2015

Studying Treatment Intensity: Lessons from Two Preliminary Studies

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Citation of this paper:
Neil, N., & Jones, E. A. (2015). Studying treatment intensity: Lessons from two preliminary studies. Journal of Behavioral Education, 24(1), 51-73. doi: 10.1007/s10864-014-9208-6

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Suggested Citation:

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Abstract

Determining how best to meet the needs of learners with Down syndrome requires an approach to intervention delivered at some level of intensity. How treatment intensity affects learner acquisition, maintenance, and generalization of skills can help optimize the efficiency and cost effectiveness of interventions. There is a growing body of research on the effects of treatment intensity but almost no systematic study of it with children with Down syndrome, providing little guidance about how to approach the study of intensity. In two preliminary studies we manipulated different aspects of the dose of treatment intensity and measured effects on skill acquisition using single-subject experimental designs. Intensity varied in terms of number of opportunities per session, session duration, and spacing of opportunities (inter-stimulus interval). Matched responses within a skill area were randomly assigned to a level of intensity and acquisition was compared. Results reveal lessons about what aspects of intensity to manipulate and how, selecting experimental designs, measuring multiple outcomes, and the influence of learner characteristics. These lessons highlight directions for future approaches to tease apart the relative contributions of different aspects of intensity on skill acquisition and determine the most effective intensity of early intervention for children with Down syndrome.

Keywords: Down syndrome, Treatment Intensity, Applied Behavior Analysis, Dose

Studying Treatment Intensity: Lessons from Two of Preliminary Studies

In a growing body of work we are examining the application of behavior analytic interventions with learners with Down syndrome (Bauer, Jones, & Feeley, 2013; Bauer & Jones, 2014; Feeley & Jones, 2006; Feeley & Jones, 2008a, 2008b, 2008c; Feeley, Jones, Blackburn, & Bauer, 2011; Jones, Feeley, & Blackburn, 2010; Jones, Neil, & Feeley, 2013). The focus of this research has been on developing interventions to address critical areas of need such as communication (Fidler, 2005), that are significantly impaired in this population. Determining how to improve outcomes for learners with Down syndrome requires an approach to intervention delivered at some level of intensity. The interventions we have developed are delivered in a discrete-trial teaching format (Lovaas, 1987) involving relatively intense involving multiple, caregiver-directed opportunities presented in close proximity with specific prompting procedures, high rates of reinforcement, and error correction procedures. This is consistent with some of the early research on interventions for young children with Down syndrome (e.g., Hanson, 1987). Until recently, we had not directly examined the necessity or the effect of intervention intensity on performance of children with Down syndrome (Jones et al., 2013).

Intervention intensity refers to the quantity and quality of intervention and has often been conceptualized as duration. For example, Lovaas (1987) compared intensive behavioral intervention for 40 hours per week, to the same intervention for only 10 hours per week. After approximately 2 years, almost 90 percent of the children who received 40 or more hours of intervention demonstrated substantial improvements in intellectual functioning and transitioned to a “less restrictive” educational placement compared to those receiving less intense intervention.

Warren, Fey, and Yoder (2007) expanded the conceptualization of intensity with a framework based upon a pharmacological model. Aspects of the quantity of intervention include dose, dose frequency, and duration. *Dose* refers to the number of opportunities per session; for example, presenting 10 opportunities to imitate words or only 2 opportunities. *Dose frequency* refers to how often sessions occur; for example, practicing imitation once per week or several times per week. *Duration* refers to the overall length of intervention. Warren et al. also suggested a measure of cumulative intervention intensity calculated as the product of dose, dose frequency, and duration. Quality of intervention, what Warren et al. refer to as *dose form*, includes aspects of intervention such as who conducts intervention (professionals, parents, peers), where intervention occurs (special setting, natural community, or home environment), and the ratio of students to interventionists. Any or all of these aspects of intensity may impact whether learners acquire skills at all, how quickly they acquire those skills, and how well those skills generalize to other situations and maintain over time. Thus, treatment intensity is related to optimizing the efficiency and effectiveness of intervention.

There is only a recent and small literature examining treatment intensity, with the research on treatment intensity focused on specific disorders even more limited. It may be that etiology and characteristics associated with specific etiologies impact the effects of intervention intensity. Many children with Down syndrome display poor task persistence and inconsistent motivational orientation (Fidler, 2005). We suggest, and so have others (Yoder & Warren, 2002), that characteristics such as task persistence may moderate the effects of intensity. For some learners with Down syndrome, it is possible that there is an optimum moderate level of intensity, past which, learners engage in greater levels of escape-motivated problem behavior and there are diminishing gains in acquisition rates.

In several studies of prelinguistic milieu teaching, Fey, Warren, Yoder, and colleagues have begun to show how learners with Down syndrome may respond differently to intervention and intervention of different intensities than children with developmental delays of other etiologies. Yoder and Warren (2002) found requesting (an area of impairment in learners with Down syndrome) in their subgroup of children with Down syndrome was negatively affected by responsive parenting education and prelinguistic milieu teaching (RPMT). Fey, Warren, Fairchild, Sokol, and Yoder (2006) altered the intervention by beginning with a less complex form of requesting and then increasing expectations in small steps as children progressed. Under these conditions, all children, including those with Down syndrome, improved. This change in the form of intervention, breaking skills into smaller steps, may be particularly important when addressing areas of significant impairment such as requesting, in learners with Down syndrome (Bauer & Jones, accepted; Feeley et al., 2011; Jones et al., 2010).

In a study examining dose frequency, Fey et al. (2013) compared milieu communication teaching provided five times per week to one time per week. Each session lasted 1 hour and intervention occurred for 9 months. There was no main effect of dose frequency, however, children who played more with objects performed better on measures of vocabulary with a higher dose frequency of intervention. In a reanalysis of these data, Yoder, Woynaroski, Fey, and Warren (2014) found that children with Down syndrome showed better outcomes in the high frequency group after controlling for cognitive functioning. Perhaps learners with Down syndrome respond to intervention and intervention intensity differently than learners with developmental delays and intellectual disability of other etiologies.

As we have begun to explore the effects of treatment intensity on performance of learners with Down syndrome, we are learning a number of lessons that illustrate the complicated nature

of the study of treatment intensity and how much more complex the effects of intensity are likely to be than we initially thought. We present two studies using within-subject comparisons of dose. The purpose of these studies was to examine the effects of dose on skill acquisition in children with Down syndrome. We manipulated dose, holding dose frequency and dose form constant. Dose is characterized by several parameters: session duration, number of opportunities/session, and inter-stimulus interval (spacing between opportunities). We manipulated the number of opportunities per session across treatment intensity conditions. Increasing the numbers of opportunities within a session, however, necessitates either longer sessions, or shorter intertrial intervals in order to deliver the increased intensity level. Thus, these three parameters were considered jointly. In Study 1, we examined the effect of dose in terms of number of opportunities on rate of skill acquisition measured in sessions to mastery. We compared the effects of two levels of dose involving either 20 or 5 opportunities with session duration held constant (at 10 min) for one child and spacing between opportunities held constant (at 30 s) for the other child. We hypothesized the sessions to master skills would show a functional relationship with dose. In Study 2, we expanded our investigation of dose using an alternating treatments design to examine the effect of five dosage levels on rate of skill acquisition measured in number of opportunities and minutes to master skills in children with Down syndrome. We hypothesized the number of opportunities and time to master skills would show a functional relationship with dose.

Study 1

Method

Participants. Two children with Down syndrome were recruited through a local Down syndrome parent group. Parents provided informed consent for participation. Henry was a 6-

year-old male child with Down syndrome and the younger of two siblings. Henry received respite services from a provider with a background in applied behavior analysis for approximately 5 hours per week, but did not receive ABA therapy outside of this study. Henry was previously involved in a study treating bruxism (teeth grinding) at Queens College. He also received 1.5 hours per week each of speech, occupational, and physical therapies. Henry requested using one-word utterances or signs and required assistance with daily living tasks including dressing and toileting. Henry scored in the moderately delayed range with a Full-Scale IQ of 43 (<.1 percentile) on the Stanford-Binet Intelligence Scale, Fifth Edition (Roid, 2003). He scored in the moderately delayed range on the Fluid Reasoning, Knowledge, Quantitative Reasoning, and Visual-Spatial Reasoning (<.1 percentile) and in the mildly delayed range on the Working Memory (1st percentile) Subscales.

Justin was a 2-year-old boy and the younger of two sons born to his family. Justin received 10 hours of early intervention services (including ABA therapy, speech/language, occupational therapy, physical therapy, and special education services) in his home. At the beginning of the study, Justin imitated one word utterances and requested a small number of items using those single words (e.g., “drink,” “ball”). He also imitated a number of gross and fine motor movements. His ABA therapists were working on many skills including receptive identification of objects, picture identification, verbal imitation, and sign language. On the Mullen Scales of Early Learning (Mullen, 1995), Justin scored in the average range on the Visual Reception Subscale (T score of 55; 69th percentile). He scored in the very low range on the Gross Motor (T score of 20; 1st percentile), Fine Motor (T score of 20; 1st percentile), and Expressive Language (T score of 28; 1st percentile) Subscales. Justin scored in the below average range on

the Receptive Language Subscale (T score of 37; 10th percentile). Overall, Justin received a standard score of 72 indicating below average general cognitive functioning.

Setting and Interventionists. Henry's sessions occurred at the Developmental Disabilities Lab "Play Room" at Queens College and Justin's occurred in his home. Graduate students and research assistants holding undergraduate degrees in Psychology conducted all sessions. The same interventionist conducted all levels of intervention intensity for a child.

Design. We examined the effects of intervention on skill acquisition using four multiple baseline across responses designs. In each multiple baseline we examined the effects of a specific treatment intensity (i.e., high or low) applied across three different responses for a specific skill area (i.e., one-step instructions or signs). Each set of responses was randomly assigned to receive high or low intensity intervention; the order in which intervention was introduced to the three responses was randomly assigned using an online random number generator.

Response definition, measurement, and interobserver agreement. Percentage of independent and prompted correct responses in high-intensity and low-intensity intervention were graphed. Interventionists recorded child performance during each session. On each opportunity the interventionist said the instruction, "Show me [one-step instruction or sign]." An independent correct response involved the child producing the target action within 3 s of the interventionist's directive. If the child produced the target action after the interventionist's instruction that also included a physical prompt (described shortly) she recorded it as a prompted response. If the child either made no response or produced an action other than that identified by the interventionist in her instruction, she recorded an incorrect response.

For each child, we identified six target responses. Targets were tailored to the learner according to current areas of need identified by the parent and confirmed with interventionist

observation. The targets involved receptive signs for Justin and one step instructions for Henry and are listed in Table 1.

To examine interobserver agreement (IOA) for children's performance during baseline, intervention, and follow-up, a trained undergraduate research assistant independently scored each child's performance on each opportunity as independent or prompted from video recordings. The first author provided the research assistant with written definitions of target responses. The research assistant then scored video recordings of sessions not used to examine IOA. She achieved 90% agreement with the first author prior to conducting IOA for this study. The research assistant scored 29% of Henry's sessions and 4% of Justin's sessions. The majority of video recordings of Justin were lost due to corrupted files. Agreements occurred when the observer and the interventionist scored the child's response in the same way. Percent agreement was calculated by dividing the number of agreements by the total number of agreements plus disagreements multiplied by 100. Overall IOA across responses was 95.26% (75-100%) for Henry and 88% (85-100%) for Justin.

Procedure. Within each set of six responses, experimenters matched skill difficulty level and then randomly assigned each pair to the two different levels of treatment intensity so the anticipated difficulty of the responses was balanced across the intensity levels. We matched on the number of words within the instruction (e.g. *turn off light* and *open the door* are three word instructions) and the complexity of the response (e.g. *turn off light* and *open the door* required the participant to leave his seat). Three of the responses in each skill area were targeted in high intensity intervention. The other three were targeted in low intensity intervention. Table 1 shows which target responses were taught at which level of intensity.

Baseline. During each *baseline* opportunity, the interventionist and child sat across from each other and the interventionist said the instruction, ‘‘Show me [one-step instruction or sign]’’ and provided the child with a 3 s interval to respond. Interventionists provided a single opportunity to perform each target response in a baseline session. Following a correct response, no response, or another response (e.g., a verbalization), the interventionist delivered no feedback to the child, but, after 5 s, continued by presenting another opportunity. Because performance was at zero, only 5 (Justin) and 6 (Henry) baseline sessions for each target were conducted before intervention was introduced for the first response. Subsequent baseline probes were conducted prior to introducing intervention to each of the next targets.

Intervention. Dose frequency (e.g., one session per week) and dose form was held constant, but dose varied. Table 1 shows dose, specifically, the number of opportunities, session duration, and spacing of opportunities during high and low treatment intensity sessions for Henry and Justin. Three responses within each response class were targeted in the high intensity intervention. The other three target responses within each response class were targeted in the low intensity intervention. For example, in the high intensity intervention for Henry, when the interventionist taught wave, she presented 20 opportunities to wave, providing the instruction every 30 s so the session lasted 10 minutes. During the low intensity intervention, when the interventionist taught arms out, she presented 5 total opportunities, one instruction every 30s, so the session lasted 2.5 minutes.

Intervention was a discrete-trial teaching format in which the interventionist and child sat across from each other on the floor or at a table and the interventionist presented opportunities for the child to respond. To prompt correct responses, interventionists used hand- over-hand prompting faded using a most-to-least prompt fading hierarchy and time delay. Full prompt

involved hand-over-hand prompting faded to a partial prompt involving only a tap on the child's hand. During time delay, the interventionist waited 3 s for the child to respond independently after presenting the instruction. If the child did not respond independently following the 3 s delay, the interventionist used the partial prompt. Prompts were faded when the child emitted correct responses on 80% or more of the opportunities during 2 consecutive sessions on 2 days. The child achieved mastery when he emitted independent correct responses on 80% of the opportunities across 2 consecutive sessions. More intrusive prompts were re-introduced following decreasing trends in acquisition and near zero performance.

Correct responses resulted in the delivery of high quality social interactions (e.g., social praise and hugs) identified by the interventionists and caregivers based on their successful use during other interventions. Incorrect responses resulted in the delivery of feedback; the interventionist said, "Uh uh," turned her face away from the child for 1-3 s, and then presented a new opportunity. When opportunities were not being presented and reinforcement not being delivered, instructors engaged participants in a neutral activity (e.g., playing with blocks, completing puzzles) that was identified by parents as not highly preferred by but not aversive to the child.

Follow-up. One month *follow-up* probes were conducted following mastery of each target response for Henry. Thus, follow-up probes occurred at different times for each target response. A single opportunity was presented in the same manner as baseline opportunities. Justin was unavailable for 1-month follow-up probes.

Intervention Integrity. The same undergraduate research assistant who examined video recordings of 29% of Henry's sessions and 4% of Justin's sessions also assessed intervention integrity. He scored the form of intervention for the accurate presentation of each of the three

components of intervention (i.e., presentation of opportunities, prompting procedure, and provision of appropriate consequences) on each opportunity and adherence to the dose of intervention in terms of number of opportunities, spacing, and session duration. The number of times the interventionist correctly presented the intervention component was divided by the total number of correct plus incorrect presentations of that component, multiplied by 100, to obtain the percentage of correctly implemented intervention procedures. Across both children, intervention integrity averaged 98.08% (99.27% for high intensity and 92.98% for low intensity) for the correct presentation of opportunities, prompting procedures, and delivery of reinforcement. Intervention integrity for the intensity levels (shown in table 1) included the observer's calculation of the average session duration and inter-stimulus interval, and the percentage of sessions with the correct number of opportunities.

Results

Table 1 presents a summary of the high and low treatment intensity conditions for each child along with the average number of sessions to mastery. Figures 1 and 2 illustrate Henry's and Justin's performances, respectively, during baseline, intervention, and follow-up. Open circles show independent correct responses during baseline, time delay, and follow-up conditions. Filled circles show prompted and independent correct responses during prompting conditions. Both children showed 0% correct independent responding during baseline for all targets.

For Henry, intervention resulted in immediate increases in the performance of the target behavior with little variability. In the high intensity intervention (20 opportunities, each presented every 30 s, in a 10 min session), Henry (Figure 1) achieved mastery criterion in 8 sessions for *wave,* 7 sessions for *arms up*, and 6 sessions for *arms out*. In the low intensity

intervention (5 opportunities, each presented every 30 s, in a 2.5 min session), Henry achieved mastery criterion in 13 sessions for *arms out,* 6 sessions for *turn off light*, and 7 sessions for *come here* in the low-intensity intervention condition. At follow-up, all responses maintained at 100% except *arms out* (0%). On average it took 8.67 sessions to reach mastery during low-intensity intervention and 7 sessions during high-intensity intervention.

During high intensity intervention, Justin showed immediate increases in responding following the introduction of the intervention. In the high-intensity intervention condition (20 opportunities presented in 10 min) Justin (Figure 2) achieved mastery criterion after 11 sessions for *thumbs up,* 17 sessions for *dad,* and 22 sessions for *drink*. In the low-intensity intervention condition (5 opportunities presented in 10 min), Justin's performance was more variable. Despite reaching mastery criterion during full and partial prompts, Justin showed decreasing trends in performance during time-delay for all three target responses. When the interventionist re-introduced physical prompts, Justin's performance increased and prompts were successfully faded. Justin achieved mastery criterion after 51 sessions for *stop,* 24 sessions for *mom,* and 14 sessions for *sing*. On average it took 16.6 sessions to reach mastery in high intensity intervention and 26.7 sessions during low intensity intervention. In addition, during the low intensity condition, more intrusive prompts were reintroduced between one and three times for each target, while in the high intensity condition this did not occur.

Study 2

Method

Participants. Two children with Down syndrome were recruited through a local Down syndrome parent group. Parents provided informed consent for participation. Henry had participated in Study 1 (described previously). George was an 11-month-old boy and the

youngest child in his family. George received early intervention services (including speech/language, occupational therapy, and physical therapy) in his home. On the Mullen Scales of Early Learning (Mullen, 1995), George performed in the average range on the Visual Reception (T score of 53; 62nd percentile) and in the below average range on Fine Motor (T score of 45; 31st percentile), Expressive Language (T score of 40; 16th percentile rank), and Receptive Language (T score of 35; 7th percentile) Subscales. He performed in the very low range on the Gross Motor Subscale (T score of 20; 1st percentile). Overall, George received a standard score of 87 indicating an average level of general cognitive functioning.

Design. We used an alternating treatments design to assess the effects of five different doses of intervention on learner's acquisition of receptive targets. The presentation of intensity levels was reverse counterbalanced. In odd numbered sessions, intensity levels were presented in ascending order. In even numbered sessions, intensity levels were presented in descending order.

In a typical alternating treatments design, multiple levels of the independent variable would be applied while measuring and graphing child performance. In this way child performance during each session of each intervention is depicted. The dependent variables of interest in this study were not child performance of behavior, but summary variables related to the duration to mastery. Specifically, we measured three outcomes: sessions to mastery, time to mastery, and percentage of errors. These are measured after intervention has been applied and the child has demonstrated performance of a behavior at a level of mastery. Thus, the different levels of the independent were applied in an alternating treatments design, however the figures show these summative dependent variables related to the duration to mastery.

Response definition, measurement, and interobserver agreement. Target responses for each child are shown in Table 1. We measured the effect of the five intensity levels on three

dependent variables: sessions to mastery, time to mastery, and percentage of errors. Interventionists recorded child performance and prompts as in Study 1. Sessions to mastery, time to mastery, and percentage of errors was calculated for each condition post-intervention. The same undergraduate research assistant as in Study 1 scored each child's performance from video recordings for 36% of Henry's sessions and 24% of George's sessions. Overall IOA across responses was 99% (97% - 100%) for Henry and 94% (83% - 100%) for George.

Procedure. As in Study 1, for each child, we identified individual target responses. We identified five receptive colors for George and five expressive signs for Henry (see Table 1) that we randomly assigned each target to one of five treatment intensity levels using an online random number generator.

Baseline. Baseline was the same as in Study 1 except that we attempted to prevent any potential positive (or negative) effects that may result from familiarity with any of the doses to be examined by ensuring the spacing of opportunities in baseline did not overlap with the spacing of opportunities in intervention. For each baseline session interventionists presented three opportunities to perform each target response with each opportunity separated by 20 min. Because performance was at zero, only two initial baseline sessions for each target were conducted before introducing intervention.

Intervention. Table 1 shows the number of opportunities, session duration, and spacing of opportunities during treatment intensity sessions for Henry and George. For example, in the highest intensity intervention for Henry, when the interventionist taught "chip", she presented 20 opportunities to sign "chip", providing the instruction every 30 s so the session lasted 10 minutes. In the low intensity intervention, when the interventionist taught "noodle", she presented 1 opportunity so the session lasted 30 s.

The form of intervention was the same as described previously except, in Study 2, prompts were faded within session. When the learner performed three correct responses with a full prompt, the interventionist probed a partial prompt. If the learner responded correctly in the presence of the partial prompt, the interventionist continued to use the partial prompt. If the learner did not respond correctly, the interventionist reintroduced the full prompt until the learner again emitted 3 correct responses. This continued with the introduction of the time delay. The learner attained mastery when he/she emitted 3 consecutive independent correct responses.

The fewest number of sessions in which a target could be mastered at the lowest intensity was 9 sessions. Intervention sessions continued at a designated level of intensity for a minimum of 9 sessions and until all targets were acquired (in 9 sessions or fewer) or 3 of 5 targets were mastered. When 3 of 5 targets were mastered and 9 sessions had occurred, unmastered targets were taught at the intensity level that produced the fastest rate of acquisition. This applied to George for whom, following 23 sessions (when 3 of 5 targets were mastered), targets in the lowest intensity level were switched to intervention at the highest intensity level (20 opportunities).

Intervention integrity. The same research assistant who examined video recordings of 36% of Henry's and 24% George's sessions for IOA also assessed intervention integrity in the same way as in Study 1. Across both children, intervention integrity for the form of intervention averaged 99% (93% - 100%) correct for presentation of opportunities, prompting procedures, and delivery of contingent high quality social interaction. Intervention integrity for the intensity levels (shown in Table 1) included the observer's calculations of average session duration and inter-stimulus interval, and the percentage of sessions with the correct number of opportunities.

Results

Figure 3 shows number of opportunities to mastery (top panel), minutes to mastery (middle panel), and percentage of correct responses (bottom panel) for Henry (left) and George (right). This information is also summarized in Table 1.

For Henry, the fewest opportunities to mastery, 9 opportunities, occurred in the lowest intensity level (1 opportunity presented in 30 s). In general, the opportunities to mastery showed a positive relationship with increasing intensity levels; the highest number of opportunities to mastery, 187 opportunities, occurred in the fourth highest intensity level (10 opportunities with 1 opportunity presented every 30 s in a 5 minute session). For George, the fewest opportunities to mastery (108 opportunities) occurred in the moderate intensity level (5 opportunities with 1 opportunity presented every 2 min in 10 a minute session). The greatest number of opportunities to mastery (277 opportunities) occurred in the highest intensity level (20 opportunities presented in 10 minutes). The two targets in the lowest intensity levels (orange and red) were not mastered with the lowest level of intervention intensity. Treatment proceeded for 24 sessions (24 total opportunities in the lowest intensity, and 48 total opportunities in the second lowest) before the targets were switched to intervention at the highest intensity level (20 opportunities with 1 opportunity every 30 s in a 10 minute session). Following this, he acquired the orange and red targets in an additional 163 and 146 opportunities, respectively.

Opportunities to mastery is a relative measure of learning that provides a comparison of the effects of intervention without regard to the time required to complete an intervention session. Time to complete intervention varied because the spacing of opportunities varied across intensities. For example, George's lowest intensity condition consisted of one opportunity within a 10 min session, whereas in the highest intensity condition, 10 opportunities took the same amount of time. The second panels of Figure 3 show total intervention time in minutes to

mastery. Henry's results are similar for opportunities and minutes to mastery. The three lowest levels of intensity produced mastery in a short amount of time (4.5, 7, and 12 minutes). The higher intensity levels took slightly longer (93.5 and 52.5 min). For George, however, the highest levels of intensity resulted in acquisition in the shortest amount of time (230 minutes). If we consider the highest intensity level for George, we have two pictures of effectiveness. The 20 opportunities in 10 min condition required the greatest number of opportunities for mastery, but the shortest duration.

Two measures of the rate of acquisition are the number of opportunities and time to mastery, but another variable of interest is the quality of acquisition across the varying intensities. The bottom panels of Figure 3 show the percentage of correct responses (with and without prompts) for each child in each condition. George's (right) percentage of correct responding does not vary across intensity levels. For Henry, correct responding was greatest in the lower intensity levels with errors more common in the higher intensity levels. This may explain why the highest intensity levels required greater numbers of opportunities and more time to mastery for Henry.

General Discussion

In these two studies we examined dose of intervention to teach children with Down syndrome receptive and expressive communication responses. We varied the number of opportunities and held the inter-stimulus interval constant for one child and session duration constant for the other child. In Study 1, we presented 2 doses of the number of opportunities (20 and 5 opportunities). We found no differences in acquisition rate when the inter-stimulus interval was held constant, but found that high intensity intervention produced faster acquisition when the session duration was held constant.

In Study 2, we presented five doses of the number of opportunities (1 to 20 opportunities). When the session inter-stimulus interval was held constant, low intensity levels produced faster rates of acquisition and fewer errors. When session duration was held constant, higher doses resulted in fewer minutes to mastery, with targets remaining unmastered at lower intensity levels.

The results from these studies provide hypotheses for future research regarding the study of dose. The results from both studies suggest that the effects of manipulating the number of opportunities are dependent on what other aspects of dose are held constant, although there are a number of limitations which should caution the interpretation of the results. Comparing the results across the individuals is limited by the differences in participant characteristics (e.g., age) and differences across the targets (e.g., receptive signs vs. receptive colors). From these two studies, we suggest a number of considerations regarding the study of treatment intensity.

Manipulating Intensity

Selecting experimental conditions. In attempting to examine the effects of one parameter of dose, number of opportunities, designing the experimental conditions proved to involve more than just manipulating number of opportunities, despite the fact that this is the approach commonly taken in the literature. For example, in investigating inter-trial intervals it is common to present an equal number of opportunities using longer and shorter inter-trial intervals. Within these designs the parameter of the inter-trial interval is always confounded with the parameter of session duration (e.g., Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007; Koegel, Dunlap, & Dyer, 1980). Therefore, such procedures do not allow for the isolation of the effects of different inter-trial intervals from those of different session durations.

In order to begin to answer a question as simple as how does the number of opportunities affect learner acquisition, we need to consider several variables together. It turned out that these different parameters of dose were relevant to child performance. In both studies, for the child for whom we held duration constant, the high intensity intervention (with more opportunities more closely spaced) was associated with faster rates of acquisition than the low intensity intervention (with fewer opportunities spaced farther apart). However, when spacing of opportunities was held constant but the number of opportunities and session duration varied, there was no difference in sessions to acquisition. These differences illustrate how the study of treatment intensity is more complicated than manipulating a single parameter.

To effectively identify which parameter of dose is responsible for differences in learner outcomes, researchers require control conditions that account for the differences in each of these parameters. As we started to do, this may require a series of studies in which one parameter is held constant, while the others vary. We present an example of the manipulations that would begin to answer this question in Table 2. Determining the effects of the number of opportunities requires control conditions that account for varying session durations and the spacing of opportunities. Differences between greater and fewer numbers of opportunities in the condition in which session duration is held constant, but not in the condition in which spacing of opportunities is held constant, suggest that the spacing may be responsible for the differences in acquisition. This could be confirmed with a third condition holding the number of opportunities constant and allowing the spacing of opportunities to vary.

As with dose, each aspect of intensity may involve multiple parameters that affect learner outcomes. For example, varying dose form by comparing one-to-one versus group format instruction will require careful consideration of any variation in the rate of opportunities.

Equating the frequency of opportunities would control for that aspect of intensity, but doing so may then impact session duration. Ideally, use of multiple control conditions could account for differences that arise when manipulating the various parameters of one aspect of intensity.

Range of levels of intensities. After identifying what aspect of intensity to manipulate and relevant parameters, we considered what levels of intensity to present. In Study 1 we compared two levels of intensity chosen based on our studies involving teaching skills to young children with Down syndrome (Bauer & Jones, accepted; Bauer et al., 2013; Feeley & Jones, 2008c; Feeley et al., 2011). In those studies, sessions consisted of 5-10 opportunities. Based on that, in this study, we chose 5 opportunities as one level of intensity. We then chose 20 opportunities as the high intensity intervention because it was a much larger number, although not out of the range of what might occur for teaching language skills to children with disabilities. Such two level comparisons of dose (e.g., Carnine, 1976; Jameson et al., 2007; Koegel et al., 1980) and dose frequency (e.g., Lovaas, 1987; Reed, Osborne, & Corness, 2007) are common.

Comparison of two levels of treatment intensity yields information about differential effects of the two intensity levels in terms of direction and amount. In study 2, we expanded the range of intensities to 5 levels. Expansion of the range of levels of intensity yields information about the dose-response relationship for an individual learner and his or her acquisition. The dose-response relationship identifies the magnitude of the effect of the intervention as a function of the dose and can be used to identify the point at which there are no longer benefits to increasing (or decreasing) intensity levels. In Study 2 we found similar relationships between intensity and acquisition with this expanded range. For George, there also appeared to be diminishing effects of increasing dose.

Dose-response relationships have been observed in behavior analytic interventions for autism. In a meta-analysis, Virues-Ortega (2010) showed linear dose-response relationships for language performance and functional and psychosocial adaptive behaviors, while the dose–response analysis for intellectual functioning showed, to some extent, diminishing effects of increased intervention intensities. This suggests that some outcomes, such as language, continue to benefit from greater intervention intensities, while others, like IQ, show an asymptotic relationship with increased intervention intensity. Along with the preliminary findings in Study 2, this suggests continued investigation of a range of levels of intensity.

Expanding the range of levels of intensity examined in a study necessarily expands the scope of the project to include more treatment groups that require more resources. Between the increased number of treatment groups to examine multiple levels of intensity and the need for various control conditions, perhaps involving several studies to disentangle the effects of different parameters of a given aspect of intensity, investigating treatment intensity becomes a monumental task. Single subject designs in which a small number of participants each serves as his/her own control may provide a way to begin to investigate treatment intensity to formulate hypotheses about levels and parameters for examination in subsequent between groups studies.

Choice of Experimental Design

Single-subject design can serve two valuable purposes in the evaluation of treatment intensity. First, before spending large amounts of resources on group studies, we can use single-subject designs to identify aspects of intensity that are likely to produce the greatest effects in larger studies. Unlike the multiple baseline design in Study 1, the alternating treatments design in Study 2 allowed us to directly compare levels of intensity as well as examine multiple levels of intensity, providing the kind of information that would better inform a group comparison.

Second, single subject designs can be used to inform decisions about the best way to provide instruction to a given learner to tailor intervention to that learner's needs. For example, Jameson et al. (2007) compared one-to-one embedded instruction to massed instruction to teach educational targets in four children with developmental disabilities. They alternated the two instructional formats across two class periods in the same day. Both interventions resulted in learner acquisition of instructional targets, but one-to-one massed instruction produced faster acquisition for two of the four learners. Using these data, teachers could tailor the intensity, in this case the form, of intervention to maximize performance of each learner.

Given the variety of individual characteristics that may potentially moderate the effects of intensity, brief individual assessments using single-subject designs could prove invaluable in incorporating treatment intensity into instructional design. Examples of the success of this approach can be seen in the use of functional analysis of problem behavior upon which to base an intervention (Hanley, Iwata, & McCord, 2003) and a similar approach being taken to determine the most effective academic instructional intervention for an individual student (e.g., Baranek, Fienup, & Pace, 2011; Daly, Martens, Hamler, Dool, & Eckert, 1999).

Using these examples as a model, a teacher might begin intervention for a particular student with an assessment of intensity during which she presents several intervention intensities in an alternating treatments design while measuring acquisition rates of carefully matched responses. This type of assessment would take a similar amount of time as a standardized test, but be sensitive enough to detect minor improvements in acquisition rates. The teacher can then use this information to develop an optimal intensity for intervention for that specific learner (Baranek et al., 2011; Skinner, Belfiore, & Watson, 2002).

Examining Multiple Outcomes

The typical variables of interest when investigating treatment intensity are related to skill acquisition: does the child acquire the skill, how quickly do they do so, and what is the quality of the acquired skill? In Study 1 we only examined whether children acquired the skill and how quickly they did so; in Study 2 we examined all three questions with multiple measures of how quickly children acquired skills. This only further complicated the answer to the question of which intensity is more effective.

Which level of intensity results in better learner performance depends on how acquisition is measured. For George, the highest level of intensity produced the greatest number of opportunities to acquisition, but the shortest number of minutes. Evaluating multiple measures of acquisition allows for the identification of the most appropriate intensity level for maximizing the most relevant measure. In some situations it is important for acquisition to occur in a short amount of time (e.g., to prepare a learner for a new activity or school); in this situation, for George, a high level of intensity would be warranted. In other situations, minimizing the number of opportunities may take precedence (e.g., in a setting where the instructor has to divide time between students); in this situation, for George, a lower intensity level would be more appropriate.

Two other measures of acquisition may be relevant to the study of treatment intensity, yet were not measured in Study 2: maintenance and generalization. The memory literature on the effects of distributed practice on retention shows that spaced presentations result in better memory performance than massed presentations (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). Few studies, however, among individuals with developmental disabilities, address the effects of intensity on maintenance and generalization. Given that intensity produces varied outcomes in

the initial acquisition of a skill it follows that intensity could affect how long that skill persists, and whether or not a learner displays that skill in a variety of contexts.

Intensity may not only affect acquisition, but also tolerability. In some studies, more intense intervention improves learner engagement and reduces problem behavior. For example, Sutherland, Alder, and Gunter (2003) found that a higher rate of opportunities to respond during math instruction was associated with greater rates of correct responding, fewer disruptive behaviors, and greater proportions of time on-task. Similar comparisons of brief versus extended wait-times (Lamella & Tincani, 2012; Tincani & Crozier, 2008) show that shorter (or more intense) instruction produces more correct responding and fewer instances of problem behavior among children with developmental disabilities.

We noticed, anecdotally, that varying treatment intensity levels seemed to affect learner engagement and problem behavior. In the case of Henry, however, we observed greater off task behavior and increased problem behavior associated with higher intensity intervention. This is only one anecdotal observation, but highlights the different outcome measures that may be affected by intensity and at least suggests further consideration in future research.

Learner Characteristics

The differing effects of intensity on different outcomes may also reflect something about this population. Very recent work suggests learners with Down syndrome respond differently than learners with other etiologies of intellectual disability to intervention and intervention intensity (Fey et al., 2006; Yoder & Warren, 2002) and, more specifically, that there may be characteristics of the Down syndrome behavioral phenotype that moderate the effects of intensity. For learners with Down syndrome, there may be some optimum moderate level of intensity, past which, learners engage in greater levels of escape-motivated problem behavior

with concomitant diminishing gains in acquisition rates. While task persistence was not measured in our studies, for Henry, we saw decreases in accuracy at greater intensity levels. Anecdotally, interventionists reported greater levels of off-task and escape-motivated behavior as session durations increased.

Behavioral phenotype may also suggest that different skill areas warrant different levels of intensity for learners with a given disorder. When a skill area is one in which learners with Down syndrome show significant weakness, increasing intensity may be one way of improving outcomes from intervention. Weaknesses identified as part of the Down syndrome behavioral phenotype such as expressive language may be particularly in need of more intensive intervention to result in acquisition of target skills in a timely fashion so learners possess the skill repertoire that will provide them with a basis for subsequent learning. For example, requesting is impaired from a very young age (Fidler, Philofsky, Hepburn, Rogers, & Abbeduto, 2005; Mundy, Kasari, Sigman, & Ruskin, 1995). In addition, in the face of requesting tasks, children with Down syndrome engage in various distracting social behaviors to escape the situation. Fey et al. (2006) may have obtained different outcomes from Yoder and Warren (2002) because they changed the form of intervention, breaking down the target response into smaller steps, something we see as an increase in intervention intensity. Our own requesting intervention takes a similar approach, in addition to increasing other aspects of intensity including dose and dose frequency (Bauer & Jones, accepted; Feeley et al., 2011; Jones et al., 2010). Thus, it may be that, within etiology, response to intervention intensity also varies across skill area.

In the preliminary intervention intensity studies here, we examined the effects of different levels of intensity on a variety of receptive skills. In our assessments of the children, receptive skills made the most sense with which to begin. We must begin to look at variability in response

to treatment intensity in relation to different types of skill areas. If we address different skill areas using the same manipulation of intensity, within the same learner, then we can examine patterns of acquisition across skill areas and levels of intensity. This information can only continue to help us provide optimal intervention that best meets the needs of learners with Down syndrome. Continuing to explore intervention intensity will require careful choice of skill areas to reflect significant weaknesses and relative strengths while also measuring learner characteristics such as task persistence to begin to untangle how intensity interacts with learner characteristics and etiology.

Conclusion

There is no shortage of discussion on the complications in studying treatment intensity (e.g., Warren et al., 2007; Yoder et al., 2012). The effective study of treatment intensity requires careful consideration of all aspects of research design. Guided by the results of two preliminary studies investigating the effects of dose on acquisition of skills in 3 participants with Down syndrome we offer four considerations in approaching the study of treatment intensity: what aspects of intensity to manipulate and how, selecting experimental designs, examining multiple outcome measures, and considering learner characteristics. We hope these guide further investigation of treatment intensity that will help optimize intervention learners with developmental disabilities.

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Table 1

Dose characteristics and treatment by intensity level for Henry, Justin, and George in Studies 1 and 2

Intensity level	Target	ISI	Integrity for ISI	Number of opportunities	Integrity for number of opportunities	Session duration	Integrity for duration	Results	
					Study 1				
								Mean sessions to acquisition	
Henry (One-step Instructions)									
High	wave, arms up, open the door	30 s	31.9 s	20	100%	10 min	10 min 17 s	7	
Low	arms out, turn off light, come here	30 s	37.4 s	5	100%	2.5 min	2 min 34 s	8.67	
Justin (Signs)									
High	thumbs up, dad, drink	30 s	43 s	20	100%	10 min	9 min 51 s	16.6	
Low	stop, mom, sing	2 min	2 min 16 s	5	100%	10 min	14 min 33 s	29.67	
					Study 2				
								Opportunities to mastery	Min. to mastery
Henry (Receptive Signs)									
Highest	Chip	30 s	31.3 s	20	100%	10 min	11 min 41 s	105	52.5 min
	Pretzel	30 s	28.4 s	10	100%	5 min	4 min 40 s	187	93.5 min
	Chocolate	30 s	32.9 s	5	100%	2.5 min	2 min 32 s	24	12 min
	Cake	30 s	26 s	2	100%	1 min	1 min 7 s	14	7 min
Lowest	Noodle	30 s	-	1	100%	30 s	32.8 s	9	4.5 min
George (Receptive Colors)									
Highest	Green	30 s	1 min 6 s	20	100%	10 min	12 min 15 s	277	230 min
	Yellow	1 min	1 min 44 s	10	100%	10 min	14 min 5 s	162	230 min
	Blue	2 min	2 min 15 s	5	100%	10 min	10 min 20 s	108	230 min

	Red	5 min	4 min 48 s	2	100%	10 min	10 min 38 s	48/146*	240/120 min*
Lowest	Orange	10 min	-	1	100%	10 min	10 min 35 s	24/163*	240/130 min*

Note. Values marked with an asterisk (*) represent targets that were not mastered in the level of intensity to which the target was initially assigned for intervention. Following a lack of mastery, a different level of intensity was provided for those targets. The first value represents the number of opportunities and minutes in the initial intensity while the second represents the number of opportunities and minutes to mastery in the higher level of intensity.

Table 2

Possible control conditions for manipulating the number of opportunities in the study of intensity.

Inter-stimulus Interval	Number of Opportunities	Session Duration	Effect on Interpretation
Varies	Varies	Constant	Fewer vs. Greater opportunities controlling for session duration
Constant	Varies	Varies	Fewer vs. greater opportunities controlling for ISI
Varies	Constant	Varies	Rule out the role of the spacing of opportunities and session duration

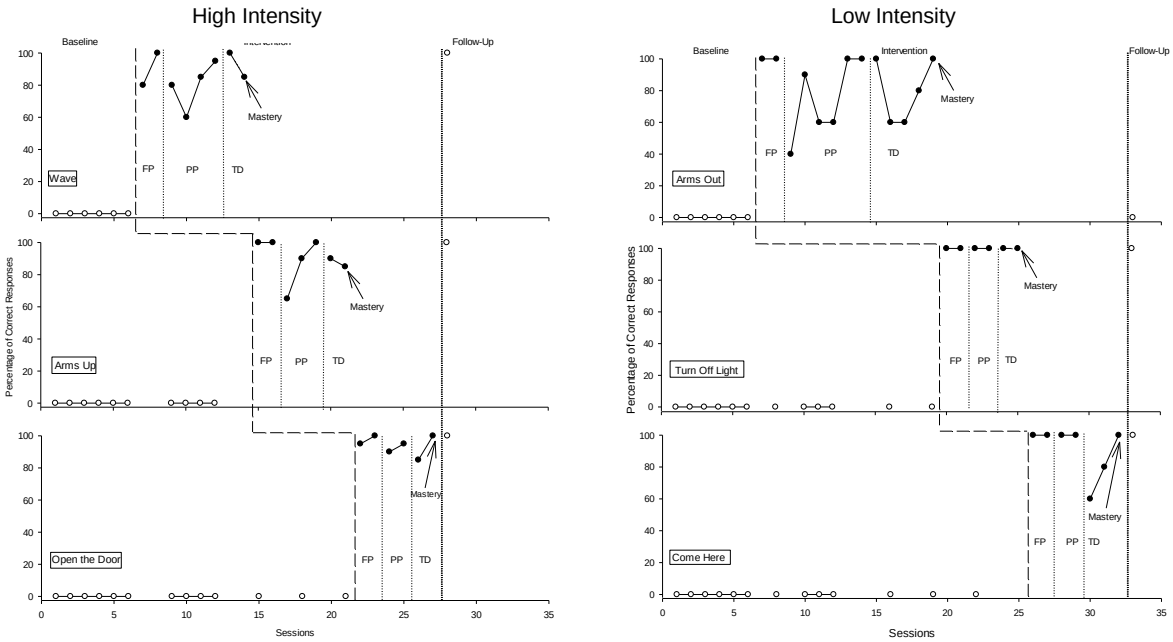

Figure 1. Percentage of correct responses in high-intensity (left) and low-intensity (right) intervention during baseline, intervention for Henry. During baseline, time delay (TD), and follow up conditions, only independent correct performance is graphed. During full (FP) and partial prompt (PP) conditions, both independent and prompted responses were considered correct and graphed performance reflects both. Open circles represent single opportunity probes, filled circles represent multiple opportunity sessions (5 in low intensity and 20 in high intensity).

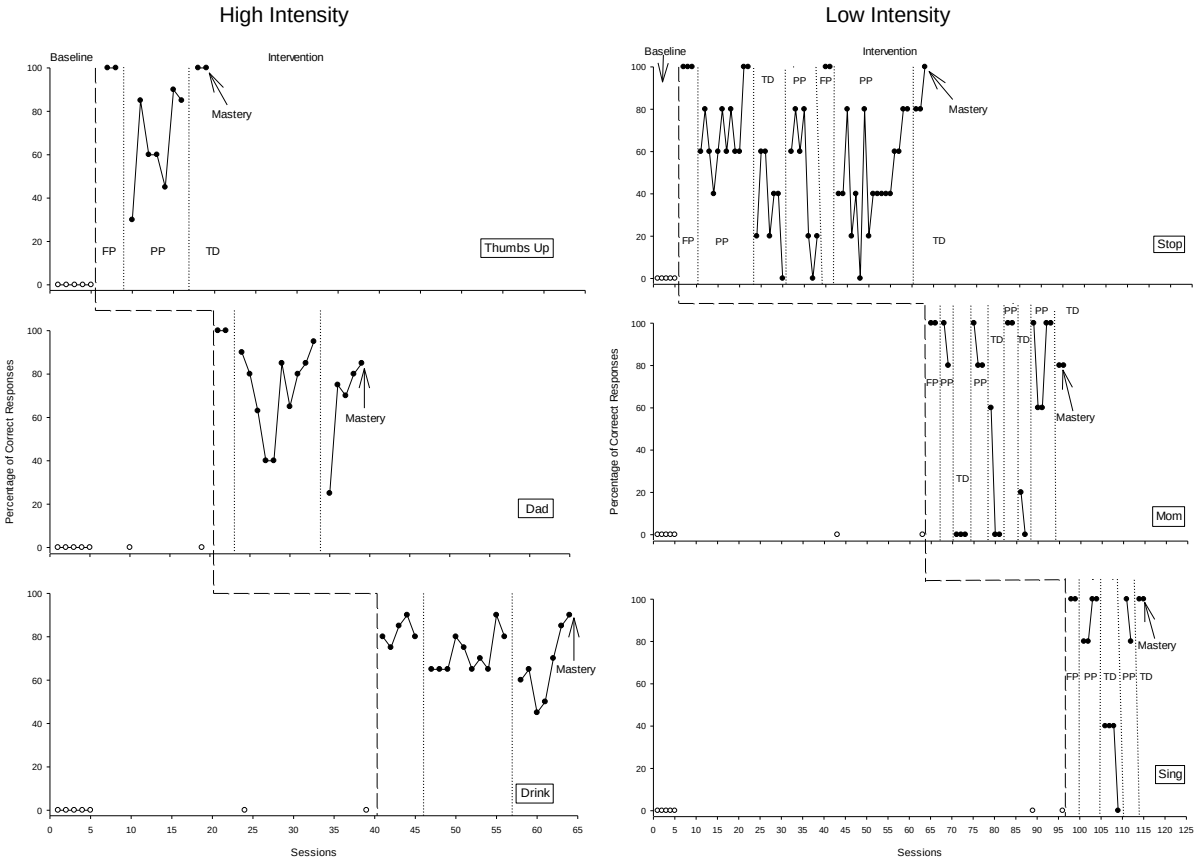

Figure 2. Percentage of correct responses in high-intensity (left) and low-intensity (right) intervention during baseline, intervention for Justin. During baseline, time delay (TD), and follow up conditions, only independent correct performance is graphed. During full (FP) and partial prompt (PP) conditions, both independent and prompted responses were considered correct and graphed performance reflects both. Open circles represent single opportunity probes, filled circles represent multiple opportunity sessions (5 in low intensity and 20 in high intensity). Note the difference in scale on the x-axes.

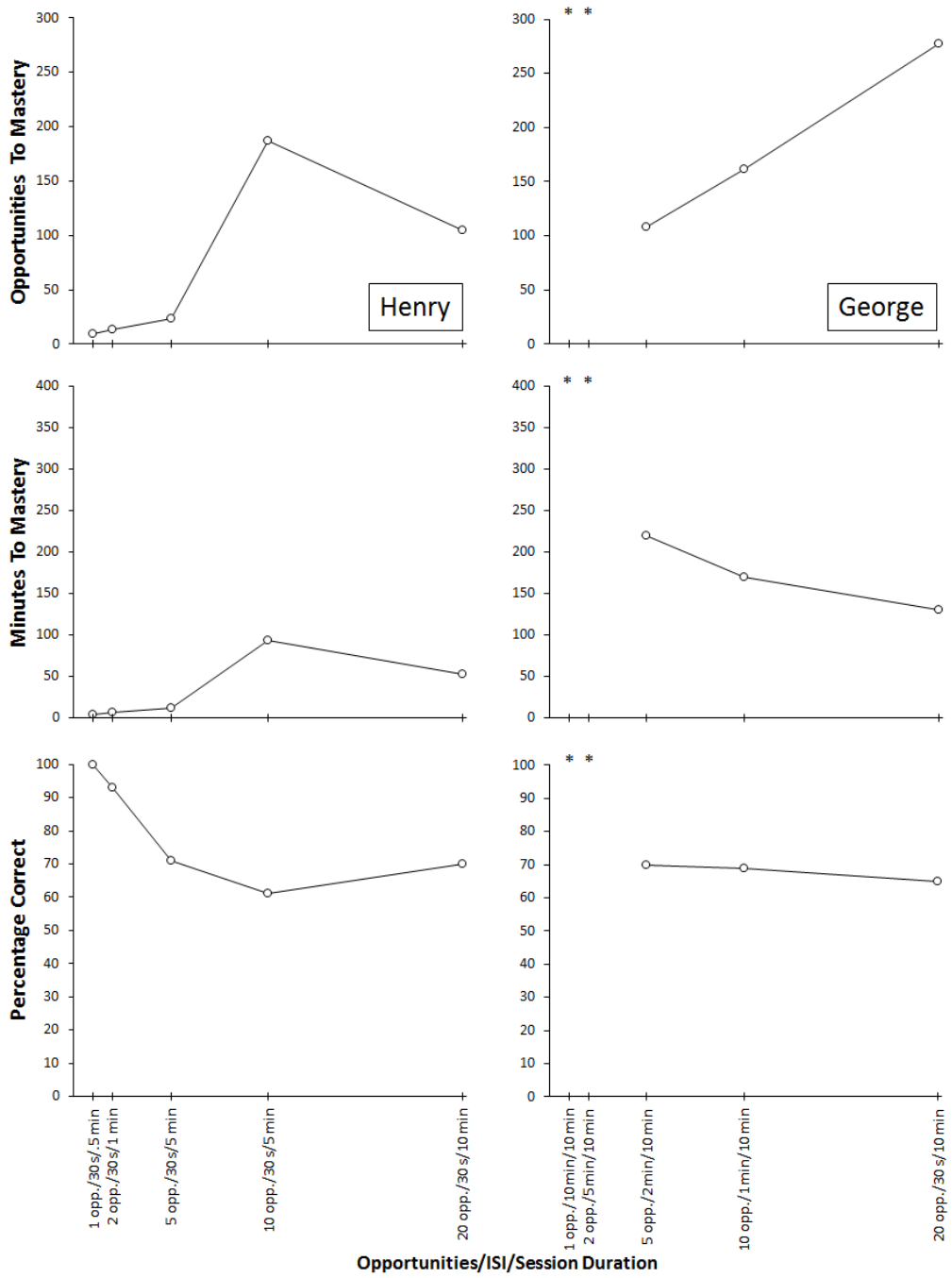

Figure 5. Opportunities to mastery, minutes to mastery, and % correct responding at each intensity level for Henry (left) and George (right). Asterisks represent targets that were not mastered at the intensity level.