (12) and footdrop (13), as well as with the problem of excess motor activity in stroke patients (14).
In the study reported here, the effectiveness of a method of training eye-hand coordination in children with cerebral palsy was examined. The method incorporated auditorially augmented feedback with a simple tracing task. The primary research questions asked in this study were: 1. Does tracing, with augmented auditory feedback, improve eye-hand coordination in the subjects of this study? 2. Does tracing practice alone result in improved eye-hand coordination? Secondary research questions were: 1. Is the relationship between chronological age and eye-hand coordination in the subjects of this study different from that of the nonhandicapped population? 2. Is their sex related to eye-hand coordination?

Method

Subjects. Fifty-nine students with cerebral palsy served as the subjects of this study. All attended the Cotting School for Handicapped Children, Boston, a private day school. Fifty-one, or 84 percent, of the students were described by their medical records as spastic. The 32 males and 27 females ranged in chronological age (CA) from 7 years to 21 years, with a mean CA of 11 years, 3 months. All had Wechsler verbal intelligence quotients between 85 and 115; had visual and hearing acuity, after correction, within normal limit; and had control of their upper body extremities sufficient to attend and respond to desktop paper and pencil tasks.

Procedures. Subjects were pre-tested with the Southern California Motor Accuracy Test (SCMAT)(13). This test consists of a line-tracing task that yields a motor accuracy score, plus an accuracy score adjusted for speed. Connolly (16) points out that motor skills have two components, accuracy and speed, and that each may be considered when examining response changes to motor skills.

The subjects were randomly assigned to one of three groups as follows: Group 1, tracing with auditorially augmented feedback; Group 2, tracing alone; Group 3, control—no tracing, no feedback. Group 1 contained 18 who were spastic and 2 with "mixed" cerebral palsy. Group 2 contained 17 who were spastic, and 2 "mixed." Group 3 was made up of 16 who were spastic, 1 ataxic, 1 ataxic, and 2 "mixed."

Subjects in Groups 1 and 2 were each given a set of 40 tracing patterns, each pattern to be traced during a 10-minute training session. Each subject was given two 10-minute training sessions per day, one in the morning and one in the afternoon. The tracing patterns were composed of lines approximately 3.1 mm (.4 inch) in thickness, on 20 x 27.5 cm (8 x 11 inch) bond paper. The patterns were developed and sequenced by levels of difficulty according to criteria suggested by Rudolph Steiner (17). All subjects completed the tracing patterns in the same sequence, supervised by their teachers, who had been oriented by the senior author (Talbot). Each subject in Group 1 was provided with a special pen for use in tracing the patterns. The pen projects a small beam of infrared light through the tip of a penlike stylus. If the light beam strays from the dark line being traced, the white background of the page causes the reflected light to be picked up by sensors in the pen. The sensors in turn trigger a buzzer mechanism that emits a tone telling the subject that the stylus has left the line; thus the subject receives immediate auditory feedback that indicates the pen has not maintained contact with the line being traced. Sensitivity controls for light and volume controls for the auditory signal were preset so that all subjects received the same
amount of feedback. Upon completion of the 40 training sessions, subjects were post-tested with the SCMAT. A second post-test was administered after an interval of 3 months. The control group received no tracing exercises, but were administered the SCMAT pre- and post-tests.

Results
In addition to the random assignment of students to groups, analysis of covariance was used to statistically equate the three groups on their pre-test SCMAT scores.

First Post-Test. The mean SCMAT score for Group 1 (460.34) was considerably higher than the means for Group 2 (448.83) and Group 3 (443.87). ANCOVA indicated a significant difference among the means ($F = 3.1000, p < .05$). A series of $t$ tests showed significance between Group 1 (feedback) and Group 2 (tracing alone) and between Group 1 and Group 3 (control).

Second Post-Test. After an interval of 3 months, the SCMAT was administered as a second post-test. Subject attrition had taken place over the intervening summer. Group 1 had lost four subjects, Group 2 had lost three, and Group 3 had lost two. Although the SCMAT mean for Group 1 (455.80) was still greater than those for Group 2 (448.60) and Group 3 (434.00), group differences were no longer significant. Figure 1 depicts the performance of the three groups across both post-tests, based on a pre-test starting point statistically equalized by ANCOVA.

The Speed Factor. SCMAT scores of all subjects were adjusted for speed and subjected to analysis of covariance. Differences among the means of the three groups at the first post-test approached, but did not reach, significance ($F = 2.985, p < .059$). Figure 2 shows that, while the adjusted SCMAT means were lower than the original means, the pattern of performance among the groups was essentially similar. The trend in favor of the feedback group was clearly maintained. The differences between accuracy scores and scores adjusted for speed are almost identical to those found with normal subjects in Ayres' standardization sample (15).

Other Variables. A Pearson product-moment correlation between CA and the SCMAT pre-test scores of all subjects resulted in a coefficient of .29 ($p < .02$). The mean CA of the subjects in this study was 14 years, 3 months. In the normal population, according to Ayres (15), a correlation of the magnitude found here tends to disappear after CA 8. There were no significant sex differences in the SCMAT pre-test scores of the 32 males and 27 females in this study.

Discussion
Auditory augmented feedback appears to have been useful in improving the eye-hand coordination (as measured by SCMAT) of the subjects in Group 1. The feedback group demonstrated a large and significant post-test performance superiority over the other two groups. The fact that this pattern, though maintained, did not retain significance after 3 months had elapsed, could be attributed to subject attrition. To examine this possibility, the first post-test SCMAT means were recalculated minus the scores of the subjects lost to attrition. The recalculated mean of the feedback group was 9 points lower than its original mean, whereas the means of the other two groups were within 1 or 2 points of their original means. It is conceivable that a disproportionately large number of high scorers were lost to the feedback group through attrition.

Another explanation for the
second post-test decrement may simply be that behavior tends to revert to pre-treatment levels once the treatment has been terminated. In his review of research on behavioral change, Walker (18) concluded that in the majority of techniques used, maintenance of effects beyond the immediate treatment situation did not occur. If such is the case in the present study, the decay of treatment effects over time should not be looked upon as a negation of the value of the treatment; we should, rather, look to ways of incorporating the treatment principles into ongoing program practices.

An important implication of this study is that the practice of an eye-hand activity in itself will not necessarily improve performance. There were no significant differences between the tracing alone group and the control group over either of the SCMAT post-tests. It seems clear that an eye-hand activity must generate feedback, and the client or student must be made aware of the feedback, if performance is to improve. If nonhandicapped individuals need feedback (19), there must certainly be a similar and more intense need in people who have central nervous system disorders affecting their abilities to process information efficiently.

The results of this study lend support to Gibson’s (3) position that visual motor deficits in individuals with cerebral palsy may be alleviated by the education of attention to the information in available stimulation. Another position to be considered is that of Abercrombie (20), who described individuals with cerebral palsy as receiving vague sensory feedback from their actions, resulting in development of an imprecise body scheme that manifests itself in inferior positional awareness of the limbs. One could infer that the auditorially augmented feedback provided to subjects in this study enhanced their “vague” sensory awareness (of the feedback) and resulted in improved body awareness during performance of the task.

Conclusion

The usefulness of augmented feedback to individuals with cerebral palsy in nonlaboratory settings remains a largely unexplored topic. This study demonstrated the viability of one augmented feedback approach in a precisely defined tracing task. The fact that the feedback group demonstrated significantly superior performance clearly implies that at least some part of this particular type of eye-hand coordination task is amenable to treatment. This should offer encouragement to therapists and other professionals concerned with teaching basic skills. It is hoped that this approach will in some small way help them to intervene in the cycles of failure and frustration that often cause clients to avoid what, to them, are high-risk activities.

Note: The Perceptuomotor Pen used in this study was Model PCR-1, a product of Wayne Industries, Skokie, Illinois.

REFERENCES

1. Cardwell VE: Cerebral Palsy: Advances in Understanding and Care, New York: Association for the Aid of Crippled Children, 1956