USING A TAPED INTERVENTION TO IMPROVE KINDERGARTEN
STUDENTS' NUMBER IDENTIFICATION

KATHERINE R. KROHN, CHRISTOPHER H. SKINNER, AND EMILY J. FULLER

UNIVERSITY OF TENNESSEE

AND

CORRINE GREER

KNOX COUNTY PUBLIC SCHOOLS

A multiple baseline design across students was used to evaluate the effects of a taped numbers (TN) intervention on the number-identification accuracy of 4 kindergarten students. During TN, students attempted to name the numbers 0 through 9 on randomized lists before each number was provided via a tape player 2 s later. All 4 students showed immediate increases and reached 100% in number-identification accuracy. One student reached 100% accuracy after TN was supplemented with performance feedback, reinforcement, and overcorrection.

Key words: mathematics, early intervention, academic responding, constant prompt delay

Although most children begin school with core number competencies, others need targeted teaching and learning activities to acquire these skills (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; National Research Council, 2009). The ability to identify numbers is a critical early numeracy competency and a prerequisite for the development of other math skills (Jordan, Kaplan, Oláh, & Locuniak, 2006). Although number-identification deficits may predict later mathematics difficulties (Clarke & Shinn, 2004; Fuchs et al., 2007), few studies have examined effective ways to remedy this early skill deficit (Chard et al., 2008; Gersten, Jordan, & Flojo, 2005).

Taped interventions offer a low-tech solution to the delivery of basic academic skill instruction and have been used to remedy sight-word reading (e.g., Bliss, Skinner, & Adams, 2006) and math-fact deficits (e.g., McCallum, Skinner, Turner, &

Saecker, 2006), enhancing both accuracy and automaticity. In taped interventions, students are presented with visual stimuli (e.g., word lists, math problems) and are instructed to say the correct response before it is provided by an audiotape recorder. Such procedures minimize errors and allow a large number of learning trials within a short amount of time, thereby maximizing learning rates (see Skinner, 2008). Taped interventions have been used with both individuals and groups, but usually have been applied with older elementary school children in special education settings. The current study extends research on taped interventions by targeting a basic numeracy skill (as opposed to higher level math skills), adapting previous procedures (i.e., using a tone to signal the introduction of a new trial rather than numbering the trials; selecting a 2-s constant prompt delay), intervening in the general education setting as a means of primary prevention, and evaluating the effects of the modified intervention with kindergarten students.

Emily J. Fuller is now at Hamblen County Schools, Tennessee.

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Correspondence concerning this article should be addressed to Katherine Krohn, who is now at the Cincinnati Children's Hospital Medical Center (e-mail: Katherine.Krohn@cchmc.org).

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METHOD

Participants and Setting

Four kindergarten students (two boys and two girls) participated. Three students were Hispanic

(referred to as Anita, Cristina, and Carlos) and received services from a teacher for English language learners who indicated that each had limited English language skills, typically spoke in short sentences, and relied heavily on nonverbal communication. The other participant (David, an African-American) was nominated for inclusion by his teacher, who felt that he might benefit from the small-group instruction in math. All four participants were referred due to difficulty with number identification. Sessions were conducted at a table in a back corner of the classroom.

Response Measurement and Interobserver Agreement

Data on correct number identification were collected using assessment sheets with the numbers 0 through 9 listed in a random order. Five different assessment sheets were constructed and alternated across sessions to ensure that students did not memorize placement of numbers. The primary experimenter assessed participants individually by pointing to each number on the sheet and asking the student to name the number. No feedback was provided. If the student did not respond accurately within 5 s, the experimenter scored an error and pointed to the next number; students were permitted one self-correction within that time frame. For each assessment, the numbers read correctly were summed and converted to a percentage score, which served as our dependent variable.

Interobserver agreement data were collected during at least 25% of assessment sessions for each participant. Agreement was determined by comparing the numbers written down by each observer. There were no disagreements across all students and sessions.

Design and Procedure

Sessions took place in the mornings 3 days per week (Monday, Wednesday, and Friday). A multiple baseline design across subjects was used to evaluate the effects of the taped numbers (TN) intervention. The intervention was applied both individually and in small

groups. Carlos received the TN intervention by himself during the first intervention session. For each of the following three TN sessions, another student was added to the TN group.

Baseline. Students received their regular mathematics instruction. Individual assessments were completed during a morning transition period.

Taped numbers. At the start of the session, each participant was given the same worksheet that contained four columns listing the numerals 0 through 9 in random order (i.e., a worksheet contained 40 trials). Five different TN worksheets were constructed, and one was randomly selected for each session. Worksheets corresponded to an audiotaped recording of the numbers, in which the numbers were read aloud in the order they appeared on the worksheet. The tapes were constructed so that each trial consisted of a 1-s tone to signal the start of the trial, followed by a 2-s delay for the student to attempt to read the number aloud, and then a recording of the number being read in English. The next trial began 2 s later when the next tone sounded. We used 2-s response intervals, because previous researchers reported that longer intervals evoked off-task behavior (Windingstad, Skinner, Rowland, Cardin, & Fearington, 2009).

The experimenter sat at the table with the participant during each session and read the following instructions at the start of the session:

Let's play this game. When you hear a noise, say the number you see and then wait until you hear what the tape says to see if you got it right. Then, repeat the number after you hear the tape say it. What you want to do is try to beat the tape and say the number before you hear the answer. Are you ready?

To help students keep their place and prompt simultaneous responding, the experimenter pointed to each number following the tone. Students were assessed both individually and immediately after each TN session. TN sessions required about 3 to 4 min (tape length was approximately 200 s), and each student's assessment never exceeded 40 s.

A treatment integrity checklist was used to evaluate whether the experimenter implemented

procedures correctly (i.e., read the appropriate directions before starting the tape, prompted students to attend to the correct stimulus, placed the appropriate worksheet in front of students, withheld feedback in the assessment). An independent observer recorded treatment integrity data during four of the 12 TN sessions. Treatment integrity was 100%.

Feedback, overcorrection, and reinforcement. Immediately after the first TN session, Carlos showed improved number-identification accuracy. However, his performance was variable, and he never reached 100% accuracy after 11 TN sessions. Consequently, on the 12th session, TN was supplemented with performance feedback, overcorrection, and reinforcement. After each TN assessment, the experimenter evaluated Carlos's assessment sheet and told him which numbers he identified correctly and incorrectly. Next, he was asked to write the latter numbers three times and to say each number aloud while writing. Carlos also was told that he would receive a sticker (a teacher-recommended reward) when he responded with 100% accuracy on assessments.

Maintenance. Participants moved to the maintenance phase when they achieved 100% accuracy on three of four consecutive assessments. Accuracy was assessed as in other phases, but children no longer participated in TN sessions.

RESULTS AND DISCUSSION

The percentage of numbers identified correctly across baseline, intervention, and maintenance phases are displayed in Figure 1 for each student (gaps in the data paths correspond to student absences). All four participants showed a clear increasing trend in number-identification accuracy following the application of TN. No overlapping data points were observed between conditions for students, with the exception of Cristina (the percentage of nonoverlapping data between Cristina's baseline and intervention phases was approximately 86%). Cristina's baseline performance was variable, and she continued to make errors when naming two

numerals (i.e., 6 and 9) until the seventh TN session. David's accuracy increased to 100% following one TN session and remained perfect for the next three sessions. David's immediate acquisition and sustained mastery, combined with teacher-reported low rates of attention and participation during regular classroom mathematics instruction, suggested the possibility of a performance deficit rather than a skill deficit. Anita demonstrated a similar pattern of responding to David, but anecdotal evidence of her behavior during lessons suggested that TN remediated a skill deficit. Anita, Cristina, and David achieved and maintained 100% accuracy with TN, whereas Carlos achieved and maintained 100% accuracy after TN was supplemented with feedback, overcorrection, and reinforcement.

The results support the effectiveness of tape-assisted interventions and provide evidence of generality to a wider population of learners (kindergarten students, three of whom were English language learners) and tasks (number identification). Although maintenance data spanned approximately 1 month, the teacher reported that all participants continued to demonstrate mastery at the conclusion of the school year. Because educators often do not have the resources (time, additional help) to supervise individual students who receive remedial interventions (Shriver, 2007), the minimal time investment required to produce the materials for this effective, low-tech intervention (i.e., approximately 2 hr) is a significant advantage. In addition, once recordings and worksheets are constructed, they can be reused or reproduced. However, to increase teachers' confidence that TN procedures can be applied and sustained in their classrooms, future research should determine if they can be applied without the high levels of supervision provided during the current study.

The current procedures can be conceptualized as an automated variation of a constant prompt-delay procedure (Wolery et al., 1992). With constant prompt delay, there is a controlling

Figure 1. Percentage of numbers identified correctly by the four participants during the assessment sessions across baseline, intervention, and maintenance phases. Supplemental intervention procedures for Carlos included feedback (F), overcorrection (O), and reinforcement (R).

prompt (the numbers produced by the tape) that follows a task direction (the tone signals the start of a number-identification trial). Previous research has explored computer-assisted instruc-

tion using prompt-delay procedures (see Kos-cinski & Gast, 1993), which has the potential to be extended to young students with deficient number-identification repertoires. Although

Hitchcock and Noonan (2000) found computer-assisted instruction with a constant prompt-delay procedure to be superior to comparable teacher-initiated instruction, teachers were needed to facilitate the preschool students' access to and use of the computer. Thus, the low-tech TN intervention may be as effective as a computer-assisted intervention in terms of necessary teacher resources.

Despite the strong and positive effects of TN on number identification for three of the participants, there are some limitations worth noting. A primary limitation is the absence of data on responding during the taped intervention sessions, which might help to discern the mechanisms responsible for behavior change. For example, it is unclear whether active responding was necessary to produce treatment effects or whether learning was simply the result of repeated exposure to the correct answer. Peer influence also was not accounted for in the current study; therefore, the contributions of the game-like structure, choral responding, and peer modeling to intervention effectiveness are unknown. Delivering the TN intervention in isolation or in a group format with headphones may allow future research on the potential impact of peer modeling or motivation to compete with peers. Finally, regarding Carlos's supplemental procedures, a component analysis might have been beneficial to determine which factors were essential in facilitating accuracy.

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