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ORIGINAL PAPER

The Generality of Interview-Informed Functional Analyses: Systematic Replications in School and Home

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Abstract Behavioral interventions preceded by a functional analysis have been proven efficacious in treating severe problem behavior associated with autism. There is, however, a lack of research showing socially validated outcomes when assessment and treatment procedures are conducted by ecologically relevant individuals in typical settings. In this study, interview-informed functional analyses and skill-based treatments (Hanley et al. in J Appl Behav Anal 47:16–36, 2014) were applied by a teacher and home-based provider in the classroom and home of two children with autism. The function-based treatments resulted in socially validated reductions in severe problem behavior (self-injury, aggression, property destruction). Furthermore, skills lacking in baseline—functional communication, denial and delay tolerance, and compliance with adult instructions—occurred with regularity following intervention. The generality and costs of the process are discussed.

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Introduction

Autism spectrum disorders affect approximately 1 in 50 children (Blumberg et al. 2013). Individuals diagnosed with autism often engage in behavior (e.g., self-injury, aggression, disruption) that is dangerous to themselves or others (Dominick et al. 2007; Murphy et al. 2009). Baghdadli et al. (2003) reported that 50 % of children diagnosed with autism under the age of seven engaged in self-injurious behavior (SIB) with regularity. Murphy et al. (2009) reported that 64 % of children aged 3–14 diagnosed with autism engaged in at least one topography of problem behavior (i.e., SIB, aggression, disruption), and 32 % of the sample engaged in all topographies of problem behavior examined. By contrast, the prevalence of similar problem behavior among individuals with intellectual disabilities was reported to be 10–15 % (Emerson et al. 2001; Holden and Gitlesen 2006). Collectively, these results demonstrate that the probability of problem behavior occurring in children with autism is relatively high, emphasizing the need for practical assessment and treatment models capable of delivering meaningful behavior change to families and teachers of children diagnosed with autism.

Functional analysis has been shown to be effective both in identifying factors influencing problem behavior commonly associated with autism and in informing effective function-based treatments (Campbell 2003; Hagopian et al. 2013; Kahng et al. 2002). For instance, when designing a functional analysis for SIB, an analyst may alternate between a test condition in which a suspected reinforcer

such as attention (i.e., statements of concern, reprimands) is delivered contingent on SIB and a control condition in which attention is provided noncontingently (i.e., delivered about every 30 s). The analyst would then compare rates of SIB in the test sessions relative to those in the control sessions. The relevant reinforcer is thought to be identified when SIB reliably occurs at a higher rate in test sessions than in control sessions. The analysis results are then be used to inform an individualized treatment. A function-based treatment may include explicitly withholding attention following SIB and instead providing it following functional communication responses (FCRs, e.g., "Play with me please;" Carr and Durand 1985; Fisher et al. 1993). If SIB was found to have an escape function, teaching the child a more socially appropriate and recognizable means of accessing a break would be the appropriately matched treatment.

Functional analyses are typically part of an extended functional assessment process. Indirect assessments (e.g., interviews), descriptive assessments, and functional analyses are distinct components often involved in the process (Iwata and Dozier 2008). Descriptive assessments involve observing and measuring problem behavior in the context in which it occurs, but excludes manipulation of that context. By contrast, functional analyses, like those described above, involve some manipulation of the context across two distinct conditions, each arranged so the factors suspected of influencing problem behavior are present in the test condition and absent in the control condition (Hanley et al. 2003). Although several authors of literature reviews have shown that larger effects of treatment are obtained when functional analyses are part of the functional assessment process (Campbell 2003; Heyvaert et al. 2012; Kahng et al. 2002), reviews of practitioner habits show that functional analyses are rarely included in the functional assessment process (Desrochers et al. 1997; Ellingson et al. 1999; O'Neill and Johnson 2000; Weber et al. 2005). Limited time and resources (e.g., padded therapy rooms) are often cited as obstacles to including functional analyses in the process (Oliver et al. 2015).

Hanley et al. (2014) recently evaluated an outpatient model explicitly designed to increase the efficiency of the functional assessment process by using an open-ended interview to inform the design of individualized analyses with three children diagnosed with autism. The analysis in this process differed in several ways from the more commonly described functional analysis procedures (Iwata et al. 1982/1994). In a typical functional analysis of problem behavior, generic reinforcers such as escape, tangibles, and attention are assessed in distinct test conditions, and all are compared to a single control condition that varies in multiple ways from each test condition (Beavers et al. 2013; Hanley et al. 2003). By contrast, in Hanley et al. (2014), multiple contingencies derived from an open-ended interview were synthesized in a single test condition (e.g., escape *to* tangibles *and* attention). Rates of problem behavior in this single test condition were compared to rates of problem behavior in a matched control condition in which the synthesized contingency was removed (i.e., all putative reinforcers were provided continuously). Process efficiency was also achieved through the omission of both close-ended indirect assessments (e.g., rating scales) and formal descriptive assessments. Hanley et al. (2014) noted that the former were omitted because close-ended assessments do not allow for the detection of unique contextual features and/or reinforcers and thus are incapable of informing the design of the functional analysis beyond the generic contingency and that the latter were omitted due to the extended time required to conduct descriptive assessments and due to the recurrent invalidity of both assessment types in detecting behavioral function (Hall 2005; Lerman and Iwata 1993; St. Peter et al. 2005; Thompson and Iwata 2007).

The functional assessment process described in Hanley et al. (2014) allowed for the implementation of a progressively developing, skill-based treatment that was effective in eliminating severe problem behavior while strengthening communication and tolerance skills and compliance of all three children. The treatment began with functional communication training (FCT; Carr and Durand 1985): the teaching of a simple FCR (e.g, "My way please") to replace problem behavior. More complex FCRs were then shaped, resulting in a more developmentally-appropriate and interactional communication response (e.g., "Excuse me, [pause], May I have my way please?"). A delay and denial tolerance training procedure was then introduced to teach the children specific tolerance skills (e.g., making eye contact, taking a deep breath, and saying "okay") to emit when delay and denial cues were sometimes presented following the emission of an FCR. Chains of behavior such as completing homework or playing alone that had a good contextual fit with the conditions that used to evoke problem behavior were then gradually shaped to increase the periods of time without reinforcement and to strengthen repertoires that were important to the participating families. Treatment outcomes were then extended and evaluated across ecologically-relevant people and settings. Treatment gains were initially realized in an outpatient clinic when implemented by Board Certified Behavior Analysts (BCBAs), but were also observed when treatment was implemented by parents in their homes. At the end of treatment, all caregivers found the assessment and treatment procedures to be highly acceptable, and all were highly satisfied with the improvement in problem behavior.

Although Hanley et al. (2014) observed socially-validated treatment gains in the homes of the participating children, most of the teaching was implemented by experts in therapy rooms at a university outpatient clinic. It is yet unknown whether direct teaching staff and home care providers can implement the same assessment and treatment procedures in homes and classrooms and produce similar outcomes.

Examples of functional analyses conducted in classrooms by teachers (Bloom et al. 2013; Broussard and Northup 1995; Harding et al. 2009; Kodak et al. 2013; Northup et al. 1994; Wallace et al. 2004; Wright-Gallo et al. 2006) and other school personnel such as a school psychologist (Wallace et al. 2004), or in homes by parents (Dunlap et al. 2006; Harding et al. 2009) do exist in the assessment and treatment literature, but very few analyses are conducted within the context of ongoing classroom and home events and people. Furthermore, we do not have studies showing socially validated outcomes from functional assessment and treatment processes being implemented by teachers and care providers in homes and schools (for a recent notable exception in classrooms, see Austin et al. 2015).

The purpose of the current study was to replicate the assessment and treatment procedures described in Hanley et al. (2014) and to extend the study in the following ways: (a) to a different and dangerous topography of problem behavior (i.e., SIB) (b) to assessment and treatment carried out from start to finish in the contexts in which problem behavior typically occurred (i.e., no interactions occurred in analogue session rooms), (c) to implementation of the assessment *and* the treatment procedures by non-experts being intermittently and remotely supervised by a Board Certified Behavior Analyst (BCBA) with experience conducting functional analyses, and (d) to extension of treatment across multiple teachers and care providers relevant to the participants. In an attempt to understand the cost of replacing problem behavior with functionally equivalent skills in home and school contexts, data regarding the amount of time and extrapolated costs of the process are also provided.

Methods

Participants

Zeke was a 14-year-old male diagnosed with autism who attended a residential, non-profit educational program. Zeke used an augmentative communication device to make simple requests. Zeke had a history of severe problem behavior, which included SIB that often resulted in tissue damage (e.g., head-to-object, hand-to-head, body slamming), aggression (e.g., head-butting, hitting), and disruptive vocalizations (e.g., screaming, grunting). Educational staff reported that severe problem behavior occurred when Zeke was presented with instructional demands that simultaneously restricted or necessitated the removal of preferred items or when attention was diverted to other students while he was expected to complete work. Severe problem behavior occurred multiple times each day, and varied in form, intensity, and duration with some episodes lasting for well over an hour. Educational staff reported a recent discussion regarding potential modifications to Zeke's behavior program to include the contingent use of a protective helmet, due to the severity of his SIB. Zeke's parents agreed to this decision, in hopes to keep Zeke safe, despite their strong opposition regarding the use of protective equipment.

Karen was an 11-year-old female diagnosed with autism, awaiting residential placement in a non-profit educational program. Karen requested vocally, answered questions, and communicated in full sentences; however, she had a history of severe problem behavior, which included aggression (e.g., hitting, pushing, hair-pulling, biting, kicking), property destruction (e.g., throwing items, tipping furniture, breaking items), and inappropriate contact (e.g., poking, shoulder shaking, wrapping herself around others). Her severe problem behavior occurred primarily when preferred items (e.g., Ipad, toys, or books) and preferred conversation topics were terminated and/or restricted or when people were too busy to attend to or talk with her. She had destroyed many items in the home during episodes of severe problem behavior, had injured staff on repeated occasions (e.g., broke a care provider's nose), and several staff members terminated their employment due to the severity of her aggression.

Setting and Personnel

All functional analysis, treatment, and extension sessions for Zeke were conducted in his classroom in the context of typical ongoing activities. Zeke shared a classroom with two other students at the time of the study. The classroom contained Zeke's work area (i.e., table, two chairs, academic materials, and leisure materials), other students' work areas and materials, a computer used by all students in the classroom, a video camera, as well as other materials relevant for data collection and observations during all sessions. Sessions were conducted 1–6 times daily, 1–4 days per week. Session duration was 5 min throughout the analysis and treatment phases, and increased to between 5 and 10 min during treatment extension. All sessions prior to treatment extension were conducted by the first author, Zeke's lead teacher, who held a bachelor's degree in psychology and was enrolled in an Applied Behavior Analysis

(ABA) Master's program. Supervision was provided by the second author who was a BCBA-D and experienced in conducting functional analyses.

All sessions for Karen were conducted in her bedroom in the context of typical ongoing activities. Session materials included toys, chairs, table, bed, a video camera, and other materials relevant for data collection. Sessions were conducted 1 to 5 times daily, 1 or 2 days per week. Sessions were 5 min in duration for all phases of the study. All sessions prior to extension were conducted by the third author who was, the child's home-based BCBA, and held a Master's degree in ABA. Supervision was provided by the second author.

Measurement

Data were collected on problem behavior, functional communication responses (FCR), tolerance responses, type of instructions delivered, compliance to instructions, and reinforcement duration. Trained observers collected data using software on a laptop, as well as using a paper and pencil method. Data were collected continuously within 10-s intervals and were reported as a rate (i.e., responses per min) or as a percentage of session. Zeke's problem behavior was defined as disruptive vocalizations (high-pitched screaming, grunting, yelling, or shouting), aggression (hitting, biting, head-butting, hair pulling, or pinching), and SIB (head-to-object, hand-to-head, body slamming, self-scratching, or self-biting). Karen's problem behavior was defined as any instance of aggression including hitting, poking, pushing, shoulder shaking, wrapping self around others, hair-pulling, biting, or kicking. Problem behavior did not include tapping on other's shoulder, handshakes, high fives, hugs, or any solicited physical contact.

Data were collected on both simple and complex FCRs. Simple FCR consisted of Zeke pressing the icon on his AAC device that emitted, "May I have my way please?" Complex FCR required Zeke to press the icon on his AAC device that stated, "Excuse me," and then wait for the acknowledgement of his teacher before pressing the icon on the his device that stated, "May I have my way please?" An FCR was considered prompted if the teacher provided any vocal, gestural, and/or physical prompt. Karen's simple FCRs were her stating "Can I have that?" and "Change topics." Karen's complex FCRs were "Excuse me… (wait for acknowledgement), can I (have or) play with _____ please?" and "Excuse me … (wait for acknowledgement), can we change topics please?" An FCR was considered prompted if the therapist and/or care providers provided any vocal prompt to aid Karen in emitting a correct and complete communicative response. Only independent responses are depicted on the figures.

Reinforcement duration consisted of the period of session time in which both children had access to the reinforcers identified in the functional analysis. Reinforcement duration was scored when the teachers removed academic instructions, provided access to preferred items and activities, and provided Zeke with high quality social attention. Reinforcement duration was scored for Karen when she was allowed to access preferred conversation topics or unrestricted play. Percentage of session with reinforcement was calculated by dividing the reinforcement duration by the session duration.

The different types of instructions presented to the children during delay to reinforcement intervals are presented in Table 1. Observers collected data on the number of responses to instructions and the type of instructions given to both children during delay intervals. Observers also collected data on the frequency of compliance to the particular type of instructions presented, which were converted into a percentage of compliance. Compliance for Zeke consisted of responding to a simple motor-based instruction in the absence of problem behavior, refusal (e.g., shaking his head no, stating "no" on AAC device), or additional prompting, and Zeke actively engaging with leisure items and/or orientating towards leisure items as instructed to by his teacher. Compliance for Karen consisted of completing simple motor demands (e.g., go get me a book, go wash your hands), talking appropriately about a non-preferred topic, and completing academic tasks (e.g., worksheets, reading from a book).

Interobserver agreement (IOA) was calculated by having a second observer collect data independently on all target behaviors during at least 20 % of sessions within each condition (overall sessions with IOA was 26 % for Zeke; 30 % for Karen). Scored data were compared on an interval-by-interval basis, and percentage of agreement was calculated by dividing the smaller number of responses or duration (in seconds) in each interval by the larger number. Quotients were then averaged and converted to a percentage. IOA averaged 96.3 % (range 79–100 %) for all measures across both participants, with the range depicting the lowest and highest scores across all target behaviors for any scored session.

Experimental Design

The test and control conditions of the functional analysis were compared using a multi-element design for both children. The experimental design used to evaluate both Zeke's and Karen's treatment followed the logic of a changing criterion design. Levels of target behavior (problem behavior, simple FCR, complex FCR, and tolerance responses) closely corresponded and changed in the expected direction to three successive criterion changes in

Table 1 Levels of instructions based on complexity, amount, and developmental appropriateness

Levels	Category	Sample instructions
Zeke		
1	Simple motor/social questions	Stand up, sit down, what's your name?
		Touch your (shoulders, head, toes)
2	IEP-related academic objective	Indicates coins and bill names (i.e., penny, quarter, dollar)
3	IEP-related leisure objective with Diverted Attention	"Play with Mr. Potato head and/or Legos while I do work with your friend"
Karen		
1	Simple motor/social questions	What did you do in school today? Go get me a book, go wash your hands
2	Simple academic demands/conversation	Read a sentence, one conversation exchange
3	Complex academic demands; Longer non-preferred conversations	Complete worksheets, read pages; 4–5 volleys of a conversation exchange led by others

the reinforcement contingencies for those responses thereby demonstrating functional control (Hanley et al. 2014). For Karen, behavior change was also evaluated using a multiple baseline design across two different contexts (i.e., tangible/attention and preferred conversation). Functional control was demonstrated when problem behavior decreased and simple and complex FCRs and tolerance responses increased when and only when the interventions were introduced in each context.

Functional Assessment Process

An open-ended functional assessment interview (Hanley 2012) was arranged with Zeke's teachers and educational supervisors (at the same time) and with Karen's parents and home staff members (at the same time) to gather information regarding potential factors influencing both children's problem behavior. The duration of the interview was about 40 min and included questions relevant to each of the children's current skills (e.g., "describe child's play skills and preferred toys or leisure activities"), problem behavior (e.g., "what are the problem behaviors?" and "what are the top 3 most concerning problem behaviors?), contexts in which problem behavior regularly occurred (e.g., "do the problem behaviors reliably occur during any particular activities?"), and others' responses to problem behavior (e.g., "what do you and others do to calm the child down problem behavior has occurred?"). Individualized questions occasionally emerged based on responses to sample questions throughout the interview.

Functional analyses were then arranged to confirm the interview-generated hypotheses regarding the participants' problem behavior and its reinforcement contingencies. The analyses involved alternating between a series of test and control sessions. In control sessions, putative reinforcers were continuously available throughout the session. In test sessions, all putative reinforcers were removed at the start of the session and reinstated for 30 s contingent on problem behavior. The only difference between the test and the control sessions was the suspected reinforcement contingency; all other factors (e.g., materials, setting, analyst) remained constant.

The results of Zeke's open-ended interview suggested that his problem behavior topographies tended to co-occur, and were evoked when instructional demands were presented and resulted in a removal of preferred items/activities (e.g., blowing bubbles, bouncing balls, toy poppers, whoopee cushions) or termination of high quality social interactions (e.g., singing songs, making silly facial expressions and noises, tickles). Escape from instructional demands to access tangible items/activities and high quality social attention was suspected to maintain his problem behavior. Problem behavior was also reported to occur when Zeke had to complete work or engage with leisure materials while his teacher taught another child. Based on the results of the interview, a synthesized contingency analysis was arranged for Zeke's problem behavior that included escape (i.e., social negative reinforcement) to tangibles and attention (i.e., social positive reinforcement) in a single test condition compared to an intimately-matched control condition. In the control condition, continuous high quality social attention and tangible items/activities were provided throughout the entire session and in the absence of instructional demands. In the escape to attention and tangible test condition, the session began with the teacher stating, "Zeke, it's time to do work," while simultaneously removing both the social attention and tangible items/activities and returning them for 30 s contingent on problem behavior. A three-step prompting hierarchy was used to ensure completion of the instructional demand presented. The teacher delivered social praise if Zeke completed the demand in the absence of

physical prompting. The analysis included 6 sessions with a 1-min break in between each session, in which conditions described for control sessions were implemented.

The results of Karen's interview suggested that (a) her problem behavior was evoked when preferred tangible items, preferred conversation topics, and adult attention were terminated and/or restricted, and (b) that her problem behavior was highly unlikely when she had access to her preferred conversation, tangibles, and others' undivided attention. Access to tangible items, preferred conversation topics, and attention was then suspected to maintain her problem behavior. Because these particular reinforcers were sometimes provided in isolation (e.g., attention) and at other times simultaneously (e.g., tangibles and attention), both isolated and synthesized contingencies were evaluated in separate analyses. Each distinct test condition was compared to a control condition in which all suspected reinforcers (i.e., attention, preferred tangible items and preferred conversation topics) were provided continuously. In addition, moderately preferred toys that were routinely available in her bedroom (e.g., stuffed animals and books) were freely available in all test and control conditions.

In the isolated attention test condition, attention (e.g., verbal praise, commenting on ongoing activities, brief physical touch) was provided for 30 s contingent on problem behavior. In the synthesized attention/tangible test condition, access to Karen's iPad was provided contingent on problem behavior. Attention was only available upon request during the period in which she had her iPad; thus, both tangibles and attention were available following problem behavior in this test condition. In the conversation test condition, changing from a non-preferred topic (e.g., talking about how her dog was a male or about non-preferred television shows or current events) to a preferred topic (e.g., having an agreeable conversation about her male dog "being a girl dog" or discussing preferred television shows) was provided contingent on problem behavior. This condition would start out with the analyst engaging Karen in a benign but non-preferred conversation topic. This test also contained a synthesized contingency in that both social negative (i.e., terminating non-preferred conversation) and positive reinforcement (i.e., initiating preferred conversation) was simultaneously provided following problem behavior.

Treatment Process

Baseline

The test sessions from Zeke's functional analysis served as his baseline. Tangible and preferred conversation test sessions from Karen's analysis served as her baseline.

Simple FCT

A most-to-least prompting hierarchy was used to teach the children to emit a simple FCR to replace problem behavior and access putative reinforcers. Zeke was taught with physical, model, then vocal prompts to emit the simple FCR, "May I have my way please?" by pressing the correct icon on his AAC device when an evocative situation was presented (i.e., teacher stating, "It's time to do work" while removing putative reinforcers). Emission of this simple FCR resulted in 30 s termination of academic instructions and access to high quality social attention, tangible items/activities. Karen was taught with model and vocal prompts, to state "Can I have that?" which resulted in 30 s delivery of unrestricted play with materials of her choosing, as well as stating, "Change topics," which resulted in the delivery of 30 s of the adult changing to a preferred conversational topic when evocative situations were presented (e.g., iPad is removed, non-preferred conversation occurring). During the initial FCT sessions, an immediate prompt to emit the communicative response was provided to the child to ensure contact with the reinforcement contingencies; the prompt level was reduced then progressively delayed as the children became more independent. Problem behavior was placed on extinction during FCT (i.e., it no longer produced any reinforcement). Access to putative reinforcers was also withheld if the child emitted problem behavior within 5 s of an FCR.

Complex FCT

The complexity of the FCR was increased following two consecutive sessions in which the children emitted the simple FCR independently and in the absence of problem behavior. Each child was now required to state "Excuse me" or press an "Excuse me" icon on the AAC device, make eye contact with the adult, wait for the acknowledgment (e.g., "yes Zeke"), then emit an FCR (i.e., "May I have my way please?" for Zeke and "Change topics please" or "Can I have that please?" for Karen) before accessing their respective reinforcers. A most-to-least prompting hierarchy was used if the child did not emit the FCRs within 5 s of the presentation of the evocative situation. Reinforcers were withheld if problem behavior occurred.

Delay and Denial Tolerance Training

Following independent emission of the complex FCR in the absence of problem behavior for two sessions, both children were taught to tolerate denials and delays to requested reinforcers. In this condition, immediate reinforcement was provided following two of every five

complex FCRs, while the remaining three of every five FCRs produced a delay and/or denial response from the adult (e.g., "Zeke, not right now," "Sorry, Karen that's not available," "not now," it's time do work," and/or a head shake "no"). Extinction remained in place for problem behavior. A most-to-least physical prompting hierarchy was used to teach the children specific responses to the delay/denial cues; these included looking at the adult following the denial cue (i.e., establishing eye contact), taking a deep breath, and then nodding head "yes" for Zeke and/or taking a deep breath and stating "okay" for Karen. Immediate access to requested reinforcers was provided initially following emission of the tolerance response. Non-reinforcement time–more specifically the conditions that historically evoked problem behavior–was then progressively introduced. The children were required initially to comply with simple instructions in order to access the requested reinforcers (i.e., initially, the respective adult required very little behavior from the children). However, the complexity and duration of the non-preferred conversation (Karen only), IEP-based instructions (Karen and Zeke), or independent play requirement (Zeke only) was gradually increased with the aim of producing lengthy sequences of desired behavior yielding the functional reinforcers. For Zeke, this included instructions to complete IEP-related work or temporally extended and independent engagement in a less preferred leisure activity during a period of diverted attention in which the teacher completed academic work or played with another student. At the close of this phase, non-reinforcement periods ranged between 2 and 3 min and reinforcement intervals ranged between 90 s and 2 min.

For Karen, this teaching context required compliance with complex academic instructions (e.g., completion of a math worksheet, reading a page of a book) or a complex conversation exchange about a non-preferred topic (e.g. 5–6 one sentence exchanges with a teacher). At the close of this phase, non-reinforcement periods ranged between 30 s and 3 min and reinforcement intervals ranged between 30 s and 2 min.

Delay periods continued to increase for Zeke with diverted attention from the teacher while the teacher completed an entire academic objective with another student and delivered a reinforcing activity to that student, as this arrangement emulated Zeke's typical work schedule at school. The criterion for an increase in the delay requirement was independent FCRs and tolerance responses and an absence of problem behavior for both children in a single session. It is important to note that delays did not end when a certain time criterion was met; they ended when the child had engaged in the target amount of desirable behavior (i.e., work, play, conversation) in the absence of any problem behavior. It is also important to note that an average amount of behavior was progressively increased such that when a delay was inserted after a tolerance response, the precise amount of behavior that was required was variable and uncertain to the child. Variable and unpredictable delays were purposely programmed to prepare Karen and Zeke for these inevitable ambiguities outside of sessions.

Treatment Extension

The intervention was extended across three teachers who worked closely with Zeke and extended across three of Karen's home care providers in order to evaluate the generality of the treatment process. Prior to implementing treatment with Zeke, teachers were encouraged to watch a previous treatment session conducted by the primary teacher. All teachers were electronically sent a written script that outlined the treatment contingencies and the precise language to be used when implementing treatment. The lead teacher directly coached others on the intervention using behavior skills training (BST; instructions, modeling, role-playing, and feedback) prior to teachers conducting their respective sessions. These coaching periods lasted for approximately 30–40 min per teacher. Next, the lead teacher conducted one session with Zeke while the teacher preparing to extend the treatment procedures was present in the classroom. The teacher observing then implemented the treatment procedures.

From the beginning of Karen's consultation, individuals who participated in the treatment extension frequently observed sessions (i.e., two staff members, mother). Similar to Zeke, prior to implementing treatment with Karen, the primary therapist directly coached others on the intervention using BST prior to conducting their respective sessions. In both cases, the primary therapist was present to provide any feedback while Karen's mother and other home-based providers conducted sessions.

Social Validity

To evaluate the social acceptability of the functional assessment and treatment process and to ensure the treatment outcomes were meaningful, a social validity questionnaire was given to Zeke's teachers and Karen's home care providers who participated in the treatment extension portion of the study. Questions were asked regarding the acceptability of the procedures used during assessment and treatment, the level of satisfaction with observed improvement in problem behavior, and the usefulness of the consultation received. Individuals were also asked how comfortable they felt when presenting situations that often evoked problem behavior prior to and after conducting the treatment extension sessions.

Results

Functional Assessment

Educational staff reported that Zeke's problem behavior occurred when instructional demands were presented that restricted and/or removed access to preferred items/activities, and that resulted in periods of diverted attention. Parents and home staff reported that Karen's problem behavior occurred when preferred tangible items were removed and/or restricted, as well as when preferred conversational topics were denied, and adult attention was diverted and/or denied. We observed zero rates of problem behavior when undivided and high quality social attention and tangible items and activities were provided to Zeke in the absence of instructional demands. When problem behavior resulted in escape from instructional demands to access undivided social attention and tangible items/activities, relatively high and consistent rates of problem behavior were observed (see Fig. 1). We observed zero rates of problem behavior, in all attention test and control session conducted with Karen, suggesting that attention, on its own, was not a reinforcer for her problem behavior. By contrast, when problem behavior resulted in access to preferred tangible items and attention or preferred conversational topics, relatively high and consistent rates of problem behavior were observed, and zero rates of problem behavior were observed when tangible items, attention, and preferred conversations were provided to Karen continuously in the control conditions (see Fig. 1).

The interviews and subsequent analyses elucidated the reinforcing contingencies influencing the severe problem behavior of both children. Zeke's problem behavior was shown to be maintained by escape from instructional demands (i.e., social negative reinforcement) to access social positive reinforcement in the form of attention and tangible items/activities. Karen's problem behavior appeared to be insensitive to attention on its own and instead maintained by access to tangible items with attention and preferred conversational topics.

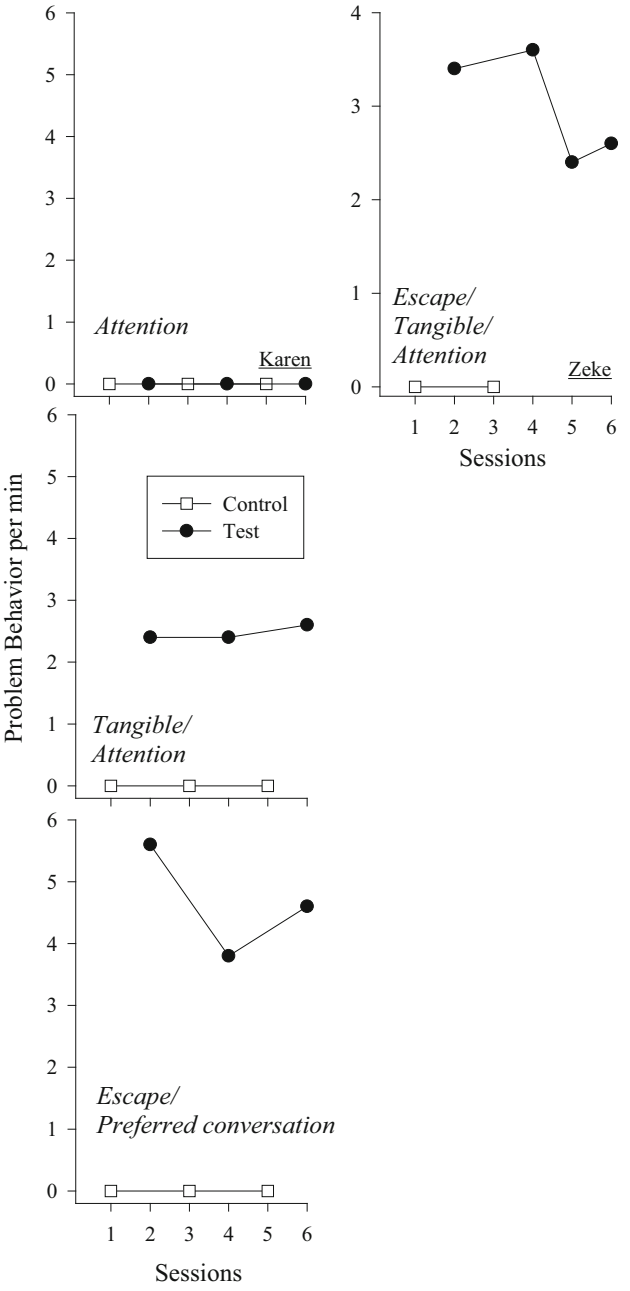

Fig. 1 Interview-informed analyses are depicted for both participants. The contingencies assessed with each child are noted in *italics*

Treatment Evaluation

FCT resulted in an immediate decrease in problem behavior for both children as well as acquisition of a simple FCR (see Figs. 2, 3). Karen's problem behavior was initially variable during FCT in the conversation context, but zero levels were observed at the completion of the simple FCT phase. A slight increase in the level and variability of Zeke's problem behavior was observed during the initial teaching of the complex FCR, but zero levels were achieved at the close of the phase. Karen only emitted problem behavior in one session of each context during complex FCT. At this time, both children were able to state, "Excuse me," make eye contact with the adult; wait for the acknowledgment, then mand using their trained FCRs, when presented with evocative situations.

At the start of the denial and delay tolerance training, problem behavior remained at zero levels, complex FCRs maintained at appropriate levels, and independent tolerance responses were acquired for both children. Functional control was demonstrated by showing the target behavior changed when and only when the reinforcement

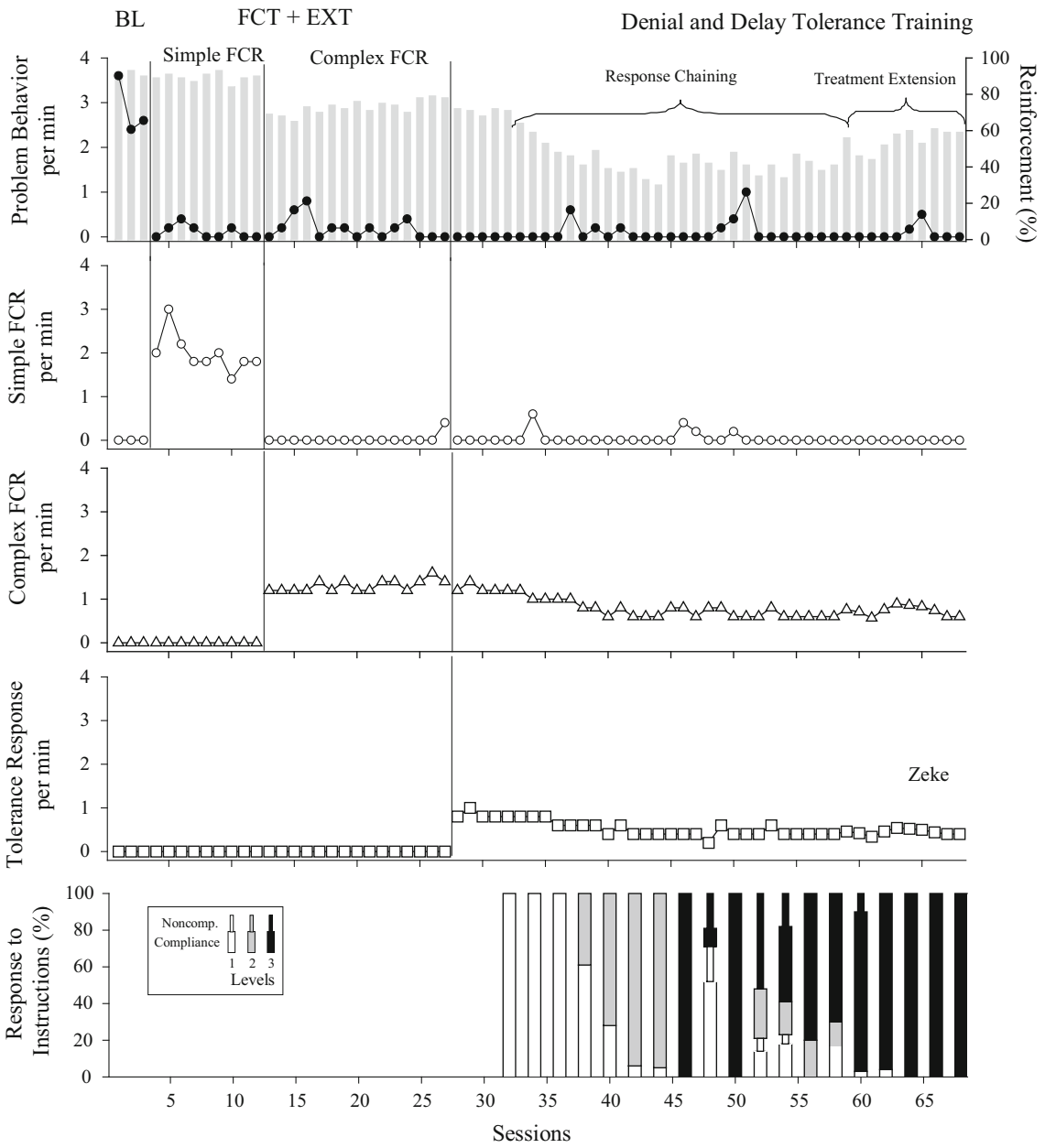

Fig. 2 Treatment analysis for Zeke. *Thin bars* on the *bottom panel* represent noncompliance, whereas the *thick bars* represent compliance. *White bars* represent performance relevant to level 1 instructions, *gray bars* represent performance relevant to level 2 instructions, and *black bars* represent performance relevant to level 3 instructions. See Table 1 for example instructions

contingency was assigned to each target behavior. For Karen, functional control was reaffirmed using a multiple baseline design across the two different contexts.

During response chaining, problem behavior remained at near-zero levels, complex FCRs and tolerance responses persisted, a decrease in the amount of reinforcement was observed, and compliance remained at high levels despite gradual exposure to the most challenging contexts and instructions (e.g., playing alone with less preferred items during diverted attention, complex academic instructions, longer non-preferred conversational exchanges).

Some variability in Zeke's problem behavior was observed following the introduction of more challenging instructions and when treatment was extended to different individuals. However, when treatment was terminated, both children's problem behavior was at zero rates, and complex FCRs, tolerance responses, and compliance continued to persist while the treatment was extended to three

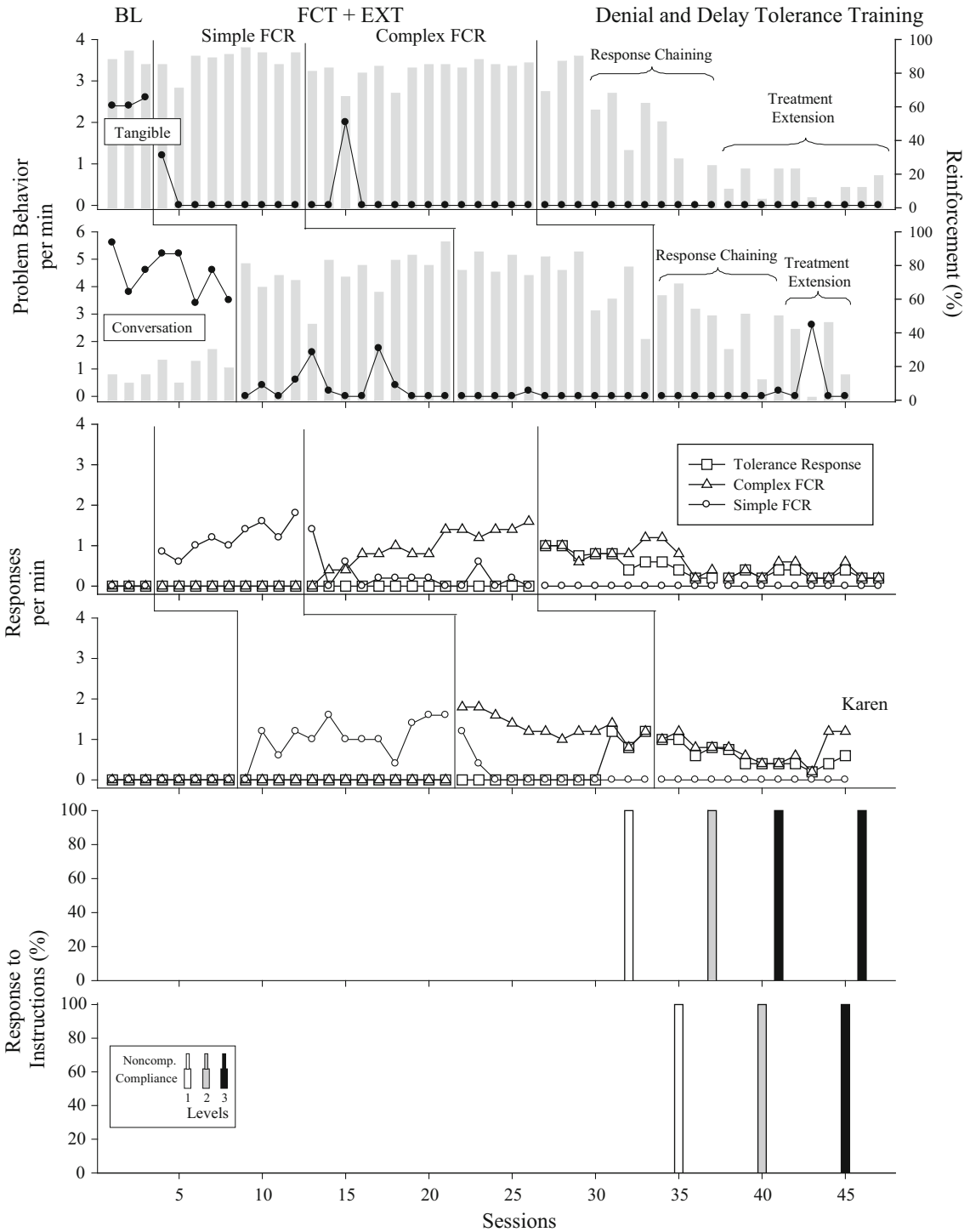

Fig. 3 Treatment analysis for Karen. *Thin bars* on the *bottom panel* represent noncompliance, whereas the *thick bars* represent compliance. *White bars* represent performance relevant to level 1 instructions, *gray bars* represent performance relevant to level 2 instructions, and *black bars* represent performance relevant to level 3 instructions. See Table 1 for example instructions

different individuals per child. At the end of treatment, Zeke's requests for reinforcement were only granted about 40 % of the time. For Zeke, the amount of reinforcement time was routinely less than 60 % and as low as 30 % while a variety of challenging academic and social instructions were reintroduced. For Karen, the amount of reinforcement time was routinely <25 % and as low as 3 % during both contexts where she learned to engage in other

activities while her preferred tangibles were unavailable and engagement in adult-initiated conversation topics was required.

Social Validity Evaluation

All individuals who participated in the treatment extension phase (i.e., Zeke's teachers and Karen's home care providers) were administered a social validity questionnaire following their participation. All individuals stated they considered the assessment procedures highly acceptable and reported that the consultation provided was very helpful. High ratings were reported regarding the treatment package procedures and the observed improvement in problem behavior (see Table 2). When assessing caregivers' comfort levels in presenting evocative situations, average ratings increased from 3.9 before treatment to 6.4 following treatment. When asked to provide any additional comments regarding the assessment and treatment process, Zeke's teacher reported, "I am SO impressed with how much of a difference this intervention made! Zeke responded so well to it and had zero problem behavior in situations where previously he would have engaged in a lot of self-injury."

Time and Cost Expenditures

There were no additional fees rendered for the family or school of the children who participated. However, information regarding the estimated time and cost expenditure of services if fees were rendered was determined. The assessment and treatment consultation lasted approximately 14 calendar weeks and required 30 one-hour classroom periods for Zeke. A BCBA was present for the interview, supervision meetings, and aided in the initial report planning and writing for Zeke; the lead teacher implemented all teaching procedures and training of the other teachers. Assuming an hourly rate of $125 per hour for the lead BCBA ($1 \times \$125 = \$125$) and a rate of $75 per hour for the teacher ($29 \times \$75 = \$2175$), as well as factoring costs associated with supervision meetings and report writing, the estimated cost of this effective assessment and treatment process for severe problem behavior associated with autism in a classroom was $2975 US dollars. The time required and cost of each step of the assessment and treatment process are depicted in Table 3.

The assessment and treatment process lasted 22 calendar weeks and required 23 one-hour home visits for Karen. Using the same algorithm described above, the estimated cost of this effective assessment and treatment process for severe problem behavior associated with autism occurring in the home was $5475 US dollars.

Discussion

The functional assessment and treatment process described by Hanley et al. (2014) was applied in two contexts, in a child's busy classroom and in another child's home. This process effectively eliminated the severe problem behavior (self-injury, aggression, disruption, property destruction) of the two participating children who were diagnosed with autism. This process also yielded functional communication, tolerance skills, and high levels of compliance and engagement for both children. Treatment effects were extended across multiple teachers and home care providers who worked closely with the participating children. We replicated the outpatient treatment outcomes of Hanley et al. (2014) and provided further empirical support for the utility and generality of interview-informed analyses for developing socially meaningful improvements in severe problem behavior associated with autism. The educational supervisors, teachers, and home care providers who participated in this study reported that the consultations were very helpful and were very pleased with the large improvements in both Zeke's and Karen's problem behavior and of the overall assessment and treatment process.

The current study extended Hanley et al. (2014) in several ways. First, all assessment and treatment procedures were implemented by the people teaching or providing services to the children within the context of naturally scheduled events occurring in Zeke's classroom and Karen's home. Effective assessment and treatment outcomes were replicated despite the "noisy" and potentially confounding assessment and teaching environments. Whereas Hanley et al. successfully *extended* treatment across ecologically-relevant individuals (i.e., parents) and settings (i.e., homes), treatment for the both participants in this study was successfully *developed* in the terminal settings and solely implemented by and evaluated across ecological-relevant individuals (i.e., teachers and care providers). This study demonstrates the efficacy of the Hanley et al. assessment and treatment model when executed in its entirety (i.e., from the initial interview and informed analyses to treatment extension) in non-clinical settings.

Second, one of the severe problem behaviors assessed and treated in this study was SIB—head-to-object, hand-to-head, body slamming, self-scratching, and self-biting—that often resulted in tissue damage to Zeke (e.g., bruised limbs, abrasions, swelling and redness to forehead). The topographies of SIB targeted were both severe and dangerous and differed from the topographies of problem behavior (i.e., meltdowns, aggression, screaming) targeted in Hanley et al. This study shows that dangerous behaviors

Table 2 Social acceptability questionnaire results

Questions	Ratings						
	Karen			Zeke			Mean
	R1	R2	R3	R1	R2	R3	
1. Acceptability of assessment procedures	7	7	7	7	7	7	7
2. Acceptability of treatment packages	7	7	7	7	5	7	6.7
3. Satisfaction with improvement in problem behavior	6	7	7	7	6	7	6.7
4. Helpfulness of consultation	7	7	7	7	7	7	7

	Comfort levels					
	Pre Rx R1	Post Rx	Pre Rx R2	Post Rx	Pre Rx R3	Post Rx
Karen						
1. Taking away preferred items	7	7	3	6	5	7
2. Talking about non-preferred topics	5	6	2	6	4	5
Zeke						
1. Taking away preferred items	3	7	7	7	5	7
2. Taking away preferred items/activities then immediately presenting work	3	7	6	6	3	7
3. Taking away preferred items/activities and attention	3	6	2	5	2	7

Overall mean	
Pre	Post
3.9	6.4

7 = highly acceptably, highly satisfied, very helpful, or very comfortable

1 = not acceptable, not satisfied, not helpful, or not comfortable

R2, R2, and R3 denote the three responders including parents and teachers

such as self-injury and aggression can be successfully assessed and treated in the classrooms and homes in which they regularly occur.

Third, whereas a BCBA was present for all sessions in Hanley et al. (2014), as well as with Karen in this current study, the lead classroom teacher was responsible for the implementation of all of Zeke's assessment and treatment procedures. This component of the study may misleadingly suggest that this assessment and treatment model can be conducted in its entirety by individuals without training in behavior analysis in general or functional assessment in particular. It should be noted, however, that the lead teacher was more than halfway through a Master's program in ABA, the entire process for both children was supervised by an experienced BCBA, who was also responsible for conducting Zeke's open-ended interview as well as determining which contingencies to incorporate in Zeke's synthesized functional analysis. Due to its complexity, it is suggested that this process not be conducted without proper supervision from an experienced BCBA. In other words, decision making and interpretation of the initial interview should probably be guided by an experienced BCBA, but all other components of the process, including interview-informed analyses, can probably be implemented by others (e.g., teachers, paraprofessional, home-based providers, parents) with very intermittent supervision by a BCBA.

The time and cost expenditures showed that severe problem behavior can be sufficiently understood and replaced with skills in home and school contexts in about 26 h distributed across a 4-month period for between 3000 and 5000 US dollars. Due to the manner in which this support was provided, these processes required more extensive calendar time than that required by the outpatient model described in Hanley et al. (2014), but because personnel working directly with the participating children implemented the analyses and skill-based teaching, the overall costs were slightly lower in the current study than in Hanley et al.

The assessment and treatment process applied in this study is not without its limitations. To start, additional measures of generality and maintenance are needed, as

Table 3 The steps in the assessment and treatment process for addressing severe problem behavior in children with autism along with the time expended and extrapolated costs

Steps	Participants					
	Karen (2 contexts)		Zeke		Average	
	# of Visits[1]	Cost[2]	# of Visits[3]	Cost	# of Visits	Cost
1. Interview*	1	200	1	200	1	200
2. Functional analysis*	2	400	2	150	2	275
3. Functional communication training	6	1200	3	225	4.5	713
4. Complex FCT	6	1200	5	375	5.5	788
5. Tolerance response training	1	200	3	150	2	175
6. Easy response chaining	2	400	3	225	2.5	313
7. Difficult response chaining*	2	400	8	750	5	575
8. Treatment extension*	3	600	4	300	3.5	450
Totals	23	4600	29	2375	26	3488
Supervision meetings[3]	3	375	4	250	3.5	313
Report writing/planning[4]	4	500	4	350	4	425
Grand totals		5475		2975		4225

* Report writing and planning periods required 1-h and occurred following each step noted by an asterisk

[1] Each family visit was 1-h in duration; lead BCBA and behavioral technicians were present at each home visit

[2] Cost is in US dollars; hourly rate of supervising and lead BCBA was $125; hourly rate of behavioral technician was $75

[3] Each school-based assessment or teaching session was 1-h in duration; only the lead teacher was present at each home visit

[4] Supervision meetings between the supervising BCBA and the lead BCBA (for Karen) or teacher (for Zeke) were 30 min in duration and occurred approximately once per week

measures demonstrating the effects of the assessment and treatment process throughout the day and over an extended period of time following the initial treatment have not yet been provided. In addition, the current study did not collect global measures of the participants' functioning prior to and/or following consultation services. In other words, there was a lack of an analysis evaluating the more general effects of the treatment process for both Zeke and Karen, such as whether or not an improvement in IEP-based learning occurred. Like many studies relying on single-case designs, this study only incorporated two participants. Future research should aim to replicate these procedures being administered by teachers and home care providers in more homes and classrooms to obtain a more precise account of the cost of this process and perhaps compare this process to other promising models of immersed functional assessment and treatment (e.g., Austin et al. 2015). Finally, formal treatment fidelity data (McIntyre et al. 2013) are not reported. Such information is apparent indirectly via the reporting of the percentage of reinforcement intervals with reinforcement. The integrity of the independent variable can also be gleaned from the control exerted over multiple direct measures of behavior within the changing criterion design. Nevertheless, as this assessment and treatment model is transported from experts in clinics to practitioners of varied backgrounds working in complicated environments, more traditional measures of treatment fidelity will be necessary. These measures will be especially important for comparative analyses or randomized clinical trials of this assessment and treatment model.

Author Contributions Ms. Santiago implemented the procedures, assisted in the design of the study, analyzed the data, and co-wrote the initial draft of the paper. Dr. Hanley designed the study, co-wrote the manuscript, and revised the manuscript according to the reviewers comments. Dr. Jin provided guidance on measurement and data analysis, developed the graphic displays, and assisted in revising the manuscript according to the reviewers comments. Ms. Moore implemented the procedures, assisted in the data analysis and in the writing of the initial draft of the paper.

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