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Recommendations for Reporting Independent Variables in Outcome Studies of Early and Intensive Behavioral Intervention for Autism

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Early and intensive behavioral intervention (EIBI) has been established as an effective treatment for autism. However, the complexity and intensity of EIBI programs make it difficult to fully report all critical aspects of the independent variable. Consequently, scientific reports of EIBI outcomes have been criticized for providing less than comprehensive treatment descriptions. In an effort to address this problem, the present article provides a template to aid outcome researchers in (a) clearly reporting each participant's curricular targets and (b) describing critical aspects of treatment.

Keywords: autism; early intervention; behavioral treatment; clinical trials

Autism is a pervasive developmental disorder characterized by severe deficits in social behavior and communication, along with a restricted repertoire of activities and interests (American Psychiatric Association, 2000). The methods of applied behavior analysis (ABA), which are based on well-established principles of learning, have been shown to produce significant improvements in children with autism, especially when intervention is intensively implemented (Smith, 1999). Such programs are often referred to as early and intensive behavioral intervention (EIBI). The goal of many EIBI programs is to teach preacademic skills (e.g., attending, imitation, matching), language, and social skills, in addition to reducing problem behavior (e.g., stereotypy, self-injury). Common instructional procedures

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include reinforcement, modeling, prompting, fading, shaping, error correction, among others.

Smith (1999) summarized the results of 10 major outcome studies from seven EIBI programs (Anderson, Avery, DiPietro, Edwards, & Christian, 1987; Birnbrauer & Leach, 1993; Fenske, Zalenski, Krantz, & McClannahan, 1985; Handleman, Harris, Celiberti, Lilleheht, & Tomchek, 1991; Harris, Handleman, Gordon, Kristoff, & Fuentes, 1991; Harris, Handleman, Kristoff, Bass, & Gordon, 1990; Hoyson, Jamieson, & Strain, 1984; Lovaas, 1987; McEachin, Smith, & Lovaas, 1993; Sheinkopf & Siegel, 1998). Although participants in some studies made substantial gains in all areas assessed (e.g., Lovaas, 1987), participants in other studies made gains in some areas but not others (e.g., Harris, Handleman, Gordon, et al., 1991; Harris, Handleman, Kristoff, et al., 1990). Smith concluded that children in the UCLA Young Autism Project (Lovaas, 1987) received the most intensive treatment and ultimately showed the most favorable results across multiple areas of functioning.

Lovaas (1987) used a between-subjects approach to evaluate the effects of EIBI. Three groups were evaluated: an experimental group ($n = 19$), a matched control group ($n = 19$), and a second "patched up" control group ($n = 21$) from another investigation. The experimental group received more than 40 hours of one-to-one treatment per week, the first control group received 10 hours or less of one-to-one treatment per week, and the second control group did not receive treatment from the Young Autism Project. Lovaas reported a number of different pretest and posttest assessments, including behavioral observations, intellectual assessments, and adaptive-behavior assessments. After 2 to 3 years of intensive intervention, nearly half (47%) of the experimental-group participants obtained an average or above average IQ and were placed in a general education 1st-grade classroom compared to only one (2%) participant between both control groups. A follow-up study (McEachin et al., 1993) demonstrated successful maintenance of treatment gains by experimental-group participants.

Despite the significant findings reported by Lovaas (1987), the study received considerable peer criticism in the literature (e.g., Gresham & MacMillan, 1997, 1998; Schopler, Short, & Mesibov, 1989). One of the primary criticisms was that Lovaas' description of his treatment methods was inexact. Lovaas did not specify exactly how many hours of therapy each child received, precluding the ability to draw firm conclusions about the effectiveness of treatment in relation to its frequency and duration (Gresham & MacMillan, 1997). In addition, Lovaas did not describe how many therapists were used, what their level of education and training was, or how they were supervised (Gresham & MacMillan, 1997). Schopler

et al. highlighted the fact that Lovaas did not describe the level of family involvement, which, by Lovaas' own admission, is an essential component of successful treatment. Lovaas also did not report the specific treatment procedures that were used, such as prompting, error correction, reinforcement, and stimulus generalization procedures. More important, Lovaas did not report each participant's curricular targets. Although he did reference his previously published manual (Lovaas, 1981) in an attempt to succinctly describe his treatment procedure, this was insufficient for providing a complete and detailed account of his independent variables. Consequently, it is difficult to ascertain exactly what skills were taught to each participant and the therapeutic procedures that were employed. As a result of these omissions and other criticisms, some cautioned that Lovaas' findings be viewed tentatively (Gresham & MacMillan, 1997, 1998; Schopler et al., 1989).

More recent outcome studies of EIBI programs have continued to provide less than comprehensive descriptions of their independent variables. For example, Smith, Groen, and Wynn (2001) compared an intensive ABA intervention group with a parent-mediated ABA intervention group. Both groups received intervention based on the Lovaas (1981) treatment manual. For the intensive training group, the authors described the number of hours per week (intensity), duration of treatment, and number of therapists per child. Smith et al. provided a brief outline depicting how treatment would generally proceed for each group and referred the reader to Lovaas (1981) manual for further details. As was the case with the Lovaas (1987) study, Smith et al. did not report specific treatment procedures or describe curricular targets for each participant.

In a recent successful replication of the original Lovaas (1987) investigation, Sallows and Graupner (2005) included a few more details about their independent variables. For example, the authors briefly mentioned how curricular targets were sequenced (e.g., receptive language was taught before expressive language) and listed several treatment methods (e.g., familiar materials were used in programs, play periods were frequently interspersed with work trials). Although such information was an improvement over earlier reports, the description of treatment was, nonetheless, insufficient for clear interpretation and replication.

One notable exception in this line of research is a single-case description of an EIBI program in which the independent variables were fully explicated (Green, Brennan, & Fein, 2002). The participant was a young girl at high risk for a subsequent diagnosis of autism. Among the many treatment details provided by the authors were (a) parents' level of education and involvement, (b) level of education and training of therapists and supervisors,

(c) intensity and duration of treatment (i.e., hours, years), (d) locations of treatment, (e) prompt-fading procedures, (f) overarching intervention formats (e.g., discrete trials, naturalistic procedures), and (g) a list of the primary curricular targets. The Green et al. report is an excellent example of sufficiently described independent variables in the behavioral treatment literature. However, because this report employed only one participant, which permitted more manuscript space to devote toward this goal, it is unclear whether this model would adequately apply to larger outcome studies with more participants.

In summary, it appears common in large outcome studies of EIBI programs for authors to provide only general descriptions of their independent variables. It is undoubtedly an overwhelming task to provide specific details of the treatment, given its intensity and duration (e.g., 4,000 hr), the number of participants, the curricular variability across participants, and the lack of available manuscript space for the task. Nonetheless, it is critical to the progress of clinical science and practice that researchers provide an explicit description of their independent variables (Gresham, Gansle, & Noell, 1993); otherwise interpretation and replication are rendered difficult, if not impossible. Clear description of the independent variable also helps target interventions to clients with greater precision, which is especially important given the large variability of the population of children diagnosed with autism (Kasari, 2002). A well-defined independent variable is also important with respect to the interpretation of results because it strengthens the conclusions that can be drawn from a study (Gresham et al., 1993). Finally, it is possible that a full specification of the independent variable might lessen the controversy surrounding a study's findings, which is becoming more critical in the autism literature (e.g., Gresham & MacMillan, 1997).

Thus far, major outcome studies of the behavioral treatment of autism have generally not provided explicit accounts of their independent variables or how they were applied across participants. Reporting the independent variable for a major outcome study presents a formidable challenge for the authors because the independent variable in a major outcome study can be conceptualized as both the entire curriculum for each participant, as well as the teaching procedures that were utilized in implementing the curriculum. This is an admittedly daunting task; however, we believe this problem must be overcome for these studies to more fully contribute to the research literature. The purpose of the present article is to provide (a) a template to aid outcome researchers in this area to clearly report each participant's curricular targets and (b) recommendations for describing critical aspects of the intervention.

Reporting Curricular Targets for Each Participant

It is a challenge to concisely report the important details of a multiyear curriculum because participants in EIBI studies learn multiple exemplar skills in dozens of curricular programs over the course of a study. To facilitate this task, we recommend researchers use a table to efficiently display the critical features of each participant's curriculum (see Table 1 for an example). The first element that should be included in the table is a list of the major curricular programs. For example, programs such as matching, receptive labels, and vocal imitation would be reported as is illustrated along the *y*-axis (left column) of Table 1. The sample programs depicted in Table 1 are based on *A Work in Progress* (Leaf & McEachin, 1999). Note that some of the programs are reported with a specific number (in parentheses) depicting the number of within-program phases. For example, Table 1 illustrates that the play program contains 6 phases, and the receptive instructions program contains 12 phases. The specific programs that are implemented and subsequently reported will, of course, vary from study to study. For example, an EIBI study in which the language curriculum is based on Skinner's (1957) analysis of verbal behavior might include the major program areas of tacts, mands, intraverbals, and receptivity by feature, function, and class (Sundberg & Partington, 1998).

The second key element of curricular reporting is to quantify each participant's performance within each program area. It is important to note how many expressive labels a participant acquired, not just that he or she was exposed to the program. Table 1 illustrates a method for conveying such information. Participant numbers are reported along the *x*-axis (top row). For each program, the number of exemplars a participant mastered is denoted with up to two numbers. The first number represents the number of mastered exemplar skills within the program. The second number (in parentheses) indicates how many phases the participant mastered. For example, Table 1 shows that Participant 1 mastered 75 exemplar skills and 9 phases in the receptive instructions program. If a program does not contain subphases, only one number would be reported in the column (e.g., Table 1 shows that Participant 1 learned 15 songs in the songs program). Finally, performance under programs in which mastery of some number of exemplars eventually generalizes to novel exemplars (e.g., vocal imitation) is denoted by a number and an asterisk. The number indicates how many exemplars the participant acquired, and the asterisk indicates that the program was fully mastered.

Table 1

Sample Table for Displaying Data of Participants' Performance Across Programs

Program	Participant									
	1	2	3	4	5	6	7	8	9	10
Compliance	4	4	4	4	4	4	4	4	4	4
NVI	30*	33*	15*	37*	25*	40*	20*	37*	32*	18*
Block imitation	30*	34*	15*	34*	24*	37*	18*	38*	35*	21*
Motor skills	30	22	40	37	25	32	35	15	17	31
Matching	45*	60*		53*	30*	62*	32*	45*	49*	33*
Play (6)	19 (2)	15 (1)	28 (3)	20 (3)	24 (2)	13 (1)	27 (4)	10 (1)	22 (3)	30 (5)
Songs	15	4	7	12	0	6	16	13	8	18
Independent work and play	15*	10*	18*	10*	20*	14*	19*	14*	13*	24*
Play scripts	5	3	1	3	0	5	6	3	4	8
Receptive instructions (12)	75 (9)	62 (7)	69 (8)	59 (5)	88 (10)	72 (9)	83 (11)	58 (6)	70 (8)	90 (12)
Receptive labels (17)	165 (14)	130 (14)	143 (13)	140 (12)	180 (15)	148 (10)	176 (13)	120 (9)	163 (15)	185 (16)
Functional communication	25*	30*	40*	42*	15*	42*	20*	38*	24*	13*
VI	10*	7*	14*	12*	3	15 *	6*	13*	7*	5*
Expressive labels (15)	190 (13)	160 (11)	140 (7)	183 (13)	0 (0)	164 (12)	197 (14)	183 (13)	188 (12)	200 (15)
Conversation-basic (5)	20 (3)	15 (2)	16 (2)	21 (3)	0 (0)	14 (1)	25 (4)	16 (2)	19 (3)	34 (5)
Yes/No	45*	48*	50*	43*	35*	40*	36*	45*	39*	28*
Negation	45*	28*	29*	30*	15*	40*	36*	47*	39*	32*
Assertiveness	20*	35*	28*	28*	20*	16*	28*	16*	17*	15*

Note: Mastery is denoted with a number and another number within parentheses for programs for which there is no limit of the number of exemplars to be taught. The number within the parentheses indicates how many phases, out of the total number of phases in the program, have been mastered. Programs that do not have numbers within parentheses do not have separate phases. Mastery is denoted by a number and a symbol (the asterisk in this example table is an arbitrary symbol) for the programs in which the skill generalizes to novel exemplars.

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The template described above and depicted in Table 1 will provide much more comprehensive information about a study's curriculum than is currently reported in EIBI outcome studies, including the curricular targets for each participant, the number of subphases mastered by each participant (when applicable), and the number of exemplars acquired by each participant. There are several potential benefits to reporting such information. Some participants will progress through a vast number of curricular targets whereas others will progress through far fewer targets within the same timeframe. Our proposed table would depict this heterogeneity of progress. Such information might also help researchers and readers better correlate larger outcome scores (e.g., receptive language scores, IQ) with specific program areas and progress within each. Perhaps of greatest importance, the template described in this section and depicted in Table 1 can report substantial information in relatively little journal space.

Reporting Specific Features of Treatment

EIBI programs not only require full specification of the curriculum for proper evaluation, they also require detailed reporting of specific treatment procedures used to teach the curriculum. Because of the intensity and curricular breadth of EIBI programs, numerous aspects of treatment are involved in their execution. It is important for the purposes of replication of outcomes, especially between studies, that these elements at least be mentioned, if not described in detail. The following section highlights what we believe are the features most critical to treatment outcome.

Personnel

Caregivers. A child's primary caregivers are a critical influence on treatment progress because they are generally the individuals who will interact with the child the most. Thus, authors should describe the primary caregivers' level of involvement in treatment. Such involvement might include directly working with the child on curricular targets (as a therapist), monitoring child progress, and assisting with curriculum development and revision. If the primary caregivers do provide direct therapy or participate in curricular development, it is important to describe their level of training in those activities.

Therapists. Therapists are the individuals responsible for implementing treatment directly with the children; thus, it is critical that authors report

information about therapists that might affect program quality such as level of education and training. This information might include the duration of training, training format (e.g., verbal instruction, role-playing), and whether a proficiency criterion had to be met before a therapist could begin working with a child.

Supervisors. Of all the instructional agents involved in the child's treatment program, the program consultant or supervisor has one of the most important roles because he or she is responsible for curriculum selection and modification, selecting instructional procedures, and staff training and management. We recommend that outcome studies report the source and duration of supervisor training (e.g., graduate education, clinical mentorship) and their level of involvement in the child's treatment program. For example, does the consultant interact with the family and the therapists every 2 weeks or every 3 months? This information is of paramount importance because recent research suggests that degree of supervisor involvement might be related to program outcomes (Bibby, Eikeseth, Martin, Mudford, & Reeves, 2001).

Instructional Procedures

Programmed consequences. The therapeutic foundation of EIBI programs is the reinforcement of correct and appropriate behavior. As such, it is crucial that authors report how reinforcers were identified and delivered. First, authors should describe how stimuli were selected. For example, was a multiple-stimulus preference assessment (DeLeon & Iwata, 1996) used or were stimuli selected solely based on caregiver nomination. In addition, if preference assessments were used, authors should describe how often they were conducted (e.g., before each instructional session, weekly). Next, the authors should describe what types of reinforcers were used. For example, were primary reinforcers (e.g., food) or secondary reinforcers (e.g., praise, toys) used? If both were used, as is often the case, authors should describe which were used primarily throughout treatment. For example, was food delivered contingent on performance in new programs, with praise reserved for performance in previously acquired (maintenance) programs? Finally, the schedules of reinforcer delivery should be described. For example, was each target continuously reinforced until a maintenance criterion was met, followed by intermittent reinforcer delivery?

Prompt and fading procedures. Prompts and their eventual fading are essential components in the process of teaching new skills and facilitating

their independence. Because there are a number of different prompt and fading strategies, authors should describe each and mention how they were used. This would include describing the different types of prompts (e.g., verbal prompts, physical prompts, within-stimulus prompts) and the direction of prompt fading (e.g., increasing assistance [least to most], decreasing assistance [most to least]).

Trial arrangements. A common practice in EIBI programs is to intersperse trials of previously acquired skills with trials of unlearned or "acquisition" tasks (e.g., Neef, Iwata, & Page, 1977). It has been established in the literature that task interspersal procedures enhance academic performance and increase positive affect (Dunlap, 1984; Koegel & Koegel, 1986). However, task interspersal procedures do not always promote learning. Research has shown that simply interspersing trials from different acquisition programs does not lead to better outcomes (Dunlap, 1984). Furthermore, Charlop, Kurtz, and Milstein (1992) showed that using the same reinforcers for both acquisition and maintenance trials can impede learning of the former (compare Chong & Carr, 2005). Thus, we recommend that authors specifically describe the task interspersal procedures they employed.

Teaching Format

Most EIBI programs heavily use the discrete-trial training approach to instruction (Smith, 2001), whereas other programs promote naturalistic teaching methods more than discrete trial methods (Koegel & Koegel, 1995). As both approaches are most likely employed together in many EIBI programs, as has been recommended (Sundberg & Partington, 1999), it would be informative for authors to describe the approximate ratio of discrete trials to naturalistic teaching time for their participants.

Skill Maintenance

One of the major goals of all EIBI programs is that the skills acquired during treatment maintain over time. However, skill maintenance rarely occurs, unless it has been explicitly programmed during therapy. Thus, we recommend authors report which features of their program were designed for skill maintenance. This would include describing whether mastered skills were retained as maintenance targets, as well as the ratio of those trials to acquisition trials. Including information on schedule thinning would also be informative because intermittent reinforcement is a well-established method of producing resistance to extinction (Jenkins & Stanley, 1950).

Stimulus Generalization

One of the major difficulties for individuals diagnosed with autism is the generalization of skills they have learned across settings and with other individuals (Haring, Kennedy, Adams, & Pitts-Conway, 1987). Programming for stimulus generalization contributes to a program's efficiency because less time is invested in reteaching skills across all relevant stimuli (e.g., settings, individuals). Given the importance of stimulus generalization to overall treatment outcome and the inherent difficulty obtaining generalization with this population, authors should describe their generalization strategies. This might entail reporting whether target skills were taught in the natural environment. For example, were social skills practiced on the playground at school or only at home with the therapist? Authors should also describe whether these skills were practiced in the natural environment by caregivers. In addition, common strategies for promoting generalization (e.g., training loosely, incorporating multiple stimuli) should be noted (Stokes & Baer, 1977). Authors should also explain at what point in the intervention generalization was programmed. For example, some treatment programs might teach a given skill at the table in the therapy room and, once it is mastered, arrange opportunities for the skill to be practiced in the natural environment (Lovaas, 1987). Other programs may start by teaching a given skill in the natural environment or by incorporating multiple stimuli from the beginning of training. Finally, the authors should describe the number of therapists that worked with each child. This would provide information about the number of opportunities the child had to generalize skills across individuals.

Data Collection Procedures

The type of data that are collected during therapy and the method by which they are collected have a major influence on the course of treatment and the decisions made about the effectiveness of a given program. Program supervisors make curricular changes based on the data they receive. Programs are considered mastered and consequently removed from the curriculum, based on these data. Therapists could potentially persist with ineffective procedures if data are not collected or properly evaluated. Given these serious implications, we recommend that authors describe what kinds of data collection (e.g., all trials, first-trial only) methods were employed in the program, on what targets (e.g., acquisition only, acquisition + maintenance) data were collected, and how often data were reviewed by supervisors.

Mastery Criteria

Mastery of skills is one way to gauge the success or failure of a treatment program. If mastery criteria are too ambitious, then learning and successes may be underreported. However, if mastery criteria are not rigorous enough, this may lead to "false positive" acquisition. There are many important variables to consider when developing a mastery criterion and they should be reported in detail. This would entail describing the percentage of correct responses required for mastery (e.g., 80% or 90%) and the number of trials deemed necessary for mastery (e.g., four out of five trials). In addition, authors should describe whether the first response in a block of trials were correct for mastery to be achieved. Finally, authors should describe whether responses were performed across therapists, settings, and sessions before mastery was achieved.

Duration and Intensity

One of the major features that likely contributed to the success of Lovaas' (1987) seminal study was the substantial duration (years) and intensity (40 hr per week) of treatment. Since then, other studies have supported the notion that an increased duration and intensity in treatment might be a key element to success (Smith et al., 2001), although it is not clearly understood exactly how lengthy or intense treatment should be (Smith, 1999). To assist in the evaluation of such information across investigations, we recommend authors describe the number of hours of therapy per week, the number of days per week, and the average length of instructional sessions. By describing such information for each participant, correlations between intensity/duration and outcome might be permitted.

Although providing the aforementioned information about duration and intensity of treatment would be beneficial, a variable that is perhaps more important in evaluating the "amount" of treatment provided is the frequency and rate of trials (i.e., learn units) presented to each participant (Greer & McDonough, 1999). We encourage authors to provide an estimate of how many trials were presented per hour in their program. Such information might ultimately permit a more valid estimation of treatment efficiency.

Procedures for Reducing or Managing Problem Behavior

Several epidemiological analyses have shown that one of the most prevalent reinforcement functions for problem behavior of individuals with

developmental disabilities is escape from instructional demands (e.g., Iwata et al., 1994). Given the enormous instructional demands placed on children in EIBI programs, it is not surprising that problem behavior often occurs during therapy (e.g., Leaf & McEachin, 1999). Such behavior not only impedes learning but also acts as a barrier to integration with typical peers. Thus, we recommend authors describe what procedures were used to address problem behavior during instruction. For example, did minor problem behavior result in different consequences than more significant problem behavior? Were aversive consequences (e.g., reprimands, time-out) delivered for problem behavior or was a function-based approach to behavior reduction employed instead?

Conclusion

EIBI has been repeatedly demonstrated as an effective treatment for autism. Unfortunately, the magnitude of EIBI (e.g., duration, intensity, number of curricular targets) makes it difficult to concisely report relevant aspects of treatment. The present recommendations were designed to assist outcome researchers in better describing their curricula and critical treatment elements. Although the current recommendations were designed specifically for EIBI programs, we believe their structure and intent can be applied to outcome studies of different interventions. Studies that evaluate complex treatments (e.g., Sofronoff, Leslie, & Brown, 2004) might benefit from a more detailed account of the independent variable as illustrated in the *Reporting Specific Features of Treatment* section. In addition, studies that evaluate complex, long-term treatments during which participants acquire different skills or a different number of skills from the same curricular domain (e.g., Wetherby & Woods, 2006) might benefit from a curricular template such as that depicted in Table 1.

In addition to the recommendations in the present article for reporting the independent variable, we suggest researchers attend to existing guidelines for other important aspects of conducting EIBI outcomes studies. Kasari (2002) provides detailed recommendations for conducting experimental group designs (e.g., matching/randomization, sample size, control groups) and Smith et al. (2007) provide further guidance in the design of randomized clinical trials and community effectiveness studies.

Matson (2007) and Kasari (2002) both provide thorough discussions of the wide range of dependent measures relevant to EIBI research. The core measures include assessments of intellectual functioning, adaptive behavior,

and problem behavior. In addition, researchers should report (a) their diagnostic system (e.g., *Diagnostic and Statistical Manual of Mental Disorders* [*DSM-IV*], ICD-10), (b) whether diagnoses were made independent of study personnel, and (c) scores from their primary diagnostic instruments. Including a wide array of dependent measures not only permits pretest-posttest comparisons for detecting intervention effects but also provides information about a study's sample. Because autism is a spectrum disorder in which symptoms may vary widely across children, it is important that researchers clearly describe their study's sample characteristics for the purposes of identifying differential responders to treatment (Kasari), clarifying the basis for comparisons between studies and generalization to community samples, and facilitating a study's contribution during the identification of empirically supported interventions (Chambless & Ollendick, 2001).

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