

# **Feasibility of Using a Single-Subject Design for Continuous Discourse Tracking Measurement**

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The feasibility of using a single-subject design to study continuous discourse tracking skills was investigated in four normal-hearing young adults. These subjects were tested on the tracking task with and without an FM assistive listening device in reverberant conditions. Results indicated that the single-subject paradigm was an effective way to measure differences in auditory behavior across these two conditions. Improved tracking rates in the aided condition were evident from visual inspection of the data. However, the effectiveness of the paradigm could be enhanced with better equivalence among tracking materials.

The present study was intended to investigate the feasibility of adopting a single-subject research design to measure the effects of an FM assistive listening device (ALD) on tracking performance in a reverberant listening condition. The goal of the study was not necessarily to show improvement in speech reception with the ALD, but rather, to explore the possibility of adapting a single-subject design to a clinical measurement problem.

Tracking is a timed procedure in which a subject repeats groups of words read by another person (De Filippo & Scott, 1978). When an error occurs in the repetition of the material, the talker (sender) and subject (receiver) employ various strategies to resolve it in order to obtain a correct verbatim repetition. Tracking performance is quantified by the number of words correctly repeated per minute.

Because the tracking procedure uses sentence-length materials, it would seem to be ideal as part of the evaluation of amplification systems. Connected

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speech is an approximation to the type of stimuli that hearing-impaired individuals encounter during everyday communication (Cox, Alexander, & Gilmore, 1987). Indeed, De Filippo and Scott (1978) have suggested that "tracking seems to tap the same perceptual skills required by other intelligibility tests plus a wider range of communication skills" (p. 1190). Continuous discourse also should be an appropriate stimulus to assess communication in reverberant conditions because reverberation tends to smear acoustical energy across syllables (Nabelek, 1982). Thus, the degradation produced by reverberant conditions probably can be measured with continuous discourse tasks better than with single-word intelligibility tasks.

Tracking rate may be influenced by such factors as sender skills and the type of material tracked (De Filippo & Scott, 1978). These can introduce variability, especially when comparisons are made with different senders. The use of single-subject designs may provide paradigms by which this inherent variability can be managed.

Single-subject research designs are those which do not rely on either parametric or nonparametric statistical analysis to identify effects of treatment(s) on dependent variables (McReynolds & Kearns, 1983). Rather, changes in dependent variables are identified visually from graphic representation of data after repeated measures with and without the treatment(s). Clinically, the designs provide a means for an amplification device to be considered as an experimental treatment. In most single-subject research, the treatment is replicated in several subjects; however, the design can easily be adapted for clinical use so that treatment effects can be observed within a single individual (McReynolds & Thompson, 1986).

## METHOD

### Subjects

Subjects for this study were four normal-hearing young female adults ranging in age from 20 to 30 years. None of the subjects had prior experience with the tracking procedure. All subjects had bilateral pure tone thresholds better than 20 dB HL, 250 Hz through 8000 Hz (ANSI, 1969).

### Procedures

The short stories used for tracking were taken from the series provided by Owens and Raggio (1987). All tracking tasks were done with the third author as sender and were done without the benefit of visual cues. Each subject participated in a training sequence in order to avoid practice effects during data collection. The training sequence consisted of two sessions. Each subject tracked four short stories during each of the two training sessions, for a total of eight training stories. Training sessions took place in a small cubicle (10 ft by 10 ft) fitted with comfortable table and chairs.

Data collection took place in a large lecture auditorium with seating capacity

of 116. The room was 13,110 cubic ft and all six surfaces were constructed of untreated hard materials. Ambient background noise during testing was 37 dBA (or an overall level of 65 dB SPL) measured at the position of the sender.

Each subject was tested individually, seated approximately 40 ft from the sender. Subjects were asked to track each entire story. Tracking rate was calculated by dividing the number of words in a story by the time required to track the story.

The entire sequence of measures consisted of 16 tracking stories with one story per measure; each subject received the stories in the same sequence. The first four measures in the sequence were done unassisted, and were considered as a baseline (non-treatment) condition. Following baseline, four measures were made in the assisted (treatment) condition. During the treatment conditions a Williams Sound Personal FM System was used by sender and receiver. This sequence of four non-treatment measures followed by four treatment measures was repeated to yield an ABAB single-subject design. The four measures in each condition were completed in a single session. The six tracking sessions were completed within a two-week period.

## RESULTS

Tracking rates in words per minute (WPM) are provided in the four panels of Figure 1. For each subject, training sessions (T1, T2) are on the left, followed by alternating baseline (A1, A2) and treatment (B1, B2) conditions. Generally, tracking rates increased over the first practice session (the first four stories). For each subject, the average tracking rate on the four measures of the second training session was close to, or below, the maximum rate achieved during the first training session. Thus, it appears that subjects were sufficiently familiar with the task by the end of training.

The average aided performance for individual subjects was nominally better than for the average baseline (unaided) conditions. This is most obvious when all four subjects are considered collectively, although variability tends to obscure the trend in individual subjects. In this time series of measurements, it is apparent that general increases in tracking rate are associated with introduction of the treatment (B1 and B2). Also, there is a trend for a decrease in tracking rate during measurements when the treatment was withheld (A2). This suggests that the observed changes in tracking rate were attributable to the treatment, as opposed to some extraneous variable(s). McReynolds and Kearns (1983, p. 25) have stated: "Intervention is judged to be effective if changes in the behavior co-occur with the presentation and removal of treatment." Data from the present study, therefore, demonstrate that the effects of the treatment (in this case, use of the ALD) can be measured using one of the simplest types of single-subject designs (ABAB).

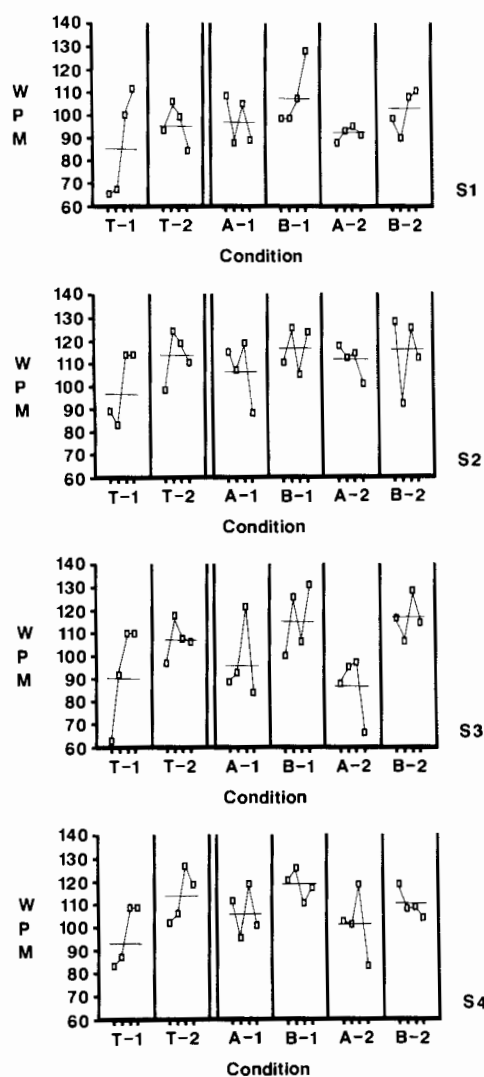


Figure 1. Tracking performance in words per minute (WPM) for subjects 1 through 4 in training (T1, T2), baseline (A1, A2), and treatment (B1, B2) conditions. Condition means are indicated by solid horizontal lines.

## DISCUSSION

Tye-Murray and Tyler (1988) described the limitations of continuous discourse tracking measurement. According to these authors, tracking is inappropriate as a test procedure. As the authors pointed out, the tracking task is not well suited to among-subjects test designs because of extraneous variables

which cannot be brought under experimental control. They also suggested that within-subjects designs are not as problematic; however, sender, receiver, and text variables can present design problems even for within-subjects measurements.

In the present study, the feasibility of using a single-subject test design was investigated. All comparisons were made within-sender and within-receiver. Comparison of results within sender-receiver dyads eliminates many sender and receiver variables. Uncontrolled variables in the present study, then, are limited to variability in story difficulty and any moment-to-moment variations in sender or receiver attention. It can be assumed that lapses in attention or motivation within sender-receiver dyads cannot be brought under control. The obvious remaining extraneous variable is the difference in difficulty among the tracking materials. The problems of text difficulty can be illustrated by subjecting the present results to established criteria for single-subject design analysis.

Furlong and Wampold (1981) identified four criteria for making visual inferences of treatment effectiveness: (a) the behavior is altered when the intervention was administered, (b) the observed change is important or meaningful, (c) the results are generalizable to other individuals, and (d) the data are reliable. In the present study, average tracking rates were changed with introduction of the treatment. Although the trend is clearest for subjects 1 and 3, all four subjects showed changes in tracking rate which co-occurred with presentation and removal of the treatment.

Two observations suggest that the changes in tracking rate are important or meaningful. First, each subject reported that listening was easier in the aided (treatment) condition. Second, the tracking task uses continuous discourse as the stimulus. Continuous discourse has been advocated as an ideal stimulus for assessing communicative effectiveness (Cox et al., 1987). To the extent that the tracking procedure simulates communication, the changes in tracking rate observed in the present study probably are meaningful.

The generalizability criterion also seems to have been met. All four subjects showed the same trend for improved performance in the treatment condition. That is, the treatment effect was replicated in four subjects. This replication suggests that the data are generalizable at least to other normal-hearing young adults. Hersen and Barlow (1976) have indicated that four replications (subjects) in single-subject designs are adequate, and that additional replications result in diminishing returns.

Achievement of the reliability criterion was more difficult to evaluate. According to Hedge (1987), measurement reliability in single-subject design can be demonstrated through multiple observations. Contrast between baseline and treatment conditions is easiest to identify when variability within conditions (that is, among the multiple observations) is at a minimum. For example, the data for subject 3 indicate a clear contrast between conditions A2 and B2. The performance difference between these two conditions is larger than the

variability within conditions. On the other hand, the contrast between conditions A1 and B1 for this subject is not as clear because the variability within conditions tends to obscure performance differences (between conditions). In the present experiment, all contrasts would have been more obvious if there had been less variability within each individual condition.

It seems apparent that some of the variability may be explained by differences in difficulty across stories. Some of the tracking stories were very easy for each subject while others tended to be quite difficult. For example, the last story in the A2 condition was difficult for every subject as shown by the low WPM tracking rates. The observed within-condition variability may have been related to differences in difficulty among stories. This tended to reduce the reliability of individual measures and obscure the contrasts between measures. The overall effectiveness of this ABAB single-subject design with tracking as the unit of measure would be enhanced by a reduction in within-subject variability. To that end, equivalent tracking materials must be developed.

Tracking promises to be a fruitful measure of communication skills in hearing-impaired listeners. Although several authors have used the approach in case study reports (Danz & Binnie, 1983; De Filippo & Scott, 1978; Owens & Raggio, 1987; Owens & Telleen, 1981; Sparks, Ardell, Bourgeois, Wiedmer, & Kuhl, 1979), a formal single-subject paradigm is necessary to conclusively demonstrate effects of treatment for an individual. This is true particularly because there will always be some amount of variability in tracking difficulty among story materials and moment-to-moment variations in sender and receiver attention. An investigator must be able to demonstrate that apparent changes in communicative behavior can be attributed to treatments rather than these extraneous variables. While case reports are useful, they do not afford the degree of certainty offered by single-subject designs.

The present data indicate that continuous discourse tracking measurements can be used with a simple (ABAB) single-subject design. However, there are certain limitations on the types of comparisons which can be made. Variables associated with sender and receiver characteristics probably dictate that comparisons must be made only within sender-receiver dyads. The present data indicated measureable differences between aided and unaided listening by normal-hearing adults in reverberation. The procedures should be investigated with hearing-impaired listeners in conditions such as aided/unaided or auditory/audiovisual. In addition, the problems associated with measurement reliability and text equivalence among tracking stories need to be examined. Once these issues have been addressed, the continuous discourse tracking technique is likely to find use in a variety of clinical and research applications.

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