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EVALUATION OF RESISTANCE TO CHANGE UNDER DIFFERENT DISRUPTER CONDITIONS IN CHILDREN WITH AUTISM AND SEVERE INTELLECTUAL DISABILITY

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Translational research inspired by behavioral momentum theory in the area of developmental disabilities has shown effects in individuals over a range of functioning levels. In the current study, behavioral momentum was assessed in 6 children diagnosed with autism and severe intellectual disability. In a repeated measures design, participants were exposed to relatively rich versus lean reinforcement contingencies in a multiple schedule with food reinforcers. This was followed by exposure to each of four disrupting conditions: prefeeding, presentation of a concurrent alternative stimulus, presentation of a movie, and the presence of a researcher dispensing response-independent reinforcers on a variable-time schedule. Consistently greater resistance to disruption in the component with the richer schedule occurred with the alternative stimulus disrupter but not with the other disrupters. These results suggest parameters that may be more (or less) effective if behavioral momentum inspired techniques are to be exploited in therapeutic environments.

Key words: behavioral momentum, autism spectrum disorders, intellectual disability, computer screen touch, human children

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One goal of translational research is to examine behavioral principles and procedures that have the potential to develop into applications for human behavior. One area in which translational research seems particularly relevant is behavioral momentum (e.g., Nevin, 1992; Nevin & Grace, 2000a). Behavioral momentum theory makes an analogy between the relationships described in the physics of motion and the psychology of behavioral persistence. In classical mechanics, the momentum of a moving body is defined as the product of mass and velocity. The degree to which an outside force can perturb the motion of a moving body depends on its momentum; increasing mass while holding velocity constant increases the resistance to change. Nevin (1992) suggested a direct parallel in the domain of behavior: Rate of responding is analogous to velocity, and the resistance of that rate to change by some perturbing operation can be used to index the behavioral analogue of mass.

Behavioral momentum is typically assessed using a multiple schedule, a procedure in which different rates of reinforcement are obtained in two alternating components signaled by different stimuli. After exposure to the multiple schedule, a potential disruption is arranged in both components by prefeeding, extinction, alternative reinforcement, or other external variables that can be imposed equally on both components. Research by Nevin, his colleagues, and others has shown that resistance to change is (a) less in the component that has the leaner schedule (e.g., Nevin, 1974) and (b) largely determined by the stimulus–reinforcer contingencies (e.g., Nevin, Tota, Torquato, & Shull, 1990).

Although the behavioral momentum analysis has been established in dozens of studies with laboratory animals (see Nevin & Grace, 2000a, for a summary), there have been relatively few studies with atypically developing humans using comparable procedures (reviewed in Dube, Ahearn, Lionello-DeNolf, & McIlvane, 2009). Although small, the literature does report effects similar to those found with nonhumans. For example, Mace and colleagues (1990) taught two adult group-home residents with intellectual disabilities to sort different colored plastic dinnerware into separate bins. For one color, snack foods were given for correct sorting on a lean schedule; for the other color, the foods followed correct sorting on a rich schedule.

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During test sessions, a movie was played during the sorting task. While rates of sorting fell for both tasks during movie presentation, sorting rates fell more during the task with the leaner schedule.

Other studies were conducted in laboratory settings. For example, Dube and colleagues studied behavioral momentum in children with developmental disabilities using computer-presented games or discrimination tasks with responding via a touchscreen (Dube, Mazzitelli, Lombard, & McIlvane, 2000; Dube & McIlvane, 2001; Dube, McIlvane, Mazzitelli, & McNamara, 2003). Across these studies, results consistent with behavioral momentum theory were found in children using different types of reinforcers (food, tokens), reinforcement schedules (variable interval [VI], variable ratio [VR]), tasks (free operant, discrete trial), and disrupters (alternative stimulus, movie plus prefeeding).

One contribution of Dube et al. (2000; 2003) was the introduction of a test methodology that addressed the problem of obtaining stable baselines with participants with developmental disabilities. In typical laboratory settings (e.g., with pigeon subjects), baseline sessions are run under multiple schedule conditions until response rates achieve a measure of predefined stability, with training often continuing for 50 or more sessions. For humans with developmental disabilities, however, extended baseline training may not always result in the degree of across-session stability necessary for typical disrupter tests (Dube et al., 2000). Using their distributed-sessions procedure, Dube and colleagues conducted a predetermined number of baseline sessions prior to a series of disrupter-test sessions. Test sessions were composed of both baseline components and alternative-stimulus disrupter components. This arrangement allowed responding in disruption to be compared to that in baseline within sessions, thereby minimizing the potential effects of variable response rates across sessions.

Behavioral momentum is attracting the interest of translational researchers in part because behavioral momentum theory makes some predictions for interventions in applied settings that challenge common practices. For example, momentum analyses have implications for differential reinforcement of other or alternative behavior (DRO/DRA) procedures that are frequently used to reduce problem behavior in applied settings. Although these procedures are often effective in reducing the rate of such behaviors, behavioral momentum theory raises the possibility that they will render the behavior more persistent in the overall richer context (Mace, 2000; Mace et al., 2010). Translation of research on behavioral momentum may be particularly appropriate for the treatment and education of individuals with Autism Spectrum Disorders (ASDs). For example, one of the defining features of ASDs is the presence of repetitive and stereotypic patterns of behavior (American Psychiatric Association, 2000), and clinical intervention often focuses on reducing such behavioral patterns. One treatment approach for automatically reinforced stereotypic behavior is known as noncontingent reinforcement (NCR) or environmental enrichment. Such treatment arranges for competition between the self-generated consequences of the stereotypy and some alternate source of reinforcement added to the environment, often via a superimposed variable-time (VT) schedule. Research shows that such treatment interventions may successfully reduce the levels of problem behavior (reviewed in Rapp & Vollmer, 2005). A behavioral momentum perspective, however, raises the possibility that such treatment may also increase the persistence of the behavior. Partial support comes from Ahearn et al. (2003): The persistence of stereotypy displayed by individuals with autism was greater in periods following access to preferred stimuli delivered on a VT schedule than in periods without access to those stimuli. In other words, this study showed greater persistence of stereotypy when reinforcement was added to the environment, as predicted by behavioral momentum theory. The paper noted, however, that exposure to the experimental contingencies was relatively brief and suggested the possibility that differential persistence might change with extended exposure. This study underscores the need for continued translational research on behavioral momentum with this population.

The primary goal of the current study was to extend translational laboratory studies of behavioral momentum to children with ASDs and severe intellectual disability. A second purpose of this study was to conduct a within-subject assessment of behavioral persistence using four different types of disrupters: an alternative stimulus, prefeeding, video presentation, and the presence of another person who provided social and food reinforcement. These disrupters may serve as a model for different types of disruption that occur in an applied setting such as a special education classroom. For instance, the alternative stimulus signals the availability of the same reinforcer as in the target task but for a different response. This disrupter seems analogous to a common classroom situation in which off-task behavior results in attention. Consider a situation in which a student is engaged in a task maintained by attention from the teacher. Off-task behavior may result in additional attention from the teacher or from students. In the laboratory procedure, responses to the multiple-schedule stimuli result in food, and additional responses to the alternative stimulus disrupter result in additional food deliveries. The prefeeding disrupter is the noncontingent delivery of some quantity of a reinforcer prior to engagement in a task in which responses result in that same reinforcer. One classroom analog may be a situation in which a student is asked to perform a discrete trial task associated with edible reinforcers soon after lunch. The movie disrupter represents the simultaneous availability of a qualitatively different reinforcer, and there are numerous classroom analogs; examples include the behavior of other students and the presence of classroom items (wall decorations, materials for other academic tasks, leisure items, etc). Finally, the presence of another person delivering response-independent praise and food is similar to the noncontingent reinforcement (NCR) procedure described above. Here, we ask whether such observed decreases are related to the type of decreases in behavior observed when NCR-like procedures are applied as a disrupter.

METHOD

Participants

Six students at a school for children with neurodevelopmental disabilities participated in the study. Five were male and one was female (AKI). Functioning level was assessed through a battery of standardized tests, including the Peabody Picture Vocabulary Test-III (PPVT; Dunn & Dunn, 1997), the Expressive One-Word Picture Vocabulary Test (EOWPVT, Brownell, 2000), the Autism Diagnostic Observation Scale (ADOS; Lord, Rutter, DiLavore, & Risis, 2001), the Leiter-R Full-Scale IQ (Roid & Miller, 1997), and the Vineland Adaptive Behavior Scale, Second Edition (Sparrow, Cicchetti, & Balla, 2005). Scores from these assessments, along with chronological age and clinical diagnosis are listed in Table 1. All assessments, except for the ADOS, were administered by research assistants. The ADOS was administered by a trained consultant. Clinical diagnoses were obtained from student records.

Apparatus

All sessions took place in a laboratory that was divided into two enclosures by the wall shown in Figure 1. On one side, researchers operated controls that programmed experimental events; on the other side, participants interacted with the teaching equipment. Details of the apparatus have been described extensively elsewhere (Lionello-DeNolf & McIlvane, 2003), and only aspects relevant to the current study will be described here.

The participant was seated in front of a tripart stimulus panel (the teaching area). Directly in front was a modified Wisconsin general teaching apparatus (WGTA) that contained several compartments. The two end-point compartments shown in the bottom row of this panel in Figure 1 were used to deliver food reinforcers throughout the session. At the top of this panel, a portable DVD player (Polaroid, PDV-1002A) was mounted behind a clear window that was used to play DVDs during some disrupter tests. At all other times, the screen was blank. The remaining compartments were not used in this study.

The side walls each contained a 43.2-cm square computer monitor with touchscreen (ELO Touch Model # ET 1725L-8SWA-1) and two audio speakers mounted on either side of the touchscreen. Each touchscreen was connected to a Macintosh G4 computer, located on the other side of the wall containing the touchscreen. Computer software controlled stimulus displays and response recording. The researcher remained behind the wall for the entire session and did not have direct contact with the participant. The researcher monitored the participant at all times via four overhead surveillance cameras. In addition, a

Table 1

Diagnosis, chronological age, and standardized test scores for individual participants.

Participant	Age	Diagnosis	PPVT	EOWVT	ADOS	Leiter-R	Vineland Percentile Rank/Adaptive Level
AHL	9-9	Autism	1-09	1-0	Autism	<2-0	<1/Low
AKI	12-1	Autism	<1-09	1-1	Autism	2-03	<1/Low
CHT	9-3	PDD-NOS	<1-09	2-11	Autism	—	1/Low
JOB	20-4	Autism	<1-09	1-0	Autism	<2-0	<1/Low
MVO	18-4	Autism	<1-09	1-0	Autism	2-05	<1/Low
SBA	9-11	Autism	<1-09	2-5	Autism	4-05	<1/Low

Note: ''PPVT,'' ''EOWVT,'' and ''ADOS'' refer to the Peabody Picture Vocabulary Test, the Expressive One-Word Vocabulary Test, and the Autism Diagnostic Observation Schedule, respectively. In the Age, PPVT, EOWVT, and Leiter-R columns, the first number refers to years and the second number refers to months. The Age column shows chronological age; other columns show age-equivalent scores. ''PDD-NOS'' refers to Pervasive Developmental Disorder—Not Otherwise Specified. Participant CHT withdrew from the study before the Leiter-R could be administered.

digital video recorder (Archos 705 Mobile DVR) recorded the view from one of the cameras.

Stimuli were blue squares presented on a yellow background and orange triangles presented on a purple background. Each stimulus was approximately 2 cm square in size. Seven identical copies of the stimuli appeared on the center third of the active touchscreen during each component. Multiple copies of the stimulus were presented in a manner similar to the animated computer game in Dube et al. (2003). Due to the severe intellectual disabilities of our participants, however, the animation was eliminated and the stimuli were stationary on the monitor screen. For 3 participants, the squares were presented on the right touchscreen and the triangles were presented on the left touchscreen for the duration of the study. For the remaining 3 participants, this was reversed. An additional

Fig. 1. The teaching area of the automated teaching laboratory. See text for details.

stimulus was a single copy of a red disc (approximately 6 cm in diameter) that was used during pretraining and disrupter tests (details below).

The defined response was a tap to the screen. A ''hit'' was recorded if the tap was within the boundaries of a stimulus. Feedback was provided with each hit. The stimulus disappeared with a ''popping'' sound and another identical stimulus appeared in a new location. When a reinforcer was scheduled, a hit to the stimulus resulted in its disappearance in an animated explosion with distinctive sounds. Concurrently, a light turned on in one of the reinforcer wells and an edible reinforcer was delivered. When an alternative stimulus (red disc) was concurrently presented, it appeared on the right third of the screen on the left-side monitor, or the left third of the screen on the right-side monitor (i.e., the side of the screen closest to the WGTA). The computer software recorded the responses to the touchscreen (hits plus touches to the background) and the number of reinforcers delivered. The researcher controlled the lights in the reinforcer wells via a software interface panel (LabView, National Instruments) running on a third Macintosh G4 computer.

Reinforcers were food items that differed for each participant. Items included candy, chips, and fresh fruit. Reinforcers were initially selected on recommendation from the participants' classroom teachers. From those food items identified, four were chosen and presented to the participant in a 36-trial, two-item per trial, forced-choice preference test (Fisher et al., 1992). The most frequently chosen item(s) was/were used in the study. For 3 participants, this resulted in the identification of one preferred food that was used throughout the study. For the other 3 participants, two to three foods were identified and a mixture of those were used during each session throughout the study. For example, for Participant AHL, deliveries of popcorn and M&Ms alternated irregularly such that approximately half of reinforcer deliveries were of each type. The same reinforcers were used in all conditions throughout the study.

Procedure

Pretraining. In the first session, several pieces of preferred food items were placed on the counter of the teaching area prior to the participant's arrival. Participants were given time to explore the environment and to consume the food. Then, foods were dispensed within the food wells at irregular intervals, until the participant was reliably taking and consuming the food items. Finally, one of the computer touchscreens was activated and a tracking task began. For this task, a red disc was presented on the screen. If the participant tapped the disc with a single finger, the disc disappeared with a popping sound, a light turned on in one of the food wells, and a food was delivered. The disc then reappeared in a new area of the touchscreen. If after several minutes the participant did not touch the disc stimulus, the researcher entered the teaching area and delivered gestural (pointing to the disk) and verbal prompts. The session ended after the participant completed 15 trials with the red disc (prompted or unprompted), or 20 min elapsed. In the second session, the red disc tracking task was presented on the other touchscreen. The order of touchscreen presentation was counterbalanced across participants.

After the participant was responding to each stimulus presentation without prompting, pretraining with the stimuli to be used in multiple schedule training began. The purpose of pretraining was to gradually reduce the frequency of reinforcement and increase the duration of the experimental sessions. All sessions consisted of multiple schedules. Initially, two 2-min components were presented (one on each touchscreen) and the schedule was multiple fixed ratio 1, fixed ratio 1 (*mult* FR 1 FR 1). Over sessions, the number of components increased to four, and then six, and the intercomponent interval (ICI) gradually increased from 5 s to 10 s. Over successive sessions, the schedules changed to *mult* fixed interval (FI) 3 s FI 3 s to *mult* FI 5 s FI 5 s and finally to *mult* VI 5 s VI 5 s. The active touchscreen alternated regularly and each session began on the opposite touchscreen from the day before. The minimum number of sessions to complete pretraining was seven. Participants advanced from one pretraining session to the next if they responded at a rate of at least 10 responses per minute per component for one session.

Baseline training. The first two sessions were rate-building sessions to prepare participants for the schedules used during the remainder of the study. In the first, a *mult* VI 7 s VI 7 s was used, and in the second a *mult* VI 10 s VI 10 s was used. For all participants, reinforcement delivered for responses to one stimulus (e.g., squares) consisted of one food item and reinforcement delivered for responses to the other stimulus (e.g., triangles) consisted of two food items. The stimuli associated with two foods versus one food remained consistent throughout all phases of the study and were counterbalanced across participants. For these, and all subsequent sessions, six 2-min components were presented. A 10-s ICI separated successive components. During ICIs, both touchscreens were grey and any responses to them had no programmed consequences. The response criterion for these sessions was at least 10 responses per min per component for one session, or that session was repeated on the next day.

Next, participants were given baseline training sessions on a *mult* VI 5 s VI 15 s in which two food items followed all reinforced responses in the VI 5 s component (rich) and one food item followed all reinforced responses in the VI 15 s component (lean). Variable interval schedules were composed of seven values as in Flesher and Hoffman (1962). The same types of food reinforcers were used for both lean and rich components throughout the study. That is, participants who earned more than one type of food (e.g., popcorn and M&Ms) received both types in both lean and rich components. Two food items were delivered in rich components so that participants with relatively slow response rates would experience an obtained rich/lean reinforcer rate ratio of at least 3.0. Previous research with similar participants (Dube & McIlvane, 2001)

Table 2
Order of disrupter test series for each participant

Participant	First Series	Second Series	Third Series	Fourth Series	Fifth Series	Sixth Series
AHL	Prefeeding	Alternative	Movie	Prefeeding	Alternative	Movie
AKI	Prefeeding	Movie	Alternative	Prefeeding	Movie	Alternative
CHT	Alternative	Prefeeding	Movie	Alternative	Prefeeding	Movie
JOB	Movie	Prefeeding	Alternative	Movie	Prefeeding	Alternative
MVO	Movie	Alternative	Prefeeding	Movie	Alternative	Prefeeding
SBA	Alternative	Movie	Prefeeding	Alternative	Movie	Prefeeding

Note. For all participants, the researcher-present disrupter test series was conducted after all the other test series.

has indicated that obtained reinforcer rate ratios of less than 3.0 may be associated with a decreased likelihood of observing differential disruption. Twelve baseline sessions were conducted, with the criterion that the obtained rich/lean reinforcer ratio was at least 3.0 for two of three successive sessions. If at any time this criterion was not met, the reinforcement schedules were adjusted (details to be presented with the results) and a minimum of 12 sessions were conducted with the new schedules.

Prior to the alternative stimulus disrupter test, two additional baseline sessions were conducted. For these, the first two components were 1-min presentations of the red disc stimulus on a grey background and foods followed responses to it on a VI 6-s schedule. The final four components of the session were as described above.

Disrupter tests. Each participant was tested with the alternative stimulus, prefeeding, and movie disrupters, with order of presentation counterbalanced across participants and each disrupter test series presented twice (see Table 2). Each test series consisted of six test sessions alternating with six baseline sessions (for a total of 12 sessions). Between successive test series (e.g., after the prefeeding test and before the movie test), six baseline sessions were conducted. When the last of these series was completed, a final series was conducted with a fourth disrupter, the presence of a researcher delivering verbal praise and food on a VT schedule.

For the alternative stimulus test, the first two components of each disrupter session were baseline components. During the final four components, one red disc stimulus was presented concurrently with the lean or rich component stimuli. Responses to the red disc were followed by one food item on a VI 6 s schedule (seven schedule values as determined by Flesher & Hoffman, 1962).

For the prefeeding test, the experimenter stood in the entryway to the laboratory and handed the participant a cup that contained 30 pieces of food. After the participant consumed all the food, the experimenter moved into the programming area, the participant moved into the teaching area, and the session began as usual. Contingencies were as in the previously described baseline session, with the addition of the response-independent delivery of 10 pieces of food during each of the five ICIs (as in Dube & McIlvane, 2001). Because experimental sessions were scheduled according to participants' availability, the time from previous food intake (e.g., lunch) varied across participants and within participants across successive sessions.

For the movie test, the first two components of the disrupter session were baseline components. For the final four components, the DVD was activated after the first response to the active touchscreen, and it played a movie or television show for the duration of the component. The video was inactive during ICIs. The video was different for each participant and was chosen based on recommendations from their classroom teachers. Videos included the Baby Einstein series, Thomas the Tank Engine, and the Wiggles.

After completing the series with the three aforementioned disrupters, a final test was conducted with 5 of the participants (JOB was not given this final test because he had graduated from the school). As before, the first two components of each disrupter session were baseline components. For the final four components, a research assistant entered the teaching area and stood midway between the two touchscreens. During these components (but not the ICI), the assistant delivered noncontingent verbal praise and food on a VT 6-s schedule. As before, six test sessions alternated with baseline sessions.

Data analysis. Response rates were calculated for each session by dividing the total number of responses per component by the total duration in min per component. Thus, in baseline sessions, total responses for the three lean components, and total responses for the three rich components, were each divided by 6 min. Time taken to consume the foods was not deducted from the total time in each component. All but one participant (JOB) consumed each food item quickly and immediately upon delivery and no differences in the time spent to consume different food types was apparent. JOB tended to save all the foods until the end of the session, at which point he consumed them. Thus, any effect of the duration of food consumption on response rates is likely minimal.

Relative resistance to possible disruption was assessed by calculating test/baseline response rate ratios for the lean and rich components separately. For all but the prefeeding disrupter test, the baseline data were mean response rates per min in the first two components in the test session (one lean baseline and one rich baseline), and disruption data mean response rates in the last four components in the test session (two lean with disrupter and two rich with disrupter). A test/baseline ratio was calculated for each of the six test sessions for each participant, and then the ratios were averaged to obtain a single measure for the test series. Because no baseline components were conducted in sessions with the prefeeding disrupter, baseline data came from the baseline session immediately prior to each test session.

RESULTS

Pretraining

All participants except AHL responded to the touchscreen pretraining program without prompting. For AHL, neither gestural nor verbal prompting was sufficient to establish the appropriate response topography. Rather, he touched the screen with a fist, an open palm, or with multiple fingers which resulted in the touchscreen interface being unable to detect a response. AHL then received 12 sessions of a program designed to shape the appropriate response topography. For this program, a researcher used hand-over-hand guidance to prompt appropriate responding to stimuli other than those used in multiple-schedule training (novel black forms on a white background). Such prompting was faded out over sessions until AHL was responding independently without the teacher present. All participants completed the remainder of the pretraining sessions in the minimum time required.

Baseline Training

Only one participant, AKI, required an adjustment to the VI schedules during multiple schedule training because her obtained reinforcer ratio dropped below 3.0. After four sessions, the reinforcement schedule in the lean component was changed to VI 20 s (the schedule in the rich component remained the same) and an additional 12 sessions were conducted. Table 3 shows average responses per min for each participant for the lean and rich components, average reinforcers obtained in each component and obtained reinforcer rate ratios (rich divided by lean) for the block of six baseline sessions just prior to each test series. Data in the table listed under each disrupter stimulus heading reflect data from the six sessions conducted prior to the test series with that disrupter. Obtained reinforcer ratios were 3 to 8 times greater in the rich than lean condition for all participants. Response rates varied across participants and were greater in the lean condition, with five exceptions: CHT (alternative stimulus 2, prefeeding 2, movie 2, and researcher-present), and MVO (prefeeding 1).

Disrupter Test Sessions

Alternative stimulus disrupter. For the test series with the alternative stimulus disrupter, response rates in disruption (the lean or rich stimulus presented with the alternative stimulus) were differentially reduced compared to baseline components. During test series 1, the mean test/baseline response rate ratio was 0.292 (range, 0.152–0.467) and 0.772 (range, 0.389–1.230) for the lean and rich components, respectively. In the second test series, the mean test/baseline response rate ratio was 0.384 (range, 0.130–0.681) and 0.703 (range, 0.236–.980) for the lean and rich components, respectively.

Table 3

Baseline average responses (reinforcers) per minute and obtained reinforcer rate ratios for six sessions prior to each test.

	Test Series 1			Test Series 2		
	Lean	Rich	Ratio	Lean	Rich	Ratio
			Alternative Stimulus			
AHL	44.3 (2.6)	15.8 (9.6)	3.7	23.2 (2.1)	8.3 (6.9)	3.3
AKI	14.9 (1.6)	4.0 (5.3)	3.3	18.5 (1.8)	5.2 (7.6)	4.2
CHT	21.4 (2.6)	15.1 (11.9)	4.6	15.1 (2.8)	18.0 (12.3)	4.4
JOB	57.6 (2.8)	55.6 (14.3)	5.1	82.0 (2.8)	67.1 (14.9)	5.3
MVO	9.5 (1.9)	7.0 (9.6)	5.1	9.4 (1.9)	7.1 (9.6)	5.1
SBA	40.0 (2.9)	35.9 (13.2)	4.6	28.1 (2.9)	15.9 (13.7)	4.7
			Prefeeding			
AHL	55.8 (3.1)	29.1 (13.4)	4.3	25.6 (2.1)	11.3 (7.4)	3.5
AKI	20.4 (2.0)	5.9 (7.2)	3.6	13.3 (1.9)	4.6 (6.8)	3.6
CHT	40.1 (2.6)	19.4 (12.8)	4.9	6.6 (2.1)	13.2 (9.8)	4.7
JOB	102.1 (3.3)	62.8 (15.7)	4.8	105.5 (3.1)	72.9 (14.8)	4.8
MVO	5.2 (1.2)	7.6 (9.3)	7.8	11.3 (2.1)	10.0 (10.8)	5.1
SBA	44.4 (3.1)	10.4 (9.6)	3.1	10.6 (2.3)	5.0 (6.6)	2.9
			Movie			
AHL	42.3 (2.6)	16.8 (8.8)	3.4	43.8 (2.8)	20.4 (9.5)	3.4
AKI	13.1 (1.5)	4.6 (6.5)	4.3	12.1 (1.9)	5.2 (7.2)	3.8
CHT	43.9 (3.4)	37.1 (15.4)	4.5	9.1 (2.3)	10.7 (9.1)	4.0
JOB	59.1 (2.9)	38.4 (13.6)	4.7	71.6 (3.1)	58.8 (13.1)	4.2
MVO	19.1 (2.7)	10.9 (10.2)	3.8	12.9 (2.5)	10.0 (11.3)	4.5
SBA	47.6 (2.8)	18.0 (10.9)	3.9	30.4 (3.0)	17.3 (13.6)	4.5
			Researcher-Present			
AHL	34.6 (2.8)	21.4 (10.4)	3.7			
AKI	26.8 (2.1)	10.3 (9.9)	4.7			
CHT	7.6 (2.2)	16.2 (10.5)	4.7			
MVO	9.8 (2.7)	9.5 (9.9)	3.7			
SBA	14.3 (2.7)	8.8 (7.2)	2.7			

Figure 2 summarizes the data from the alternative stimulus disrupter test for individual participants. The first set of bars for each participant represents the first test series, and the second set represents the second series. A value of 1.0 indicates equal responding in test compared to baseline whereas a value less than 1.0 indicates less responding in test relative to baseline, or disruption. Error bars represent standard error over the six test sessions for each participant. These data indicate that the alternative stimulus was a generally effective disrupter, with lower response rates during test than baseline components in every case except AKI test series 1, rich component. Moreover, this disruption was differential, with greater decreases in responding in the lean components than the rich component in 9 of 12 tests. The exceptions were AHL second series, CHT first series, and JOB second series.

Table 4 shows response rates to the component stimuli during baseline and compares them to response rates to the component and alternative stimuli during each of the two-disrupter test series with the alternative stimulus. Response rates are shown separately for the component stimuli and the alternative stimulus for the lean and rich components, and also are shown combined (i.e., total = component plus alternative). Three findings are evident from this table. First, responding to the lean and rich component stimuli in testing was less than or equal to responding in baseline, with one exception (AKI, first series rich component). Second, all the participants responded to both the component and alternative stimuli. Finally, in terms of overall responding during test (i.e., component plus alternative), there was no consistent pattern. For some participants, there was a lower overall response rate during test than in baseline (e.g., JOB), but for others there was a higher overall response rate in the rich component but not the lean (e.g., AKI) or a similar response rate (e.g., MVO).

Prefeeding disrupter. For the test series with the prefeeding disrupter, overall response rates were also reduced compared to baseline

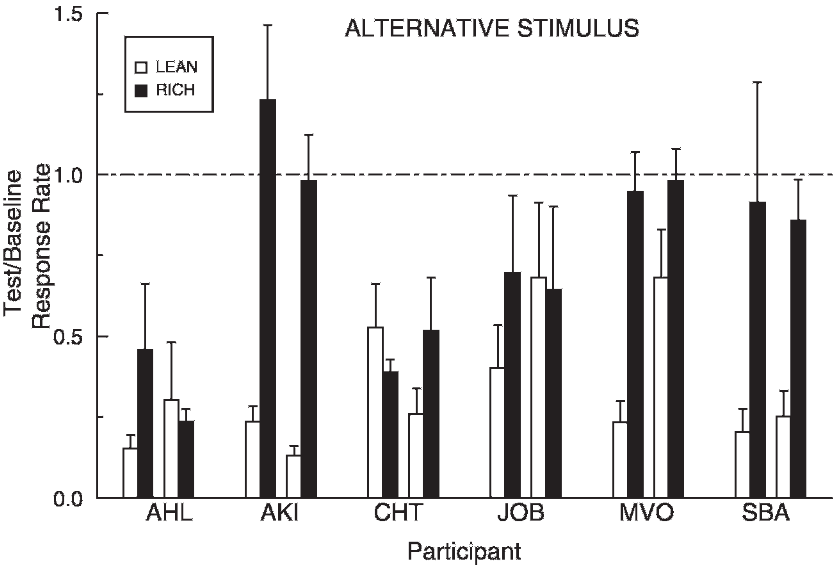

Fig. 2. Mean test/baseline response rate ratios during disruption with the alternative stimulus for individual participants. The first set of bars for each participant refers to the first test series, and the second set refers to the second series. The dashed line at 1.0 indicates equal responding in baseline and test. Responses to the alternative stimulus are not shown.

components, but the magnitude of disruption was substantially less than with the alternative stimulus. The mean test/baseline response rate ratio was 0.794 (range, 0.479–1.072) and 0.848 (range, 0.666–1.044) for the lean and rich components, respectively, during test series 1. In the second test series, mean test/baseline response rate ratio was 0.861 (range, 0.446–1.235) and 0.906 (range, 0.406–1.334) for the lean and rich components, respectively.

Figure 3 summarizes the test data for individual participants for the prefeeding disrupter in the same way as Figure 2. Data were more variable with the prefeeding disrupter than with the alternative stimulus disrupter. For four tests, there was greater

Table 4

Response rates during baseline and disruption during the alternative stimulus tests.

	Baseline		Disruption					
			Lean			Rich		
	Lean	Rich	Target	Alt	Total	Target	Alt	Total
				Test Series 1				
AHL	37.08	16.33	5.67	17.21	22.88	6.13	11.25	17.38
AKI	18.42	5.92	3.88	6.46	10.33	6.50	4.63	11.13
CHT	22.70	21.00	9.04	12.79	21.83	7.71	8.75	15.13
JOB	69.58	61.08	26.92	21.42	48.33	34.08	14.79	48.88
MVO	9.25	7.25	2.04	5.96	8.04	6.33	0.33	6.67
SBA	49.67	32.50	6.92	18.51	26.09	19.21	9.21	28.42
				Test Series 2				
AHL	33.50	19.67	7.08	13.46	20.54	4.50	7.88	12.38
AKI	25.50	8.58	2.96	13.38	16.33	7.42	5.83	13.25
CHT	23.00	27.17	6.38	8.38	16.08	9.67	12.40	22.08
JOB	65.75	75.67	41.29	12.88	54.17	43.33	17.79	61.13
MVO	11.83	10.42	7.29	4.29	11.58	9.58	0.71	10.29
SBA	28.08	14.75	5.46	20.21	25.83	11.58	6.88	18.46

Note. ''ALT'' refers to alternative (red disc) stimulus.

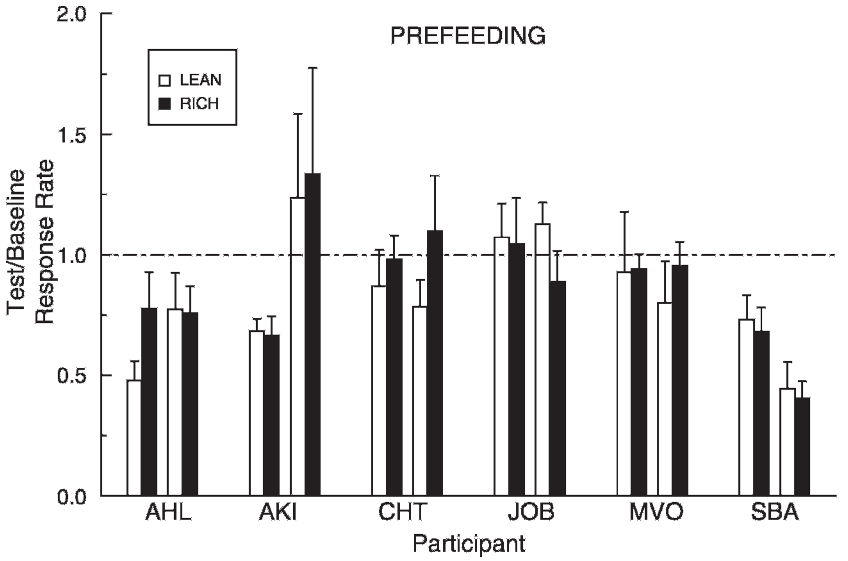

Fig. 3. Mean test/baseline response rate ratios with the prefeeding for individual participants. The first set of bars for each participant refers to the first test series, and the second set refers to the second series. The dashed line at 1.0 indicates equal responding in baseline and test.

disruption in the lean than the rich component (AHL series 1, CHT series 1 and 2, and MVO series 2). However, there were three tests in which there was greater disruption in the rich than the lean component (JOB series 2, SBA series 1 and 2) and three tests in which there was approximately equal disruption (AHL series 2, AKI series 1, and MVO series 1). For the remaining two tests, there was no observed disruption in either component (AKI series 2 and JOB series 1). Overall, the observed within-subject variability was greater than that observed with the alternative stimulus disrupter.

Movie and researcher-present disrupters. For the test series with the movie disrupter, there was generally less evidence of disruption than with the alternative stimulus or prefeeding. The mean test/baseline response rate ratio was 0.815 (range, 0.272–1.328) and 1.010 (range, 0.494–1.554) for the lean and rich components, respectively, during test series 1. In the second test series, mean test/baseline response rate ratio was 1.225 (range, 0.276–2.222) and 1.396 (range, 1.190–1.489) for the lean and rich components, respectively. Thus, the second test series response rates were higher on average during presentation of the movie than during baseline components.

Figure 4 presents the test data for individual participants for the movie disrupter. Differential disruption in the direction predicted by behavioral momentum theory was seen in 4 of 12 tests (AHL series 2, AKI series 1, and SBA series 1 and 2). In addition, there was one instance of similar disruption in both components (AHL series 1) and one instance of greater disruption in the rich than the lean component (JOB series 1). In the remaining six tests, response rates increased relative to baseline during the movie presentation.

For the test series with the researcher-present disrupter, the mean test/baseline response rate ratio was 0.481 (range, 0.044–1.322) and 0.607 (range, 0.157–1.136) for the lean and rich components, respectively. Figure 5 shows data for individual subjects. For 4 of the 5 participants, disruption was greater in the lean than the rich component. For CHT, however, response rates increased relative to baseline in the lean component and decreased in the rich component.

Statistical analyses. The data from each of the disrupter test series were analyzed using the Wilcoxon Signed-Ranks test and were modeled using Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Zeger & Liang, 1992). The results from these analyses can be found in Table 5. Shown in the table are the significance levels for each test and disrupter, as well as the mean test/baseline response rate

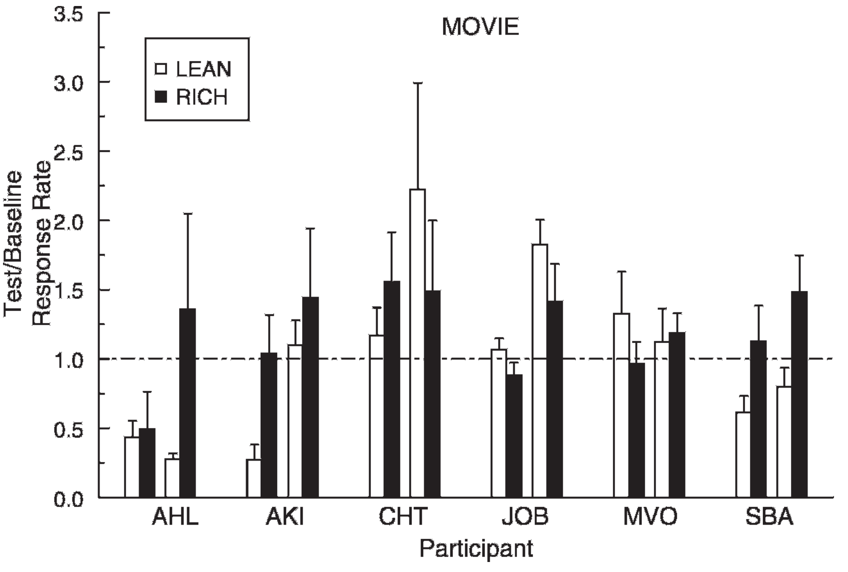

Fig. 4. Mean test/baseline response rate ratios with the movie disrupter for individual participants. The first set of bars for each participant refers to the first test series, and the second set refers to the second series. The dashed line at 1.0 indicates equal responding in baseline and test.

ratios. With Type 1 error level set at .05, the Wilcoxon test indicated significantly greater disruption in the lean component for the alternative stimulus disrupter, series 1, and an effect approaching significance in series 2. No other significant differences were found. Because of the relatively low power of the Wilcoxon test with $n = 6$, GEE modeling was also conducted. The results of this analysis indicated significant differences between the lean and rich components in both test series with the alternative stimulus disrupter, and not

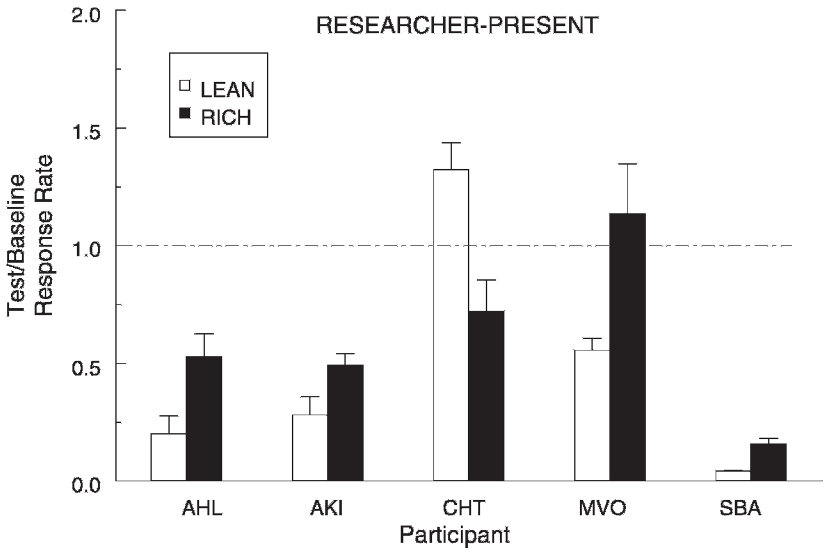

Fig. 5. Mean test/baseline response rate ratios with the researcher-present disrupter for individual participants. The first set of bars for each participant refers to the first test series, and the second set refers to the second series. The dashed line at 1.0 indicates equal responding in baseline and test.

Table 5

Results of analyses using the Wilcoxon Signed-Ranks test, one-tailed and Generalized Estimating Equations.

	Mean (Confidence Interval)		Wilcoxon Signed-Ranks Test	Generalized Estimating Equations
	Lean	Rich	*p*-value	*p*-value
Alt Stim 1	0.29 (0.22–0.38)	0.77 (0.52–0.96)	.02	.0009
Alt Stim 2	0.38 (0.20–0.52)	0.70 (0.48–0.89)	.06	.008
Prefeed 1	0.78 (0.64–0.95)	0.85 (0.73–0.97)	.38	.27
Prefeed 2	0.86 (0.65–1.07)	0.91 (0.68–1.14)	.30	.53
Movie 1	0.82 (0.52–1.10)	1.01 (0.71–1.18)	.12	.16
Movie 2	1.23 (0.73–1.69)	1.40 (1.14–1.48)	.30	.58
Res - Pres	0.48 (0.09–0.88)	0.61 (0.33–0.89)	.21	.48

Note. ''Mean'' refers to the mean test/baseline response rate ratio averaged across participants for each disrupter test. ''Alt Stim'' refers to alternative stimulus, ''Prefeed'' refers to prefeeding and ''Res - Pres'' refers to researcher-present.

with any other disrupter. Moreover, if the Type 1 error level is adjusted for multiple comparisons (.05/7 = .007), then the results from alternative stimulus series 1 remain significant and those from series 2 just miss significance.

DISCUSSION

The data from the alternative stimulus disrupter test demonstrate reliable behavioral momentum effects in children with autism and severe intellectual disability. Response rates were more resistant to disruption in the presence of a stimulus associated with a rich rate of reinforcement than in the presence a stimulus associated with a leaner rate of reinforcement. These data replicate the results of Dube et al. (2003) and extend the findings to include a group of children with severe intellectual disability. Results for the researcher-present disrupter test were consistent with a behavioral momentum analysis in 4 of the 5 participants tested, although these findings missed statistical significance (perhaps due to low power resulting from the small number of observations). The data suggest that the alternative stimulus and the researcher-present test conditions can be used to model classroom situations in which the reinforcers earned for task engagement are also available from additional sources.

In contrast, the data from the movie and prefeeding tests were more variable and a pattern of results consistent with behavioral momentum theory was found in only 8 of 24 tests. The movie-test results included two noteworthy and possibly related findings. First, results were consistent with behavioral momentum theory for only 3 of 6 participants (AHL, AKI, and SBA). Second, in the majority of tests, multiple-schedule responding was not disrupted by the movies but rather response rates accelerated during movie presentation. This acceleration was most pronounced in the 3 participants whose results were inconsistent with momentum theory predictions: CHT, JOB, and MVO (Fig. 4, mean test/baseline response rate ratios > 1 in 10 of 12 components for these participants). In previous studies, videos and movies have been assumed to function as disrupters because they are distracting, that is, they compete with the multiple-schedule task for control of participants' observing and attending. For example, Mace et al. (1990) referred to the video presentation procedure as a ''concurrent distracting stimulus'' (p. 166) and described behavioral persistence during video presentations as ''resistance to distraction'' (p. 163 et seq.). For Participants CHT, JOB, and MVO in the present study, however, the movies seem better described as stimulating than distracting, and the data in Figure 4 show no consistent relation between the behavioral acceleration and the rich versus lean multiple-schedule contexts. The source(s) of these individual differences remain unclear. Among the possibilities that could be examined in future studies are interactions among the characteristics of the environmental stimulation (auditory and visual), the multiple-schedule response requirements (i.e., repetitive tapping on a touchscreen), and other behavior that was not measured in this experiment (e.g., manual stereotypies; cf. Rapp, 2005).

The generally negative results with the prefeeding disrupter tests in the present study stands in contrast to the results typically found in nonhuman subjects (for reviews see Nevin, 1992; Nevin & Grace, 2000a). One obvious difference concerns the motivational state of the participants. Unlike laboratory animals, the children in our study were not subjected to any food deprivation whatsoever. Although the foods they earned during the experimental sessions were highly preferred, as suggested by interviews with classroom teachers and confirmed by preexperimental preference tests, they lacked the biological significance of the foods presented during sessions with nonhuman animals. Prefeeding was a weak disrupter in the present study, as shown by the relatively minor suppression of overall response rates in the prefeeding tests. One previous study used prefeeding as a disrupter with developmentally disabled children (Dube & McIlvane, 2001), but did so in combination with other distracting disrupters (videos, a toy, an audiotape of sound effects) and thus the contribution of prefeeding in that study cannot be determined. Additional study will be needed to determine whether there are any conditions in which prefeeding can function as a disrupter in nondeprived children who receive food consequences as part of educational or behavioral treatment programs. For example, prefeeding may be insufficient alone, but may contribute additively to disrupter compounds (Nevin & Grace, 2000b).

Future research could investigate the use of presession disrupters other than food. For example, behavior on classroom tasks, such as discrete trial instruction, is sometimes maintained by positive social attention. Research outside of the behavioral momentum literature has suggested that the availability of presession attention can influence behavior during a subsequent functional analysis involving contingent attention (e.g., Berg et al., 2000; O'Reilly et al., 2007). For example, O'Reilly and colleagues showed that a period of continuous attention just prior to alone and attention-extinction conditions resulted in fewer instances of problem behavior compared to situations in which the preceding period was one of no attention. Future studies could examine whether a presession period of noncontingent attention differentially disrupts responding on two tasks maintained by attention and associated with different reinforcement rates in a manner predicted by behavioral momentum theory.

This study represents an early stage of translational research. We used the multiple-schedule-disrupter paradigm (Dube et al., 2009) to investigate behavioral momentum in a clinical population. The baseline tasks and disrupters could be considered analogous to events that occur naturally in special education settings. For example, a child with severe intellectual disability and problem behavior may receive snack food consequences for completing some tasks and praise (attention) for other tasks. The alternative stimulus may be similar to situations in which additional attention reinforcers are gained by engaging in off-task behavior, the movie similar to additional types of reinforcement for off-task behavior (e.g., looking at interesting items in the classroom), prefeeding similar to consuming lunch just prior to earning food reinforcers for a task, and the presence of the researcher delivering response-independent food and praise may be analogous to "noncontingent reinforcement" (NCR) procedures to treat problem behavior (e.g., Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993).

The next stage of the translational research cycle moves out of the laboratory and into clinical settings, with responses and disrupters that are typically found in those settings. This stage was initiated by Mace et al.'s (1990) demonstration of behavioral momentum effects in 2 adults with intellectual disabilities. Participants sorted plastic dinnerware and the multiple-schedule components were distinguished by different dinnerware colors. In a recent extension of that line of research, children with developmental disabilities alternated between various classroom activities with different response topographies (jigsaw puzzles, blocks, etc.) and disrupters were common classroom events (videos, toys, computer games; Parry-Cruwys et al., in press). Five of the 6 participants showed greater resistance to disruption in the rich versus lean component.

Another potential vector for early- or mid-stage translational research concerns the multiple-schedule paradigm. What are the analogous naturally occurring clinical situations? One naturally occurring multiple schedule might be found in the alternation between group instruction and one-on-one instruction. Another possibility is training in multiple settings to promote skill generalization. If the characteristic overall reinforcement rates vary across settings, then the resulting measures of generalization may reflect varying levels of behavioral persistence. Further, reliable variations in the characteristic reinforcer rates across settings may be relevant to analyses of problem behavior that occurs during transitions between those settings (Ardoin, Martens, & Wolfe, 1999; Cote, Thompson, & McKerchar, 2005; Kennedy & Itkonen, 1993). For example, the occurrence of such behavior may be related to a discriminable negative shift in reinforcement schedules between tasks, as when the transition is from a relatively rich task or setting to a relatively lean task or setting (Bejarano, Williams, & Perone, 2003). If the problem behavior is related to persistence of pretransition responding, then a momentum analysis suggests that reducing the reinforcement rate just prior to a rich-to-lean transition may reduce problem behavior during the transition.

To conclude, we view behavioral momentum theory as part of an overall richer and evolving understanding of environmental contingency interactions as they apply in basic, translational, and applied behavior analysis environments. Regarding applied behavior analysis applications specifically, this understanding can help to increase the effectiveness of clinical procedures for encouraging desirable behavior and for discouraging undesirable behavior. More informed understanding of environmental contingency relations may thus enhance the effectiveness and (perhaps) reduce the cost of currently available evidence-based therapy.

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