Relative Efficiency of Response-Contingent and Response - Independent Stimulation on Child Learning and Concomitant Behavior

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Observations of teachers' use of noncontingent stimulation to elicit behavior from young children with multiple disabilities and profound developmental delays led us to evaluate the relative efficiency of response-contingent and response-independent stimulation to affect child behavior change. Data from three children (2 females, 1 male) with multiple disabilities and delays were analyzed to determine how many child contingency, visual attention, and social affective behavior would be produced per 100 learning opportunities under contrasting stimulus conditions (contingent vs. noncontingent). Results showed for all three child behaviors, response-contingent stimulation was overwhelmingly more efficient in affecting behavior change compared to response-independent stimulation. Implications for intervention are described.
Keywords: Response-contingent stimulation, response-independent stimulation, child operant learning, concomitant child behavior, efficiency

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More than 25 years ago, we initiated a line of research and practice investigating the value of response-contingent learning opportunities with young children with multiple disabilities and profound developmental delays (e.g., Dunst, 1981; Dunst, Cushing, & Vance, 1985; Dunst & Didoha, 1976; Laub & Dunst, 1974). This work was begun in response to experience showing that traditional early intervention and therapy was not effective in promoting the learning and development of these children. Observations of many practitioners over many years have found that the interventions they used with young children with profound developmental delays more often than not involved response-independent or noncontingent stimulation to elicit or evoke child behavior. In most cases, the more disabled and delayed the children, the greater the likelihood that practitioners would spend large amounts of time using noncontingent stimulation to attempt to affect changes in child behavior.

The influences of response-contingent and response-independent stimulation on child learning and behavior has been the focus of investigation for many years (e.g., Dunst, 1984; O'Brien, 1992; Utley, Duncan, Strain, & Scanlon, 1983; Vietze, Foster, & Friedman, 1974). Response-contingent stimulation involves the provision of stimulation contingent upon a child's behavior, whereas response-independent stimulation involves the provision of stimulation that is noncontingent or nondependent upon a child's behavior. Findings from studies indicate that noncontingent stimulation at least initially elicits child attention and increased behavior responding, but that children habituate to the response-independent stimulation the longer it is available. In contrast, response-contingent stimulation elicits and maintains child behavior responding for longer periods of time and is often associated with positive social--emotional behavior following contingency detection and awareness (see e.g., Dunst, 2003). The purpose of the analyses in this brief report was to determine the relative efficiency of response-contingent and response-independent stimulation on child operant learning and two concomitant child behavior (visual attention and affective behavior).

The analyses were completed on data collected as part of a study promoting teachers' use of contingency games as a form of early childhood intervention with young children with multiple disabilities and profound developmental delays (Raab, Dunst, Wilson, & Parkey, 2007). During the baseline condition of the study, teachers were observed using noncontingent stimulation to elicit child behavior. The effect appeared to be behavior suppression rather than behavior enhancement. The extent to which this observation was confirmed in a secondary analysis of the study data was the focus of this report.

The conduct of the original study was guided by a conceptual and operational framework that postulated both immediate and extended benefits of contingency learning opportunities (Dunst et al., 1985; Raab & Dunst, 1997). Contingency learning games are characterized by behavior-based contingencies where the production or provision of reinforcement is contingent on the child's behavior (Tarabulsy, Tessier, & Kappas, 1996). The immediate effect of the learning games is increased operant responding. The extended benefits of the contingency games include, but are not limited to, increased child visual attention to the consequences of contingency behavior and child affect (smiling, laughter, and vocalizations) in response to the consequences of a child's behavior.

Method

Participants

The participants were three children ("Amy," "Brenda," and "Cory") with profound developmental delays and their teachers. The three children, who were between 34 and 52 months of age, attained developmental ages of only 3 to 5 months of age as determined by the Griffiths (1954) developmental scales. The children had Griffiths GDQs (General Development Quotients) between 6 and 16. The three children each had cerebral palsy, two had visual impairments, and one had a seizure disorder. Two of the three children had multiple disabilities.

Setting and Procedure

Data collection during the different study phases was done in the children's classrooms. A multiple baseline design across study participants was used to assess the effectiveness of the contingency learning games for promoting response-contingent child behavior and child concomitant behavior. The study included baseline, intervention (both acquisition and mastery), and maintenance phases.

The baseline phase consisted of observations of the teachers implementing 2 or 3 activities they currently used to promote child learning. The two intervention phases consisted of behavior-based contingency games (activities) where a child used a behavior to produce an environmental consequence (e.g., batting at a mobile producing movement and sound) or a behavior was reinforced by the teacher (e.g., teacher singing to the child for reaching toward and touching the teacher's mouth). An intervention session typically included 2 or 3 games. Maintenance included teacher implementation of 2 or 3 contingency games following the termination of teacher coaching. Any one game or activity could include up to 15 trials (learning opportunities). The study was implemented over the course of 44 sessions (days).

Measures

Measures of child response-contingent behavior, visually attending to the consequences of a contingency behavior, and child smiling, laughter, and vocalizations, were obtained from observations of the children by the study investigators. A child contingency behavior was defined as a behavior that produced or elicited a reinforcement during a game trial that was unprompted or unaided by the teachers. Child visual attention was defined as a fixated look on the consequence of his or her behavior. Smiling or laughter was defined as a closed or open upward turning of the corners of the mouth or an audible laughing sound without smiling indicative of joy or exuberance. A vocalization was defined as an audible open vowel sound (other than laughing). Inter-rater reliability was assessed for 26% of the games. Percent agreement was 91 (Range = 84 to 96) for contingency behavior, 72 (Range = 69 to 75) for visual attention, and 91 (Range = 87 to 94) for child affect (smiling/laughing/vocalizations).

Efficiency

Efficiency was measured in terms of the relationship between inputs (i.e., learning opportunities) and outputs (e.g., child operant responding), and was calculated as the number of outputs produced by a predetermined number of inputs (Rumble, 1997) and the number of inputs necessary to produce a predetermined number of outputs (Coelli, 2005). The former, termed educational efficiency (UNESCO, 1995), is calculated as:

$$\text{Educational Efficiency} = (\text{Outputs}/\text{Inputs}) \times 100.$$

The latter, termed allocative efficiency (Comanor & Leibenstein, 1969), is calculated as:

$$\text{Allocative Efficiency} = (\text{Inputs}/\text{Outputs}) \times 100.$$

Each provides a different lens for understanding the efficiency of different kinds of inputs.

Efficiency was determined for the baseline (noncontingent stimulation) and each of the three contingency (acquisition, mastery, and maintenance) phases of the study, and was calculated for child contingency, visual fixation, and social affective behavior. First, we calculated the number of contingency and concomitant behavior that would be produced per 100 game trials during each phase of the study (educational efficiency). For example, if a study phase included 200 game trials, and a child produced 150 contingency behavior, his or her contingency efficiency score would be 75 ([150/200] x 100), meaning that 100 learning opportunities would likely result in 75 reinforcing consequences. Second, efficiency was assessed in terms of the ratio of the number of inputs (learning opportunities) necessary to produce 100 outputs (e.g., response-contingent behavior) (allocative efficiency). In the example above, it would require 133 game trials to produce 100 reinforcing consequences ([200/150] x 100). The larger the allocative efficiency score, the less efficient is the learning condition.

Results

Child Learning

Figure 1 summarizes the results of the multiple baseline design. (See Raab et al. (2007), for a more complete presentation of the patterns of learning.) Results showed that few learning game trials during the baseline phase included behavior that produced or elicited reinforcing consequences. In contrast, the children demonstrated improved operant learning during the sessions immediately following the introduction of the contingency games (acquisition), followed by sustained high levels of operant responding (mastery). The children continued to demonstrate high levels of operant responding during follow-up (compared to the baseline).

Efficiency

The educational efficiency of response-contingent and response-independent learning opportunities on child operant responding is shown in Figure 2. Response-contingent learning opportunities were clearly more efficient in terms of the likelihood that the children would produce behavior having reinforcing consequences. Two of the three children (Amy and Brenda) showed incremental increases in the efficiency of their contingency behavior from the acquisition to mastery to maintenance phases of the study. Cory showed incremental increases in the efficiency of his contingency behavior from the acquisition to mastery phases.

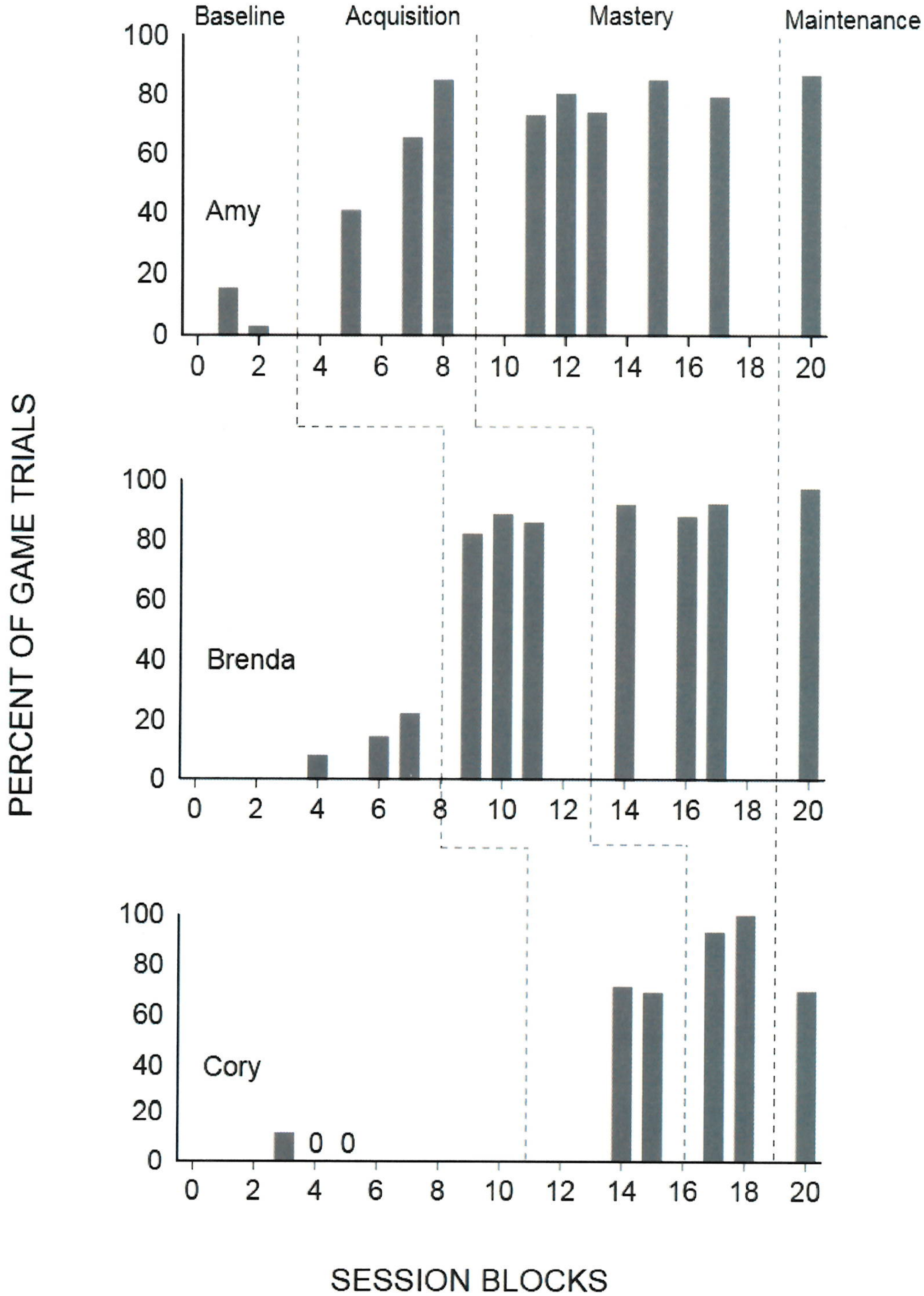

Figure 1. Child production of contingency behavior during the response-independent (baseline) and response-contingent (acquisition, mastery, maintenance) phases of the study.

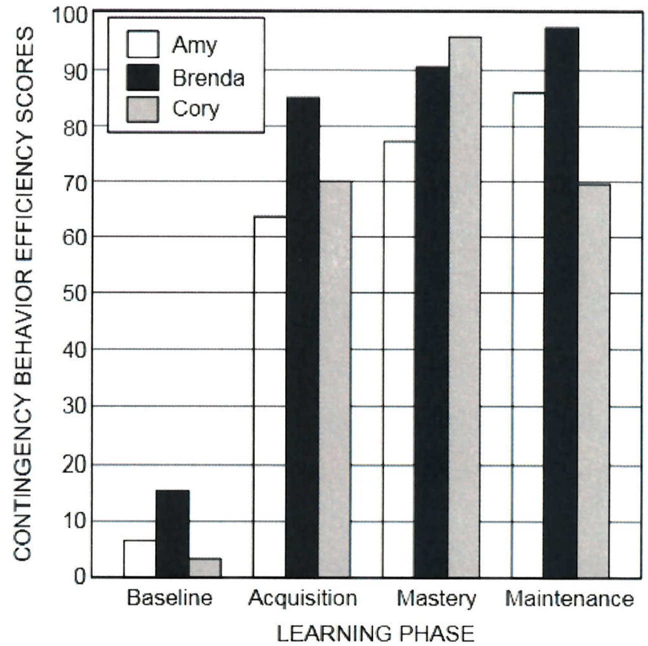

Figure 2. Relative efficiency of response-independent and response-contingent learning opportunities on the production of child behavior producing reinforcing consequences.

Allocative efficiency, measured in terms of the number of learning opportunities (inputs) needed to produce 100 contingency behavior (outputs), makes clear the differences in the effects of response-independent and response-contingent stimulation. The number of response-independent inputs (baseline) needed to elicit 100 behavior producing reinforcing consequences was 1,529 for Amy, 641 for Brenda, and 3,015 for Cory. In contrast, the number of response-contingent inputs (intervention and maintenance) needed to elicit 100 contingency (output) behavior was between 103 and 157 for the three children.

Figure 3 shows the educational efficiency scores for the children's visual attention to the consequences of their behavior during the baseline (noncontingent) and three learning (acquisition, mastery, maintenance) phases of the study. Results again show that response-contingent learning opportunities were more efficient for affecting changes in child visual behavior compared to response-independent stimulation.

The relative efficiency of response-independent and response-contingent stimulation is highlighted by the differences in the input to output ratios of learning opportunities necessary to produce 100 visually fixated responses (allocative efficiency). The number of noncontingent-stimulation baseline learning episodes needed to produce 100 fixated looks was 369 for Amy, 495 for Brenda, and 1,633 for Cory. In contrast, it would require just between 107 and 171 learning episodes to produce the same number of fixated behaviors during the response-contingent learning phases of the study.

The educational efficiency of response-contingent and response-independent learning opportunities in terms of influencing the display of child social affective behavior is shown in Figure 4. The likelihood that child affective behavior would be affected by contingent and noncontingent learning opportunities showed that noncontingent stimulation was associated with very few social affective behavior, but that there were incremental increases in child smiling, laughter, and vocalizations across the three contingency study phases. The pattern and amount of responding is very much like that found in other studies (Dunst, 2003). The small increase during the acquisition phase followed by larger increases during the mastery and maintenance phases is indicative of a child's contingency detection and awareness (Tarabulsy et al., 1996; Watson, 2001).

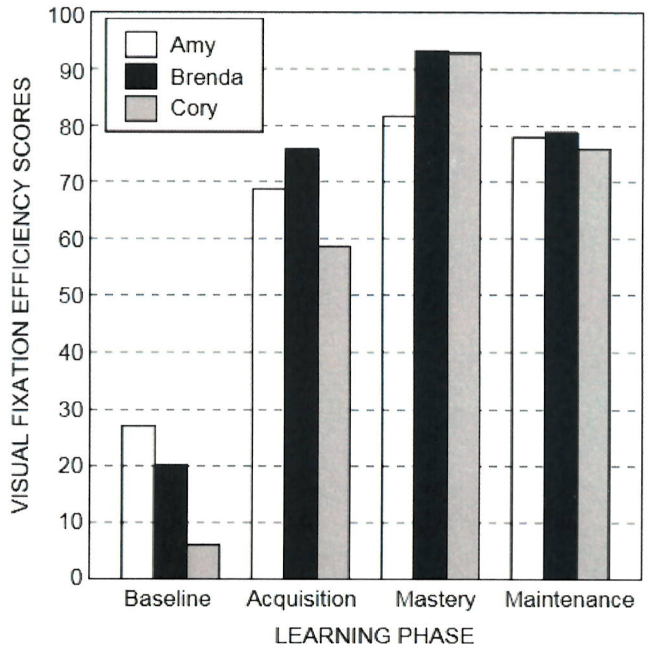

Figure 3. Relative efficiency of response-independent and response-contingent learning opportunities on the children visually attending to the consequences of their behavior.

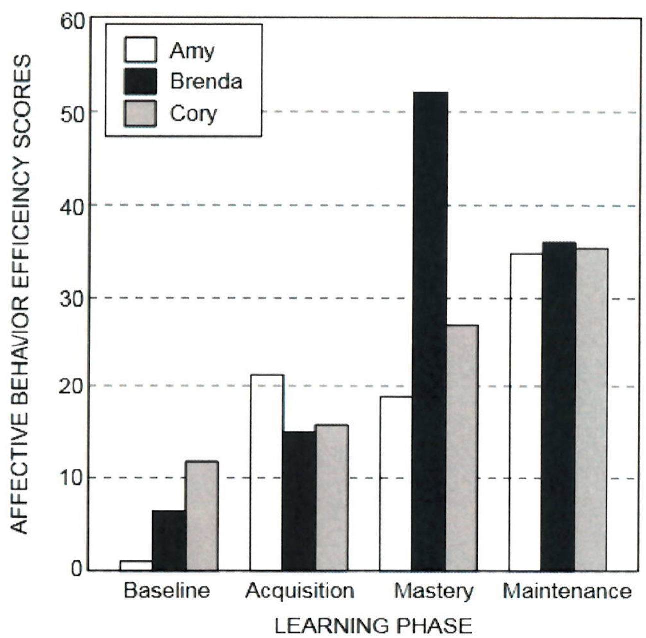

Figure 4. Relative efficiency of response-independent and response-contingent learning opportunities on the production of child social affective behavior.

The input to output ratios of the number of learning opportunities needed to elicit 100 child positive affective behavior (allocative efficiency) shows with little doubt that response-contingent stimulation is much more efficient in producing child social-affective behavior compared to response-independent stimulation. The number of noncontingent stimulation game trials needed to elicit 100 social affective behavior, for all three children combined, was 1,126 (Range = 852 to 10,700), whereas the number of response-contingent stimulation game trials needed to produce the same number of affective behaviors at the end of the study was 280 (Range = 273 to 287).

Discussion

Findings showed that response-contingent learning opportunities were overwhelmingly more efficient in affecting changes in children's behavior compared to response-independent stimulation. Results indicated that attempts to elicit child behavior using noncontingent stimulation suppress or inhibit child behavior responding whereas response-contingent stimulation enhance and promote child behavior as well as have concomitant behavior consequences.

A cursory examination of intervention procedures used with young children with disabilities indicates that despite the fact that noncontingent stimulation is not an efficient treatment procedure, it is a major part of many different kinds of interventions with young children with disabilities, and especially children with profound developmental delays and multiple disabilities. These include, but are not limited to, passive range of motion exercises (Flett, 2003), infant massage (Booth, Johnson-Crowley, & Barnard, 1985), cranialsacral therapy (Sullivan, 1997), neurodevelopmental theory (Palisano, 1991), therapeutic electrical stimulation (Sommerfelt, Markestad, Berg, & Saetesdal, 2001), oral motor stimulation (Domaracki & Sisson, 1990), and vestibular stimulation (Sandler & Voogt, 2001), many of which are used widely by early intervention practitioners (IDEA Infant and Toddler Coordinators Association, 2002; McWilliam, 1999).

Further examination of available information indicates that many early intervention practices used with young children with profound developmental delays and multiple disabilities are not likely to be effective because so many intervention activities include large doses of noncontingent stimulation. Ironically, large doses of noncontingent stimulation over extended periods of time probably make children with disabilities and delays more passive and more resistant to learning contingency behavior (Dunst, 1982; Hutto, 2003; Watson, 1971). This is most likely the case because young children subjected to noncontingent stimulation learn that "people do things to them" rather than acquire an understanding of how their behavior can be used to affect environmental consequences. As part of extensive examination of children's IFSPs and IEPs, for example, we found that the largest number of intervention activities on these plans included procedures that involved use of noncontingent learning opportunities, calling into question the value of the interventions (Dunst, Bruder, Trivette, Raab, & McLean, 1998).

Early childhood practitioners have at their disposal a wealth of information about the characteristics of and conditions under which early learning activities and opportunities are most likely to have optimal behavior enhancing consequences. There is most certainly a need to use this information to ensure that young children with disabilities and delays, and especially children with multiple disabilities and profound developmental delays, are afforded the kind of learning opportunities that are most likely to affect positive changes in their behavior and collateral responding. Available evidence, however, indicates that this does not seem to widely be the case in many Individuals with Disabilities Education Act (IDEA) Part C early intervention programs and Part B(619) preschool special education programs (see e.g., Campbell & Halbert, 2002; McBride & Peterson, 1997).

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