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Outcomes of the Application of Methods of Subtyping Self-Injury Behavior to Stereotypy

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OUTCOMES OF THE APPLICATION OF METHODS OF SUBTYPING SELF-INJURY BEHAVIOR TO STEREOTYPY

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Abstract

The general purpose of this study was to determine whether the subtyping methods developed to analyze automatically reinforced self-injury (SIB), described by Hagopian et al. (2015, 2017), apply to stereotypy. The Structured Visual Inspection Criteria were applied to FAs of stereotypy, and the levels of differentiation (LoD) between the alone/no interaction were calculated. Eleven students diagnosed with autism, between 3 and 18 years old, and who engaged in stereotypy, participated in the study. Five students were exposed to the following: Functional Analysis (FA); Augmented-Competing Stimulus Assessment (A-CSA); and Treatment Analysis consisting of two condition types: 1) access to alternative sources of reinforcement; and 2) prompting of functional/contextual engagement. Interventions for the other six students were not informed by the ACSA but were assessed in a treatment analysis of the same two condition types following FA; however, they did not experience an A-CSA prior to the treatment analysis.). The statistics r Pearson score showed a positive correlation between LoDs FA play alone and Treatment 1 ($r = 0.71$ with $p < .01$). We discuss the treatments predicted as effective by the subtyping model and LoD analyses.

Keywords: Subtyping, automatically reinforced behavior, stereotypy, prediction of RTI, functional analysis.

Outcomes of the Application of Methods of Subtyping Self-Injury Behavior to Stereotypy

Automatically reinforced maintained behavior poses a challenge to the clinician because they do not have direct access to the contingency between responding and its consequence(s) (Vollmer, 1994). Stereotypy and self-injurious behavior (SIB) are sometimes examples of automatically reinforced challenging behavior (Iwata, Pace, et al., 1994; Rapp & Vollmer, 2005). Stereotypy has been estimated to almost always be automatically reinforced maintained behavior (Rapp & Vollmer, 2005) while SIB has been found to be much more varied in function with automatic reinforcement accounting for at least 17% of cases analyzed (Melanson & Fahmie, 2023).

One common technique in treating SIB involves identifying and then presenting activities associated with low occurrence of SIB. Shore et al. (1997) demonstrated that the concurrent presentation of preferred activities correlated with low SIB levels. Shore et al. suggested that those activities effectively substituted the stimulation produced by the SIB in their participants. Piazza et al. (1998) examined the effects of stimuli hypothesized to match (produce similar apparent sensory stimulation as SIB) and stimuli hypothesized to not matched the same sensory stimulation as SIB. For all participants, matched activities were correlated with low levels of SIB (pica). This study is credited by Haddock and Hagopian (2020) as the first formal competing stimulus assessment (CSA) because it included a no-stimulus control trial and measures for SIB and engagement in alternative activities. Piazza et al. (2000) replicated Piazza et al. (1998) with three distinct response topographies of automatically reinforced maintained behavior. They showed that stimuli categorized as matched were associated with the lowest levels of problem behavior for all three participants. On the other hand, Ahearn et al. (2005) showed that preferred

unmatched stimuli were correlated with the lowest rates of automatically reinforced maintained behavior for two participants.

Jennett et al. (2011) conducted multiple CSAs to identify stimuli for decreasing the SIB of a 3-year-old girl . In the initial CSA, free access to stimuli did not produce clinically acceptable levels of SIB for any stimuli presented. When the CSA was combined with stimulus representation, lower levels of SIB and higher stimulus contact occurred but did not meet clinically significant levels. When CSA was combined with representation and blocking, all items were associated with low levels of SIB and the high levels of engagement. Haddock and Hagopian (2020) defined this sequence of exposure to stimuli across the 3 variations of stimulus presentation has been referred to as the *augmented competing stimulus assessment* (ACSA).

In addition to conducting a CSA to assist with treatment development, interpreting FA outcomes according to subtypes may be helpful in further informing the development of treatment. Hagopian et al. (2015) found that a functional analysis (FA) of automatically reinforced maintained behavior may predict what will and will not be effective treatments for automatically reinforced self-injurious behavior (ASIB). The authors described three subtypes of ASIB. Subtype 1, which displays high differentiation of SIB between the play and alone conditions, was effectively treated by reinforcement-based treatments alone (Hagopian et al., 2015) in that they do not include any specific intervention contingent upon the occurrence of ASIB (e.g., (i.e., response reduction procedures such as blocking or redirection will not be needed). Subtype 2, which displays low differentiation between the alone and play conditions, was not effectively treated by reinforcement-based treatments alone (Hagopian et al., 2015, 2017). More resource intensive treatment, like; more direct interventions (e.g., response blocking/redirection and/or prompting alternative behavior) were necessary to reduce ASIB to

clinically significant levels. Subtype 3 is Subtype 2 plus self-restraint. This subtype was given because self-restraint is a relevant behavioral feature in some individuals who emit ASIB.

Hagopian et al. (2015) identified the subtypes by comparing the levels of problem behavior during an FA using two methods to inspect FA graphs. In the first method, Hagopian et al. (1997) developed the structured visual inspection criteria. They first drew an upper criterion line (UCL) between the second and third highest data points and a lower criterion line (LCL) between the second and third lowest points from the play condition. Next, they subtracted the number of points in the alone condition that were below the LCL from the number of points above the UCL. Then, Hagopian et al. (2015) converted this value to a subtype quotient score by dividing it by the number of alone sessions.

Roane et al.(2013, Section Appendix) adapted the **Structured Visual Inspection Criteria** from Hagopian et al. (1997) for FAs with at least seven data points and stated three rules for scoring FA graphs as automatic reinforcement. The rules are: 1. Alone is the highest condition and is significantly higher than toy play; 2. The rates of behavior tend to be higher in conditions with less external stimulation; and 3. All conditions are high and relatively stable with no overall trends.

Hagopian et al. (2015) incorporated the modification from Roane et al. (2013) and classified behavior as Subtype 1 if the quotient was higher than 0,5. They classified behavior as Subtype 2 if the quotient was less than 0,5 or more than 30% of the data points were overlapping between the play and alone conditions, or the mean rate of SIB was more than 50 responses per minute in both the play and alone conditions.

The second inspection method is the calculation of the **level of differentiation** (LoD) between FA conditions. To calculate LoD, Hagopian et al. (2018) divided the mean of ASIB in

the play condition by the mean of ASIB in the alone condition. They subtracted the resulting quotient from 1 and converted it to a percentage. Hagopian et al. (2015) initially presented the LoD calculation to evaluate the effect of competing items on repetitive ASIB. They considered effective competition if a competing item produced an 80% or greater reduction in SIB. However, LoD was reliably related to the subtypes, leading Hagopian et al. (2018) to suggest that the LoD is a Predictive Behavior Marker for ASIB in FAs. This predictive value states a cut off score of 63.7% of differentiation in which a higher value predicts a Subtype 1 sensitivity to treatment and a lower value predicts a Subtype 2. This cut of score came from the positive predictive value (PPV) analysis, which is the conditional probability of having a good treatment outcome Hagopian et al. (2018).

The experimenters demonstrated the utility of the subtype assessment in a prospective analysis (Hagopian et al., 2015) and retrospective analysis. (Hagopian et al., 2017) applied the subtype assessment when reviewing the published literature on ASIB. Hagopian et al. (2017) and retrospective analysis. Hagopian et al. (2017) applied the subtype assessment when reviewing the published literature on ASIB. Hagopian et al. (2017). There were two significant conclusions from Hagopian et al. (2017): 1) Subtype-1 ASIB tends to be more sensitive to treatments that use reinforcement alone; and, 2) Subtype-2 ASIB tends to be more resistant to reinforcement-based treatment, which replicated Hagopian et al. (2015).

Wunderlich et al. (2022) extended the ASIB subtype assessment to the published literature on stereotypy. They included 89 data sets whose target repetitive behavior had little to no risk of causing immediate physical harm. Their results found no difference between reinforcement-based intervention efficacy between Subtype 1 and 2. Wunderlich et al. (2022) was a retrospective study, in which the participants were not exposed to an ACSA, which is a

more specific means to identify competing stimuli and a better means of testing whether or not the subtyping assessment applies to stereotypy.

The current study is a prospective analysis using the ACSA to inform treatments. The general purpose of this study was to determine whether the subtyping methods of automatically reinforced SIB, described by Hagopian et al. (2015), can be helpful in informing treatment selection. The first objective was assessing the structured visual inspection criteria applicability on stereotypy FA graphs. The second objective was to evaluate the applicability of level of differentiation analysis to stereotypy. We are attempting to replicate the findings of Hagopian et al. (2015) with Stereotypy. It might be the case that Subtype 1 and Subtype 2 stereotypy differentially responds to treatment. Subtype 1 participants would respond to respond to alternative sources of reinforcement in the environment, while Subtype 2 participants do not. That is, Subtype 2 participants require more resource intensive treatment.

Method

Participants

Eleven students diagnosed with autism, and who engaged in stereotypy, participated in this study. They were between 3 and 18 years old, attended a school for individuals diagnosed with autism and related disabilities in either a home-based, day school, or residential placement. Dan and Tim were specifically recruited for this study for this prospective analysis. In alignment with this prospective analysis, Brian, Daniel, and Amy participated in Rosenzweig et al. (2024) and their data are fully duplicated in this study with the additional data analyses described below. George, Seth, Hank, Sam, Scott, and Andy participated in Steinhauser et al. (2021) and their FA data, independent and collaborative play are duplicated on the current study, again, with the

additional data analyses described below. George's data were not included in the final Steinhauser et al. (2021) published manuscript. In all 11 cases, individuals participated in these studies if their clinical team reported disruptive engagement in any form of stereotypy and low rates and/or non-severe forms of aggressive behavior. From now on, Dan, Tim, Brian, Daniel and Amy, who participated in ACSA will be referred as ACSA participants and George, Seth, Hank, Sam, Scott, and Andy, who did not participate in the ACSA, will be referred as non-ACSA participants.

Settings and Materials

Two participants had sessions conducted at their homes. The other participants had sessions conducted in a 3m x 3m room, with two chairs, session specific materials, and a table. There was a one-way mirror allowing observation by data collectors, and materials remained behind the experimenter until presented to the participant.

Dependent measures.

Stereotypy was specifically defined for each student but was generally any repetitive behavior unrelated to the context they were observed in. Contact was defined as any participant's contact with the presented item (Haddock & Hagopian, 2020). During the functional analysis, the observers measured only stereotypy. Engagement is the participant's interaction with the presented item according to its original function (Haddock & Hagopian, 2020). For example, holding a train and staring at the walls constitutes contact with the item, and engagement requires using the train along with the train tracks set. Observers measured item contact and engagement during ACSA and Treatment Analysis. Engagement is a particular type of contact meaning that all occurrences of engagement were also counted as contact but not all occurrences of contact

were counted as engagement. *Blocking* involved preventing or interrupting the occurrence of stereotypy by the therapists putting their hands over the hands of the participant. *Redirection* involved representing the items and manually guiding the participant to use the item properly (Ahearn et al., 2007). In current research, the terms *Prompt Engagement* and *Redirection* refer to contingent prompting of appropriate alternative responses. *Prompt Engagement* was implemented when participant did not make contact with the item for 10 s (Hagopian et al., 2020). *Redirection* was implemented when the participant emitted stereotypy (Steinhauser & Ahearn, 2023). Observers measured *Prompt Engagement* during ACSA and the treatment analysis for ACSA participants. Observers measured *Redirection* during the treatment analysis with non-ACSA participants. Appropriate social responses such as breaks, refusal to participate in sessions, and requests to use the bathroom were honored and not considered stereotypy.

Interobserver agreement

Therapists recorded videos for all sessions, and observers coded videos using momentary time sampling (Meany-Daboul et al., 2007). Observers recorded the occurrence of target behavior such as stereotypy, contact, or engagement during the first 2 s of a 10 s observation interval. In the scoring sheet, the observer marked the occurrence of the target behavior if it happened during the second 0 to 2. Each minute has six 10 s intervals, allowing six scoring opportunities for each minute. Results for each session were calculated in percentage of occurrence by dividing the number of intervals in which target behavior occurred by the total of scoring opportunities times a hundred.

A second independent observer scored at least 30% of the sessions in each condition for each participant. An agreement refers to the extent to which observers agree in their scoring of

the behavior (Kazdin, 2011). In the current research, an agreement means the second observer recorded the same behavior occurrence for a particular observation period. We counted different recordings between observers as a disagreement. The mean total interobserver agreement (IOA) score was calculated by dividing the agreements by the sum of agreements plus disagreements times a hundred.

ACSA participants

During the functional analysis, the mean IOA for stereotypy was 94.1%. For each participant, IOA was 94.7% for Dan, 90.2% for Tim, 98.8% for Brian, 90.2% for Daniel, and 98.8% for Amy. In the ACSA free access, the mean IOA for stereotypy and item contact were 94% and 95.1%, respectively. For each participant, IOA was 92% and 93.3% for Dan, 91% and 99% for Tim, 99% and 100% for Brian, 98% and 99% for Daniel, 99% and 99% for Amy, respectively. In the ACSA prompt engagement, the mean IOA for stereotypy, item contact, and engagement were 97.6%, 97.8%, and 99%, respectively. For each participant, IOA scores were 96%, 97%, 98% for Dan, and 99%, 99%, and 100% for Amy, respectively. In the ACSA using blocking and prompting, the mean IOA for stereotypy, item contact, and engagement were 98.5%, 99%, and 100%. For each participant, IOA scores were 98%, 99%, 100% for Daniel, and 99%, 99%, and 100% for Amy, respectively. During the Treatment 1 analysis, the mean IOA for stereotypy, contact, engagement, and swapping was 95.6%, 99.5%, 94.7%, and 100%, respectively. For each participant, IOA scores were 97.8%, 100%, 86.7%, 100% for Dan; 90%, 99.3%, 96%, 100% for Tim; 100%, 99%, 100%, 100% for Brian; 91%, 99%, 91%, 100% for Daniel, and 99%, 100%, 100%, 100% for Amy, respectively. During the Treatment 2 analysis, the mean IOA for stereotypy, contact, engagement, and swapping was 96.2%, 98.1%, 94.7%, and 99.8%, respectively. For each participant, IOA scores were 98.3%, 93.3%, 86.7%, 100% for

Dan; 92.7%, 99.3%, 96.0%, 100% for Tim; 100%, 99%, 100%, 100% for Brian; 91%, 99%, 91%, 99% for Daniel; and 99%, 100%, 100%, 100%, for Amy, respectively.

Non-ACSA participants.

During the functional analysis, the mean IOA for stereotypy was 94.9%. For each participant, IOA was 98.2% for George, 94.3% for Seth, 94.7% for Hank, 95.1% for Sam, 91.1% for Scott, and 96.1% for Andy. During the Treatment 1 analysis, the mean IOA for stereotypy and engagement was 94.9% and 96.6%, respectively. For each participant, IOA was 98.2%, 99.1% for George, 94.3%, 98.2% for Seth, 94.7%, 97.5% for Hank, 95.1%, 92.2% for Sam, 91.1%, 93.5% for Scott, and 96.1%, 98.8% for Andy, respectively. During the Treatment 2 analysis, the mean IOA for stereotypy and engagement was 98.2%, 99.4% for George, 94.3%, 98.9% for Seth, 94.7%, 87.1% for Hank, 95.1%, 93.5% for Sam, 91.1%, 90.5% for Scott, and 96.1%, 96.5% for Andy, respectively. Table B4 displays IOA score data rage for all participants.

Procedure

Functional Analysis

Generally following the procedures described by Iwata et al. (1982/1994), each individual experienced conditions of access to play materials (control), alone/no interaction, academic demand, and attention presented in a quasi-random order in a multi-element design. The FA procedures were described in both Rosenzweig et al. (2024) and Steinhauser et al. (2021) though the session length varied across participants. Dan, Tim, George, Seth, Hank, Sam, Scott, and Andy participated in 10 min FA sessions. Brian, Daniel, and Amy participated in 5-min FA sessions. All individuals participated in no more than five blocks of the FA condition because it has been found that stereotypy is likely maintained by automatic reinforcement to the

near exclusion of any other operant functions (Rapp & Vollmer, 2005) and we determined that a maximum of five blocks of conditions constituted a satisfactory data sample for our analysis. Academic and Demand materials were informed by participant clinical team report.

The terms "no-interaction" and "alone" were used interchangeably for the same FA condition in the current study meaning because there were no procedural differences other than the presence of a therapist.

Subtype Assessment

After obtaining a minimum of three blocks and a maximum of five 3 to 5 data points for each condition type, we scored the FA graphs using the structured visual inspection criteria (Hagopian et al., 1997, 2015).

This method classifies ASIB into different subtypes. A subtype was calculated by conducting the following four steps: Step 1, we drew an upper criterion line (UCL) between the second and third highest data points from the play condition, and; Step 2. We drew a lower criterion line (LCL) between the second and third lowest points from the play condition; Step 3, We subtracted the number of points in the alone condition that were below the LCL from the number of points above the UCL; Step 4, we divided the obtained value in step 3 by the number of alone sessions. We categorized a case of automatically reinforced SIB as Subtype 1 if the subtype quotient score was greater than or equal to 0.5. Hagopian et al. (2015) categorized a case of automatically reinforced SIB as Subtype 2 if: "(a) the quotient less than 0.5; (b) more than 30% of the data points overlap between the play and alone conditions, and; (c) mean rate of SIB was more than 50 responses per minute in both play and alone conditions" (Hagopian et al., 2015, p. 529).

Our research considered only the criterion “a” to categorize a case as a Subtype 2. Criterion "b" was not practical because, in a 3 to 5 data points FA, 30% of data points means 2 data points. If we admitted criterion "b," any FAs that display 2 overlapping data points would be automatically classified as Subtype 2, making almost all cases Subtype 2. Criterion “c” was impractical for two reasons. First, stereotypy is so frequent that it often occurs more than 50 times per minute, making almost all cases a Subtype 2. Second, because of its high rate of occurrence, we measure the percentage of intervals in sessions rather than the response rate.

Criterion “b” and “c” were practical in Hagopian´s (1997, 2015) model because it was developed for FAs that include more at least 10 data points per condition. Roane et al. (2013) showed that Hagopian’s (1997) model is consistent for FAs with seven data points. Because the FAs conducted in the current study included only three to five data points per condition, only one of the criteria described by Hagopian (2015) was applicable.

Expanded Structured Visual Inspection Criteria

Hagopian et al. (2015) subtyping model is based on the differentiation in the occurrence of target behavior between the play and alone condition. We expanded this model by investigating the differentiation between the attention and alone condition and the demand and alone condition. The **Expanded Structured Visual Inspection Criteria** consisted of applying the Structured Visual Inspection Criteria procedure described by Hagopian et al. (1997, 2015) to the analysis of the attention and alone condition and the demand and alone condition, producing a subtype quotient for each one pairs. The **Expanded Structured Visual Inspection analysis** is also referenced in this document simply as **expanded analysis**. Thus, the subtype quotients that came from expanded analysis came from the application of the **Structured Visual Inspection** to the pair of attention-alone condition and the demand-alone condition.

This expansion was based on the rationale given by Hagopian et al. (2015) , which describes the subtypes as a descriptor of behavioral sensitivity. The literature points out that stereotypy diminishes if the participant engages in other activities and appropriate behavior often occurs in place of stereotypy (Ahearn et al., 2007; Steinhauser & Ahearn, 2023). It might be the case that the stereotypy is more likely to be displaced by other behavioral arrangements. Thus, we expanded Hagopian's model by calculating subtypes and differentiations for attention-alone and demand-alone pairs of conditions.

LoD assessment for FA.

Subtypes are a qualitative description of behavioral sensitivity, varying between two categories, in which Subtype 1 cases are sensitive to reinforcement-based treatment, and Subtype 2 would require more resource intensive treatments components such as blocking and prompting. The subtype literature has previously reported a threshold of 63.7% differentiation between play and alone conditions to be categorized as Subtype 1 (Hagopian et al., 2018). The main difference between Subtypes and LoD analysis is how they describe behavior sensitivity to reinforced-based activities. Subtypes present a two-level classification, while LoD analysis describes behavior sensitivity on a continuum scale, ranging from 0 to 100%.

The significance of Subtypes and LoD assessments lies in their ability to guide treatment decisions. Subtypes establish a threshold of behavioral sensitivity, informing whether to incorporate more resource intensive components or not. On the other hand, LoD´s continuum classification allows for different levels of behavioral sensitivity within the same subtype category, and it also supports the statistical calculation of the threshold between subtypes 1 and 2.

Hagopian et al. (2018) calculated the level of differentiation by dividing "the mean rate of ASIB in the play condition by the mean rate of ASIB in the no-interaction condition, subtracting the resulting quotient from 1, and then converting that value to a percentage" (Hagopian et al., 2018, p. 450).

Our analysis used the percentage of occurrence in session instead of the response rate. We adapted Hagopian's calculation by dividing the mean percentage level of stereotypy in Play (MSTPlay) by the mean percentage level of stereotypy in Alone (MSTAlone) condition, subtracting the resulting quotient from 1. Then, we multiplied the resulting value by a hundred to convert it to a percentage. The calculation is expressed by the formula (1- (MSTPlay / MSTAlone))*100.

The expanded LoD model. We also expanded Hagopian´s model (2018) levels of differentiation model by applying the same formula to calculate the levels of differentiation between Attention/Alone and Demand/Alone conditions.

LoD assessment for Treatment Analysis.

We used a similar formula to calculate LoD for treatments. We divided the mean stereotypy in treatment by the mean stereotypy in the FA alone condition. This result was subtracted from 1 and multiplied by a hundred to convert the subtraction result into a percentage. We related stereotypy in treatment to stereotypy in FA alone condition because that was a common procedural condition among all participants. In non-ACSA participants, baseline treatments often involved materials or DRA contingencies.

Augmented Competing Stimulus Assessment (ACSA)

ACSA sequence of conditions. Prior to the ACSA, the therapist collected information from teachers and reviewed the history of preference assessments the participant had previously

experienced to make a list of possible items to use during the assessment. The therapist chose six items from this list for the ACSA. The test items included cards, musical instruments such as flutes or harmonicas, coloring books, paint-by-stickers books, Play-Doh, Slinky, Jenga, trains, and car tracks. Before the session, the therapist presented each test item in a single session, allowing the participant to interact with each item for 5 to 10 s. This initial presentation assessed if the participant would emit any form of contact to the presented materials.

Each ACSA started with the control condition (no item access), followed by six free access periods presented quasi-randomly across sessions. The baseline and test conditions had a 5 min duration. During baseline, the therapist did not interact with the participant, and there were no programmed consequences for stereotypy. In the test condition, the therapist sat at the table, presented a single item to the participant, and started a 5 min timer. After time elapsed, the therapist substituted the item for a different one. The session ended after the therapist presented all six items to the participant.

The sessions occurred under three conditions: Free Access, Prompt Engagement (PE), and Prompt Engagement plus Response Blocking (PE + RB). The first condition conducted was Free access. The sequence of the subsequent conditions (see Figure A10) depended on levels of stereotypy during the previously conducted conditions. The assessment ended if the Free Access condition reduced stereotypy levels for three stimuli by at least 80%. If the reduction in stereotypy was lower than 80%, then the therapist consulted the level of contact. If contact was higher than 80% for half of the items, then the therapist conducted the PE + RB condition, followed by another free access condition.

If contact was below 80% for more than half of the items during the free access condition, then the therapist conducted the PE condition. If three competing stimuli were

identified during the PE condition, then another free access condition was conducted, and the ACSA ended. If fewer than three competing items were identified during the PE condition, then PE + RB was conducted, followed by the free access condition.

During the free access condition, no consequences for stereotypy or engagement were in effect. During PE, after 10 s of no contact, the therapist put the participant's hands on the item for 3 to 5 s and stated, "You can play like this." During the PE + RB condition, the therapist prompted accordingly and blocked all the stereotypic responses instances of stereotypy. The mean data from three sessions produced the result for each condition. The therapist blocked motor stereotypy by gently placing their hand over the participant's hands, forearms, or shoulders until the participant's behavior stayed free of stereotypy for 3 to 5 s. The therapist blocked vocal stereotypy by asking mastered social questions that include "How What is your name?", "How old are you?", "What is the color of this card?"

The implementation of the three conditions depended on the reduction of stereotypy for each condition. Figure A10 summarizes the sequences of the augmented competing item assessment. First, the individuals participated in the Free Access condition. The assessment ended if the Free Access condition reduced stereotypy levels for three stimuli by at least 80%. If the reduction in stereotypy was lower than 80%, the therapist consulted the level of engagement. If engagement was above 80% for half of the items, the assessment followed to PE + RB condition, ending after one series of free access.

The PE followed if engagement was below 80% for more than half of the items. If PE produced three competing stimuli, one series of free access followed, ending the assessment. If PE produced less than three competing items, PE + RB followed, then one more series of free access, and then the assessment was done.

Treatment Analysis

ACSA Participants. Each treatment session lasted 5 min. For both treatments, the therapist used the items assessed during ACSA. During the baseline condition, the therapist sat across the table and did not interact with the participant for 5 min. During treatments, the therapist presented one item at a time and implemented specific consequences for each treatment after 10 s of no contact with the presented item. Treatment 1 consequence consisted of the therapist substituting the item. Treatment 2 consequence consisted of the therapist prompting engagement and stating: "You can play like this."

Non-ACSA Participants. All non-ACSA participant had their stereotypy redirected by the therapist in both Treatment 1 and 2. In the current study, we considered the independent leisure context as a Treatment 1 because it consisted simply in presenting items. In the independent leisure context, the therapist offered the participant three leisure items at the same time according to their preexisting skills. Exceptionally for Hank, tokens were added contingent on independent play, which were initially delivered on a fixed-interval (FI) 15-s schedule, exchanged on an FR 10 schedule. Then the fixed schedule changed to a variable-interval (VI) 15-s schedule.

We considered the interactive leisure training context Treatment 2 because it consisted of prompting behavior involved in building play skills. In the interactive leisure context, the therapist presented the participant with a turn-taking game. The therapist provided least-to-most prompting to engage in interactive play and provided verbal directives (e.g., “Your turn,” “Let’s put it together,” “We need to sort the pieces”). For Treatment 2 participants, the therapist delivered tokens contingent on interactive play and exchanged those tokens for a preferred edible

according to each participant's schedule. Treatments are described in detail in Steinhauser et al. (2021).

Results

FA Results

FA results for all participants showed patterns suggesting that behavior is likely maintained by automatic reinforcement (see Figures A1 for ACSA participants and A2 for non-ACSA participants.). The results of the subtyping analysis are depicted in Figures A3 and A4. Four participants (Dan, George, Andy, and Sam) showed repetitive behavior occurring at high differentiation in mean stereotypy between play and alone conditions, whereas seven participants (Tim, Daniel, Amy, Brian, Seth, Hank, and Scott) showed variable levels across FA conditions. We analyzed these results according to the subtyping analysis described by Hagopian et al. (2015) (see Figures A3 and A4). Table B1 summarizes all the subtype calculations. Table 2 presents all the LoD calculations for all pairs of conditions.

ACSA Results

Five participants (Dan, Tim, Brian, Daniel, and Amy) had their stimuli treatments informed by ACSA. For ACSA results, check Figure A11. Dan experienced six stimuli in the Free Access condition showing at least an 80% reduction of stereotypy when playing with magnets and at least 80% of engagement when playing with playdoh and potato head. The result in the Free Access directed PE condition, in which Dan showed at least an 80% reduction for five items and at least 80% engagement for all six items. For Dan, stickers, playdoh, magnets, potato-head, and pop tube were the stimuli used in Treatments 1 and 2.

Tim experienced six stimuli in the Free Access condition showing at least an 80% reduction of stereotypy when playing with four items and at least 80% of engagement when playing with the same four items plus Legos. These results described Potato Head, Magforms, Playdoh, and Trains as effective competitors, and they were the stimuli used in Treatment 1 and 2 for Tim.

Brian experienced nine stimuli in the Free Access condition showing at least an 80% reduction of stereotypy when playing with three items and at least 80% of engagement when playing with six items. These results described Popsicle Sticks, Puzzle, and Pull tube as effective competitors and were the stimuli used in Treatments 1 and 2 for Brian.

Daniel experienced seven stimuli in the Free Access condition showing an 80% reduction of stereotypy for zero items and at least 80% of engagement when playing with five items. The result in the Free Access condition directs to PE + BL condition, in which Daniel showed an 80% reduction for three items and at least 80% engagement for five items. These results described Fidget Spinner, Putty, and Glitter Ball as effective competitors, and they were the stimuli used in Treatment 1 and 2 for Daniel.

Amy experienced seven stimuli in the Free Access condition showing at least an 80% reduction of stereotypy for zero items and at least 80% engagement when playing with two items. The result in the Free Access condition led to the PE condition in which Amy showed an 80% reduction of stereotypy for one item and at least 80% of engagement when playing with two items. The result in the PE condition led to the PE + BL in which Amy showed an 80% reduction of stereotypy for four items and more than 80% of engagement when playing with one item. These results described Pull Tube, Laptop, Alphabet Spinner, and Beads as effective competitors, and they were the stimuli used in Treatments 1 and 2 for Amy.

Subtype Results

ACSA Participants

Dan's FA conforms with Subtype 1, and the LoD between the play-alone conditions was 83.1%. We also calculated The LoD between the attention-alone and demand-alone conditions. It may be that differentiation between alone and any condition in the function analysis would be predictive of sensitivity of stereotypy to alternative sources of reinforcement in the environment. In this expanded analysis, the LoD between the attention-alone conditions was 48.4%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was -2.2%, which in this expanded analysis this is equivalent to the Subtype 2.

Tim's FA conforms with Subtype 2, and the LoD between the play-alone conditions was 4.1%. In the expanded analysis, the LoD between the attention-alone conditions was 48.4%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was -16.4%, which in this expanded analysis this is equivalent to the Subtype 2.

Brian's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 48.8%. In the expanded analysis, the LoD between the attention-alone conditions was 16.6%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 92.4%, which in this expanded analysis this is equivalent to the Subtype 1.

Daniel's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 24.4%. In the expanded analysis, the LoD between the attention-

alone conditions was 55.3%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 33.3%, which in this expanded analysis this is equivalent to the Subtype 1.

Amy's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 57.1%. In the expanded analysis, the LoD between the attention-alone conditions was 48.4%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 75.8%, which in this expanded analysis this is equivalent to the Subtype 1.

Non-ACSA participants

George's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 11.1%. In the expanded analysis, the LoD between the attention-alone conditions was 91.9%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 93.5%, which in this expanded analysis this is equivalent to the Subtype 1.

Seth's FA conforms with Subtype 2, and the Level of Differentiation (LoD) between the play-alone conditions was 14.1%. In the expanded analysis, the LoD between the attention-alone conditions was 66.2%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 36.8%, which in this expanded analysis this is equivalent to the Subtype 1.

Hank's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 16.2%. In the expanded analysis, the LoD between the attention-alone conditions was 75.6%, which in this expanded analysis this is equivalent to the Subtype 1, and

the LoD between the demand-alone conditions was 62.2%, which in this expanded analysis this is equivalent to the Subtype 1.

Sam's FA conforms with Subtype 2, and the Level of Differentiation (LoD) between the play-alone conditions was 10.5%. In the expanded analysis, the LoD between the attention-alone conditions was 76.3%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 15.9%, which in this expanded analysis this is equivalent to the Subtype 1.

Scott's FA conforms with Subtype 1, and the Level of Differentiation (LoD) between the play-alone conditions was 38.1%. In the expanded analysis, the LoD between the attention-alone conditions was 25.3%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 42.4%, which in this expanded analysis this is equivalent to the Subtype 1.

Andy's FA conforms with Subtype 2, and the Level of Differentiation (LoD) between the play-alone conditions was 11.8%. In the expanded analysis, the LoD between the attention-alone conditions was 35.1%, which in this expanded analysis this is equivalent to the Subtype 1, and the LoD between the demand-alone conditions was 61.6%, conforming with which in this expanded analysis this is equivalent to the Subtype 1.

Subtype Sensitivity Analysis Results

The subtyped graphs were compared against their respective treatment to test the prediction made by Hagopian et al. (2015) (see Figures A5, A6, and A7). Table B1 summarizes the predicted versus actual responsiveness to treatment according to each participant subtype.

CSA Participants

In Dan´s FA stereotypy was classified as Subtype 1, and he responded to T1 and T2 with near-zero levels of stereotypy (see Figure A5). As a Subtype 1, we expected stereotypy reduction in Treatment 1 and 2 (see Table B1). In Tim´s FA stereotypy was classified as Subtype 2, and his stereotypy was expected to reduce effectively only during Treatment 2 and poorly during Treatment 1 (see Table B1). However, the data shows stereotypy reduction and increased engagement in Treatments 1 and 2 (see Figure A5).

In Brian´s FA stereotypy was classified as Subtype 1 and his stereotypy reduced during T1 and T2 (see Figure A5 and Table B1). In Daniel´s FA, stereotypy was classified as a Subtype 1. His stereotypy was expected to reduce effectively during Treatments 1 and 2, but he did only during Treatment 2 (see Figure A5 and Table B1). In Amy´s FA stereotypy was classified as Subtype 1 and her stereotypy effectively reduced during Treatment 2. According to the predictions,

Non-ACSA Participants

In George´s FA stereotypy was classified as a Subtype 1. His stereotypy reduced during independent play treatment (Treatment 1), and he was not exposed to a prompted play treatment, a Treatment 2 in our study (see Figure A6 and Table B1). In Seth´s FA stereotypy was classified as Subtype 2, and his stereotypy reduced during the second and third presentation of DRA treatment (Treatment 1). However, reducing stereotypy to near-zero levels often appeared in redirection contexts, a Treatment 2 in our study (see Figure A6 and Table B1).

As a Subtype 1, Hank´s stereotypy was according to predictions and responded to Treatment 1 when tokens were incorporated into the treatment package. We considered Hank´s

behavior according to predictions because tokens constitute an extra reinforcement layer, and no interruption or redirection was implemented (see Figure A6 and Table B1).

As a Subtype 2, Sam´s stereotypy was according to the prediction and showed a moderate reduction in stereotypy in DRA treatment and effective reduction under contextual redirection treatment (see Figure A7 and Table B1). As a Subtype 1, Scott´s stereotypy was not according to predictions. His behavior presented moderated reduction in stereotypy under DRA treatment (Treatment 1) and an effective decrease in stereotypy under contextual redirection context (Treatment 2) (see Figure A6 and Table B1). As a Subtype 2, Andy´s stereotypy was not according to the prediction and presented low levels of stereotypy when exposed to an independent play treatment (see Figure A7 and Table B1).

Expanded Model Results

After comparing all the participants behavior subtypes and their responsiveness to treatment, 5 out of 11 participants (Dan, Brian, George, Hank, and Sam) behaved according to the predictions made by Hagopian et al. (2015) subtype model (see Table B1, column "Match?"). The low prediction accuracy led us to consider some elements in the analysis between assessment and treatment, such as severity, response type, and the number of data points per condition in FA. The subtype model was intended to categorize the level of sensitivity of behavior to treatment (Hagopian et al., 2015).

Hagopian et al. (2015) participants were patients from a hospital facility receiving treatment for SIB. Our participants come primarily from day programs, and stereotypy is not a primary concern. Some of our participants were from a residential program but had low levels of aggression and SIB.

Aside from the severity of the problem behavior, the target response is under different requirements. There is much less tolerance for the occurrence of SIB than stereotypy in a person's repertoire. While SIB treatments usually target zero or near-zero occurrences to be considered clinically acceptable, stereotypy is not a treatment objective in many cases due to more pressing concerns. FAs for SIB often target precursive responses rather than the actual SIB response. However, precursive responses are not available sometimes. Due to safety concerns, the therapist implements response blocking or interruption contingently upon SIB occurrence. The harmless characteristic of stereotypy allows the individual to freely emit this behavior without interruption.

The subtyping model (Hagopian et al., 2015) was developed for FAs that took ten data points per condition. Roane et al. (2013) tested the reliability of a sample of FAs with seven data points on average for each condition. Our FAs were up to 5 data points per condition. Like Roane et al. (2013). we assume that the difference in the length of FA might affect the reliability of the subtype scores.

The subtyping model takes the subtypes as predictive behavioral markers of responsiveness to treatment (Hagopian et al., 2018). These markers were obtained by comparing the play and alone conditions of the FA. Alone condition is a prevalent condition in the natural environment in which problem behavior maintained by automatic reinforcement tends to occur. Play condition is usually a control condition in FA intended for low problem behavior rates. Play condition also refers to a desirable behavior in the overall repertoire of the participant, in which play behavior is a more socially acceptable response than stereotypy.

However, behavior is not only sensitive to play materials but to whatever aspect of the environment that assumes a stimulus function (Cooper et al., 2020; Skinner, 1953). Two more

conditions present stimuli in FA: attention and demand. Considering the differences in severity, type of response, and length of FA in which the subtype model was created, we thought of trying other FA combinations as predictive behavioral markers of responsiveness. Thus, we expanded Hagopian's subtyping model by calculating subtypes for the conditions attention-alone and Demand alone. Table B1 shows the scores for all pairs of conditions in FA for all participants.

ACSA Participants Expanded Model Results

We put together and compared all subtypes calculated and their response to treatment (see Table B1). Dan responded to Treatments 1 and 2, conforming with Subtype 1 obtained on play-alone and attention-alone quotient calculations. Tim responded to Treatments 1 and 2, conforming with Subtype 1 obtained on attention-alone quotient calculation. Brian responded to Treatments 1 and 2, conforming with Subtype 1 obtained on play-alone, attention-alone, and demand-alone quotient calculations. Daniel and Amy responded to Treatment 2, conforming with Subtype 2 and not obtained in any subtype calculation.

Non-ACSA Participants Expanded Model Results

George responded to Treatment 1, conforming with Subtype 1 obtained on play-alone, attention-alone, and demand-alone quotient calculations. Seth responded to Treatments 1 and 2, conforming with Subtype 1 obtained on attention-alone and demand-alone quotient calculations. Hank responded to Treatment 1, conforming with Subtype 1 obtained on play-alone, attention-alone, and demand-alone quotient calculations. Sam responded to Treatment 2, conforming with Subtype 2 obtained on play-alone, quotient calculation. Scott responded to Treatment 2, conforming with Subtype 2 and not obtained in any subtype calculation. Andy responded to Treatment 1, conforming with Subtype 1, not obtained on play-alone and obtained on attention-alone and demand-alone quotient calculation.

The expanded analysis revealed that three out of 11 cases (Daniel, Scott, and Amy) could not be explained by any subtype. Tim, Seth, and Andy had their performances explained by subtypes obtained in the expanded model. Finding a matching subtype for 8 out of 11 participants indicated that the other pair of lines (attention-alone and demand-alone) would also give a good account of subtyping stereotypy.

Subtypes are binary classifications created to label a sensitivity threshold to reinforcement-alone-based interventions. Subtype 1 describes the conditional probability of having a good outcome on a treatment based on reinforcement alone. Thus, the importance of subtypes is to describe a level of prediction in which some treatment might work. In this case, Hagopian et al. (2015) found two groups among their participants: The Subtype 1 group, who responded to reinforcement alone treatments, and the Subtype 2 group, who responded to treatments that incorporated blocking and prompting. This threshold of responsiveness to treatment was calculated based on the level of differentiation analysis.

LoD assessment results.

Hagopian et al. (2015) also found that the LoDs in FAs positively correlates with differentiation in treatment (see Figure A9). The authors presented a correlation graph that presents two defined data groups. The first group correlates a high LoD in the FA with high treatment effects. The first data group, on the right top of the panel, comes primarily from Subtype 1 participants. The second group presents scattered data on the left lower part of the graph, correlating low differentiation in FA and low treatment effects. The second data group, on the left bottom of the panel, comes primarily from Subtype 2 participants. We replicated

Hagopian's analysis to our data and expanded his analysis by calculating the LoDs of other FAs pairs and correlating these results with treatment effects.

ACSA Participants LoD assessment Results

Dan's LoD play-alone was 83,1%, the LoD between the attention-alone conditions was 48.4%, and the LoD between the demand-alone conditions was -2.2%. He responded to both treatments with a differentiation between stereotypy and contact of 98.7 for Treatment 1 and 95.9% for Treatment 2. Tim's play-alone LoD was 4.1%, attention-alone LoD was 48.4%, and demand-alone LoD was -16.4%. He responded 36.6% to Treatment 1 and 40.1% to Treatment 2.

Brian's play-alone LoD was 48.8%, the attention-alone LoD was 16.6%, and demand-alone LoD was 92.4%. He responded 76.7% to Treatment 1 and 65.7% to Treatment 2. Daniel's play-alone LoD was 24.4%, the attention-alone LoD was 55.3%, and demand-alone LoD was 33.3%. He responded 54.5% to Treatment 1 and 89,6% to Treatment 2. Amyes's play-alone LoD was 57.1%, the attention-alone LoD was 48.8%, and demand-alone LoD was 75.8%. She responded 67.0% to Treatment 1 and 82,6% to Treatment 2.

Non-ACSA Participants LoD assessment Results

George's play-alone LoD was 11,1%, the attention-alone LoD was 91.9%, and demand-alone LoD was 93.5%. He responded 88.7% to Treatment 1 and 96,8% to Treatment 2. Seth's play-alone LoD was 14.1%, the attention-alone LoD was 66.2%, and demand-alone LoD was 36.8%. He responded 29.4% to Treatment 1 and 91.4% to Treatment 2. Hank's play-alone LoD was 16.2%, the attention-alone LoD was 75.6%, and demand-alone LoD was 62.2%. He responded 43.9% to Treatment 1 and 56.7% to Treatment 2. Sam's play-alone LoD was 10.5%, the attention-alone LoD was 76.3%, and demand-alone LoD was 15.9%. He responded 16.3% to Treatment 1 and 88.5% to Treatment 2. Scott's play-alone LoD was 38.1%, the attention-alone

LoD was 25.3%, and demand-alone LoD was 42.4%. He responded 57.1% to Treatment 1 and 97.2% to Treatment 2. Andy's play-alone LoD was 11.8%, the attention-alone LoD was 35.1%, and demand-alone LoD was 61.6%. He responded 42.2% to Treatment 1 and 91.1% to Treatment 2. Table B2 presents all the numeric scores for level differentiation analysis, depicted in Figure A8, which contains all the visual analyses for levels of differentiation.

Correlating FA´s LoDs against Treatment´s LoDs

The levels of differentiation provide material for two kinds of inspection. The first was visual, locating at least two data groups in the graph according to their subtype. The second analysis was the correlational statistic score. We used the Pearson r (Gravetter & Wallnau, 2013) to describe how much two variables are correlated. We also calculated the p value that shows the significance of Pearson r score.

All Participants FA x Tx LoD Correlation Results

The play-alone T1 graph directly replicates Hagopian et al. (2015) analysis by correlating the level of differentiation in FAs against the differentiation in treatment based on reinforcement alone (see figure A8). The Person r was 0.71 with $p < .01$ showing high statistical significance. Also, our analysis replicates Hagopian's by showing two separate groups of data. Because our visual analysis got scattered data for Subtype 1, we did the same calculations on the expanded subtyping model. The subtype data labeling remained consistent with the play-alone graph for all graphs in Figure A8. Pearson r for play-alone T1 was the only Treatment 1 correlation that was statistically significant.

The attention-alone T1 graph presented two distinct groups of data distributed by subtypes and produced Pearson $r = - 0.14$ and $p < 0.07$. The same two distinct groups of data

were found in demand-alone T1 and produced Pearson r = 0.30 and p < 0.37. MaxLoD T1 also displays two groups of data and produced Pearson r = 0.51 and p < 0.1. Pearson r correlations for attention-alone, Demand- Alone T1 and Max LoD T1 were not statistically significant, but visually they still present two groups of data.

Treatment 2 has better treatment effects across the comparisons with all pairs of FAs conditions. Treatments incorporating interruption and prompting produce better treatments effects when compared to any Treatment 1 condition. We calculated Person r and p values for all Treatment 2 graphs. Play-alone T2 showed Pearson r = 0.26 and p < 0.44, attention-alone T2 showed r = 0.19 and p < 0.57, demand-alone T2 showed r = -0.02 and p < 0.95, MaxLoD T2 showed r = 0.21 and p < 0.54. There was no statistical significance in any correlation between LoD for any FA pairs against Treatment 2.

ACSA Participants FA x Tx LoD Correlation Results

All ACSA Participants FA x Tx LoD Correlation Results displayed on Figure A12 and Table B3. play-alone T1 graph presented r = 0.97 and p= 0.01. Attention -Alone T1 graph presented r = -0.09 and p= 0.70. demand-alone T1 graph presented r = -0.01 and p= 0.99. MaxLoD T1 graph presented r = 0.87 and p= 0.06.

Play-alone T2 graph presented r = 0.73 and p= 0.17. Attention -Alone T2 graph presented r = 0.52 and p= 0.37. Demand-Alone T2 graph presented r = -0.10 and p= 0.87. MaxLoD T2 graph presented r = 0.50 and p= 0.39.

Non-ACSA Participants FA x Tx LoD Correlation Results

All ACSA Participants FA x Tx LoD Correlation Results displayed on Figure A13 and Table B3. Play-alone T1 graph presented r = 0.18 and p= 0.73. Attention -Alone T1

graph presented r = 0.14 and p= 0.70. Demand-Alone T1 graph presented r = 0.88 and p= 0.02. MaxLoD T1 graph presented r = 0.28 and p= 0.59.

Play-Alone T2 graph presented r = 0.17 and p= 0.54. Attention-Alone T2 graph presented r = -0.29 and p= 0.58. Demand-Alone T2 graph presented r = -0.04 and p= 0.95. MaxLoD T2 graph presented r = -0.20 and p= 0.70.

Discussion

The subtype model developed for SIB (Hagopian et al., 2015) applies to stereotypy, which contradicts the results presented in the Wunderlich et al. (2022) review. That is, Subtype 1 participants responded to alternative sources of reinforcement in the environment. Some characteristics in the current study might explain the difference in the results. Wunderlich et al. (2022) presented a retrospective study, and only some treatments analyzed in their sample are similar to those implemented here. Treatments in our study were informed by an ACSA and incorporate blocking/interruption and prompting appropriate behavior.

The LoD assessment replicates Hagopian et al. (2015) by showing subtypes 1 and 2 aggregated in two distinct groups. Treatment 1, which involves access to alternative sources of reinforcement in the environment, was generally effective among Subtype 1 participants. This replicates the outcome of Hagopian (2015, 2017) , which states that more differentiation in functional analysis indicates more responsiveness in treatment.

On a case-by-case analysis, some FAs did not predict effective results whether by Hagopian et al. (1997, 2015) Structured Visual Inspection or by the expanded model. This lack of prediction might be an issue regarding the relation between the FA subtype assessment implemented and treatments implemented in the current study. For example, in the FA play condition of the current study, the therapist presents toys or leisure activities, informed by

preference assessments and inputs from the clinical team and family. Currently, the selection of FA's play material is not informed by the measurement of engagement. Future research should investigate what happens to FA's LoD when the FAs' play items are selected based on a measure of item engagement rather the item preference. Hagopian et al. (2020) have already begun an augmented competing stimulus assessment (ACSA) investigation model, taking engagement as a primary dependent variable to inform what toy effectively competes with stereotypy. FAs informed by ACSA might produce less scattered data, increasing its predictive value.

When taking all 11 participants, the expanded model did not identify any statistically significance for any FA pair of conditions. However, the expanded model corroborates with an underlying assumption: stereotypy does not vary randomly. By expanding the analysis to other pairs of lines like attention-alone and demand-alone on top of the original play-alone analysis, we could increase the description power of the Structured Visual Inspection subtype assessment in a case-by-case analysis. While the expanded model provided no significant correlation in grouped data analysis, it gave a visual perspective of subtype data varying as a cloud together.

The ACSA consists of an assessment that evaluates the sensitivity of repetitive behavior to treatment and whether they need to incorporate prompting and blocking. ACSA directly identifies competing stimuli, and this may be helpful in identify in materials to include in play condition in an FA. The current research describes a positive correlation between LoD FA play-alone against treatments informed by an ACSA. Recently, this correlation has been strengthened by receiving operating characteristic curve analysis (Hagopian et al., 2023). Future research should investigate possible correlations between treatments informed by Demand assessments that target high differentiation and LoD FA demand-alone. Also, future research should

investigate possible correlations between treatments informed by attention assessments that target high differentiation and LoD FA attention-alone.

When only the five ACSA participants are taken into the analysis, the correlation between LoD FA play-alone and Treatment 1 gets even more robust. The linear regression raises to 0.97 with a $p < 0.01$. The increase in statistical power reinforces the perspective that FA play-alone predicts the effectiveness of treatments informed by ACSA. Other interesting correlation appeared for the Max LoD, with $r = 0.88$ and $p < 0.06$. Given the high r score, this p-value might be improved in future analyses by increasing the number of participants in the analysis.

The demand-alone FA pair presents the only statistically significant description when taking only the six non-ACSA participants into the analysis. It also shows Subtypes 1 and 2 visually separated, as in the FA play-alone analysis. The fact that demand-alone FA was the only condition that predicted treatment effectiveness makes a solid point for pursuing the expanded model analysis to find an additional possible index of behavioral sensitivity like the FA play-alone analysis.

Overall, Treatment 2 presented the most effective intervention and corroborated the literature on automatic reinforcement treatment, which states that interruption and redirection are highly effective interventions for repetitive behavior maintained by automatic reinforcement (Steinhauser & Ahearn, 2023). The analysis of Treatment 1 shows promising results in describing the less resource intensive yet effective intervention.

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Figure A1

FAs from ACSA Participants. Legend applies to all figures of Functional Analysis in this study.

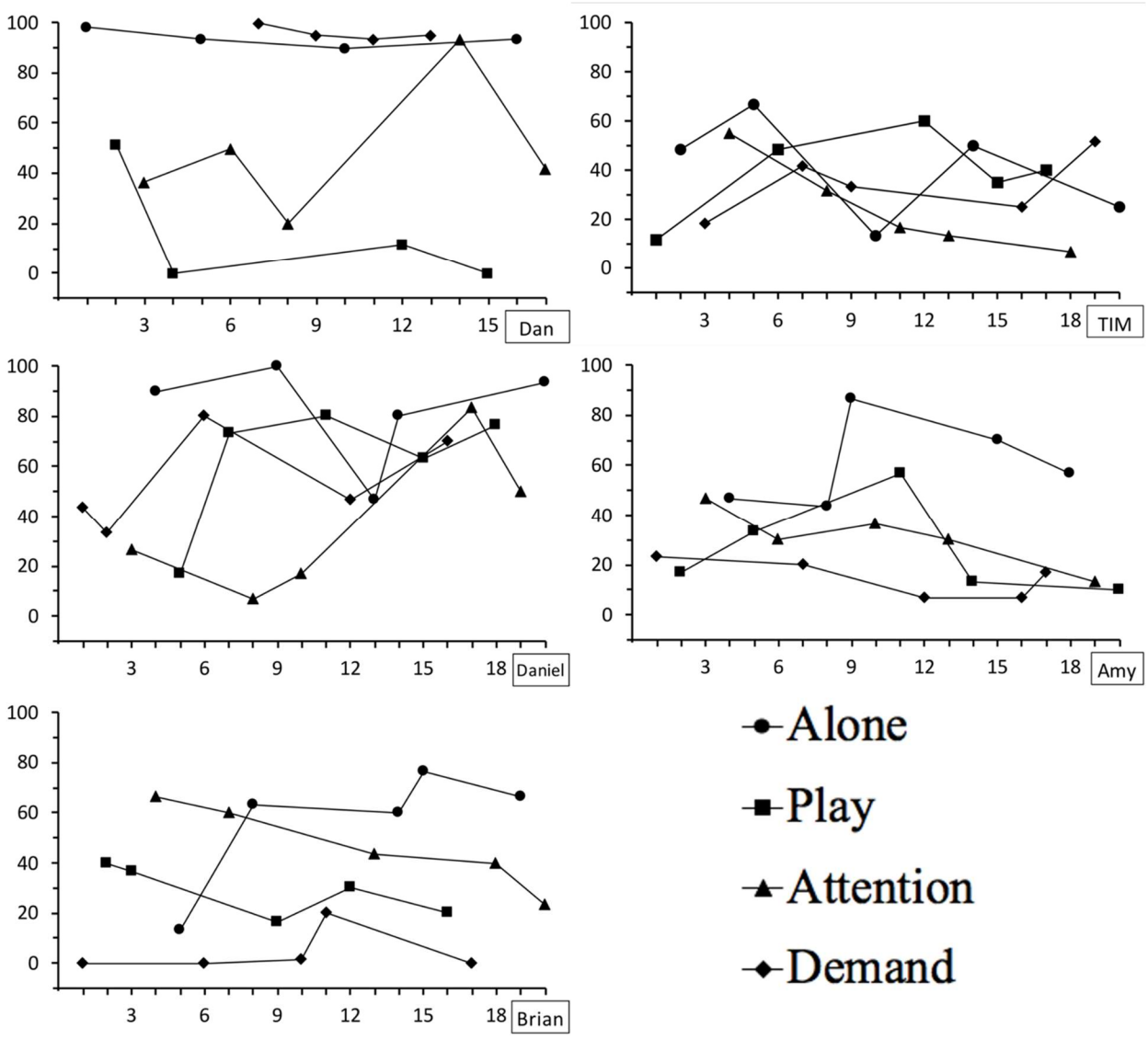

Figure A2

Functional Analysis from Non-ACSA participants (Steinhauser et al., 2021).

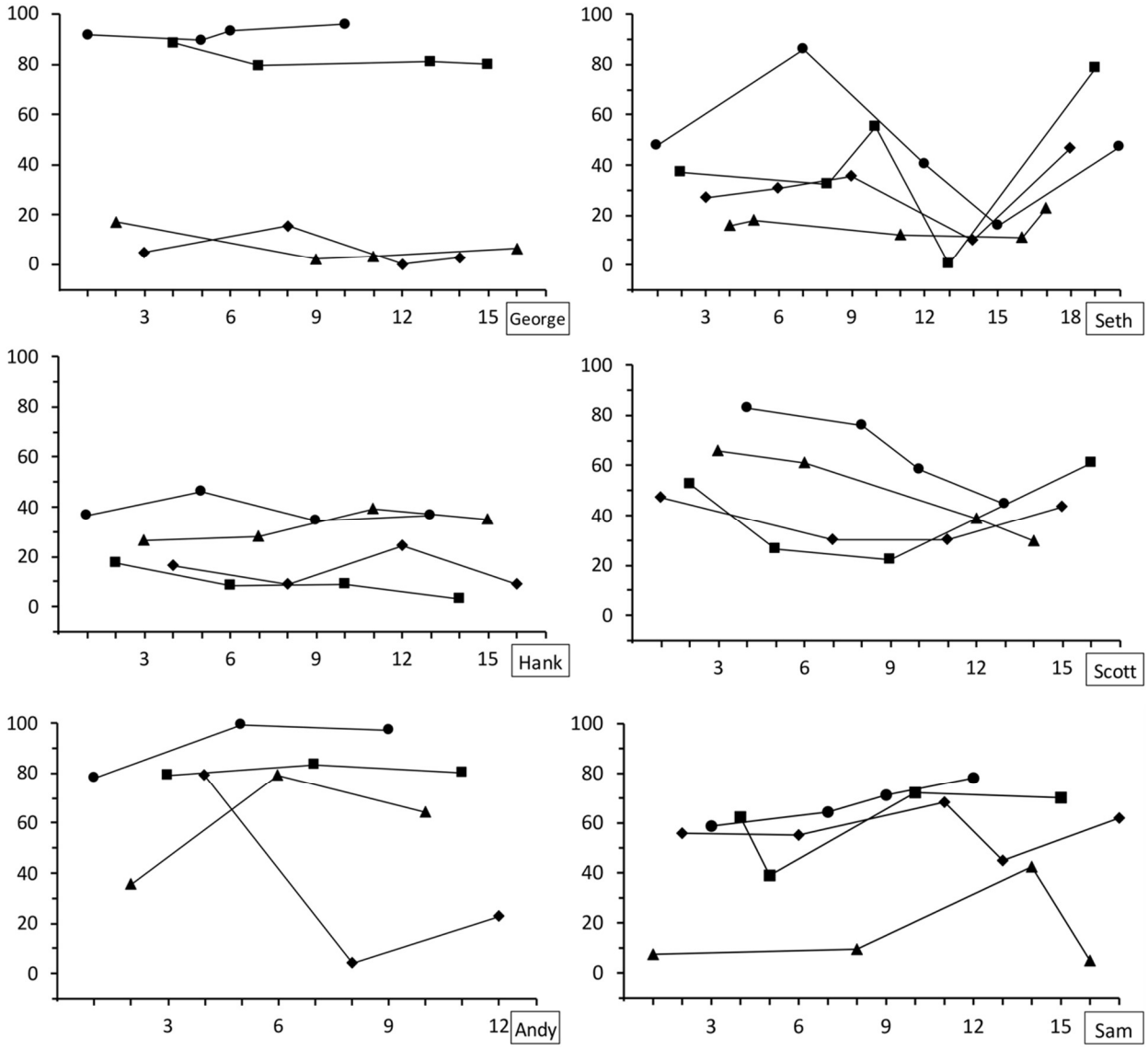

Figure A3

FAs subtypes from ACSA Participants.

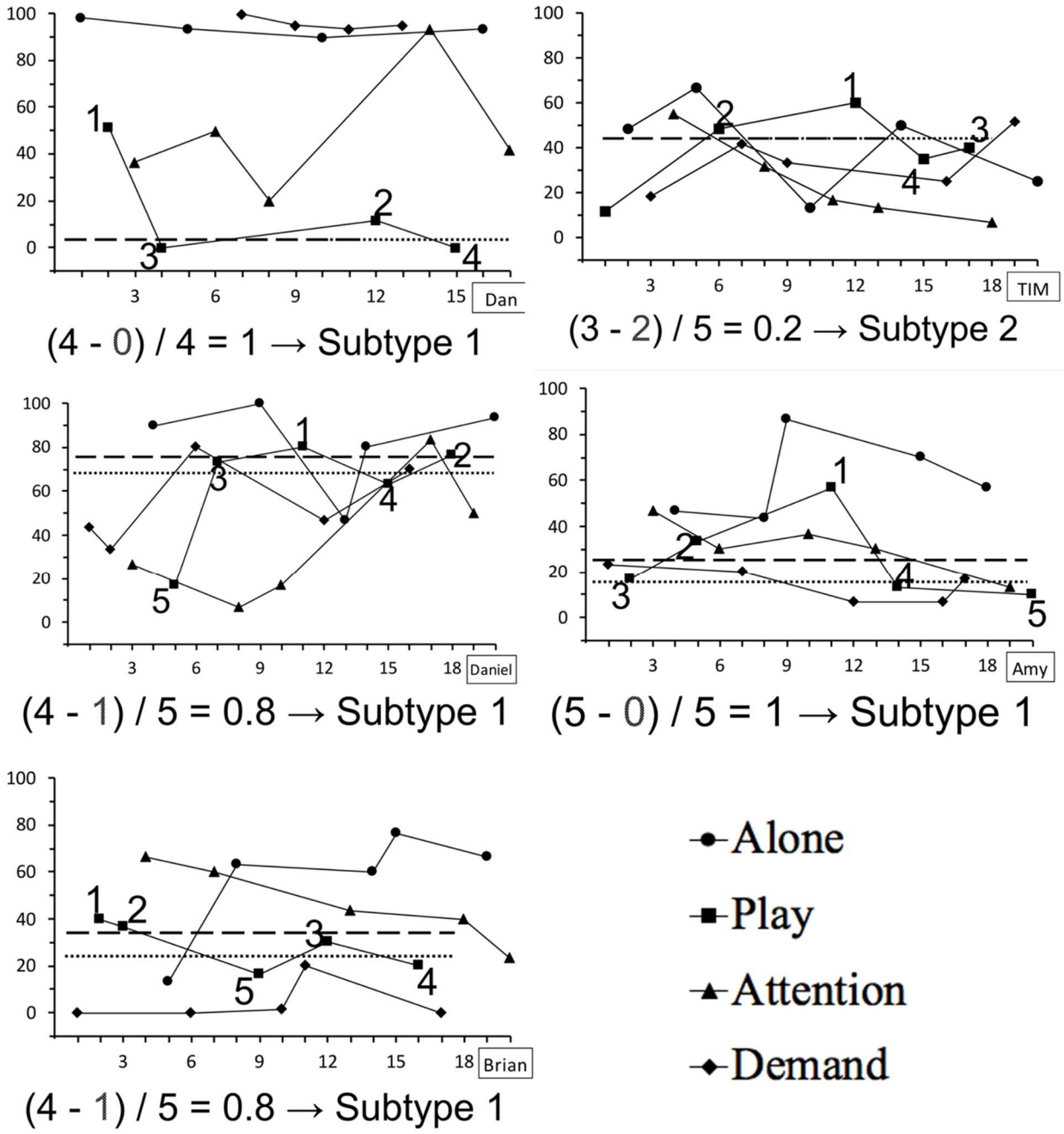

Figure A4

FAs subtypes from Non-ACSA Participants (Steinhauser et al., 2021).

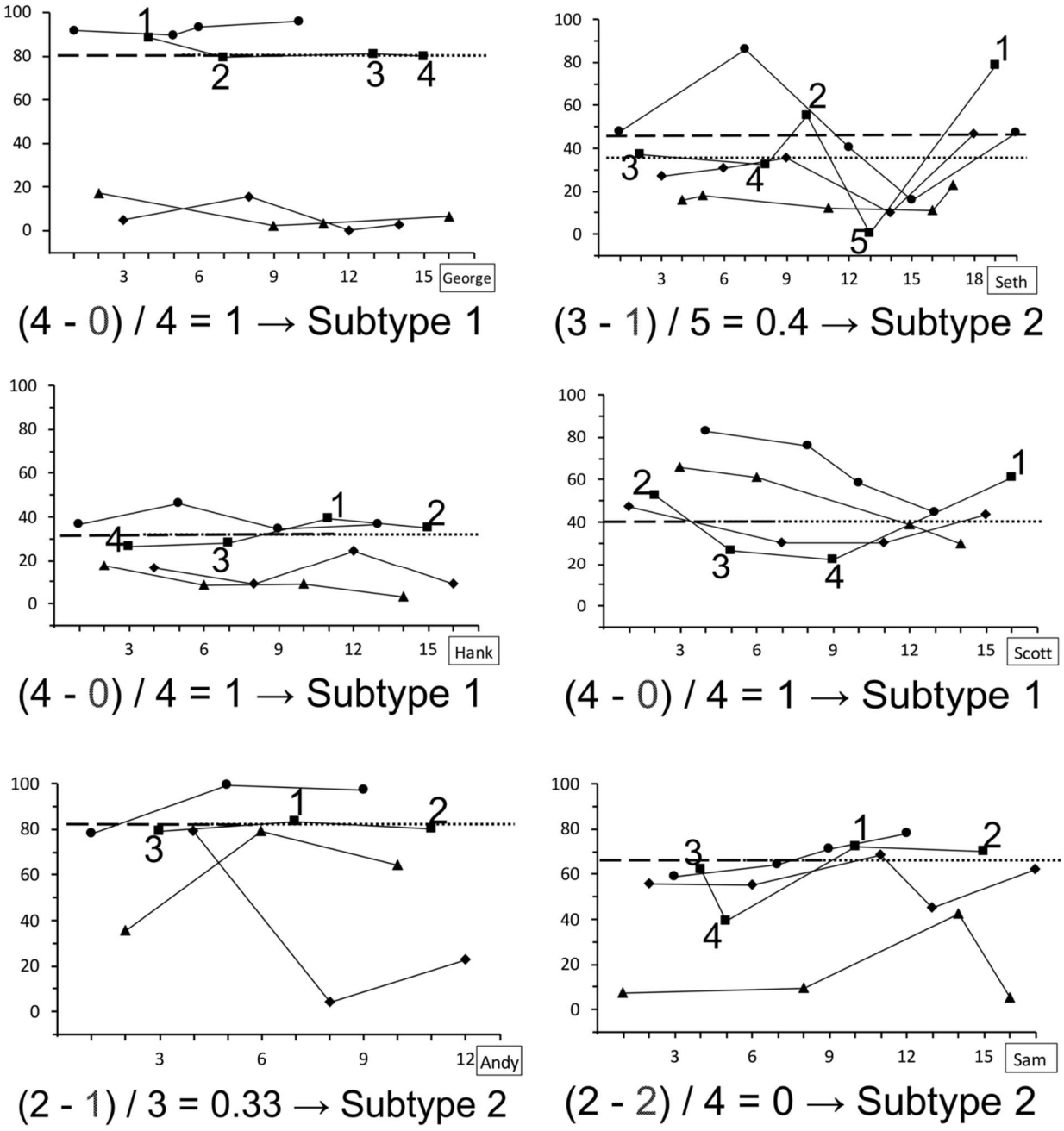

Figure A5

Comparison between FAs against TXs for ACSA participants (Dan, Tim, Daniel, Amy, Brian).

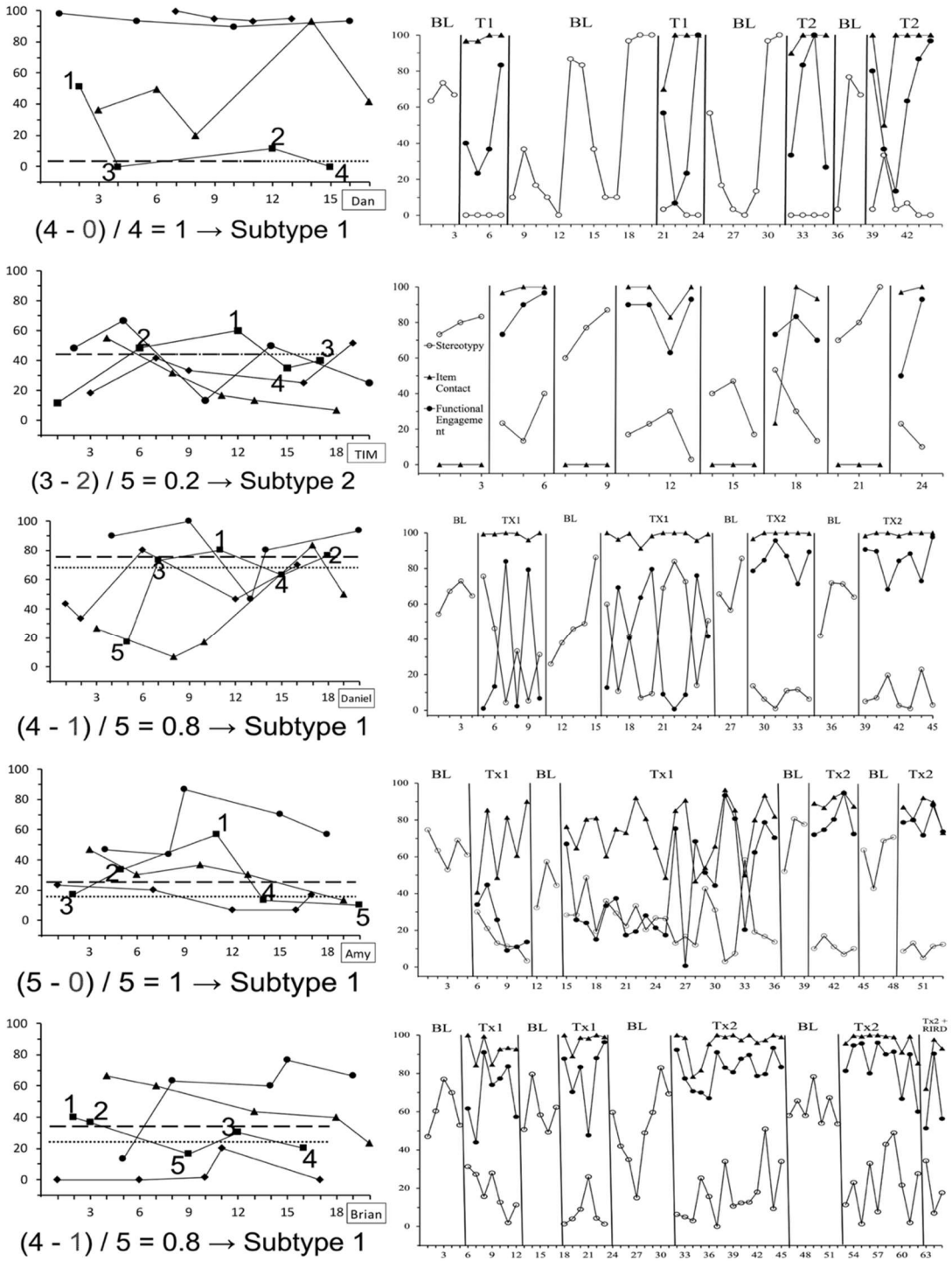

Figure A6

Comparison between FAs against TXs for non-ACSA participants (George, Seth, Hank, and Scott).

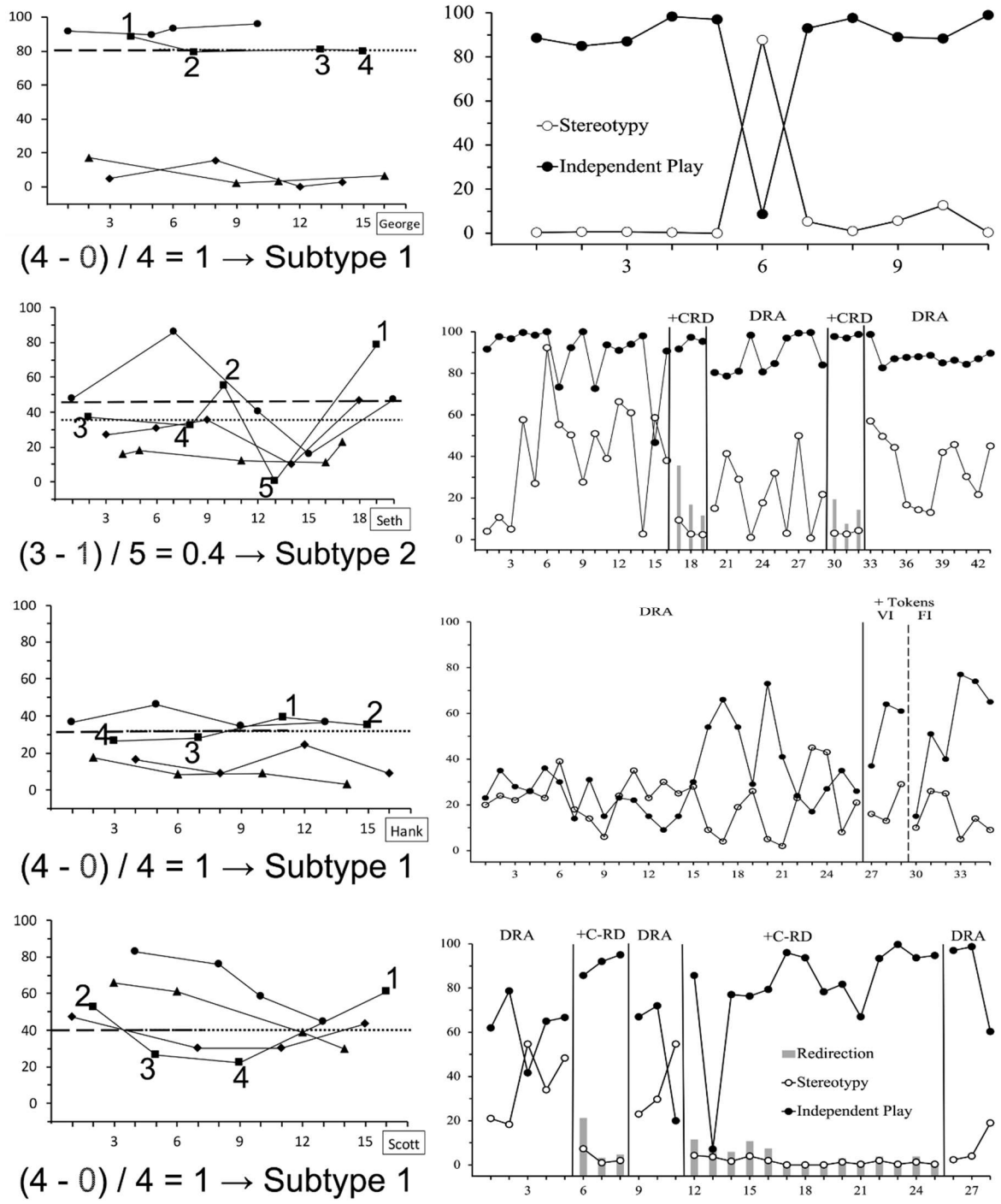

Figure A7

Comparison between FAs against TXs for non-ACSA participants (Andy and Sam).

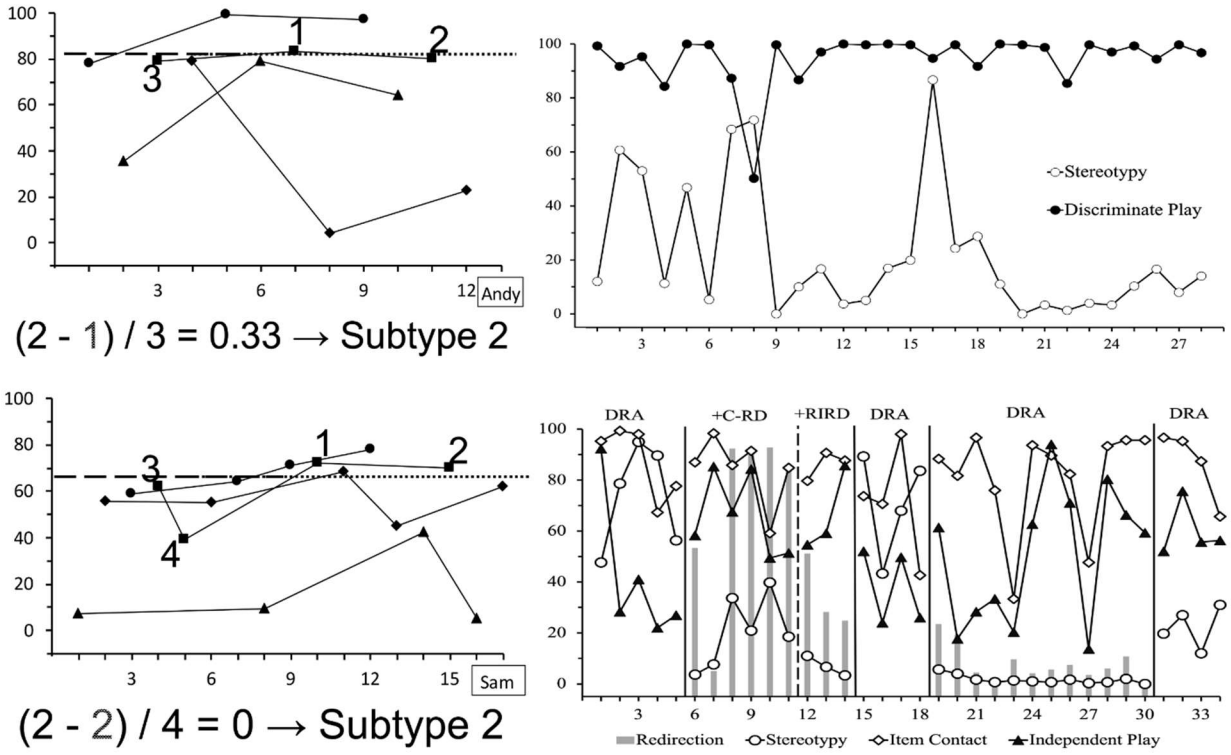

Figure A8

Level of differentiation between the Treatments and FAs for All participants.

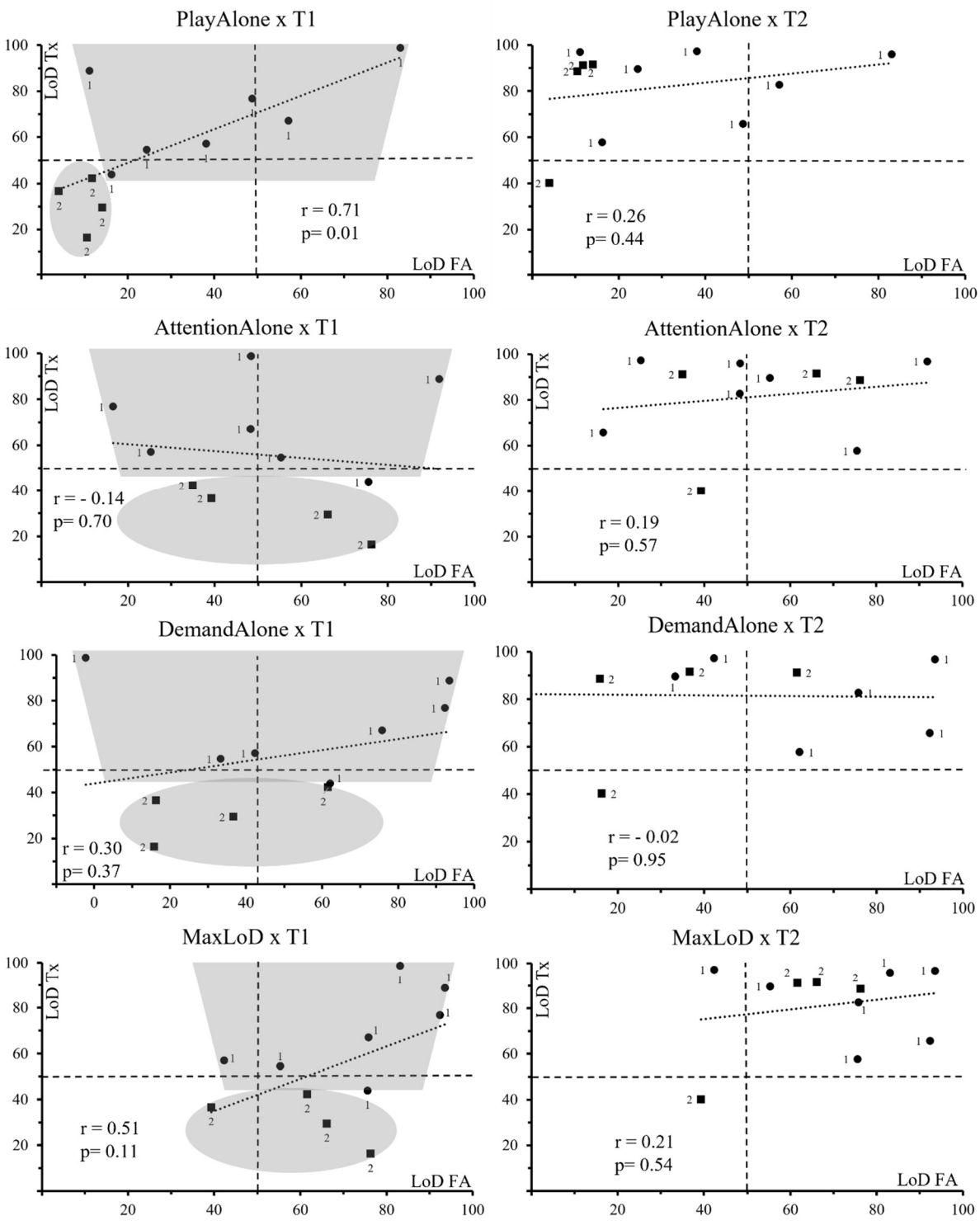

Figure A9

Correlation FA LoD x Treatment Effects (Reprinted from Hagopian et al. 2015)

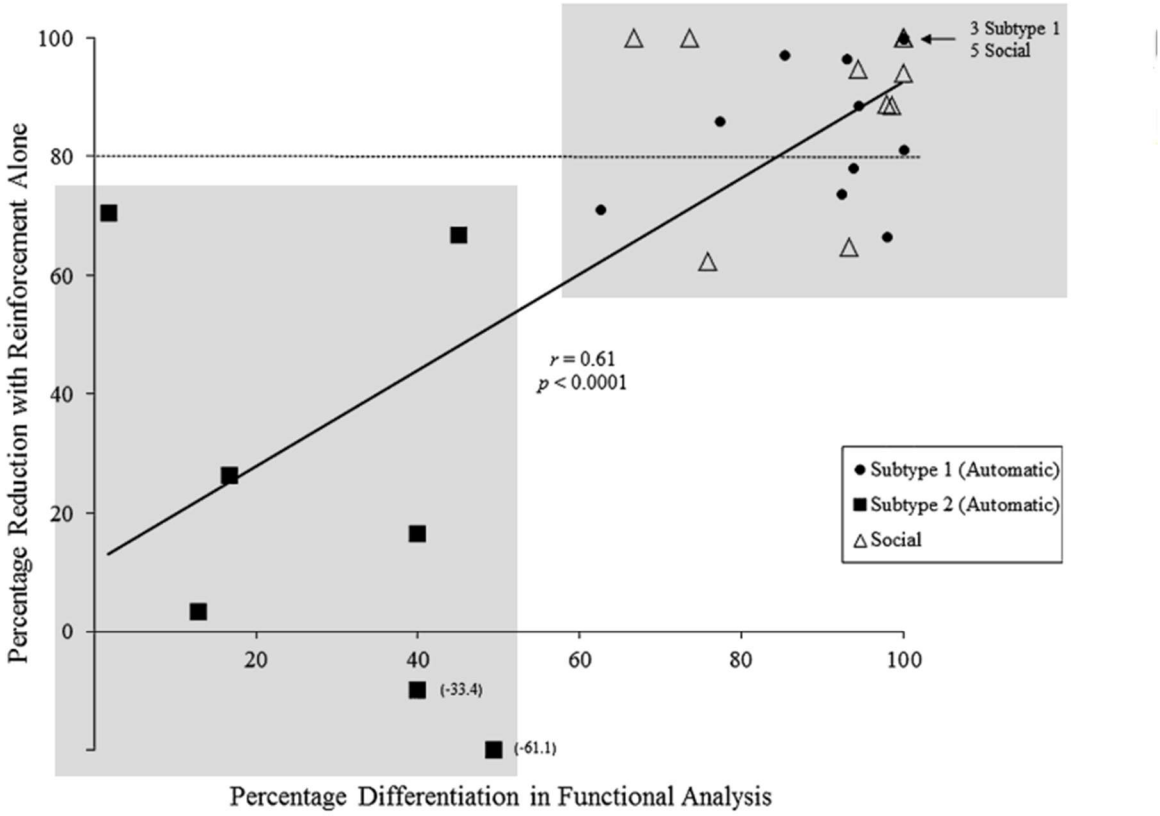

Figure 4. Relation between differentiation in the functional analysis and percentage reduction of SIB for each subtype with reinforcement during treatment. The trend line represents the linear relation between these two variables, which was statistically significant (Pearson $r = 0.61$; $p < .0001$).

Figure A10

Sequences of the Augmented Competing Item Assessment

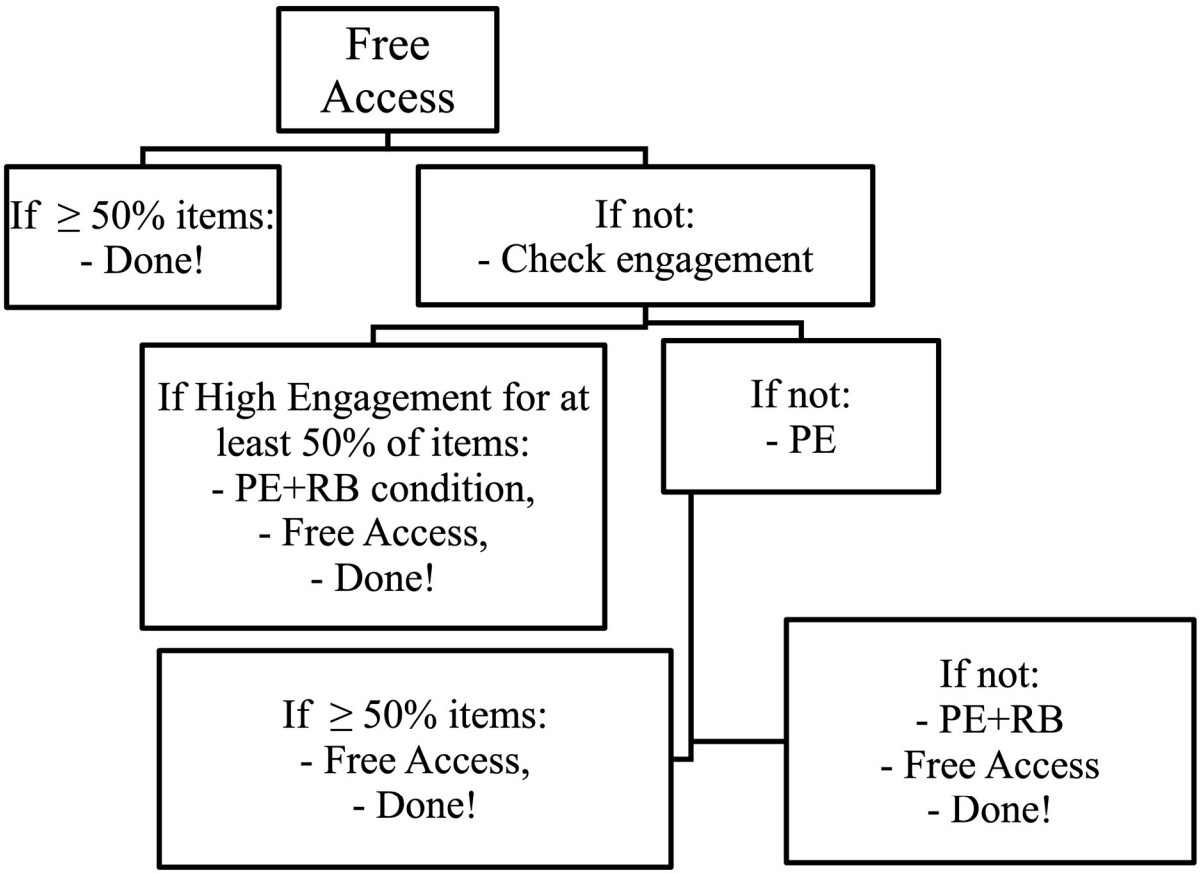

Figure A11

Results from ACSA

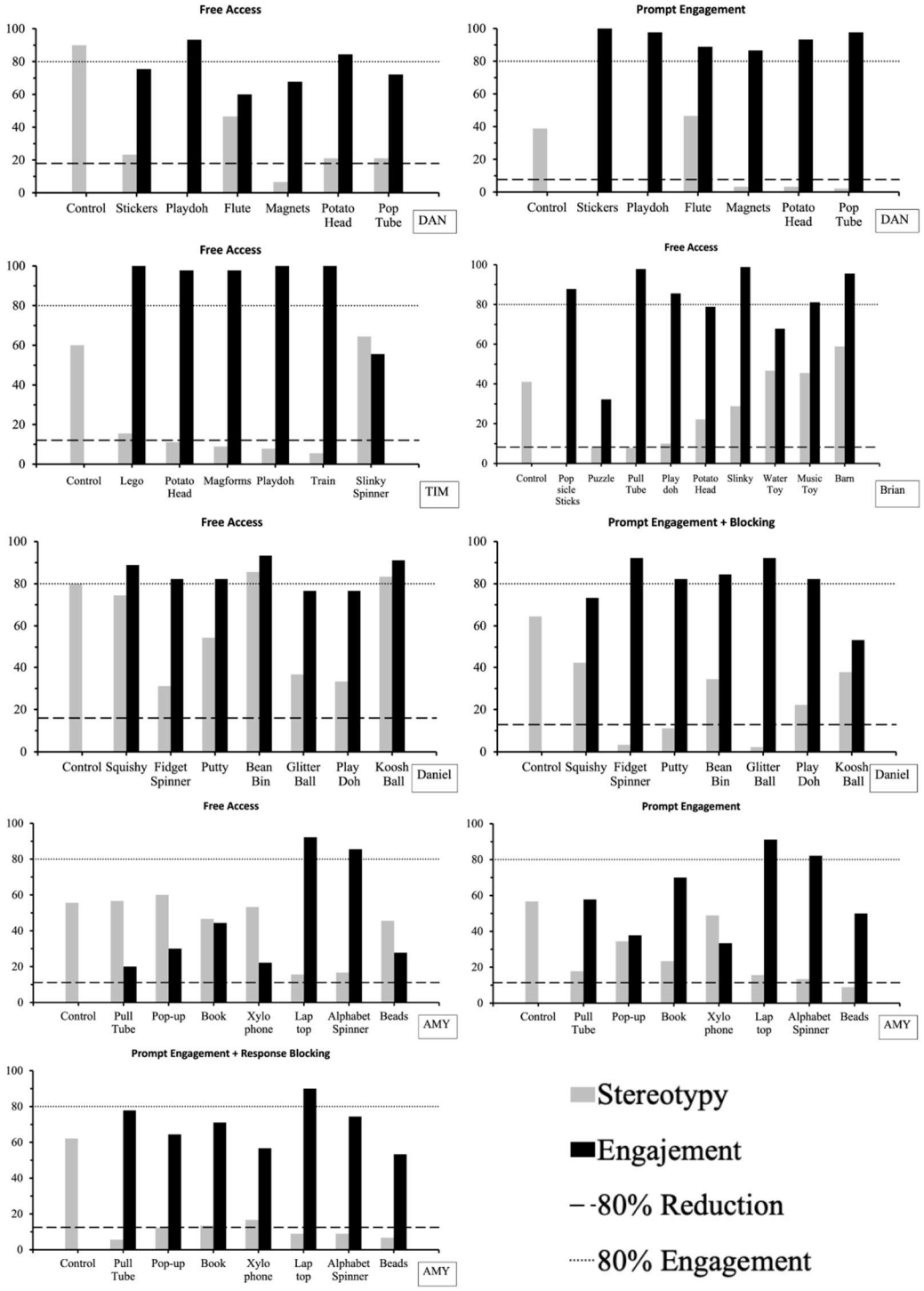

Figure A12

Level of differentiation between the Treatments and FAs for ACSA participants

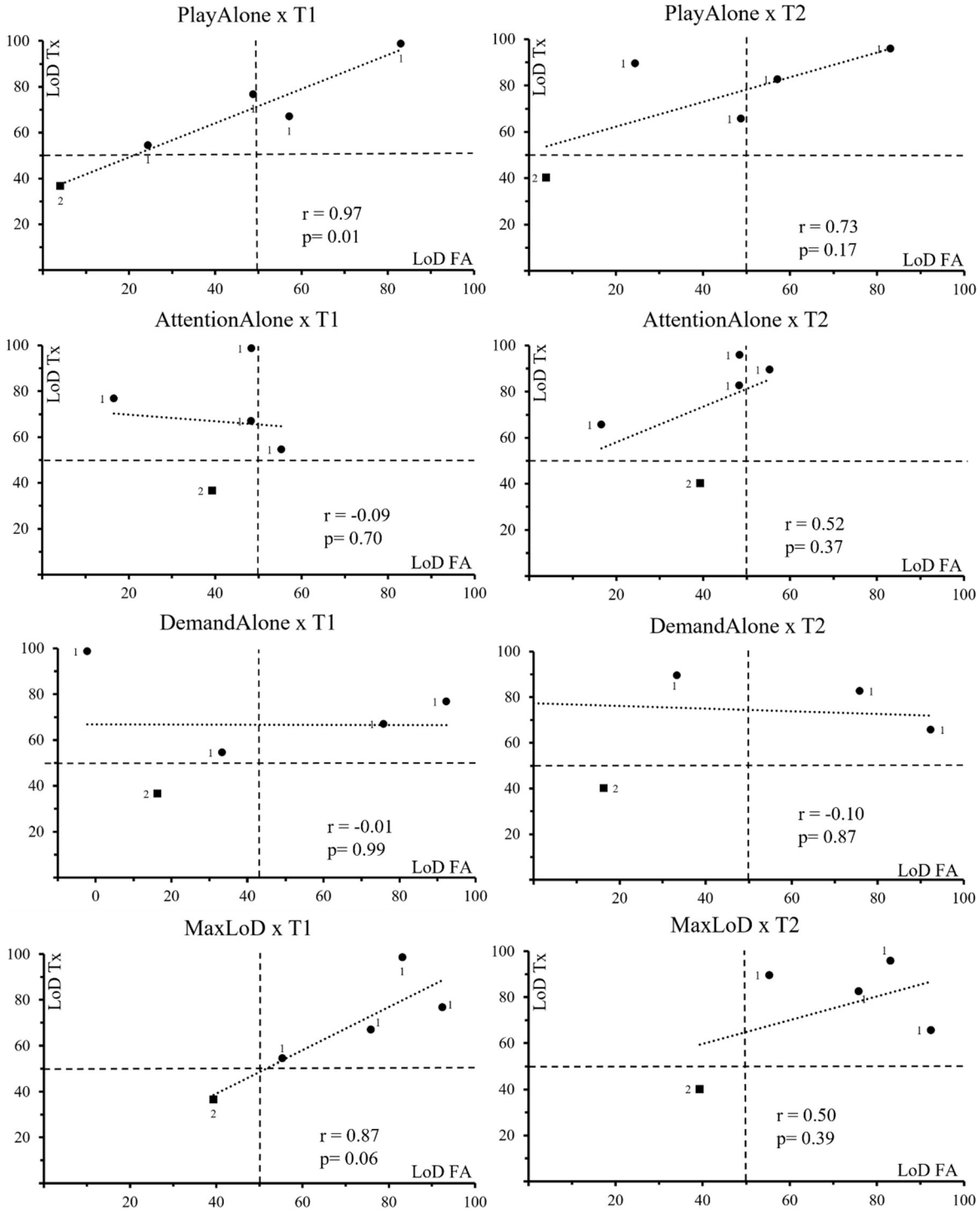

Figure A13

Level of differentiation between the Treatments and FAs for Non-ACSA participants

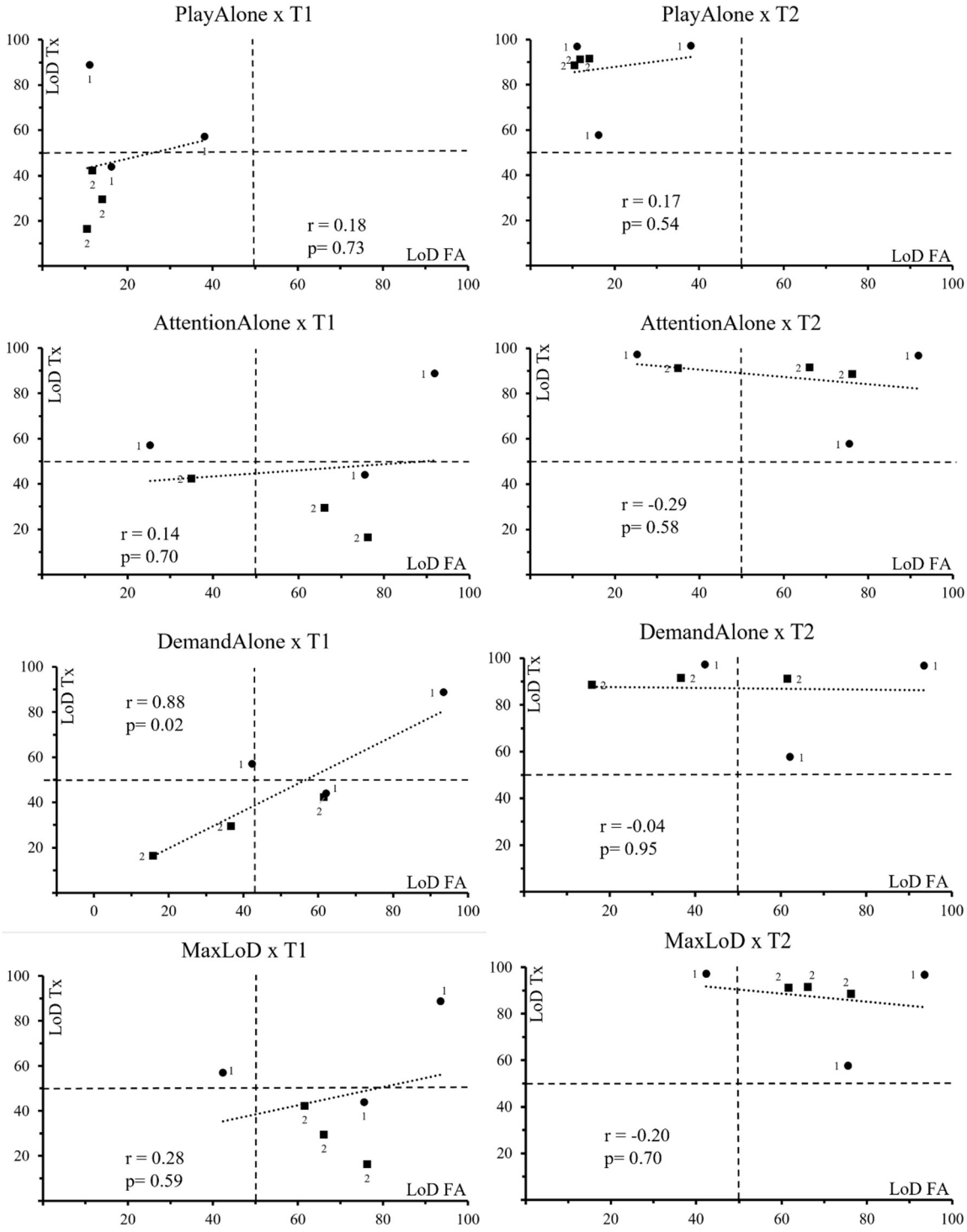

Table B1

Subtypes for all FAs pair of conditions and their responsiveness to treatment

Participant	FA Subtype quotient			Does the quotient change?	Responsiveness to treatment			
	Play	Attention	Demand		Predicted	Actual	Match PA?	Match EXT?
Dan	1	1	2	***Y***	1,2	1,2	***Y***	***Y***
Tim	2	1	2	***Y***	2	1,2	N	***Y***
Brian	1	1	1	N	1,2	1,2	***Y***	***Y***
Daniel	1	1	1	N	1,2	2	N	N
Amy	1	1	1	N	1,2	2	N	N
George	1	1	1	N	1*	1	***Y***	***Y***
Seth	2	1	1	***Y***	2	1,2	N	***Y***
Hank	1	1	1	N	1*	1 + Tokens	***Y***	***Y***
Sam	2	1	1	***Y***	2	2	***Y***	***Y***
Scott	1	1	1	N	1,2	2	N	N
Andy	2	1	1	***Y***	2	1	N	***Y***

Note. Gray highlights relate the actual responsiveness to any matching subtype quotient. If the actual responsiveness is 1,2 on the right side, a subtype quotient 1 on the left side is shadowed. If the actual responsiveness is 2 on the right side, a subtype quotient 2 on the left side is shadowed. The predicted responsiveness was calculated based on Play-Alone Subtype. *Participant was not exposed to treatment 2.

Table B2

Levels of Differentiation in FAs and Treatments

Participant	Levels of Differentiation					Treatments	
	Play - Alone	Attention-Alone	Demand - Alone	Max LoD	Min LoD	T1	T2
Dan	83.1	48.4	-2.2	83.1	-2.2	98.7	95.9
Tim	4.1	39.3	16.4	39.3	4.1	36.6	40.1
Brian	48.8	16.6	92.4	92.4	16.6	76.7	65.7
Daniel	24.4	55.3	33.3	55.3	24.4	54.5	89.6
Amy	57.1	48.4	75.8	75.8	48.4	67.0	82.6
George	11.1	91.9	93.5	93.5	11.1	88.7	96.8
Seth	14.1	66.2	36.8	66.2	14.1	29.4	91.4
Hank	16.2	75.6	62.2	75.6	16.2	43.9	57.6
Sam	10.5	76.3	15.9	76.3	10.5	16.3	88.5
Scott	38.1	25.3	42.4	42.4	25.3	57.1	97.2
Andy	11.8	35.1	61.6	61.6	11.8	42.2	91.1

Note. Max LoD and Min LoD columns state the highest and lowest differentiation scores among FAs differentiation calculations.

Table B3

Correlation description by FA LoD versus responsiveness to treatment

FA LoD	Treatment 1		Treatment 2	
	r	p	r	p
	All Participants			
Play-Alone	0.71	0.01	0.26	0.44
Attention - Alone	-0.14	0.07	0.19	0.57
Demand - Alone	0.30	0.37	- 0.02	0.95
MaxLoD	0.51	0.11	0.21	0.54
	ACSA Participants			
Play-Alone	0.97	0.01	0.73	0.17
Attention - Alone	-0.09	0.7	0.52	0.37
Demand - Alone	-0.01	0.99	-0.10	0.87
MaxLoD	0.87	0.06	0.50	0.39
	Non-ACSA Participants			
Play-Alone	0.18	0.73	0.17	0.54
Attention - Alone	0.14	0.70	-0.29	0.58
Demand - Alone	0.88	0.02	-0.04	0.95
MaxLoD	0.28	0.59	-0.20	0.70

Note. Significant p values are highlighted.

Table B4

IOA agreement by participant

Procedure	FA	ACSA								Treatment Analysis							
Phase		Free Access		Prompt Engagement			BL+RD			Treatment 1 - Swapping				Treatment 2 - BL+RD			
	ST	ST	CT	ST	CT	PRT	ST	CT	BL+RD	ST	CT	ENG	Swap	ST	CT	ENG	BL+RD
Dan	94.7	92.0	93.3	96	97	98				97.8	100.0	86.7	100	98.3	93.3	86.7	100
Tim	90.2	91.0	99							90.0	99.3	96.0	100	92.7	99.3	96.0	100
Brian	98	99	100							100	99	100	100	100	99	100	100
Daniel	90	98	99				98	99	100	91	99	91	100	91	99	91	99
Amy	98	99	99	99	99	100	99	99	100	99	100	100	100	99	100	100	100
George	98.2									98.2		99.1		98.2		99.4	
Seth	94.3									94.3		98.2		94.3		98.9	
Hank	94.7									94.7		97.5		94.7		87.1	
Sam	95.1									95.1		92.2		95.1		93.5	
Scott	91.1									91.1		93.5		91.1		90.5	
Andy	96.1									96.1		98.8		96.1		96.5	

Note. Shadowed fields represent implemented procedures. ST = Stereotypy; CT = Contact; PRT - Prompt; BL+RD = Blocking and redirection; ENG = Engagement