HHS Public Access
Author manuscript
J Appl Behav Anal. Author manuscript; available in PMC 2017 September 01.

Published in final edited form as:
J Appl Behav Anal. 2016 September ; 49(3): 617–638. doi:10.1002/jaba.303.

AN INTEGRATED MODEL FOR GUIDING THE SELECTION OF TREATMENT COMPONENTS FOR PROBLEM BEHAVIOR MAINTAINED BY AUTOMATIC REINFORCEMENT

Wendy K. Berg, **David P. Wacker**, **Joel E. Ringdahl**, **Jason Stricker**, **Kelly Vinquist**, **Anuradha Salil Kumar Dutt**, **Danielle Dolezal**, **Jeffrey Luke**, **Lisa Kemmerer**, and **Jayme Mews**
THE UNIVERSITY OF IOWA

Abstract

We evaluated the usefulness of 2 assessments to guide treatment selection for individuals whose prior functional analysis indicated that automatic reinforcement maintained their problem behavior. In the 1st assessment, we compared levels of problem behavior during a noncontingent play condition and an alone or ignore condition. In the 2nd, we assessed participants' relative preferences for automatic reinforcement and social reinforcers in a concurrent-operants arrangement. We used the results of these 2 assessments to assign 5 participants to a treatment based on noncontingent access to social reinforcers or to a treatment based on differential access to social reinforcers. We conducted monthly probes with the participants over 10 to 12 months to evaluate the effects of the treatment procedures. All participants showed reductions in problem behavior over this period.

Keywords

automatic reinforcement; competing reinforcers; concurrent operants; differential reinforcement; noncontingent reinforcement; problem behavior; self-injurious behavior

Problem behaviors that occur exclusively during the alone condition of a functional analysis (FA) or that occur across FA alone and noncontingent reinforcement (NCR) play conditions in an undifferentiated pattern have been described as being maintained by automatic reinforcement (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Mason & Iwata, 1990; Querim et al., 2013). These behaviors do not appear to be mediated by the social reinforcers typically evaluated in an FA. Behaviors maintained by automatic reinforcement are particularly difficult to treat because the events that evoke or reinforce the behaviors typically cannot be observed or manipulated directly (Vollmer, 1994).

Address correspondence to: Wendy K. Berg, Center for Disabilities and Development, 100 Hawkins Dr. Room 251, Iowa City, Iowa 52242 (wendy-berg@uiowa.edu).
Joel Ringdahl is now at the University of Georgia, Athens. Jason Stricker is now at Sanger Unified School District, Sanger, California. Anuradha Salil Kumar Dutt is now with National Institute of Education, Singapore. Danielle Dolezal is now at Seattle Children's Hospital, Seattle, Washington. Jeffrey Luke is now with the May Institute, Randolph, Massachusetts. Lisa Kemmerer is now with STAR Autism Support, Inc., Iowa City, Iowa.

Reinforcement-based treatments to reduce problem behavior maintained by automatic reinforcement have focused primarily on identifying alternative stimuli that individuals will engage with to the exclusion of automatically reinforced problem behavior (e.g., Piazza et al., 1998; Shore, Iwata, DeLeon, Kahng, & Smith, 1997). Competing stimuli have included those that are relatively more preferred than gaining access to automatic reinforcement (e.g., Shore et al., 1997) and those with sensory properties similar to those hypothesized to maintain problem behavior (Piazza et al., 1998).

Assessments to identify stimuli that are relatively more preferred than behaviors associated with automatic reinforcement typically include arbitrary stimuli that do not appear to be functionally related to the targeted problem behavior (Fischer, Iwata, & Mazaleski, 1997). For example, Vollmer, Marcus, and LeBlanc (1994) presented items (e.g., cookies, blocks, magnets, etc.) that had been identified with a paired-choice preference assessment (Fisher et al., 1992) to three children who engaged in self-injurious behavior (SIB) maintained by automatic reinforcement. Other studies have included measures of the targeted problem behavior (e.g., SIB, stereotypy, pica) in addition to measures of item selection during preference assessments to identify stimuli that will compete with problem behavior during subsequent reinforcement-based treatments. For example, Shore et al. (1997) assessed the substitutability of alternative stimuli by providing them individually for 10 min and measuring levels of object manipulation and SIB. For all participants, objects associated with high levels of object manipulation and low levels of SIB effectively reduced SIB when presented continuously on a time-based schedule (i.e., NCR) but not when presented contingent on the absence of SIB (differential reinforcement of the absence of behavior; DRO) nor when the response effort required to engage in object manipulation increased.

Other studies have focused on identifying alternative stimuli that produced sensory stimulation hypothesized to be similar to the sensory consequences produced by problem behavior (i.e., matched stimuli; Goh et al., 1995; Piazza et al., 1998). For example, Piazza et al. (1998) hypothesized that the oral stimulation produced by pica functioned as automatic reinforcement for this response for three participants. To test this hypothesis, they conducted single-item preference assessments with items that provided oral stimulation (matched items) and with other preferred stimuli that did not provide oral stimulation (unmatched items) in rooms baited with materials associated with pica for each participant. Results of the preference assessment showed that matched items produced higher levels of item interaction and lower levels of pica than unmatched items.

The collective results of the studies cited above show that allocation between responses associated with alternative stimuli (e.g., object manipulation) and responses associated with problem behavior can be influenced by several dimensions of the alternative stimuli (e.g., preference, response effort, and sensory components). In each of these studies, the investigators presented competing stimuli initially on an NCR schedule. Many participants selected the competing stimuli to the exclusion of problem behavior associated with automatic reinforcement. Other participants required additional treatment components to reduce automatically reinforced problem behavior. For example, some investigators have found that some participants continued to engage in problem behavior when provided with alternative stimuli on an NCR schedule, but problem behavior decreased when the same stimuli were removed contingent on the occurrence of problem behavior via a response cost (Falcomata, Roane, Hovanetz, Kettering, & Keeney, 2004) or time-out (Ringdahl, Vollmer, Marcus, & Roane, 1997; Vollmer et al., 1994).

Response blocking and response interruption also have been used to reduce problem behavior maintained by automatic reinforcement when noncontingent access to alternative stimuli was insufficient for reducing problem behavior to clinically acceptable levels. Roscoe, Iwata, and Zhou (2013) presented preferred stimuli on an NCR schedule with 14 participants who engaged in hand mouthing maintained by automatic reinforcement. Noncontingent access to the preferred stimuli significantly reduced hand mouthing for seven of the participants. Roscoe et al. added response blocking or response blocking paired with differential reinforcement (DR) for the remaining participants. The addition of response blocking with or without the DR component was effective in reducing hand mouthing for six of the remaining participants. The 14th participant continued to show hand mouthing during the NCR and NCR plus blocking treatments; therefore, a restraint procedure was added to the NCR treatment to reduce hand mouthing. Other studies have similarly shown that additional procedures like response blocking can increase the effectiveness of NCR when treating automatically reinforced problem behavior (e.g., Hagopian, Rooker, & Zarcone, 2015; Piazza, Hanley, & Fisher, 1996).

Collectively, these studies showed that for some participants, alternative stimuli competed with problem behavior when the participant was able to maintain access to both potential reinforcers (i.e., alternative stimuli and problem behavior) simultaneously (e.g., Shore et al., 1997), whereas other stimuli competed with problem behavior only when access to both potential reinforcers was mutually exclusive (e.g., Falcomata et al., 2004) or when response blocking or punishment was added (e.g., Roscoe et al., 2013). However, in most (if not all) of these studies, experimenters introduced supplemental procedures (i.e., those added to noncontingent presentation of preferred or matched stimuli) only after NCR alone was unsuccessful. What is now needed is an assessment procedure that matches an effective treatment option with the target behavior.

The results of previous studies show that the absence of problem behavior during assessments such as free-operant preference assessments has been predictive of the absence of problem behavior within NCR-based treatments that include the same stimuli for some participants (Lindberg, Iwata, Roscoe, Worsdell, & Hanley, 2003; Rapp, 2007; Ringdahl et al., 1997). Thus, one assessment could be free access to preferred stimuli in a condition similar to the play or leisure condition of an FA. Unfortunately, the absence or presence of problem behavior within an NCR schedule has not been predictive of the absence of problem behavior within a subsequent DR schedule (Piazza, Fisher, Hanley, Hilker, & Derby, 1996; Shore et al., 1997). Additional research is needed to identify assessments that could be useful for selecting between an NCR- and a DR-based treatment to reduce problem behavior maintained by automatic reinforcement.

The purpose of this study was to evaluate the effectiveness of two assessment procedures for identifying the conditions under which participants would allocate their responding towards alternative stimuli to the exclusion of problem behavior maintained by automatic reinforcement. We conducted the procedures within a progressive arrangement. Both procedures followed the completion of an FA that showed problem behavior to be maintained by automatic reinforcement. We used the results of the assessments to guide treatment selection between NCR- and DR-based treatments and for predicting whether blocking would need to be added for individuals who engaged in problem behavior maintained by automatic reinforcement. The assessment model is shown in Figure 1.

We conducted this progressive assessment with five participants who showed problem behavior maintained by automatic reinforcement. We assigned participants who showed low levels of problem behavior during the NCR play condition to a treatment that provided access to preferred stimuli on an NCR schedule. We assigned participants who showed problem behavior during the NCR play condition to a preference assessment arranged to measure the participant's allocation between two potential reinforcers (alternative stimuli and automatic reinforcement) that were concurrently available but mutually exclusive (allocation between concurrent-operants assessment with blocking; COAB), similar to the contingencies associated with treatments based on DRO. We assigned participants who consistently selected at least one set of alternative stimuli over access to automatic reinforcement to a DR-based treatment (DR + RC). We evaluated the effects of both treatments via monthly probes over a 10- to 12-month period in a reversal design that directly compared the treatments to baseline.

METHOD

Participants, Settings, and Target Behaviors

Four males and one female (ages 7 to 47) with intellectual disabilities who had been initially referred to an outpatient clinic for an FA of SIB participated. Results of a 90-min brief FA showed a pattern of behavior consistent with behavior maintained by automatic reinforcement. We selected five participants who enrolled in a larger project (Berg, Ringdahl, Wacker, & Bosch, 2003) for this study because (a) they engaged in SIB that was maintained by automatic reinforcement, (b) their parent or guardian consented to their participation, and (c) they were not included in other research protocols.

All participants engaged in SIB that resulted in tissue damage, and some also engaged in other stereotypic responses that matched patterns associated with automatic reinforcement. Age, gender, diagnoses, and target behaviors for each participant are provided in Table 1.

If it appeared that tissue damage might occur, we would have ended the assessment or treatment session immediately and blocked the behavior. It was not necessary to take these measures with these participants.

We conducted all assessment and treatment sessions in treatment rooms (3.5 m by 3.5 m or 3.4 m by 3.1 m) at an outpatient service center in a large hospital. Each room contained a table, chairs, work and play materials, and a wall-mounted video camera. We selected work and play materials for each participant based on caregiver reports of activities in their home, work, or school settings and on experimenter observations.

Data Collection, Dependent Measures, and Interobserver Agreement

Data collection and dependent measures—We video recorded all sessions. Trained observers used laptop computers to collect data on three dependent variables: (a) object manipulation, (b) problem behaviors, and (c) response allocation. We defined *object manipulation*, a duration measure, as the participant making physical contact with an object without using the object to engage in problem behavior.

We assigned each target response to either a duration key (e.g., object manipulation, response allocation, repeated scratching, rubbing ears, mouthing hands) or an occurrence key (e.g., hitting head on hard surfaces, slapping head, biting self) on the laptop computer. We used a duration measure for response topographies that typically lasted 5 s or longer and a frequency measure for topographies that lasted less than 5 s. All of Dustin's response topographies were coded as duration measures, and his results are reported as percentage of session. The response topographies for the remaining participants included both duration and frequency measures. We coded the data for these participants into 5-s bins using a partial-interval method and reported those measures as percentage of intervals with object manipulation or problem behavior.

We collected response-allocation data only during the COAB. During this assessment, the room was divided into two equal halves by a strip of Velcro on the floor or by the placement of furniture (e.g., cabinets). *Response allocation* was defined as placement of the participant's body in one side of the room or the other. Observers activated one duration key when the participant's entire body was in the side of the room that contained alternative stimuli, and they activated a second duration key when the participant's entire body was in the alone side of the room. During transitions, the participant could spend part of an interval in the alone side and part of the same interval in the alternative side. Neither key was activated if the participant straddled the line. Therefore, the percentage of time allocated to the two sides of the room did not always equal 100%.

We computed reduction in problem behavior from each of the baseline conditions (alone and NCR) to the final three treatment sessions by subtracting the mean of the final three treatment sessions from the mean of the relevant baseline session, dividing the difference by the mean of the relevant baseline session, and converting the quotient to a percentage.

Interobserver agreement—We evaluated interobserver agreement by having two independent observers record the participants' behaviors. We calculated agreement scores using the interobserver reliability function in the data-collection program. We scored an agreement when the two observers recorded the same response in the same second plus or minus 2 s. We calculated agreement coefficients by dividing the number of agreements by the number of agreements plus disagreements and converting the result to a percentage. Agreement coefficients averaged 95% across participants and assessments, and mean coefficients were at or above 84% for each individual assessment or treatment evaluation and at or above 78% for each individual session.

Design

We conducted the FA and pairwise (PW) analysis using multielement designs, the COAB using a concurrent-schedules design, and the treatment evaluations using a reversal design. The baseline condition for each participant was based on the results of the PW analysis for that participant. We used the alone sessions from the FA and PW sessions as the baseline for the participant (Dustin) who fit Pattern 1 (see Figure 1). We used the NCR play sessions from the FA and the PW assessment as the baseline conditions for participants (Jordan, Kevin, Nadia, and Stephen) who fit Pattern 2 (see Figure 1). For Kevin and Stephen, we used the alone or ignore sessions from the FA and PW evaluation as an additional baseline due to inconsistent levels of problem behavior during the PW evaluation (Kevin) or the absence of a behavioral reversal during the second set of NCR probes (when Stephen primarily played with the materials appropriately).

Procedure

Preference assessment—We conducted a single-item preference assessment (Pace, Ivancic, Edwards, Iwata, & Page, 1985) each day to identify preferred stimuli to use for that day's sessions for Dustin. We presented each object once for 3 min, and we counterbalanced the order of stimulus presentation across days. We conducted multiple-item preference assessments (Roane, Vollmer, Ringdahl, & Marcus, 1998) that lasted 5 min each day for the remaining participants using a pool of items nominated by parents and staff.

Functional analysis—We conducted an FA of problem behavior based on the procedures described by Iwata et al. (1982/1994) for each participant, except that sessions lasted 5 min and a tangible condition was included. Items were available to bite (Nadia) and throw (Stephen) during FA ignore sessions. Contingencies were provided only for the target behaviors listed in Table 1 during the FA. The FA continued until we observed a consistent pattern of responding in each condition.

Pairwise analysis of NCR—The PW analysis followed the FA and consisted of the FA NCR play and FA alone or ignore conditions, which continued until the participant showed a consistent pattern of responding between the two conditions (i.e., Dustin, Nadia, and Stephen) or showed variable responding during PW NCR play sessions, suggesting that NCR play was unlikely to result in consistently low levels of problem behavior (i.e., Jordan and Kevin). There were three purposes for the PW analysis: (a) to determine if the results of the PW supported the results of the FA, (b) to provide a brief test of the effects of noncontingent access to preferred stimuli as a treatment to reduce problem behavior (i.e. NCR treatment), and (c) to assign participants to an NCR treatment (i.e., Pattern 1 in Figure 1) or to the next assessment condition (COAB; i.e., Pattern 2 in Figure 1).

Concurrent-operants assessment with blocking—We conducted four COAB conditions using procedures similar to those described for a concurrent-operants assessment in Berg et al. (2007) and Harding et al. (1999). In each condition, we evaluated the participant's preference for the reinforcer automatically produced by problem behavior compared to one of the four following alternative reinforcers: (a) attention, (b) toys, (c) attention plus toys, and (d) work. We continued the COAB until we observed consistent patterns of responding within each set of comparisons. At the start of the session, we positioned the participant in the middle of the room, which was divided in half by a Velcro strip. If the participant moved to the side of the room containing the therapist and materials, he or she was given free access to alternative stimuli but attempts at problem behavior were blocked (to prevent access to the automatic reinforcement produced by the response). If the participant moved to the empty (i.e., alone) side, we prevented access to the alternative stimuli and allowed free access to problem behavior and its automatic reinforcement (i.e., no response blocking). Two experimenters positioned themselves on the side of the room with the alternative stimuli; one blocked attempts at problem behavior and the other delivered the alternative stimuli. The participant was free to alternate between both options (i.e., could move from one side of the room to the other at any time) but could not have access to both sources of reinforcement simultaneously. We interrupted attempts to take materials into the alone side of the room by taking the materials and placing them on the side of the room with the alternative stimuli.

At the beginning of each session, an experimenter asked the participant to stand in the center of the room. The participant faced the west side of the room at the start of some sessions and faced the east side of the room for other sessions to vary the position of the alone side of the room. The experimenter provided a brief (20 s) demonstration of the stimuli available in the alternative side of the room, then stood on the alone side of the room for approximately 20 s. We counterbalanced the sequence of demonstrating the alternative stimuli and the alone sides of the room across COAB sessions. Following the demonstration, we allowed the participant to enter either side of the room. One experimenter did not interact with the participant except to block problem behavior while the participant was in the alternative side of the room (i.e., the experimenter did not look at the participant's face, did not talk, and did not touch the participant other than to block problem behavior). The other experimenter provided at least one vocal reminder of the options available on both sides of the room during each session. We presented each COAB comparison condition at least twice to each participant ($M = 3$, range, 2 to 6 sessions). Each COAB session lasted 5 min.

The COAB assessed the relative value of behavior maintained by automatic reinforcement compared to different sets of alternative stimuli. If the participant consistently allocated his or her responding to the alternative stimuli over the automatic reinforcement produced by problem behavior, then that set of alternative stimuli would be more preferred (Fisher & Mazur, 1997; Fisher, et al., 1992) than the automatic reinforcers associated with problem behavior and might be effective at reducing problem behavior when used in a DR schedule. We assigned participants who chose at least one set of alternative stimuli over problem behavior during the COAB (i.e., Pattern 2 on Figure 1) to a DR treatment with a response cost for problem behavior (DR + RC). We provided access to the preferred alternative stimuli contingent on an appropriate response and the absence of problem behavior during the DR + RC treatment. This treatment was similar to the COAB in that we provided access to either potential reinforcer (i.e., alternative stimuli or problem behavior maintained by automatic reinforcement) concurrently, but we prevented participants from accessing both sources of reinforcement at the same time.

Treatment—We used the results of the PW evaluation and COAB to assign a treatment to each participant. Treatment continued until the participant completed a minimum of 10 months of monthly treatment observations (*M* = 11 months). For Jordan, Nadia, and Stephen, an experimenter conducted the initial treatment sessions with the caregiver in the room and then coached the caregiver as she conducted the treatment and reversal sessions. The caregivers for Dustin and Kevin chose to observe the treatment and reversal sessions from an observation room while an experimenter described the conditions. We asked each caregiver to continue the treatment in the participant's residential setting on a daily basis. We evaluated the effects of the assigned treatments via probes conducted during monthly follow-up visits. We conducted a minimum of two 5-min probes during each follow-up visit.

Noncontingent reinforcement (NCR)—Dustin showed minimal problem behavior during the FA and PW NCR play sessions; we therefore assigned him to an NCR treatment. We provided attention and preferred stimuli identified during the preference assessment throughout the NCR treatment sessions independent of his behavior. We did not block problem behavior. We conducted reversals to the alone condition in the same manner as the FA and PW alone sessions.

Differential reinforcement with response cost (DR + RC)—The remaining participants showed an undifferentiated pattern of responding during the PW assessment and consistently allocated responding to at least one set of alternative stimuli during the COAB. We assigned these participants to a DR + RC treatment. We selected the set of alternative stimuli to which the participant allocated the highest percentage of time, and with the highest percentage of object manipulation during the COAB, as the alternative reinforcer for that participant. During the DR + RC treatment, we provided access to the alternative reinforcer contingent on an appropriate response and the absence of problem behavior. The appropriate response for Jordan and Stephen was to make an appropriate response with a neutral toy (e.g., place a toy car on a ramp; press a button on an electronic book). The appropriate response for Kevin was to extend his hand without showing problem behavior when the therapist offered the alternative stimuli, and the appropriate response for Nadia was to make the manual sign for "please."

We used a three-step prompting procedure (verbal, gestural, physical) to prompt the participant to complete the appropriate response at the start of each treatment session. If he or she completed the response with or without physical prompting, we provided access to the alternative reinforcer identified during the COAB. The participant maintained access to the reinforcer until problem behavior occurred or the session ended. Problem behavior resulted in removal of the reinforcer for approximately 20 s to 30 s (Jordan, Kevin, and Stephen) or 10 s (Nadia), followed by a prompt for the appropriate response. If problem behavior continued beyond the 30-s interval, the experimenter waited until 5 s elapsed without problem behavior before initiating the prompt for the appropriate response. We did not block problem behavior during the DR + RC treatment. However, if Nadia hit herself with an item or Stephen threw an item, we withheld access to that item for 10 s (Nadia) or 20 s (Stephen) as the RC component. The participant continued to have access to other items in their hands or in the room. We conducted a reversal to the NCR baseline with each participant.

We conducted NCR reversals sessions during the 6th month for Jordan, the 10th month for Kevin, the 5th and 10th months for Nadia, and the 3rd and 7th months for Stephen. We conducted a reversal to the FA and PW alone condition during the 9th month for Kevin and Stephen.

RESULTS

Assessment

Preference assessment—Across the preference assessments, we presented a total of 17 items for Dustin, Jordan, and Stephen and 16 items for Kevin and Nadia. We identified (a) six items as preferred objects for Dustin (i.e., frog toy, red ring, string ball, strobe light, vibrating tube, and vibrating switch), (b) eight items for Jordan (i.e., bus, cars, fiber light, karaoke, keyboard, music book, musical toy, and snake toy), (c) eight items for Kevin (i.e., ABC pad, books, Bop It, clicker toy, squeak toy, steering wheel, string ball, and vibrating tubes), (d) seven items for Nadia (i.e., bells, lady bug toy, maraca, spin ball, square rattle, triangle rattle, and tambourine), and (e) nine items for Stephen (i.e., ball, blocks, books, car ramp, cars, pop-up toy, puzzles, shape sorter, and spin toy).

Functional analysis—FA results (see the top left panels of Figures 2, 3, 4, 5, and 6) indicated that automatic reinforcement maintained problem behavior, at least in part, for each participant. We identified an automatic reinforcement function when problem behavior was elevated in the alone or ignore condition in comparison to the remaining conditions (differentiated responding; Dustin) or when problem behavior occurred in both the alone and NCR play conditions (undifferentiated responding; Jordan, Kevin, Nadia, and Stephen).

One participant, Dustin (Figure 2, top) showed a differentiated pattern of responding with high levels of problem behavior during the alone sessions ($M = 85\%$ of the session) and very low levels of problem behavior during the NCR play sessions ($M = 0.3\%$ of the session). He showed low levels of problem behavior during the remaining FA sessions. Problem behavior ranged from 0% of the session during the escape sessions to a mean of 10% of the session during the tangible sessions.

The remaining four participants showed problem behavior during every FA condition. Jordan (Figure 3, top) showed similar levels of problem behavior in all FA conditions: *M*s = 20%, 39%, 20%, 28%, and 35% of the intervals during the ignore, NCR play, escape, tangible, and attention conditions, respectively. Kevin (Figure 4, top) showed higher levels of problem behavior during the alone condition ($M = 44\%$ of the intervals) than during the remaining conditions: *M*s = 26%, 24%, 20%, and 31% of the intervals during the NCR play, escape, tangible, and attention conditions, respectively. Nadia (Figure 5, top) showed the broadest range of problem behavior across FA conditions: *M*s = 64%, 88%, 70%, 78%, and 87% of the intervals during the ignore, NCR play, escape, tangible, and attention conditions, respectively. Stephen's FA results (Figure 6, top) showed a narrow range of scores for all but the escape condition: *M*s = 16%, 25%, 7%, 23%, and 26% of the intervals during the ignore, NCR play, escape, tangible, and attention sessions, respectively.

Participants had free access to problem behavior maintained by automatic reinforcement and free access to object manipulation during the NCR play sessions, and the four participants accessed both reinforcers during these sessions. Object manipulation occurred during the FA NCR play session: *M*s = 54%, 76%, 91%, and 64% of the intervals for Jordan, Kevin, Nadia, and Stephen, respectively (see open diamonds on bottom panels of Figures 3, 4, 5, and 6, respectively).

Pairwise analysis—The results of the PW NCR play and alone or ignore conditions are shown in the top right panels of Figures 2, 3, 4, 5, and 6. Dustin continued to show a differentiated pattern of responding during the PW analysis, with high levels of problem behavior during the PW alone sessions (*M* = 63% of the session) and low levels of problem behavior during the PW NCR play sessions (*M* = 0.2% of the session).

Jordan, Nadia, and Stephen continued to show problem behavior during the PW NCR play sessions (*M*s = 36%, 81%, and 28% of the intervals for Jordan, Nadia, and Stephen, respectively). Kevin showed lower levels of problem behavior during four of the eight PW NCR play sessions (*M* = 11% of the intervals) than during the FA NCR play sessions (*M* = 26% of the intervals). Each of the four participants continued to show problem behavior during the PW alone or ignore sessions (*M*s = 12%, 37%, 63%, and 28% of the intervals during the PW alone or ignore sessions for Jordan, Kevin, Nadia, and Stephen, respectively). Although Kevin showed differentiation between the alone and NCR play conditions during the PW assessment, problem behavior continued to occur during the NCR play condition, with an increase in problem behavior to 42% of the intervals during the final session (Session 32).

The PW NCR play sessions served as an initial test of the effects of an NCR treatment on the occurrence of problem behavior for each participant. The results suggested that noncontingent access to preferred tangible items and attention would be an effective treatment to reduce problem behavior for Dustin, so he was assigned to an NCR-based treatment. The remaining participants continued to show problem behavior during the PW NCR sessions. These results suggested that noncontingent access to preferred items and attention would not be sufficient to reduce problem behavior for these participants, and we assigned each participant to the COAB to identify stimuli that might compete with problem behavior when we required the participants to choose between sets of alternative stimuli and access to problem behavior associated with automatic reinforcement.

Concurrent-operants assessment with blocking—We conducted the COAB with Jordan, Kevin, Nadia, and Steven (see middle panels of Figures 3, 4, 5, and 6), which identified at least one set of alternative stimuli that the participant allocated more of his or her time to than he or she allocated to the alone side of the room. Jordan (Figure 3, middle) allocated more time to the side of the room that contained attention plus preferred toys (*M* = 65%) than to the alone side (*M* = 35%) or to any other alternative stimuli. Jordan also showed the highest level of object manipulation in the attention-plus-toys side of the room

(*M* = 57% of the intervals). Therefore, we selected access to attention and preferred toys as the alternative reinforcer for Jordan for the DR + RC treatment.

Kevin (Figure 4) allocated more time to the toys-only side of the room (*M* = 95%) than to the alone side of the room (*M* = 0.3%) or to any other alternative stimuli, and he also showed the highest level of object manipulation (*M* = 90% of the intervals) when on the toys-only side of the room. Therefore, we selected access to toys without attention as the alternative reinforcer for Kevin.

Nadia (Figure 5) showed a similar pattern of responding. She allocated more time to the toys-only side of the room (*M* = 89%) than to the alone side of the room (*M* = 10%) or to any other alternative stimuli. She showed the highest percentage of object manipulation (*M* = 74% of the intervals) on the toys-only side of the room compared to the remaining alternatives, and we selected access to toys without attention as the alternative reinforcer for Nadia.

Stephen (Figure 6) allocated most of his time to the attention-plus-toys and toys-only sides of the room (*M*s = 98% and 100%, respectively), and he displayed more object manipulation in the attention-plus-toys alternative (*M* = 35% of the intervals) than in the toys-only alternative (*M* = 19% of the intervals). Therefore, we selected attention plus toys as the alternative reinforcer for the DR + RC treatment.

Treatment

NCR treatment results—We used the FA and PW alone sessions as the baseline for the NCR treatment for Dustin (Figure 2, bottom), and he showed high levels of problem behavior during these sessions (*M* = 68%). With the onset of the NCR treatment, problem behavior immediately decreased to the low levels observed during the PW NCR play sessions. We conducted a reversal to baseline and problem behavior immediately increased (*M* = 63%). When we reintroduced the NCR treatment, problem behavior immediately decreased to the levels observed during the PW NCR play sessions. After 10 months of treatment, Dustin displayed low levels of problem behavior (*M* = 2% during the final three treatment sessions), for a 97% reduction in problem behavior.

DR + RC treatment results—The bottom panels of Figures 3, 4, 5, and 6 depict the results of the DR + RC treatment evaluations for Jordan, Kevin, Nadia, and Stephen, respectively. Object-manipulation data are shown for the NCR play baseline and reversal sessions.

With the introduction of the DR + RC treatment, Jordan showed a decrease in problem behavior (from *M* = 37% during the NCR baseline and *M* = 20% during the ignore baseline to *M* = 7% during the first 5 months of treatment). When we withdrew the treatment, problem behavior increased and became more variable (*M* = 21%). When we reintroduced the DR + RC treatment, problem behavior again decreased to low levels (*M* = 6%) across the remaining 5 months of treatment. After 10 months of treatment, Jordan displayed low levels of problem behavior (*M* = 0.7% during the final three treatment sessions), for a 98% reduction in problem behavior from the NCR play baseline and a 96% reduction from the alone or ignore baseline. Object manipulation occurred for a mean of 51% of the intervals during the NCR play baseline sessions and for a mean of 53% of the intervals during the NCR play reversal.

Kevin showed variable but decreasing levels of problem behavior with the introduction of the DR + RC treatment (from M = 16% during the NCR baseline and M = 40% during the alone baseline to M = 12% over the first 8 months of treatment). After four consecutive treatment sessions with no instances of problem behavior (Sessions 60 to 63), we conducted a reversal to the alone baseline condition. Problem behavior immediately increased (M = 68%) for these two sessions. We reintroduced DR + RC, and problem behavior decreased (M = 10% for the remaining treatment sessions). We conducted a reversal to the baseline NCR condition during the last month of treatment and problem behavior increased (M = 20%). The DR + RC treatment was not resumed because Kevin's participation in the project ended. He engaged in low levels of problem behavior (M = 5% for the final three treatment sessions), resulting in a 69% reduction in problem behavior from the NCR play baseline and an 88% reduction in problem behavior from the alone baseline. Object manipulation occurred for a mean of 95% of the intervals during the NCR play baseline sessions and for a mean of 74% of the intervals during the NCR play reversal. Object manipulation showed a sharp decrease (50% of the intervals) during the final NCR play reversal session.

Nadia showed a reduction in problem behavior (from M = 84% during the NCR play baseline condition and M = 63% during the ignore baseline to M = 30% during the first 5 months of treatment). When we withdrew the treatment and returned to the NCR baseline condition, problem behavior immediately increased (M = 92%). When we reintroduced DR + RC, problem behavior decreased but remained somewhat variable (M = 28%; range, 5% to 52%). When we conducted another reversal to the NCR baseline, problem behavior increased again (M = 95%). When we reintroduced DR + RC, problem behavior immediately decreased but continued to show some variability (M = 21%; range, 8% to 33%). Problem behavior occurred for a mean of 21% during the last three treatment sessions for an overall reduction of 75% from the baseline NCR play sessions and 67% from the baseline alone sessions. Nadia showed high levels of object manipulation across the NCR play baseline sessions (M = 92% of the intervals), the first NCR play reversal sessions (M = 96% of the intervals), and the second NCR play reversal sessions (M = 78% of the intervals).

Stephen showed a decrease in problem behavior (from M = 27% during the NCR play baseline and M = 25% during the ignore baseline to M = 8% during the first 4 months of treatment). When we withdrew the treatment, problem behavior increased (M = 34%). Reintroduction of DR + RC decreased problem behavior again (M = 5%). Another reversal to the NCR play baseline was conducted, but problem behavior did not increase (M = 2.5% of the intervals). We conducted a series of four alone sessions with toys to determine if Stephen would show problem behavior when an adult was not in the room with him. Problem behavior increased somewhat (M = 13%), but object manipulation remained high (M = 84%) during the alone-with-toys sessions. When we reintroduced the DR + RC treatment, problem behavior decreased immediately (M = 1.7% of the intervals during the last three treatment sessions), resulting in a 94% reduction in problem behavior from the NCR play baseline and a 92% reduction in problem behavior from the ignore baseline.

Stephen showed increasing levels of object manipulation in the NCR play baseline sessions (*M* = 55% of the intervals), the first NCR play reversal sessions (*M* = 63% of the intervals), and the final NCR play reversal sessions (*M* = 94% of the intervals).

In summary, results of the PW assessment suggested that noncontingent access to preferred leisure items would not be sufficient to reduce problem behavior for Jordan, Stephen, and Nadia. The PW NCR produced somewhat mixed results for Kevin and suggested that an NCR-based treatment might be effective in reducing problem behavior, but given the increase in problem behavior during the final PW NCR play session, Kevin was assigned to the COAB. The COAB identified at least one set of alternative reinforcers that each participant preferred over the automatic reinforcement produced by problem behavior (i.e., higher durations of allocation to the side of the room with the alternative reinforcers). We used the alternative reinforcer with the greatest allocation or object manipulation during the COAB as the reinforcer within DR + RC treatment, which reduced problem behavior for all four participants. In addition, each of the participants showed appropriate object manipulation (*M* = 75%; range, 53% to 95%) during the NCR play baseline and during the final NCR reversal sessions (*M* = 74%; range, 53% to 94%).

DISCUSSION

The participants in the current study had a long history of SIB (at least 2 years), and some also showed stereotypy that interfered with their participation in educational and leisure activities. We used results from a progressive set of assessments to identify (a) alternative reinforcers that would compete with problem behavior maintained by automatic reinforcement, and (b) the reinforcement schedule (i.e., NCR or DR + RC) under which the reinforcers would effectively compete with problem behavior without the use of response blocking during a reinforcement-based treatment. The treatments resulted in clinically significant reductions in problem behavior over a 10- to 12-month period for each participant.

This evaluation yielded two broad findings. First, results of the PW assessment largely matched those of the FA and also predicted which participant would show greater and lesser decreases in problem behavior during an NCR-based treatment. Dustin showed very low levels of problem behavior during FA and PW NCR play sessions and continued to show low levels of problem behavior during the subsequent NCR treatment. The remaining participants showed problem behavior and object manipulation during the FA and PW NCR play sessions and continued to access both reinforcers during subsequent probes to the NCR treatment, with the exception of the second set of reversal probes for Stephen. The match between the FA and PW results suggests that a PW comparison between alone and NCR play conditions could be a useful first step for evaluating behaviors hypothesized to be maintained by automatic reinforcement, and could be informative for selecting initial treatment components.

Second, the results suggest that response allocation between two potential reinforcers can be influenced by the reinforcement schedules used during preference assessments and treatments. The reinforcement schedule (NCR, concurrent schedule, and DR + RC) conducted during the assessment and treatment conditions affected the competition between access to alternative stimuli and access to problem behavior maintained by automatic reinforcement. We identified reinforcers that competed with problem behavior for Dustin during single-item preference assessments in which access to the alternative stimuli and access to problem behavior were available simultaneously and without restriction (NCR schedule; Pattern 1). The same reinforcers and schedule were effective in maintaining low levels of problem behavior for Dustin during a subsequent NCR treatment.

Stimuli identified as preferred during a free-operant preference assessment did not function as effective competing stimuli during subsequent NCR sessions for Jordan, Kevin, Nadia, and Stephen; these participants accessed both sources of reinforcement during the NCR sessions. Previous studies have shown that some participants who showed problem behavior maintained by automatic reinforcement during NCR conditions showed reductions in problem behavior when a response cost or time-out was added to the NCR treatment (e.g., Falcomata et al., 2004; Vollmer et al., 1994; Watkins & Rapp, 2014). The addition of the response cost or time-out prevented the participants from maintaining access to both sets of reinforcers simultaneously, thereby requiring them to choose between the two reinforcers. The participants in these studies allocated responding toward the alternative stimuli (relative to the automatic reinforcement produced by problem behavior), indicating that they preferred the alternative reinforcers to the automatic reinforcers.

In the current study, the preferred stimuli and problem behavior were available concurrently during the COAB and DR + RC treatment, but allocation toward one potential reinforcer precluded access to the other reinforcer (via blocking during the COAB and response cost during DR + RC). The COAB was useful for identifying alternative stimuli that were more preferred than the automatic reinforcers that maintained problem behavior (Pattern 2). We used the preferred stimuli identified during the COAB as reinforcers during DR + RC, which reduced problem behavior maintained by automatic reinforcement without the use of response blocking. Jordan and Stephen showed consistent reductions in problem behavior during the DR + RC treatment sessions compared to the NCR play sessions. For these two participants, the stimuli identified during the COAB functioned as competing stimuli within the contingencies used during DR + RC treatment. Kevin and Nadia also showed clinically significant reductions in problem behavior (69% reduction for Kevin and 75% reduction for Nadia), but problem behavior remained somewhat variable throughout treatment. The degree to which the preferred stimuli identified in the COAB consistently functioned as competing stimuli during the DR + RC treatment for Kevin and Nadia may be debatable.

One potential limitation of the current study was that we did not measure problem behavior during the initial preference assessments, which included 16 or 17 items for each participant. Previous research has shown that measuring both item interaction and problem behavior, as is typically done in a competing stimuli assessment (e.g., Piazza et al., 1998; Shore et al., 1997), can often identify stimuli that effectively compete with automatic reinforcement. However, when we provided free access to these items and the automatic reinforcement produced by problem behavior during the NCR play condition, we observed unacceptably high levels of problem behavior for four of the participants (all except Dustin). It is possible that the addition of more stimuli during the preference assessment would have resulted in the identification of items associated with high levels of object manipulation and minimal levels of problem behavior during the subsequent FA and PW sessions.

We elected to pursue the COAB to determine if we could identify stimuli that were relatively more preferred than problem behaviors associated with automatic reinforcement. As discussed by Fisher and Mazur (1997), an assessment of response allocation between two concurrent operants puts two potential reinforcers in direct competition with each other. The participant's allocation between the two reinforcers provides a direct measure of the relative value of each reinforcer. In this study, the COAB provided a method for identifying stimuli that participants preferred over the automatic reinforcement produced by problem behavior. The COAB also provided a comparison of the relative value of a broader range of potential reinforcers (i.e., social reinforcers) and reinforcers associated with problem behavior than previous evaluations. The alternative reinforcers evaluated during the COAB included adult attention, preferred items (with and without attention), and attention paired with work tasks. Previous research has focused primarily on the competition between tangible items and automatic reinforcers.

Another potential limitation of the current investigation is the lack of recurrence of problem behavior during the final NCR play reversal for Stephen and relatively low levels of problem behavior during the NCR play reversal for Kevin. The second NCR play reversal sessions for Stephen occurred during the 7th month of treatment, and we observed near-zero levels of problem behavior. He showed consistent increases in appropriate object manipulation across the FA and PW NCR play sessions (M = 55%), the first NCR play reversal condition (M = 63%), and the final NCR play reversal condition (M = 94% of the intervals). Problem behavior increased when the therapist left the room during the alone sessions with toys, but he continued to display high levels of object manipulation (M = 84%). Stephen's results suggest that appropriate object manipulation had become more preferred than the behaviors associated with automatic reinforcement by the 7th month of treatment. These results are similar to those discussed in Nevin and Wacker (2013).

Kevin showed increased problem behavior during a reversal to the FA alone condition but a much smaller increase during a reversal to the NCR play condition. Thus, it is possible that treatment of Kevin's problem behavior with NCR play would have produced comparable reductions in problem behavior (relative to DR + RC) had we implemented NCR play throughout the 10-month treatment period. Nevertheless, based on the data we have, the DR + RC treatment produced a 69% reduction in problem behavior relative to the FA and PW NCR play sessions.

Falcomata et al. (2004) paired a response cost with an NCR schedule and produced larger reductions in vocal stereotypy than NCR alone. In the current study, we paired a response cost with a DR treatment to reduce problem behavior and achieved similar results. Use of the DR schedule had clinical appeal because the participants practiced an appropriate response to gain access to the alternative stimuli. Results from Falcomata et al. and the current study suggest that the contingencies required to maintain access to preferred stimuli may be as (or even more) important than the contingencies for gaining access to those same stimuli when one develops treatments for reducing problem behavior.

Hagopian et al. (2015) conducted a retrospective analysis of assessment and treatment results for 39 participants who received evaluations for SIB maintained by automatic reinforcement, and used the results of the analyses to identify three subtypes for automatic reinforcement. As in the current study, Hagopian et al. (2015) used differentiation in levels of problem behavior between the FA alone and NCR play sessions to predict the effectiveness of NCR-based treatments for reducing problem behavior maintained by automatic reinforcement. In both studies, noncontingent access to preferred alternative stimuli (NCR-based treatment) was sufficient to achieve consistent reductions in problem behavior for participants who showed relatively high levels of problem behavior during the FA alone sessions and very low levels of problem behavior during the NCR sessions (Subtype 1 for Hagopian et al., 2015, and Pattern 1 for the current study). This pattern of responding replicates the findings reported by Lindberg et al. (2003), Rapp (2007), Ringdahl et al. (1997), and Shore et al. (1997).

Participants who engaged in problem behavior during the FA NCR sessions were assigned to Subtype 2 or Subtype 3 according to the presence (Subtype 3) or absence (Subtype 2) of self-restraint in Hagopian et al. (2015). These authors hypothesized that behaviors that continued in the presence of alternative stimuli (i.e., NCR conditions) were less sensitive to changes in their environment and would require more intensive treatment components than behaviors that decreased in the presence of alternative stimuli to achieve an 80% reduction in the behaviors. The results of their analysis supported this hypothesis. Participants in Subtype 2 were assigned to treatments that included reinforcement supplemented by response blocking, restraint, punishment, or some combination; Participants in Subtype 3 were assigned to treatments with restraint or protective equipment.

The behaviors that fit Pattern 2 in the current study appear to represent a different category of automatically maintained problem behavior than the behaviors with Subtypes 1, 2, or 3 in Hagopian et al. (2015). The behaviors that fit Pattern 2 (current study) were sensitive to changes in their environment (i.e., reinforcement contingencies and loss of preferred alternative stimuli), as evidenced by the reductions in automatically reinforced problem behavior during DR + RC and resurgence of the same behaviors during the NCR reversal sessions. The DR + RC treatment resulted in reductions in automatically maintained behavior without blocking the participant's access to automatic reinforcement.

In the current study, participants with automatically reinforced problem behavior that occurred during the FA and PW NCR sessions were assigned to the COAB. Participants that allocated responding to at least one set of alternative stimuli rather than problem behavior were assigned to the DR + RC (Pattern 2). Participants who selected automatic reinforcement rather than each set of alternative stimuli during the COAB (Pattern 3) were assigned to a reinforcement treatment with response blocking (see Figure 1), similar to the participants in Subtype 2 in Hagopian et al. (2015).

Based on the information provided in Hagopian et al. (2015), it appears that participants with Subtypes 2 and 3 may have been exposed to a competing stimuli assessment but were not exposed to a preference assessment that required choosing between access to alternative stimuli and access to automatic reinforcement (e.g., COAB). It is possible that such an assessment might identify at least one set of stimuli that could compete with automatic reinforcement when it is presented in a response-dependent treatment for some participants with Subtypes 2 or 3. These results would match Pattern 2 of the current study and could potentially reduce the need for treatment components that prevent access to automatic reinforcement via blocking, protective equipment, and restraint.

Additional research is needed to determine if varying the contingencies for obtaining access to alternative stimuli during the preference assessment would be informative for treatment selection. For example, Hagopian et al. (2015) suggested that comparing the amount of work a participant would complete to gain access to automatic reinforcement might provide information on the relative potency of automatic reinforcement compared to alternative stimuli. Additional research is also needed to evaluate the application of the progressive model of assessment evaluated in the current study to participants who engage in problem behavior maintained by automatic reinforcement and self-restraint (Subtype 3 in Hagopian et al., 2015).

The long-term effects of treatments to reduce problem behavior maintained by automatic reinforcement have not been adequately studied. The current study provided a long-term evaluation of the effects of an NCR treatment and a DR + RC treatment ($M = 11$ months of treatment) on the occurrence of problem behavior maintained by automatic reinforcement for five participants. Both treatments resulted in relatively quick and long-term reductions in problem behavior, but these reductions were maintained only in the treatment conditions. As evidenced by the quick increase in problem behavior during the initial reversal to baseline for all participants, the targeted problem behavior remained in each participant's repertoire following months of treatment. For example, although the targeted problem behaviors for Dustin appeared to have little response strength in the context of preferred alternative stimuli, it returned to baseline levels within 5 min after the removal of the preferred stimuli during the reversal to the alone condition. These results highlight the need for further analyses of different patterns of responding for behavior maintained by automatic reinforcement and long-term maintenance of reinforcement-based treatment effects on severe problem behavior maintained by automatic reinforcement.

Acknowledgments

This project was supported in part by Grant R01HD042813 from the National Institute of Child Health and Human Development of the National Institutes of Health. The opinions expressed do not necessarily reflect the position or policy of that agency. We thank the families who participated in this study and Agnes DeRaad for manuscript preparation.

References

Berg, WK.; Ringdahl, JE.; Wacker, DP.; Bosch, JA. Competing stimuli and automatic reinforcement. National Institutes of Health & Human Services; 2003. Award No. 5 R01 HD042813-03

Berg WK, Wacker DP, Cigrand K, Merkle S, Wade J, Henry K, Wang YC. Comparing functional analysis and paired-choice assessment results in classroom settings. Journal of Applied Behavior Analysis. 2007; 40:545–552. DOI: 10.1901/jaba.2007.40-545 [PubMed: 17970268]

Falcomata TS, Roane HS, Hovanetz AN, Kettering TL, Keeney KM. An evaluation of response cost in the treatment of inappropriate vocalizations maintained by automatic reinforcement. Journal of Applied Behavior Analysis. 2004; 37:83–87. DOI: 10.1901/jaba.2004.37-83 [PubMed: 15154219]

Fischer SM, Iwata BA, Mazaleski JL. Noncontingent delivery of arbitrary reinforcers as treatment for self-injurious behavior. Journal of Applied Behavior Analysis. 1997; 30:239–249. DOI: 10.1901/jaba.1997.30-239 [PubMed: 9210304]

Fisher WW, Mazur JE. Basic and applied research on choice responding. Journal of Applied Behavior Analysis. 1997; 30:387–410. DOI: 10.1901/jaba.1997.30-387 [PubMed: 9316255]

Fisher WW, Piazza CC, Bowman LG, Hagopian LP, Owens JC, Slevin I. A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. Journal of Applied Behavior Analysis. 1992; 25:491–498. DOI: 10.1901/jaba.1992.25-491 [PubMed: 1634435]

Goh HL, Iwata BA, Shore BA, DeLeon IG, Lerman DC, Ulrich SM, Smith RG. An analysis of the reinforcing properties of hand mouthing. Journal of Applied Behavior Analysis. 1995; 28:269–283. DOI: 10.1901/jaba.1995.28-269 [PubMed: 7592144]

Hagopian LP, Rooker GW, Zarcone JR. Delineating subtypes of self-injurious behavior maintained by automatic reinforcement. Journal of Applied Behavior Analysis. 2015; 48:523–543. DOI: 10.1002/jaba.233 [PubMed: 26223959]

Harding JW, Wacker DP, Berg WK, Cooper LJ, Asmus J, Mlela K, Muller J. An analysis of choice making in the assessment of young children with severe behavior problems. Journal of Applied Behavior Analysis. 1999; 32:63–82. DOI: 10.1901/jaba.1999.32-63 [PubMed: 10201104]

Iwata BA, Dorsey MF, Slifer KJ, Bauman KE, Richman GS. Toward a functional analysis of self-injury. Journal of Applied Behavior Analysis. 1994; 27:197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2*, 3–20, 1982). DOI: 10.1901/jaba.1994.27-197 [PubMed: 8063622]

Lindberg JS, Iwata BA, Roscoe EM, Worsdell AS, Hanley GP. Treatment efficacy of noncontingent reinforcement during brief and extended application. Journal of Applied Behavior Analysis. 2003; 36:1–19. DOI: 10.1901/jaba.2003.36-1 [PubMed: 12723863]

Mason SA, Iwata BA. Artifactual effects of sensory-integrative therapy on self-injurious behavior. Journal of Applied Behavior Analysis. 1990; 23:361–370. DOI: 10.1901/jaba.1990.23-361 [PubMed: 2249971]

Nevin, JA.; Wacker, DP. Response strength and persistence. In: McMadden, GJ., editor. APA handbook of behavior analysis: Vol. 2. Translating principles into practice. Washington, DC: American Psychological Association; 2013. p. 109-128.

Pace GM, Ivancic MT, Edwards GL, Iwata BA, Page TJ. Assessment of stimulus preference and reinforcer value with profoundly retarded individuals. Journal of Applied Behavior Analysis. 1985; 18:249–255. DOI: 10.1901/jaba.1985.18-249 [PubMed: 4044458]

Piazza CC, Fisher WW, Hanley GP, Hilker K, Derby KM. A preliminary procedure for predicting the positive and negative effects of reinforcement-based procedures. Journal of Applied Behavior Analysis. 1996; 29:137–152. DOI: 10.1901/jaba.1996.29-137 [PubMed: 8682733]

Piazza CC, Fisher WW, Hanley GP, LeBlanc LA, Worsdell AS, Lindauer SE, Keeney KM. Treatment of pica through multiple analyses of its reinforcing functions. Journal of Applied Behavior Analysis. 1998; 31:165–189. DOI: 10.1901/jaba.1998.31-165 [PubMed: 9652098]

Piazza CC, Hanley GP, Fisher WW. Functional analysis and treatment of cigarette pica. Journal of Applied Behavior Analysis. 1996; 29:437–450. DOI: 10.1901/jaba.1996.29-437 [PubMed: 8995829]

Querim AC, Iwata BA, Roscoe EM, Schlichenmeyer KJ, Virués Ortega J, Hurl KE. Functional analysis screening for problem behavior maintained by automatic reinforcement. Journal of Applied Behavior Analysis. 2013; 46:47–60. DOI: 10.1002/jaba.26 [PubMed: 24114084]

Rapp JT. Further evaluation of methods to identify matched stimulation. Journal of Applied Behavior Analysis. 2007; 40:73–88. DOI: 10.1901/jaba.2007.142-05 [PubMed: 17471794]

Ringdahl JE, Vollmer TR, Marcus BA, Roane HS. An analogue evaluation of environmental enrichment: The role of stimulus preference. Journal of Applied Behavior Analysis. 1997; 30:203–216. DOI: 10.1901/jaba.1997.30-203

Roane HS, Vollmer TR, Ringdahl JE, Marcus BA. Evaluation of a brief stimulus preference assessment. Journal of Applied Behavior Analysis. 1998; 31:605–620. DOI: 10.1901/jaba.1998.31-605 [PubMed: 9891397]

Roscoe EM, Iwata BA, Zhou L. Assessment and treatment of chronic hand mouthing. Journal of Applied Behavior Analysis. 2013; 46:181–198. DOI: 10.1002/jaba.14 [PubMed: 24114093]

Shore BA, Iwata BA, DeLeon IG, Kahng S, Smith RG. An analysis of reinforcer substitutability using object manipulation and self-injury as competing responses. Journal of Applied Behavior Analysis. 1997; 30:21–41. DOI: 10.1901/jaba.1997.30-21 [PubMed: 9103985]

Vollmer TR. The concept of automatic reinforcement: Implications for behavioral research in developmental disabilities. Research in Developmental Disabilities. 1994; 15:187–207. DOI: 10.1016/0891-4222(94)90011-6 [PubMed: 7938787]

Vollmer TR, Marcus BA, LeBlanc L. Treatment of self-injury and hand mouthing following inconclusive functional analyses. Journal of Applied Behavior Analysis. 1994; 27:331–344. DOI: 10.1901/jaba.1994.27-331 [PubMed: 8063632]

Watkins N, Rapp JT. Environmental enrichment and response cost: Immediate and subsequent effects on stereotypy. Journal of Applied Behavior Analysis. 2014; 47:186–191. DOI: 10.1002/jaba.97 [PubMed: 24424774]

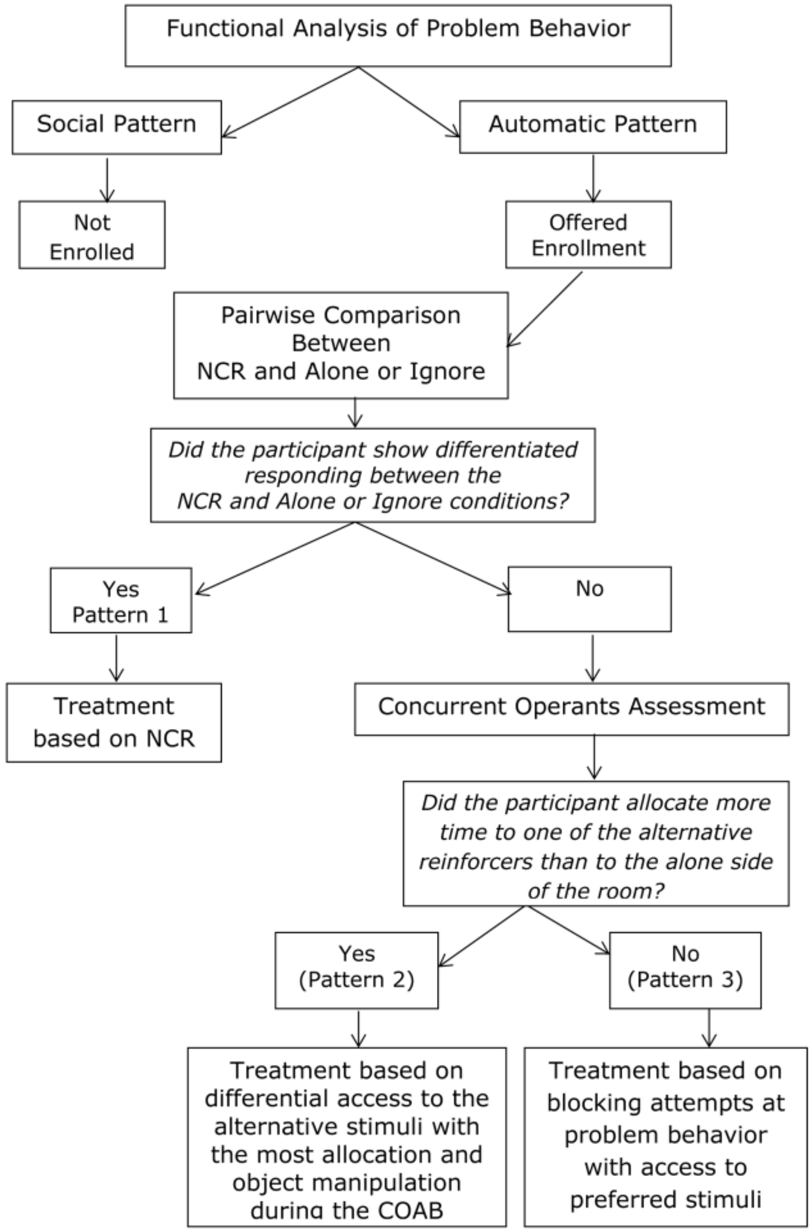

Figure 1.
Flow chart for integrated model.

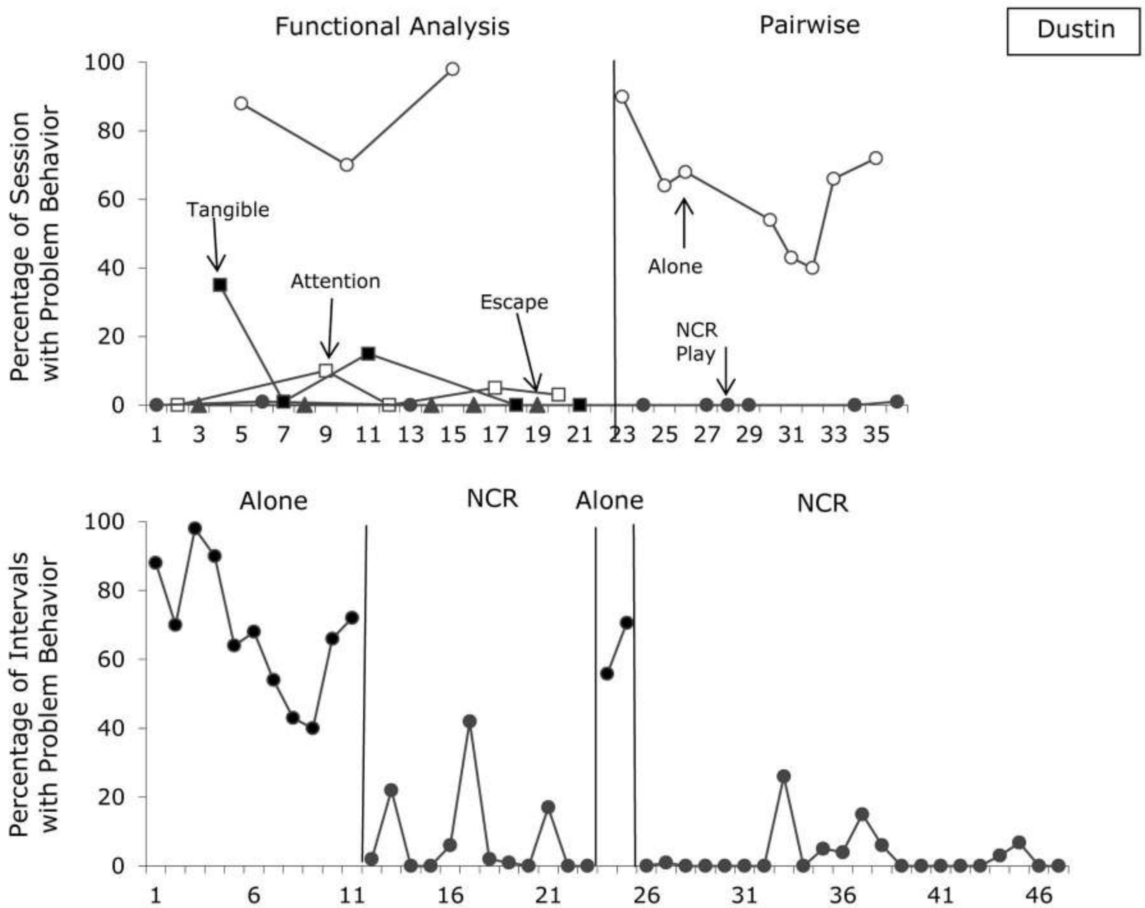

Figure 2.

The top panel shows the percentage of session with problem behavior during the functional analysis and pairwise analysis for Dustin. The bottom panel shows the percentage of session with problem behavior during the alone and NCR treatment evaluations.

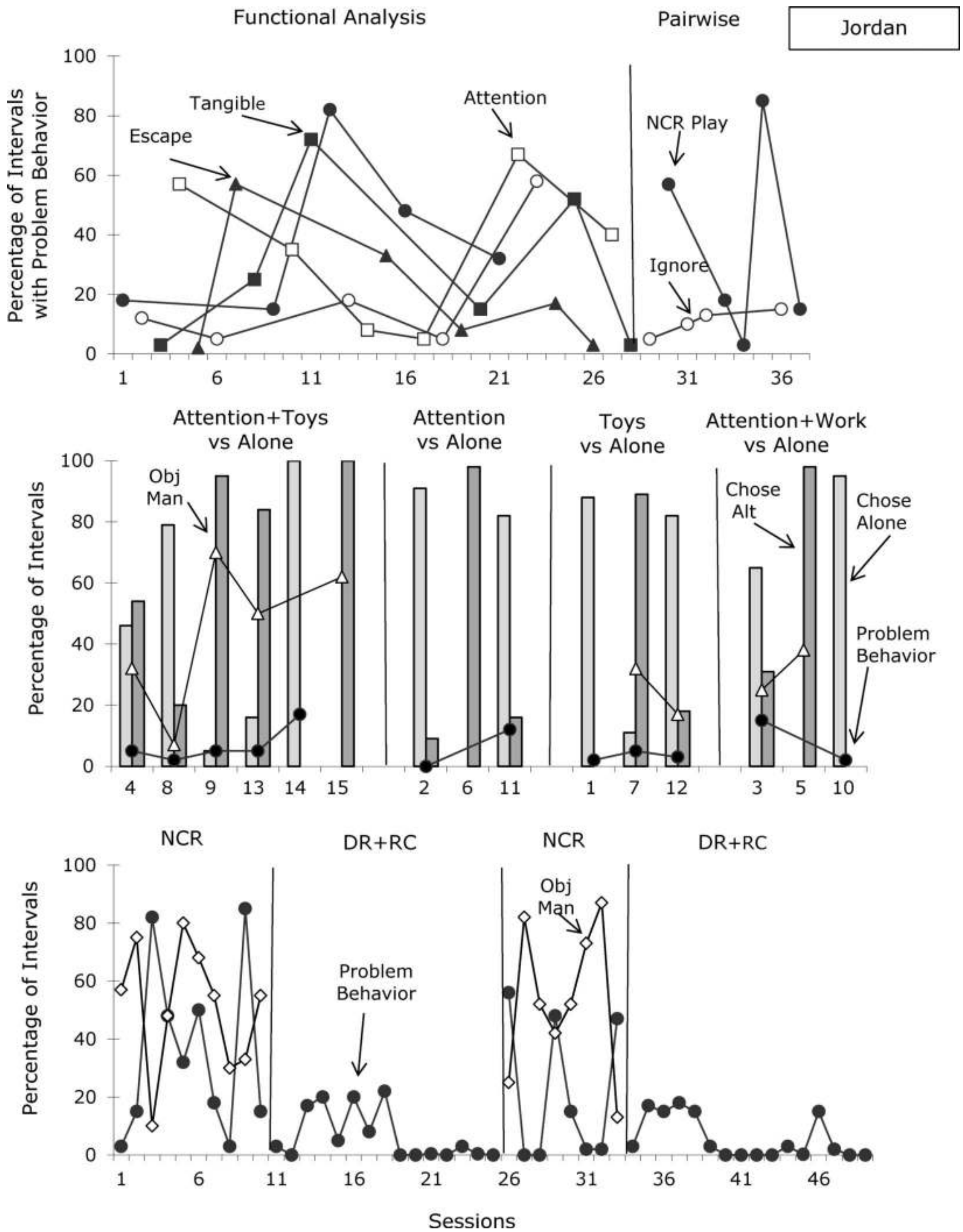

Figure 3.

The top panel shows the percentage of intervals with problem behavior during the functional analysis and pairwise analysis for Jordan. The middle panel shows the percentage of intervals with allocation to each side of the room, problem behavior, and object manipulation during the concurrent-operants assessment with blocking. The light shaded bars show allocation to the alone side, dark shaded bars show allocation to the alternative stimuli side, filled circles show problem behavior, and open diamonds show object manipulation. The bottom panel shows percentage of intervals with problem behavior (filled circles) and object manipulation (open diamonds) during the treatment evaluation. Obj Man = object manipulation, Chose Alt = chose the alternative stimuli side of the room.

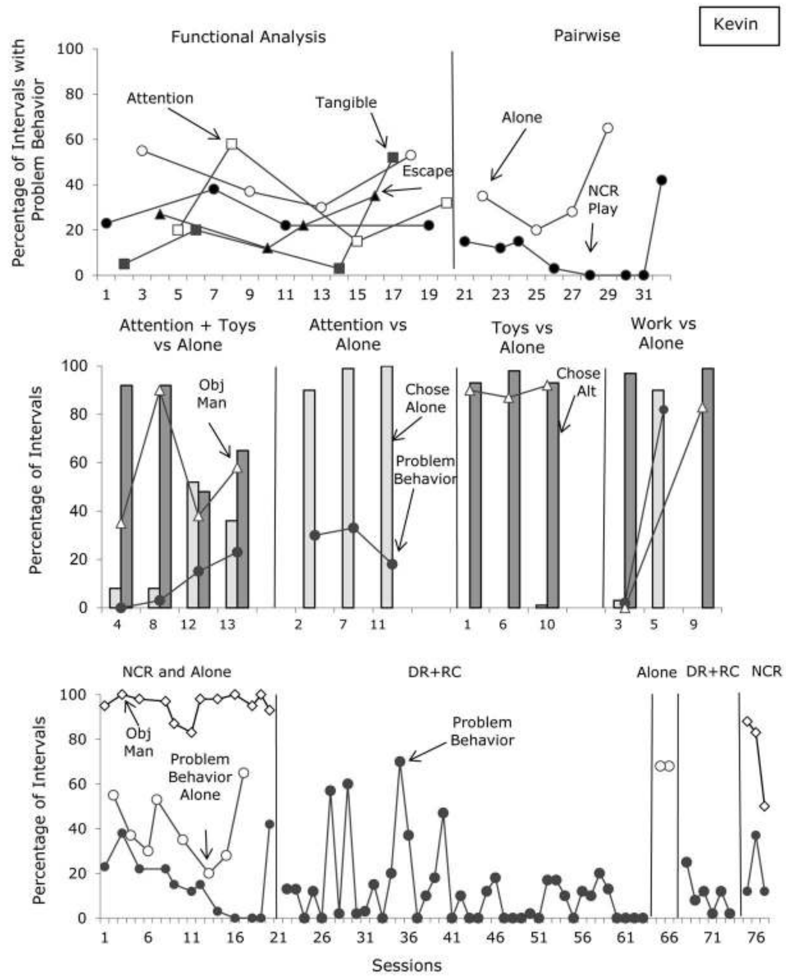

Figure 4.

The top panel shows the percentage of intervals with problem behavior during the functional analysis and pairwise analysis for Kevin. The middle panel shows the percentage of intervals with allocation to each side of the room, problem behavior, and object manipulation during the concurrent-operants assessment with blocking. The light shaded bars show allocation to the alone side, dark shaded bars show allocation to the alternative stimuli side, filled circles show problem behavior, and open diamonds show object manipulation. The bottom panel shows percentage of intervals with problem behavior (filled circles) and object manipulation (open diamonds) during the treatment evaluation. Obj Man = object manipulation, Chose Alt = chose the alternative stimuli side of the room.

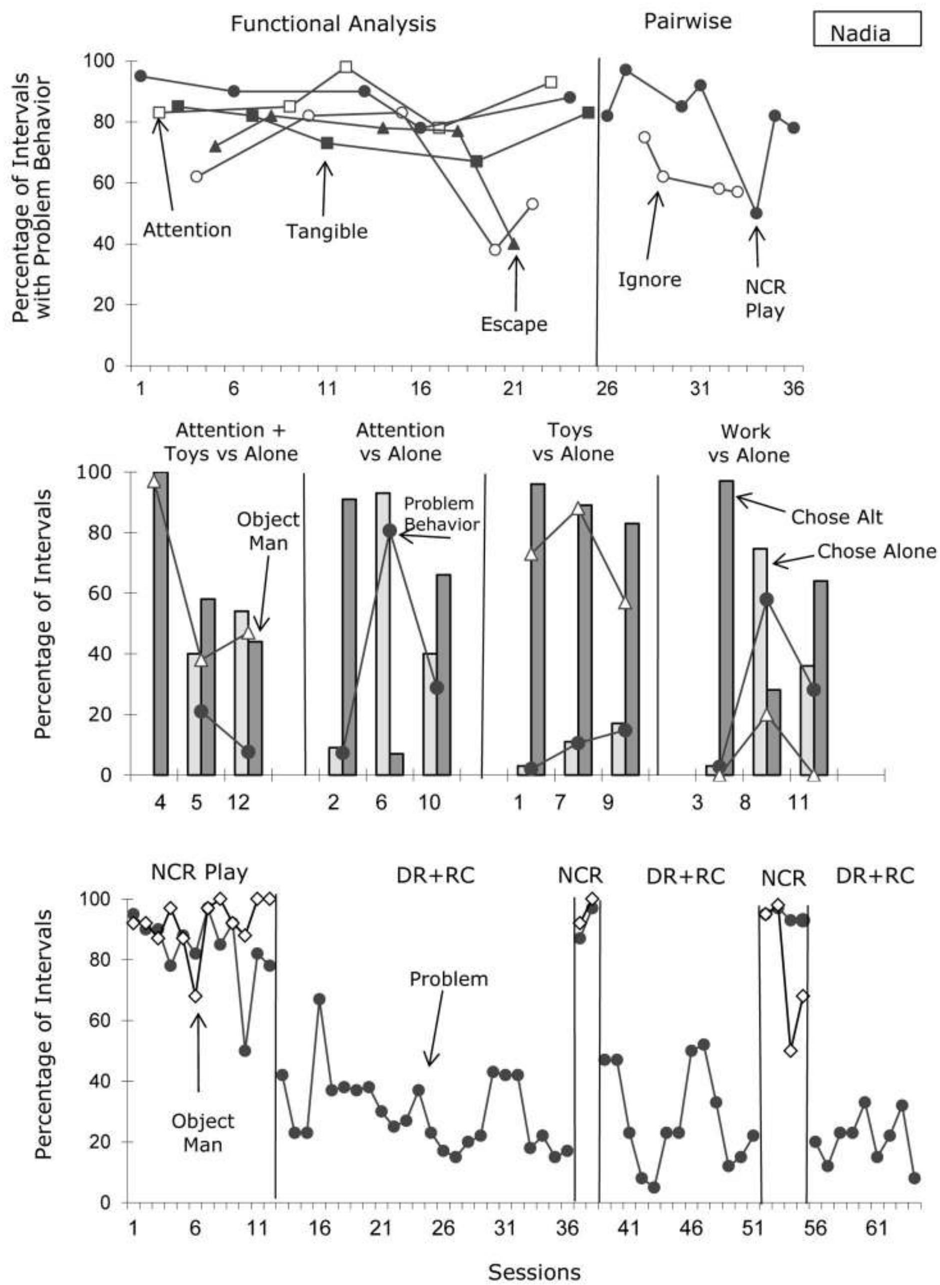

Figure 5.

The top panel shows the percentage of intervals with problem behavior during the functional analysis and pairwise analysis for Nadia. The middle panel shows the percentage of intervals with allocation to each side of the room, problem behavior, and object manipulation during the concurrent-operants assessment with blocking. The light shaded bars show allocation to the alone side, dark shaded bars show allocation to the alternative stimuli side, filled circles show problem behavior, and open diamonds show object manipulation. The bottom panel shows percentage of intervals with problem behavior (filled circles) and object manipulation (open diamonds) during the treatment evaluation. Obj Man = object manipulation, Chose Alt = chose the alternative stimuli side of the room.

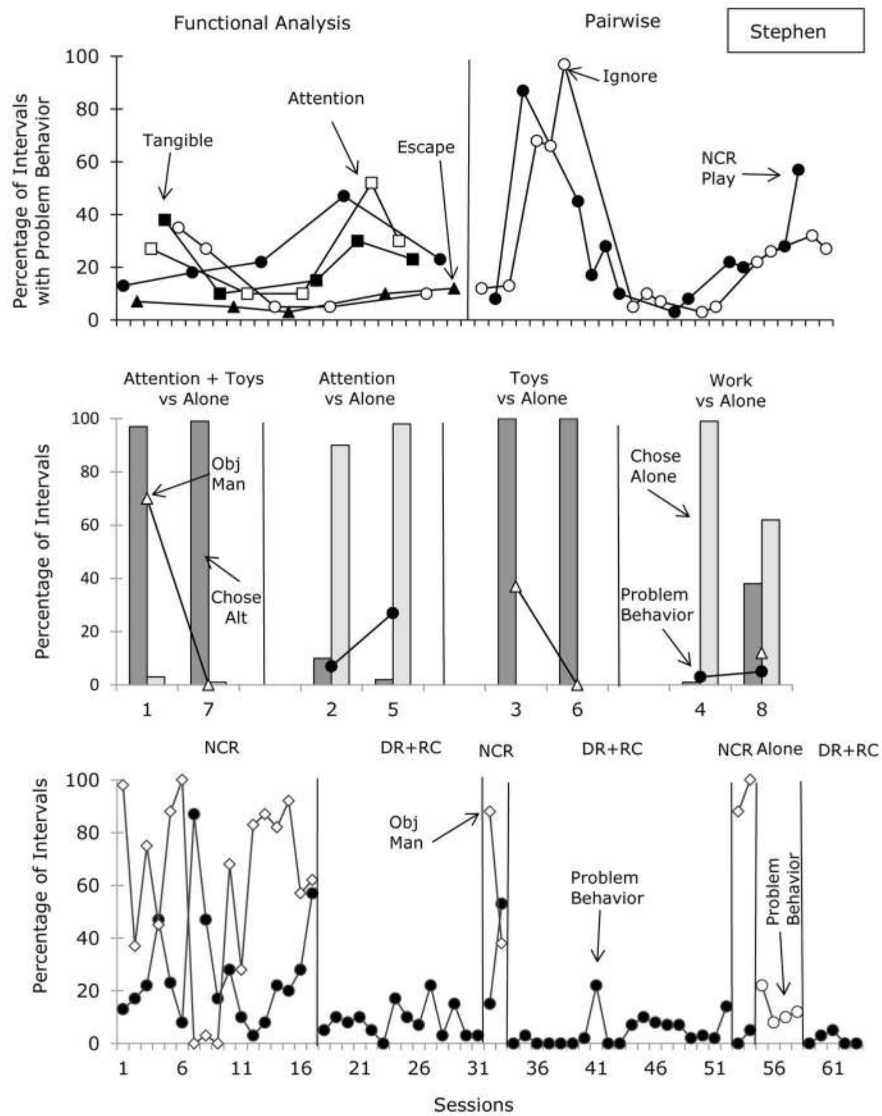

Figure 6.

The top panel shows the percentage of intervals with problem behavior during the functional analysis and pairwise analysis for Stephen. The middle panel shows the percentage of intervals with allocation to each side of the room, problem behavior, and object manipulation during the concurrent-operants assessment with blocking. The light shaded bars show allocation to the alone side, dark shaded bars show allocation to the alternative stimuli side, filled circles show problem behavior, and open diamonds show object manipulation. The bottom panel shows percentage of intervals with problem behavior (filled circles) and object manipulation (open diamonds) during the treatment evaluation. Obj Man = object manipulation, Chose Alt = chose the alternative stimuli side of the room.

Table 1

Participants and Target Behavior

Name	Gender	Age (years)	Diagnoses	Target behavior
Dustin	M	47	ID, severe cerebral palsy, epilepsy	Hit collar bone area with fist, scratch fingernails against objects
Jordan	M	9	ID, moderate autism, cystic fibrosis	Put fingers or hand in mouth, bite fingers, bang head on hard surfaces, make motion of dropping items with hands with or without holding an object
Kevin	M	11	ID unspecified, autism	Hit chest with fist, put finger in eye socket, press on eye with knuckle, hit head with open palm of hand, rub ears, fold top of ear or earlobe over ear opening, hit objects with hand
Nadia	F	23	ID, profound epilepsy	Bite hands, put mouth on objects, bang teeth on objects, hit heels against floor, hit self with objects, rub elbows
Stephen	M	5	ID, severe autism	Bite hand, bite objects, throw objects

Note. ID = intellectual disability.