JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2001, **34,** 487–490 NUMBER 4 (WINTER 2001)

A METHOD FOR ANALYZING CHANGES IN RESPONSE EFFICIENCY

CAROLE M. VAN CAMP, DOROTHEA C. LERMAN, AND MICHAEL E. KELLEY

LOUISIANA STATE UNIVERSITY

Although experimental effects typically are evaluated by summarizing levels of responding across time (e.g., calculating the mean levels of problem behavior during 10-min sessions), these data summaries may obscure important mechanisms that may be responsible for changes in responding. A case study is reported to illustrate alternative methods of data analysis when decreasing trends in responding may be due to increases in response efficiency.

DESCRIPTORS: data analysis, developmental disabilities, efficiency, transition states, problem behavior

In experimental analysis, the effects of independent variables on behavior typically are evaluated by summarizing or averaging levels of responding across brief time periods. For example, the effects of differential reinforcement on aggression might be evaluated by calculating the frequency or rate of aggression during each of a series of 10-min sessions before and after reinforcement is manipulated. Nevertheless, results of several studies indicate that alternative analyses of data collected during experimental sessions sometimes may be needed to identify or clarify functional relations (Northup et al., 1991; Roane, Lerman, Kelley, & Van Camp, 1999; Vollmer, Ringdahl, Roane, & Marcus, 1997).

One phenomenon that may be obscured by traditional data summaries is a decrease in overall levels of behavior due to an increase in response efficiency. This may occur when behavior that has been maintained by intermittent reinforcement in the natural environment is exposed to continuous reinforcement during functional analysis and pretreatment baseline sessions. Overall levels of behavior may decrease across sessions as responding conforms more closely to the new response requirement. Data for 1 participant are presented to illustrate the methodology and potential utility of alternative data analyses designed to evaluate this phenomenon.

Requests for reprints should be sent to Dorothea C. Lerman, Department of Psychology, 236 Audubon Hall, Louisiana State University, Baton Rouge, Louisiana 70803 (E-mail: dlerman@lsu.edu).

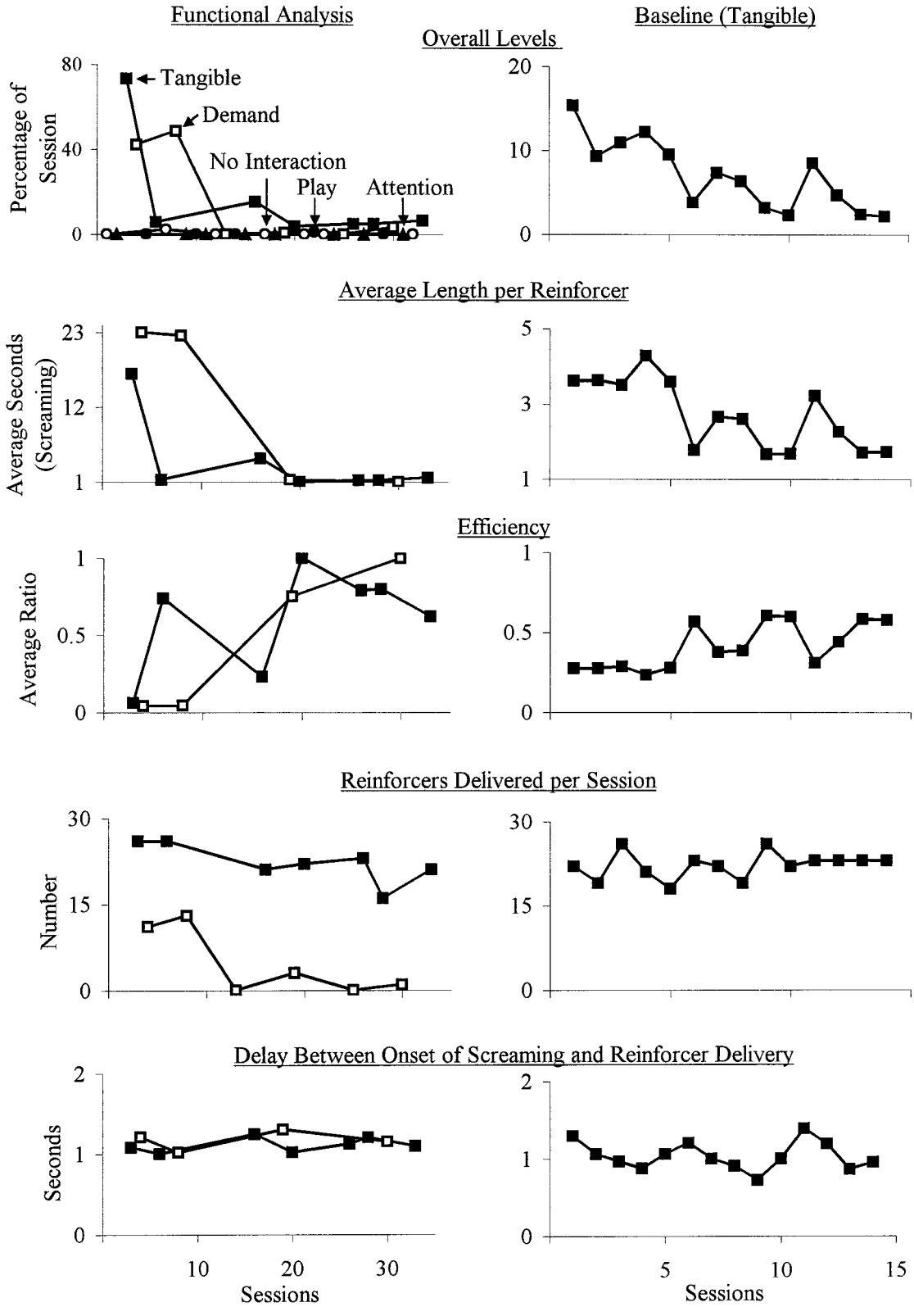
METHOD

Participant and Setting

Tacita was a 21-year-old woman who had been diagnosed with severe mental retardation and who had been referred for the assessment and treatment of screaming. Sessions were conducted in an unused room at Tacita's school. The room contained desks, chairs, and materials needed to conduct the sessions. Two to four sessions were conducted each day, usually 5 days per week.

Response Measurement and Reliability

Screaming was defined as vocalization above conversation level lasting at least 1 s. Data on screaming were collected via laptop computers using frequency and duration recording. Data on the therapist's behavior (delivery of leisure items or attention, escape from tasks) were collected using frequency and duration recording. A second observer


Functional Analysis
Baseline (Tangible)
Overall Levels
Percentage of Session
80
40
0
Tangible
Demand
No Interaction
Play
Attention
20
10
0
Average Length per Reinforcer
Average Seconds (Screaming)
23
12
1
5
3
1
Efficiency
Average Ratio
1
0.5
0
1
0.5
0
Reinforcers Delivered per Session
Number
30
15
0
30
15
0
Delay Between Onset of Screaming and Reinforcer Delivery
Seconds
2
1
0
2
1
0
10
20
30
Sessions
5
10
15
Sessions

simultaneously and independently collected data on target behaviors during at least 50% of all sessions. Agreement between the two observers was computed using the exact agreement method. Average percentage of agreement for screaming was 98% (range, 89% to 100%) for functional analysis sessions and 97% (range 90% to 100%) for baseline sessions. Average percentage of agreement for reinforcer delivery was 99% (range, 90% to 100%).

Functional Analysis and Pretreatment Baseline Sessions

A functional analysis was conducted using procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Attention, tangible, demand, no-interaction, and play conditions were conducted. Potential reinforcers were delivered for 20 s contingent on each scream of at least 1 s in the attention, tangible, and demand conditions. Conditions were presented in a multielement design. During the pretreatment baseline sessions, procedures were identical to those in the tangible condition of the functional analysis. All sessions lasted 10 min.

Data Analysis

Data on screaming were analyzed four ways for the tangible and demand conditions of the functional analysis and for all pretreatment baseline sessions. Initially, data for each session were calculated by dividing the total number of seconds of screaming by the total seconds of the session (600 s) and multiplying by 100% to generate the percentage of session time with screaming. This analysis showed decreasing trends in each of the three conditions. We hypothesized that screaming decreased across tangible and baseline sessions due to an increase in response efficiency and that screaming was placed on extinction in the demand condition. Thus, the average length of each scream emitted prior to and during each reinforcer delivery was calculated for each session. Next, these averages were divided into the reinforcement requirement (i.e., 1 s) to produce a measure of response efficiency ranging from 0 to 1, where 1 indicates perfect efficiency. For example, if the average length of each scream was 2 s during a session, the schedule requirement of 1 s was divided by 2 s to produce an efficiency ratio of .5. Finally, the total number of reinforcers earned each session was calculated. The average delay between the onset of screaming and reinforcer delivery (i.e., treatment integrity) also was calculated to insure that the change in efficiency was due to Tacita's behavior rather than to the therapist's behavior.

RESULTS AND DISCUSSION

High levels of screaming initially occurred in both the demand and tangible conditions of the functional analysis (Figure 1).[1] Although decreasing trends were observed in both conditions, responding persisted in the tangible condition, indicating that the behavior was maintained by access to leisure items (a See & Say® and a musical turtle). The percentage of session time with screaming also decreased across baseline sessions, and the average duration of each scream per

[1] Results of Tacita's functional analysis have been reproduced from Roane et al. (1999).

←

Figure 1. Overall levels of screaming per session (upper panel), average length of screams per reinforcer (second panel), efficiency (third panel), average number of reinforcers delivered per session (fourth panel), and average delay between the onset of screaming and reinforcer delivery (lower panel) across functional analysis sessions (left column) and baseline sessions (right column).

reinforcer delivery decreased across all sessions. Two additional measures were calculated to clarify whether deceleration reflected an increase in response efficiency or the gradual elimination of behavior. As shown in Figure 1, the measure of efficiency increased across sessions for all conditions. However, the number of reinforcers earned per session decreased across demand sessions, whereas this measure remained stable across the tangible and baseline sessions. These results suggest that leisure items remained potent reinforcers for screaming, whereas escape from demands did not maintain responding. These findings also suggest that both measures (response efficiency and number of reinforcers) should be evaluated to determine whether a decline in responding is due only to increased efficiency (as in the tangible condition) or to a decrease in reinforcement effects (as in the demand condition). Finally, the analysis of treatment integrity showed that results were a function of changes in the participant's behavior rather than changes in the therapist's behavior.

Results of these data analyses clarified the mechanisms responsible for the descending trends, suggesting that responding was in a transition state during the initial portion of the tangible and baseline sessions (Sidman, 1960). Screaming likely was reinforced intermittently in the natural environment and, thus, contacted a new reinforcement schedule during functional analysis and baseline sessions. Responding gradually conformed to the new response requirement with sufficient exposure to the continuous schedule. This phenomenon may be common because continuous schedules often are used in functional analysis and pretreatment baseline sessions. An advantage of this methodology is that this mechanism can be identified rapidly when changes in response efficiency are obscured by typical data summaries. By doing so, treatments may be developed in less time.

Future research is needed to test the utility of the model with other behaviors and data-calculation methods (e.g., responses per minute). The data presented here are correlational, and conclusions about the factor responsible for changes in responding must remain tentative. In further studies, reinforcement schedules could be manipulated to examine response patterns during transitions from one schedule to another. For example, responding under fixed-ratio (FR) 3 and FR 6 schedules could be evaluated following exposure to FR 10. These alternative data analyses then could be used to directly compare possible changes in efficiency under FR 3 and FR 6. Further studies also are needed to determine whether the efficiency ratio alone is inadequate to differentiate extinction effects from reinforcement effects, as was the case for Tacita.

REFERENCES

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27,* 197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2,* 3–20, 1982)

Northup, J., Wacker, D., Sasso, G., Steege, M., Cigrand, K., Cook, J., & DeRaad, A. (1991). A brief functional analysis of aggressive and alternative behavior in an outclinic setting. *Journal of Applied Behavior Analysis, 24,* 509–522.

Roane, H. S., Lerman, D. C., Kelley, M. E., & Van Camp, C. M. (1999). Within-session patterns of responding during functional analyses: The role of establishing operations in clarifying behavioral function. *Research in Developmental Disabilities, 20,* 73–89.

Sidman, M. (1960). *Tactics of scientific research.* New York: Basic Books.

Vollmer, T. R., Ringdahl, J. E., Roane, H. S., & Marcus, B. A. (1997). Negative side effects of noncontingent reinforcement. *Journal of Applied Behavior Analysis, 30,* 161–164.

Received September 21, 2000
Final acceptance August 15, 2001
Action Editor, David P. Wacker