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The Effects of Precision Teaching With Textual or Tact Relations on Intraverbal Relations

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The role of Precision Teaching (PT) in establishing intraverbal relations was explored in 2 ways. In the first study, the experimenters explored the role of PT in controlling for baseline levels of textual repertoires prior to transferring stimulus control from the text to the question. Experimenters assessed the impact of pretransfer fluency-based instruction on textual relations on the efficiency of transfer of stimulus control, maintenance, and generalization of intraverbal relations. Extending Emmick, Cihon, and Eshleman (2010), who also compared the effectiveness of 2 textual prompting procedures (with and without fluency-based instruction) on the acquisition of intraverbal relations, the current study incorporated time-delay (rather than stimulus fading) for transfer of stimulus control and used questions that shared similar stimulus features. Results indicate that textual prompts and transfer of stimulus control were effective in establishing intraverbal responses regardless of the inclusion of fluency-based instruction. In the second study, the experimenters explored component-composite relations between tacts and intraverbals. Specifically, the experimenters examined the effects of teaching thematically related tact responses to fluent levels on the emergence of thematically related intraverbal relations (e.g., what are some animals) using a multiple baseline across thematic clusters design. The results indicate that once a fluent level of responding for the target tact relations was achieved (evaluated through endurance and stability checks with later checks for retention), the participant was able to engage in the intraverbal relations without additional training. These data extend the research pertaining to developing intraverbal relations, fluency-based instruction and Precision Teaching, component-composite relations, and recombinative repertoires.

Keywords: autism, component-composite, fluency, intraverbal, Precision Teaching, tact, textual

Researchers have found that intraverbal behavior[1] can be taught when an individual is prompted with pictures, text, or other stimuli to provide an appropriate response following a verbal stimulus (Braam & Poling, 1983; Coon & Miguel, 2012; Emmick, Cihon, & Eshleman, 2010; Finkel & Williams, 2002; Ingvarsson, Tiger, Hanley, & Stephenson, 2007; Luciano, 1986; Miguel, Petursdottir, & Carr, 2005; Partington & Bailey, 1993; Vedora, Meunier, & Mackay, 2009; Watkins, Pack- Teixeira, & Howard, 1989). Many researchers have compared the efficiency of different prompt types (Braam & Poling; Coon & Miguel, 2012; Emmick et al., 2010; Finkel & Williams, 2002; Ingvarsson & Le,

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[1] Skinner (1957) defines the intraverbal as a verbal response that has no point-to-point correspondence to the preceding verbal stimulus, maintained by a generalized conditioned reinforcer.

2011; Vedora et al., 2009). In general, participants acquire the intraverbal relations regardless of prompt type, but the results regarding the efficiency of one prompt type over the other have been inconclusive.

Axe (2008) and Sundberg and Sundberg (2011) hypothesized that the differences in the stimulus sets (questions or statements used to evoke responses typically classified as intraverbal) between experimental conditions regarding prompt types could be responsible for the idiosyncratic findings in prompt type efficiency. They suggested the intraverbal stimuli should be constructed to control for difficulty with respect to verbal conditional discriminations. Others have attributed the differences in responsiveness to prompt type to the participants' learning histories (Coon & Miguel, 2012; Emmick et al., 2010). Coon and Miguel (2012) found that the most recent prompt type to which the participant had been exposed was more efficient when teaching subsequent intraverbal relations. Cihon (2007) suggested that a focus on the fluency of verbal responses rather than their accuracy alone might lead to stronger verbal repertoires and improved maintenance and generalization. Subsequently, Emmick et al. (2010) explored participants' learning histories in terms of the fluency of the prompt type repertoire prior to transferring stimulus control, following up on Cihon's recommendations for research related to verbal behavior and Precision Teaching.

Lindsley (1992) defined Precision Teaching (PT) as "basing educational decisions on changes in continuous self-monitored performance frequencies display on standard celeration charts" (p. 51). The Standard Celeration Chart (SCC) is a measurement and instructional decision making system and is one of the critical features of PT (Kubina & Yurich, 2012). PT is based on the basic premise that learning is observed by evaluating proportional changes in responding and that learning is measured as a change in response rate over time (i.e., celeration). PT focuses on frequent, usually daily, measures of rate of response, and the measurement of celeration, or a change in behavior frequency over time (Cooper, Heron, & Heward, 2007). As a field, PT has often been criticized for its reliance on presentations (e.g., convention symposia or workshops) rather than publications to share its findings (cf., Binder, 1996), its lack of concern with traditional definitions of steady state responding in baseline conditions (cf., Cooper, 2005), and strong advocacy for its inductive approach that seldom follows the current norms of applied behavior analysis (cf., Heinicke, Carr, LeBlanc, & Severtson, 2010). Because PT has most often focused on academic behavior skills, and thus easily fits within Skinner's (1957) verbal behavior framework, Cihon (2007) conducted a review of the literature on the use of PT to establish intraverbal repertoires. She found fewer than 10 published studies (outside of the Great Falls, MT project; cf., Brent, 1977) that have examined the effects of PT to establish intraverbal relations. However, Calkin (2002) reported that nearly 1.2 million SCCs were generated between 1965 and 2002, and many pertained to the development of intraverbal relations (e.g., basic math facts).[2]

The studies included in this manuscript extended the exploration of variables, particularly those related to PT and fluency-based instruction, that may impact the acquisition of intraverbal relations by individuals with autism. Specifically, the first study involved an extension of Emmick et al. (2010) in which fluency-based instruction on the textual[3] relations involved in transfer of stimulus control was included for one set of stimuli but not another. The second study explored the effects of fluency-based instruction on thematically related tact[4] relations on the emergence of related intraverbal relations.

Study 1

Emmick et al. (2010) taught three individuals with disabilities intraverbal relations with transfer of stimulus control via stimulus fading from text to intraverbal. Using an alternating treatments design, Emmick et al. taught textual repertoires for one set of intraverbal responses to

[2] Many of these SCCs either may no longer exist or are otherwise inaccessible.

[3] Skinner (1957) defines the textual as a verbal response that has point-to-point correspondence but no formal similarity to the preceding written stimulus, maintained by a generalized conditioned reinforcer.

[4] Skinner (1957) defines the tact as a verbal response to a nonverbal stimulus, maintained by a generalized conditioned reinforcer.

fluency before transferring stimulus control to intraverbal relations and did not teach the textual repertoires to fluency for another set of intraverbal responses before transferring stimulus control to intraverbal relations. Their results indicated that transfer of stimulus control from textual stimuli to vocal verbal stimuli resulted in the targeted intraverbal relations and that the pretransfer fluency-based instruction allowed some participants to acquire the target responses more rapidly. However, the role of textual fluency before transfer of stimulus control from text to intraverbal could not be clearly determined due to some limitations of the study. Namely, their question sets did not consider verbal conditional discriminations (Axe, 2008; Sundberg & Sundberg, 2011), which could have contributed to the differences in rates of acquisition. Furthermore, the results for the generalization and maintenance checks were inconsistent because not all of the participants maintained and generalized the intraverbal relations.

The purpose of Study 1, then, was to further determine the role of the participants' learning history with respect to fluency of the pretransfer textual repertoires. Experimenters addressed the limitations of Emmick et al. (2010) and deviated from Emmick et al. in several ways. First, experimenters used a question set in which all target intraverbals were presented in the same autoclitic frame (cf., Alessi, 1987; Skinner, 1957) "what do you [verb] with?" to control for variations in verbal conditional discriminations in the questions. Second, experimenters used transfer of stimulus control via time delay (Touchette, 1971) rather than transfer of stimulus control via stimulus fading to transfer control from the text to the question. Finally, experimenters withheld training on some intraverbal relations tested before and after transfer of stimulus control with or without fluency for other intraverbal relations to get a better picture of maintenance and generalization. The experimental questions were as follows: Is acquisition of intraverbal responses enhanced by adding a fluency component prior to textual prompt transfer of stimulus control? How does pretransfer textual fluency impact the maintenance and generalization of intraverbal relations?

Method

Participants, setting, and materials. Three 6-year-old children with autism (two male and one female) participated. Participants' preexperimental verbal repertoires were assessed using portions of the Assessment of Basic Language and Learning Skills – Revised (Partington, 2006). Each participant emitted at least 50 textual responses and could follow one- or two-step instructions. When asked questions that required a vocal response, Amelia typically responded incorrectly and Wilbur and Orville would repeat a portion of the question or respond incorrectly. All participants were receiving Early Intensive Behavior Intervention services. Experimental sessions took place in a therapy room in a one-to-one format with a one-way mirror for observation.

Materials included questions that the participants would answer vocally (see Table 1). Target responses for the fluency-building condition were printed 20–40 times each on an 8 [1/2]″ × 11″ sheet of paper containing up to 180 words. Participants chose between four sheets of paper with the words presented in random order. Textual stimuli associated with the nonfluency building condition and transfer of stimulus control conditions were printed in 48-point Helvetica print on a 3″ × 5″ index card. The format of the textual stimuli changed from fluency building to transfer of stimulus control so that participants could emit responses in a free operant paradigm during fluency building and responses could be restricted during transfer of stimulus control. Fluency building was implemented with the use of a timer and two forms of the Standard Celeration Chart (SCC; Dpmin-12ED and Tpmin-4EC). The SCC is a semilogarithmic data display tool that allows researchers and clinicians to obtain a picture of the rate of response as well as the rate of learning (celeration) put into a standard visual display. SCCs were used during textual fluency conditions to assist researchers in determining the participants' daily frequency aims (or target number of responses per minute for daily fluency-based instructional conditions).

Independent variables, dependent variables, and experimental design. Two levels of the independent variable were manipulated: transfer of stimulus control from textual to intraverbal (cf., Vedora et al., 2009) and transfer

Table 1
Target Questions

Participant	Fluency questions	Nonfluency questions
Wilbur	Taught	Taught
	What do you think with? [brain]	What do you drink with? [cup]
	What do you feel with? [fingers]	What do you eat with? [mouth]
	What do you cook with? [oven]	What do you dry with? [towel]
	Untaught	Untaught
	What do you smell with? [nose]	What do you wash with? [soap]
	What do you write with? [pencil]	What do you measure with? [ruler]
	What do you chew with? [teeth]	What do you sweep with? [broom]
Orville	Taught	Taught
	What do you feel with? [fingers]	What do you eat with? [mouth]
	What do you wash with? [soap]	What do you bang with? [drums]
	What do you take a picture with? [camera]	What do you dig with? [shovel]
	What do you taste with? [tongue]	What do you sweep with? [broom]
	What do you kiss with? [lips]	What do you dry with? [towel]
	Untaught	Untaught
	What do you chew with? [teeth]	What do you cook with? [oven]
	What do you think with? [brain]	What do you write with? [pencil]
Amelia	Taught	Taught
	What do you wash with? [soap]	What do you cut with? [scissors]
	What do you taste with? [tongue]	What do you bang with? [drum]
	What do you think with? [brain]	What do you write with? [pencil]
	What do you chew with? [teeth]	What do you dig with? [shovel]
	What do you hear with? [ears]	What do you type with? [keyboard]
	Untaught	Untaught
	What do you feel with? [fingers]	What do you cook with? [oven]
	What do you dry with? [towel]	What do you eat with? [mouth]
	What do you smell with? [nose]	What do you sweep with? [broom]

Note. Target responses are indicated in brackets. Untaught questions were never directly taught.

of stimulus control from textual to intraverbal with fluency-based instruction on the textual repertoire (cf., Emmick et al., 2010). Experimenters assessed the participants' responses to the questions "what do you [verb] with?" (i.e., respond intraverbally) in three ways. First, experimenters assessed the rate of acquisition of accurate responses to the target questions with or without fluency-based instruction for the associated textual repertoires (as measured by the cumulative number of trials to criterion). Second, experimenters measured maintenance of accurate responses to the target questions 1 week and 1 month following transfer of stimulus control. Lastly, experimenters assessed generalization across people and settings and with respect to untaught questions that shared similar stimulus properties with the taught intraverbals (see Table 1). An adapted alternating treatment design (Sindelar, Rosenberg, & Wilson, 1985) was selected to demonstrate experimental control.

Procedure

Assessments. Probes were conducted with each of the questions to determine if the participants would answer accurately. Each question was selected randomly and read out loud three separate times. No differential consequences were provided for correct or incorrect answers; praise statements were delivered on a VI 30-s schedule of reinforcement contingent on appropriate attending behavior (e.g., eye contact, sitting in the seat). If a question was not answered or was answered incorrectly two or more times, it was chosen for intervention.

Textual fluency. Some textual responses were taught to a frequency aim of 80 to 90 words per minute; the aim was based on previously suggested aims (Emmick et al., 2010; Fabrizio & Moors, 2003; Kubina, Morrison, & Lee, 2002). The transfer of stimulus control phase followed the participant meeting the frequency aims. In each session of fluency building, the experimenter (the second author) conducted up to three timings that consisted of the following steps. First, the experimenter asked the participant to choose a textual stimulus array. Second, the experimenter chose three words that the participant had missed in the previous session to "prime." To prime, the experimenter read each of the chosen words aloud and had the participant echo the experimenter's model. As the experimenter read each word (once), the participant then would repeat the word (once) and the experimenter delivered behavior specific praise if the participant repeated correctly. Third, the experimenter showed the participant a visual goal that showed him how many words he needed to read to beat his previous "personal best" (the highest number of correct responses and the lowest number of incorrect responses emitted during the previous fluency building session). Fourth, the experimenter started a timer for 30 s and asked the participant to read the words quickly (one timing). Finally, the experimenter delivered behavior specific praise at the end of each attempt in which an equal or lesser number of words were read correctly than during previous timings, or the participant was able to request and receive a highly preferred item if he exceeded or tied a prior personal best score. If the participant responded incorrectly, then those words were noted and presented for priming before the next session began. If a participant hit their personal best, then the fluency building session ended. Sessions continued for up to three timings or until the participant hit their personal best, whichever occurred first. Rate of response data for each timing were charted on the timings SCC (Tpmin-4EC), and rate of response data for the best timing in each session were then plotted on the daily per-minute SCC (Dpmin-12EC). Timings always lasted for 30 s, and correct and incorrect responses were converted to a per-minute measure (e.g., 12 correct responses in 30 s were converted to 24 correct responses per minute).

The overall purpose of this phase was to train textual fluency as defined by Retention (maintenance), Endurance, Stability, and Application (RESA; Fabrizio & Moors, 2003). Experimenters completed retention, endurance, and stability checks after participants met the predetermined frequency aims. Endurance was tested by tripling the length of the timing (experimenters set the timer for 90 s and asked participants to read the target words from a stimulus array from the fluency building condition). Stability was assessed by conducting a timing that lasted 30 s in the presence of more distractions than the original experimental setting. Retention checks were completed 1 month following the offset of textual fluency building.

Transfer of stimulus control. Questions were randomly divided into two sets: those in which responses were taught to fluency[5] (pretransfer fluency set) and those in which responses were not taught to fluency (nonfluency set; Table 1). One question from each set was taught separately but simultaneously. In each session, the experimenter would start with a pretransfer fluency or a nonfluency question selected randomly prior to each session, and the target question would move through transfer of stimulus control. Transfer of stimulus control sessions for either question consisted of no more than 10 trials and would be terminated with fewer trials if participants emitted three consecutive correct responses before the prompt was delivered.

To start the session, the experimenter asked the participant the question. Next, the experimenter prompted the response by showing an index card with the correct written stimulus and allowed the participant 3 s to respond. A response was scored as incorrect if participants emitted an inappropriate or incorrect response or did not respond. The experimenter emitted a praise statement and delivered a highly preferred item or activity (of the participant's choosing) when the participant responded with a correct answer. Contingencies and recording for correct or incorrect responses were consistent throughout the transfer of stimulus control condition.

Once correct responding occurred for three consecutive trials after the prompt, experimenters used a time-delay procedure. The delay between asking the question and the presentation of the textual prompt was increased by 1 s following the emission of three consecutive correct responses. This continued until the delay

[5] Fluency is used here in lieu of frequency because at this point in the experiment researchers had assessed (via RESA checks) that textual repertoires had been established to fluency. Fluency incorporates both frequency and accuracy.

reached a maximum of 5 s or when participants emitted three consecutive correct responses before the prompt was delivered.

Maintenance and generalization checks. Maintenance of the participants' accurate answering of the target questions was assessed 1 week and then 1 month following mastery during the transfer of stimulus control for each experimental condition. The experimenter asked the participant each of the previously taught questions one time each in a random order, similar to the transfer of stimulus control condition but without presenting a written prompt. Participants were given 3 s to respond before the response was recorded as correct or incorrect. Participants received praise and preferred items were delivered contingent on correct responding.

Generalization across people and settings was also assessed after 1 month (at a different time than the maintenance check). Parents and teachers were given the target questions and emitted a praise statement and delivered a highly preferred item or activity (of the participant's choosing) when the participant responded correctly. Responses were recorded and returned to experimenters.

Experimenters conducted untaught question generalization checks with questions that had not been taught but shared similar stimulus features as the target questions twice within the experiment. The first untaught question check occurred for the question sets for which the answers had been taught to textual fluency. This check occurred following the conclusion of textual fluency training. The second untaught question generalization check occurred for the question sets for which the answers had not been taught to textual fluency. Questions that were not explicitly taught in either condition, then, were used for the untaught question generalization probes (see Table 1). These probes were conducted to test whether responses trained to textual fluency (pretransfer fluency question sets) and responses not taught to fluency would be applied as answers to questions never directly trained. As in the other generalization checks, experimenters asked the question and gave participants 3 s to respond before the response was recorded as correct or incorrect. Participants received preferred items and praise contingent on correct responding.

Interobserver agreement and treatment integrity. Interobserver agreement (IOA) and treatment integrity data were collected on at least 45% of all sessions by two independent observers. IOA was calculated by dividing the number of agreements by the total number of agreements plus disagreements, and the quotient was multiplied by 100. The IOA for all participants was 100% in baseline, transfer of stimulus control, retention (maintenance), endurance, stability, and generalization. Mean IOA during fluency building was 98% (range, 83% to 100%) for Wilbur, 98% (range, 92% to 100%) for Orville, and 99.5% (range, 97% to 100%) for Amelia. Treatment Integrity (TI) was 100% for baseline, transfer of stimulus control, retention (maintenance), endurance, stability, and generalization. The mean TI for fluency building was 99% (range, 91% to 100%) for Wilbur and 100% for Orville and Amelia.

Results and Discussion

Our results support those of previous studies such as Vedora et al. (2009) that have used transfer of stimulus control via time delay to generate intraverbal relations. All participants also reached frequency aims during fluency building for textual repertoires. These repertoires withstood the retention, endurance, and stability checks.[6] Participants also acquired the target intraverbal responses via transfer of stimulus control (see Figures 1–3). These data replicate other studies (Coon & Miguel, 2012; Emmick et al., 2010; Saunders & Spradlin, 1993) that have transferred stimulus control from text to intraverbal stimuli. Furthermore, as more intraverbal sets were acquired, participants required fewer transfer phases consistent with "learning sets" (cf., Catania, 1998). These responses maintained and, for the most part, generalized across people and settings. Participants also emitted some responses to questions that were not directly taught (see Figures 4–6).

The results of the current study are also similar to those of Emmick et al. (2010), who noted little difference between fluency and nonfluency

[6] SCCs, while not included in the manuscript, are available by contacting the first author.

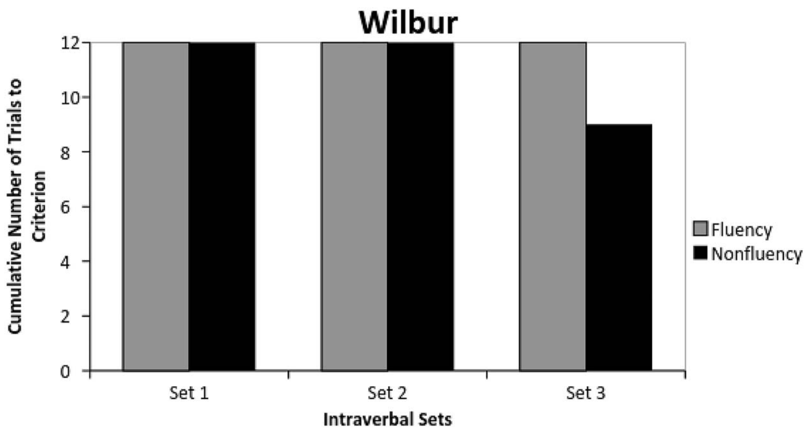

Figure 1. Teaching trials to criterion for Wilbur.

transfer of stimulus control conditions. Even with carefully constructed stimulus sets (e.g., in the same autoclitic frame), there was little differentiation across experimental conditions, maintenance assessments, and generalization across people, stimuli, and untaught questions. The confluence of this study and Emmick et al. suggests that establishing fluency with textual repertoires prior to transfer of stimulus control is not necessarily beneficial as it did not result in major differences regarding efficiency, maintenance, or generalization. This further suggests that the temporal relation of transfer of stimulus control prompt type to transfer may be important (Coon & Miguel, 2012); however, fluency of the textual repertoires may not be as important (Emmick et al., 2010).

This study extends the research in Precision Teaching and intraverbal training. First, the controlled stimulus set allows for a clearer analysis of the role of textual fluency prior to transfer of stimulus control to intraverbal relations. Moreover, the inclusion of probes for untaught questions that shared similar stimulus features to the taught questions allowed experimenters to measure the impact of fluency-based instruc-

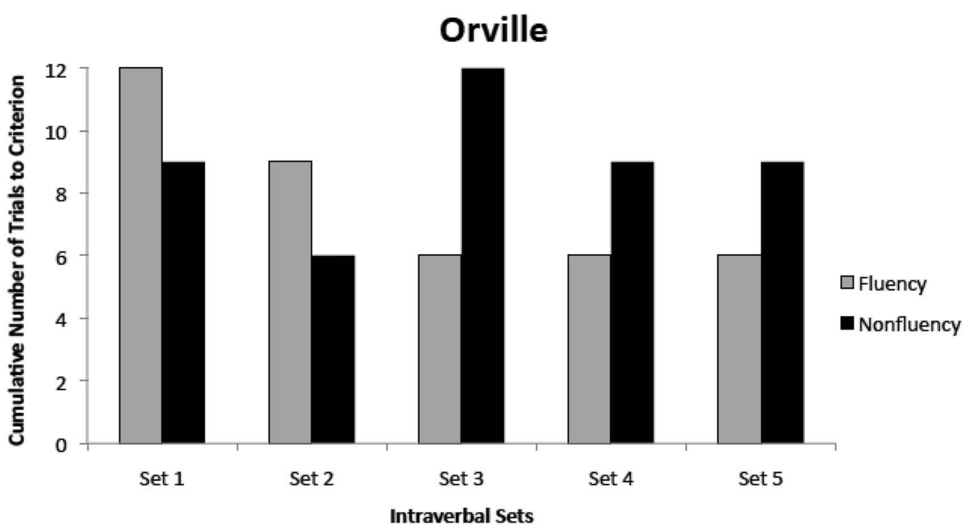

Figure 2. Teaching trials to criterion for Orville.

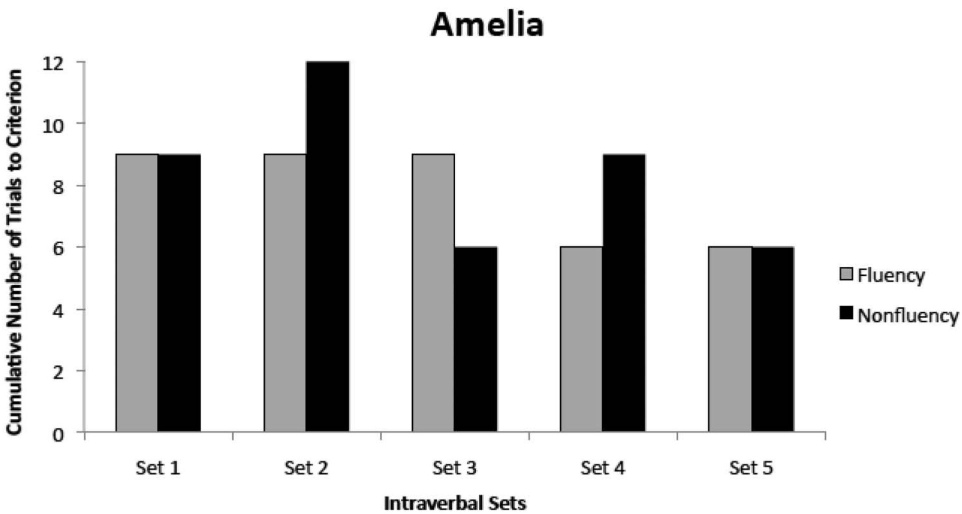

Figure 3. Teaching trials to criterion for Amelia.

tion for textual responses on a larger class of intraverbal relations including those that were not directly taught. Nevertheless, teaching textual repertoires to fluency does not seem to lead to noteworthy gains with respect to untaught intraverbal relations. Rather, the question frame appears to have been more influential in generating untrained relations. On one hand the lack of separation across experimental conditions may suggest that fluency-based instruction is unnecessary; it could also be argued that a component-composite perspective in selecting the prompt type for intraverbals may generate a different outcome.

It is also possible that the intraverbal stimulus arrangements were still not sufficiently controlled with respect to verbal conditional discriminations (Axe, 2008; Sundberg & Sundberg, 2011). The current data do not guarantee that verbal conditional discriminations were established; however, future researchers could assess this using more varied stimulus sets that ensure conditional discriminations are established (cf., Eikeseth & Smith, 2013, for a broader discussion of the role of conditional discriminations and intraverbal behavior) and that stimulus overselectivity is minimized. Another variable that requires additional research is how the role of the questions, arranged with shared stimulus features (as autoclitic frames), impacted the participants' performance. It is likely that the stimulus arrangements in this study more closely resembled those consistent with autoclitic frames associated with convergent multiple control (cf., Michael, Palmer, & Sundberg, 2011) in the sense that all intraverbal stimuli were cast in the "what do you [verb] with?" Experimenters could examine the impact of textual fluency training (or other tool skill fluency training) with more varied stimulus sets to better understand the role of convergent multiple control in intraverbal relations. Eikeseth and Smith (2013) suggest additional considerations in the selection of antecedent stimuli for establishing intraverbal relations and caution clinicians and researchers alike to consider the case of discriminated operants, conditional discriminations, and compound stimuli. Eikeseth and Smith suggest more careful consideration of how the learning history is arranged to ensure responding to the complex stimulus control inherent in intraverbal behavior. Their suggestions, in combination with the findings of Coon and Miguel (2012) and the findings of this study could prove fruitful for future research on establishing intraverbals.

The present study corrects for the limitations of Emmick et al. (2010) and offers a description of outcomes in multiple testing conditions when a carefully constructed stimulus set is arranged and transfer of stimulus control is used to teach intraverbal relations. Future research could also focus on longer mean lengths of utterance for the intraverbal responses and for variations in

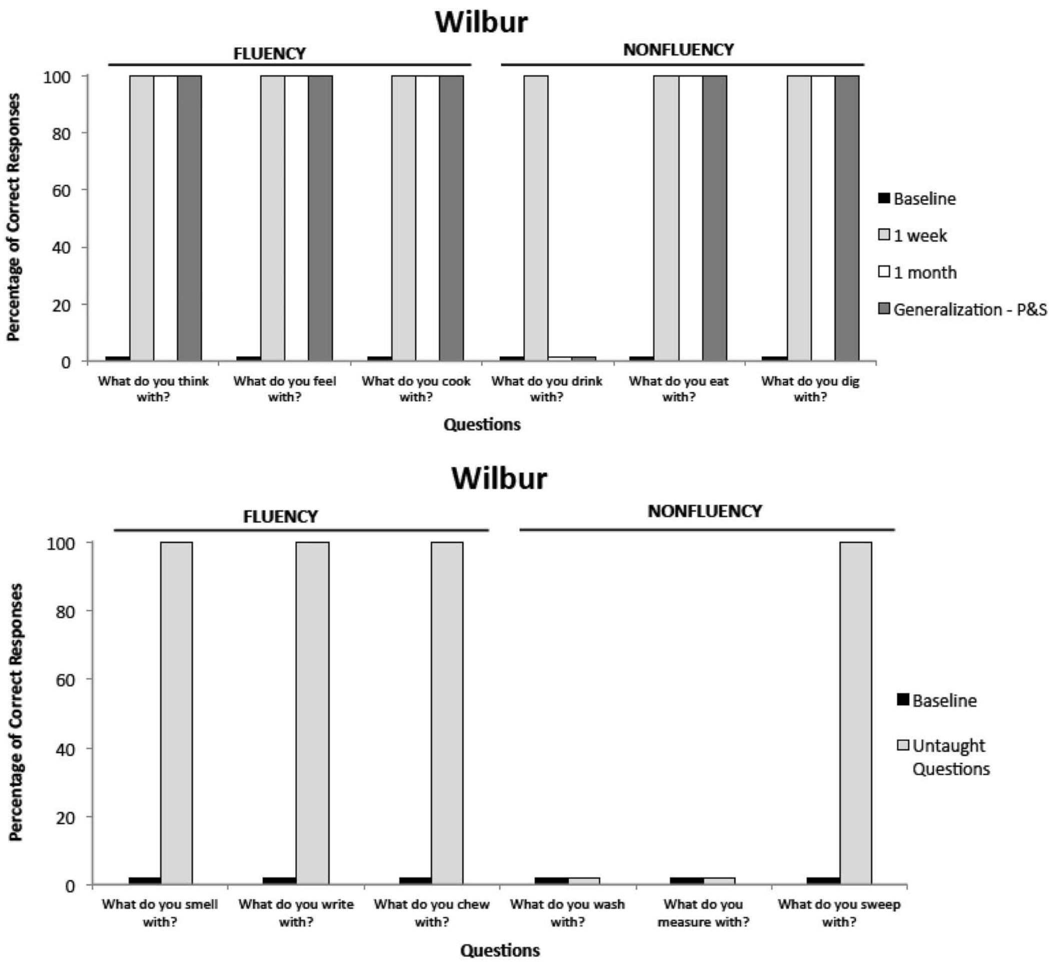

Figure 4. Maintenance and generalization across people and settings (top panel) and generalization to untaught questions (bottom panel) for Wilbur.

the number of intraverbal sets taught concurrently. Here, experimenters required only one-word responses. It is possible that if longer responses were required, there might have been more separation between the fluency and nonfluency conditions. Additionally, the stimulus sets included only one question from each condition. Targeting larger sets of questions from each condition may produce different results. Moreover, the target stimuli were set up in question frames (i.e., What do you ___with?). Sundberg and Sundberg (2011) highlight the tendency of children with autism to focus on sameness as a hindrance in their ability to adopt more complex intraverbal relations. Selecting a question frame and a carefully controlled set of target stimuli may act as a cusp (Rosales-Ruiz & Baer, 1997) to novel, vocal verbal stimuli. Future studies may control stimulus sets but use a general case strategy (Stokes & Baer, 1977) for question frames to determine the effects on generalization and application of larger intraverbal repertoires.

However, some persons associated with PT have made the case that to be successful at a composite skill one must be fluent at the associated component skills (Alessi, 1987; Andronis, 1983; Andronis, Goldiamond, & Layng, 1983; Johnson & Layng, 1992). They argue that key component skills (once fluent) function as

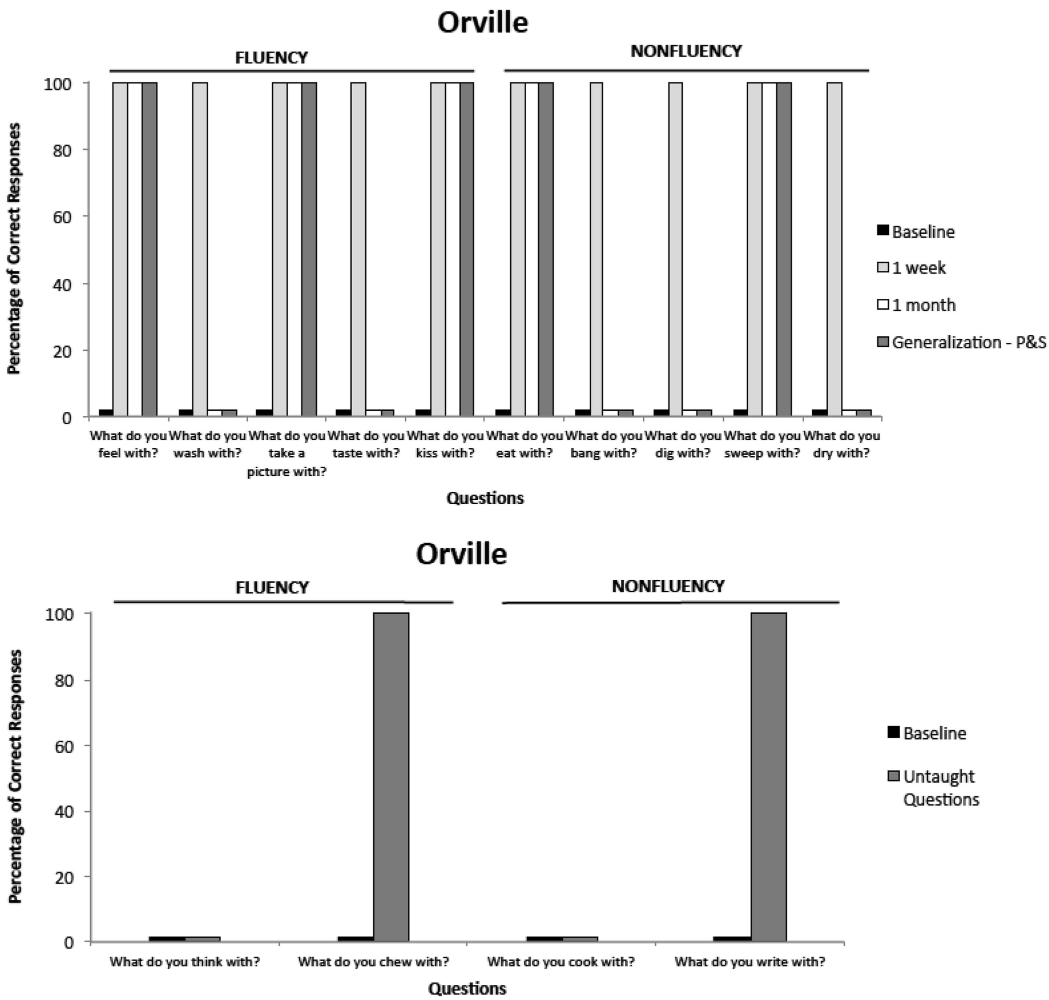

Figure 5. Maintenance and generalization across people and settings (top panel) and generalization to untaught questions (bottom panel) for Orville.

recombinative repertoires that allow for the emergence of complex skills (Alessi). Emmick et al. (2010) evaluated the effects of training textual prompts to fluent levels prior to establishing intraverbal relations by way of stimulus fading. They were interested in seeing if these repertoires recombined as component-composite relations might. They found that the transfer of stimulus control established intraverbal relations regardless of the fluency of the textual repertoires and that the effects of the textual fluency prior to transfer of stimulus control did not show consistent benefits across learners and responses on measures of efficiency (i.e., rate of acquisition). In essence, they did not see a strong recombinative effect. In Study 1, the experimenters extended Emmick et al. in an effort to ensure the findings were not due to limitations in experimental design and stimulus conditions. Specifically, the experimenters used a carefully controlled question set that shared stimulus features and used time delay rather than stimulus fading to transfer stimulus control. Despite these refinements, the experimenters also did not see a strong recombinative effect. Therefore, it is possible that the textual repertoire, while critical to responding to textual cues, may not be a component skill for the

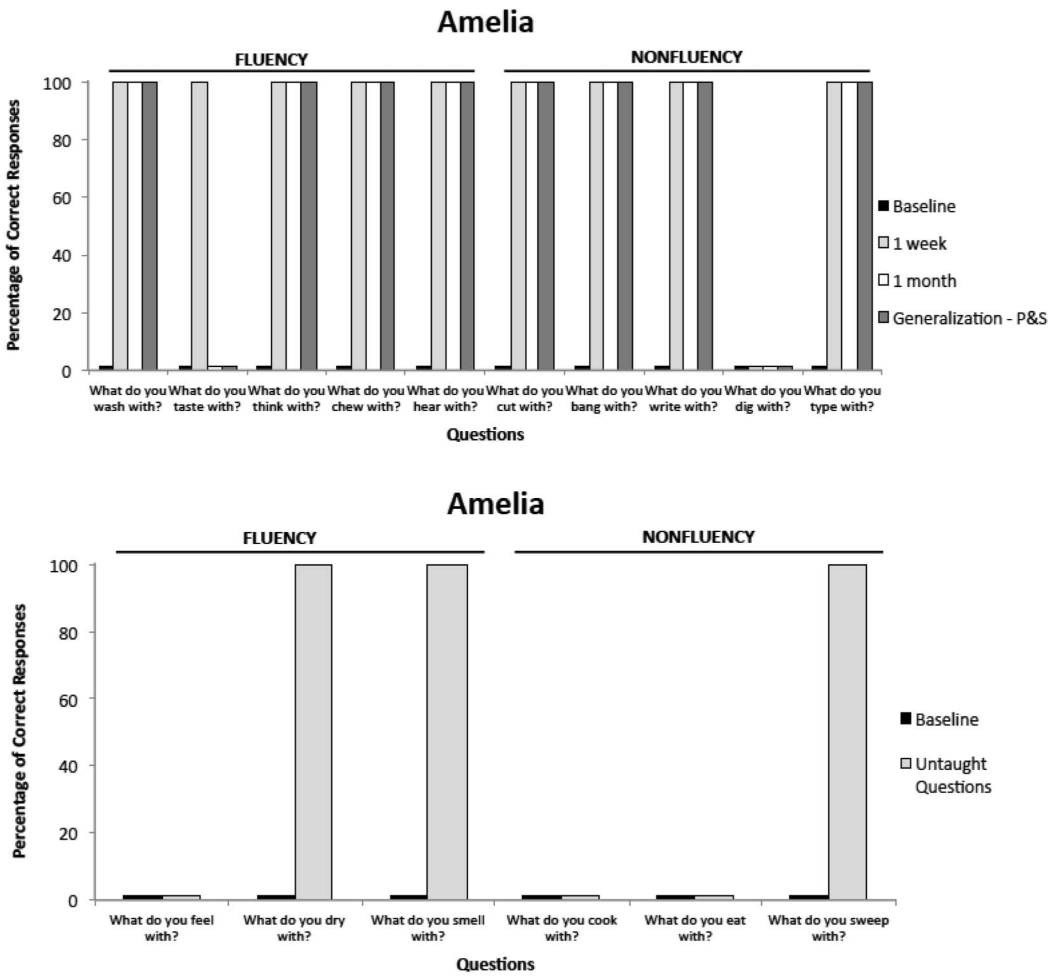

Figure 6. Maintenance and generalization across people and settings (top panel) and generalization to untaught questions (bottom panel) for Amelia.

intraverbal. However, pretransfer fluency tact training may have a more noticeable impact. A fluent tact repertoire may supply students with more responses to future questions, which could be recombined into novel responses in a similar question frame (Alessi, 1987).

Study 2

In Study 2, the experimenters explored the possible recombinative effects of thematically related tacts, when taught to fluency, on intraverbals. Few studies have been conducted exploring the notion of recombinative repertoires. However, in certain intraverbal relations (e.g., stating members of a class or category), tacts and intraverbals may have component-composite recombinative relations. For example, if a learner is unable to say the names of various animals (with the additional prompt of name some animals), it seems unlikely that the learner will be able to "Name some animals" when asked either when seeing animals themselves or when the animals or pictures of animals are not present. The recombinative effect of fluency on thematically related tacts as component skills for intraverbals as the composite repertoires could be tested.

Braam and Poling (1983) and Luciano (1986) provided a procedural framework for the design of Study 2. Braam and Poling trained three individuals diagnosed with mental retardation (sic) and hearing impairments to respond intraverbally using American Sign Language across three studies. They trained thematic (categorical) clusters (Winokur, 1976). For example, when the researchers signed the word "food," the participant then was taught to respond with a number of different foods. In all three experiments, the participants learned to emit new intraverbals. Luciano replicated and extended Braam and Poling with vocal verbal responses. Three individuals with mental retardation(sic) participated and all acquired new intraverbal relations related to the targeted thematic clusters.

Unlike Braam and Poling (1983) and Luciano (1986), the current study included a fluency measure for the tact relations. The tact relations for four thematic clusters (component skills) were taught to fluent levels using PT while the associated intraverbal relations (composite skills) were not explicitly taught but probed throughout the experiment. Furthermore, the fluency measure was assessed using steady state baseline logic.[7] The use of steady state baseline logic in this context provided the opportunity to assess if the composite skill (intraverbal) maintains a steady state while PT is applied to the component skill (tact), until fluency (as tested RESA[8] checks; Fabrizio & Moors, 2003) is reached on the component skill. If experimental control is demonstrated, evidence for recombinative repertoires may be achieved and a strategy for combining PT and steady state baseline may be established (see also Twarek, Cihon, & Eshleman, 2010, for another example of this design).

The purpose of Study 2 was to evaluate the effects of PT derived techniques for tact relations on the acquisition of intraverbal behavior with an individual with autism. The specific experimental question was: Does training thematically related tact component skills to fluency result in the recombinative emergence of the composite intraverbal relations (naming items in a category without a nonverbal discriminative stimulus)?

Method

Participant, setting, and materials. Prior to participation in the current study, Felicity (6-year-old female diagnosed with autism) labeled fewer than 10 thematically related pictures in 15 s and did not name members of a thematic cluster when asked without pictures of the items. Experimenters conducted sessions in a 1:1 treatment room or classroom at an autism treatment center where Felicity concurrently received 8 hr per week of behaviorally based intervention. The rooms included a table(s), chairs, and toys; other children often were present in the classroom. The experimenter and participant sat at a table or on the floor about 1 m apart. When present, a second observer would sit near the experimenter. The experimenter arranged one of three different 8[1/2]″ × 11″ arrays of colored images with an average of 17 pictures (e.g., for the school supplies array pictures of crayons, glue, scissors, etc. were included) per array (range, 15 to 21). The images on a given sheet were pictures of items that were all members of a thematic cluster targeted for the tact fluency condition (vehicles, school supplies, furniture, and tools). Experimenters timed sessions with an electronic timer and charted rate of response data from tact fluency conditions on a daily per-minute SCC on which celeration could be monitored.

Procedure

Intraverbal probes. The experimenter collected probe data continually until a steady baseline (flatlining; no increasing or decreasing trend) emerged for one of the questions to which the participant's answer was a dependent variable (i.e., one intraverbal relation). To begin, the experimenter stated a variation of the intraverbal frame (e.g., "name some [category],

[7] The use of steady state baseline logic is perhaps somewhat atypical in PT research and is often cited as one of the reasons for the dearth of PT research in mainstream behavior analytic journals (cf., Binder, 1996; Cooper, 2005). PT appreciates that steady state logic is necessary when nonstandard charts are used, but it is less of a concern when standard charts are used. On an SCC you can have trends in baseline, and this is fine, because an independent variable could produce a trend effect (a celeration turn). Moreover, even bounce does not need to stabilize or become "steady" when displayed on an SCC, because the effect of an independent variable might be to increase or decrease the bounce or to converge or diverge it. These changes show up if rate data are charted on a standard visual display like the SCC.

[8] There is a relative dearth of experimental analytic support regarding RESA and its implications.

tell me some [category]") and then recorded the number of consecutive correct responses (excluding repeats) Felicity emitted. Probe trials ended after an incorrect response was emitted or after a 6 s period without a response. Probe sessions generally lasted fewer than 5 min. Experimenters conducted subsequent probes at the beginning of approximately every third session, and the order of the probes alternated at each successive probe session.

Tact fluency training. Timed practice sessions occurred after intraverbal probes were conducted. The experimenter provided two of the three arrays of pictures from a thematic cluster from which Felicity could choose (to prevent chaining of responses) and then set the chosen array in front of Felicity and started a *priming period.* The priming period consisted of the experimenter pointing to and labeling up to three nonverbal stimuli Felicity had labeled incorrectly in previous timed practice sessions and required her to echo the modeled tact. The experimenter then stated the goal (i.e., frequency aim [e.g., "you must get 10 in 15 seconds to earn the bubbles"]), which was determined by increasing the previously met goal by one; the goal was unchanged if it had not been met. The researcher then asked Felicity to "name some [category]", while presenting the array that contained several stimuli (to mimic a free operant paradigm, the instruction was not presented prior to each tact, only to signal the onset of a timing) to initiate the first of up to five timed practice attempts. In total, timed practice sessions lasted no longer than 10 min.

To conduct a timed practice session, the experimenter started the stopwatch after the first response Felicity emitted, reminding Felicity to "keep going" if she stopped responding for 2 s. The experimenter recorded correct and incorrect responses Felicity emitted during the 15-s timed practice. Correct responses consisted of Felicity accurately labeling the picture, (a) at which she had been instructed to begin, (b) immediately to the right of the image to which she had just responded (e.g., scanning left to right), and (c) at left-most position in the row immediately below the row she had just completed. Incorrect responses consisted of Felicity saying any word other than the correct label for the picture to which she was responding. Felicity received a preferred item/activity contingent upon meeting her goal (at least one correct response more than the previous timed practice session). If she did not meet her goal, then she would complete up to four more timed practices. If she did not reach her goal within five timings, then she returned to the activity she had been engaged in prior to the practice session. Timed practices always lasted for 15 s, and the number of correct and incorrect responses was converted into a count-per-minute measure (e.g., 10 correct responses in 15 s would be converted to 40 correct responses per minute).

RESA. To determine if fluency was achieved, the endurance and stability components of RESA (cf., Fabrizio & Moors, 2003) were assessed. Once Felicity reached her frequency aim (between 50 and 100 responses per minute correct with 0 errors) for one thematic cluster, and the data remained stable, the experimenters then tested for endurance and stability for that cluster. Endurance probes involved a timed practice session that was three times longer in duration than the training timing length (45 s). Endurance helps precision teachers to see if the performance will continue at similar frequencies for sustained periods of time longer than those in which the skill was practiced. Experimenters assessed stability by running a timed practice session while both visual and auditory distractions were present in the teaching environment (e.g., toys that were moving, lighting up, and/or making noises). Experimenters conducted retention probes 1 month after Felicity reached the frequency aim for the given thematic cluster. Retention probes were identical to the timed practice sessions conducted during initial tact fluency training. Retention, endurance, and stability performances were considered to demonstrate fluency so long as performances exceeded 30 responses per minute with 0 errors. Application was assessed throughout by way of the intraverbal (composite skill) probes (see Intraverbal Probes).

Independent and dependent variables. The independent variable was the Tact Fluency Training. These sessions included fluency-based data collection and charting on the SCC; making systematic changes to the intervention as indicated by Felicity's performance recorded on the SCC; timed practice sessions, a stated frequency aim that was at least one response higher than the previous session's aim as the basis for differential reinforcement; and the retention, endurance, and stability components of the RESA criteria to test fluency.

Felicity's accurate responses to the instruction to "name some [category]" (i.e., intraverbal responses specific to the thematic cluster) served as the primary dependent variable (used to demonstrate experimental control). Experimenters counted correct, incorrect, and repeated responses. Trained correct responses included any response that was included in the stimulus array during Tact Fluency Training for the thematic cluster (e.g., saying "pencil" when told "tell me some school supplies"). Incorrect responses involved responses that were not a part of the thematic cluster (e.g., saying "ball" when told "name some foods"). Repeated responses counted as a repeat in a separate category, not as incorrect responses, and did not count against the frequency aim.

The number of correct tact responses emitted per minute served as the secondary dependent variable (used to evaluate the effectiveness of fluency training). Responses were counted as correct or incorrect and were charted on the appropriate calendar date on the daily per-minute SCC. Correct responses included vocal verbal responses that corresponded to the nonverbal stimulus. Responses that were repeated in the same timing and skipped pictures did not count as incorrect or correct.

Experimental design. The experimenters addressed the research questions with a multiple probe across thematic clusters design (Sidman, 1960). The participant's responses to the vocal stimulus, "name some [category]" for each of the four thematic clusters began in the Intraverbal Probe condition. Experimenters started Tact Fluency Training once a stable baseline was established for the first thematic cluster (no increasing or decreasing trend). The remaining thematic clusters remained in the Intraverbal Probe condition. Tact Fluency Training then began for the second thematic cluster with a stable baseline once an experimental effect was demonstrated with Felicity's ability to respond to the "name some [category]" cue associated with the first thematic cluster and so on. There was no overlap in stimuli included in each thematic cluster to minimize the possibility of sequence effects. Furthermore, there were multiple arrays used in Tact Fluency Training for each cluster to reduce the likelihood of rote memorization of the sequence of responses.

Interobserver agreement and treatment integrity. Experimenters calculated interobserver agreement (IOA) for 68% of intraverbal probes in baseline (100%) and 36% of intraverbal probes in treatment and posttreatment (M = 94%; range, 80% to 100%). A second observer collected data during 30% of Tact Fluency Training timed practice sessions (M = 96%; range, 87% to 100%), 80% of endurance probes (M = 94%; range, 80% to 100%), 80% of stability probes (100%), and 60% of retention probes (100%). IOA was calculated by dividing the number of agreements by the total number of agreements and disagreements, and multiplying the quotient by 100. A secondary observer collected treatment integrity data for 35% of Tact Fluency Training timed practice sessions (M = 92%; range, 88% to 100%) and 71% of intraverbal probes (100%). Treatment integrity percentages were calculated by dividing the number of correctly implemented steps by the total number of possible steps and multiplying by 100.

Results and Discussion

The results are depicted in Figure 7. The data show that intraverbal responses for each thematic cluster remained at near zero rates of responding until endurance and stability criteria were met for the tact responses in each thematic cluster (i.e., reached fluent levels). Furthermore, intraverbal responding maintained during intraverbal probes after Tact Fluency Training had been discontinued for all thematic clusters except furniture. Experimenters conducted a Tact Fluency Training timed practice session for furniture, which was sufficient to regain the initial treatment effect for the duration of the experiment. Retention probes suggest that the established tact repertoires maintained at fluent levels following the withdrawal of Tact Fluency Training. The results demonstrate a functional relation between Tact Fluency Training and intraverbal responding in that the composite intraverbal relations maintained steady state responding until fluent responding was established for component tact repertoires.

A limitation of the current study that should be considered in replications and extensions is the number of nonverbal stimuli included in the

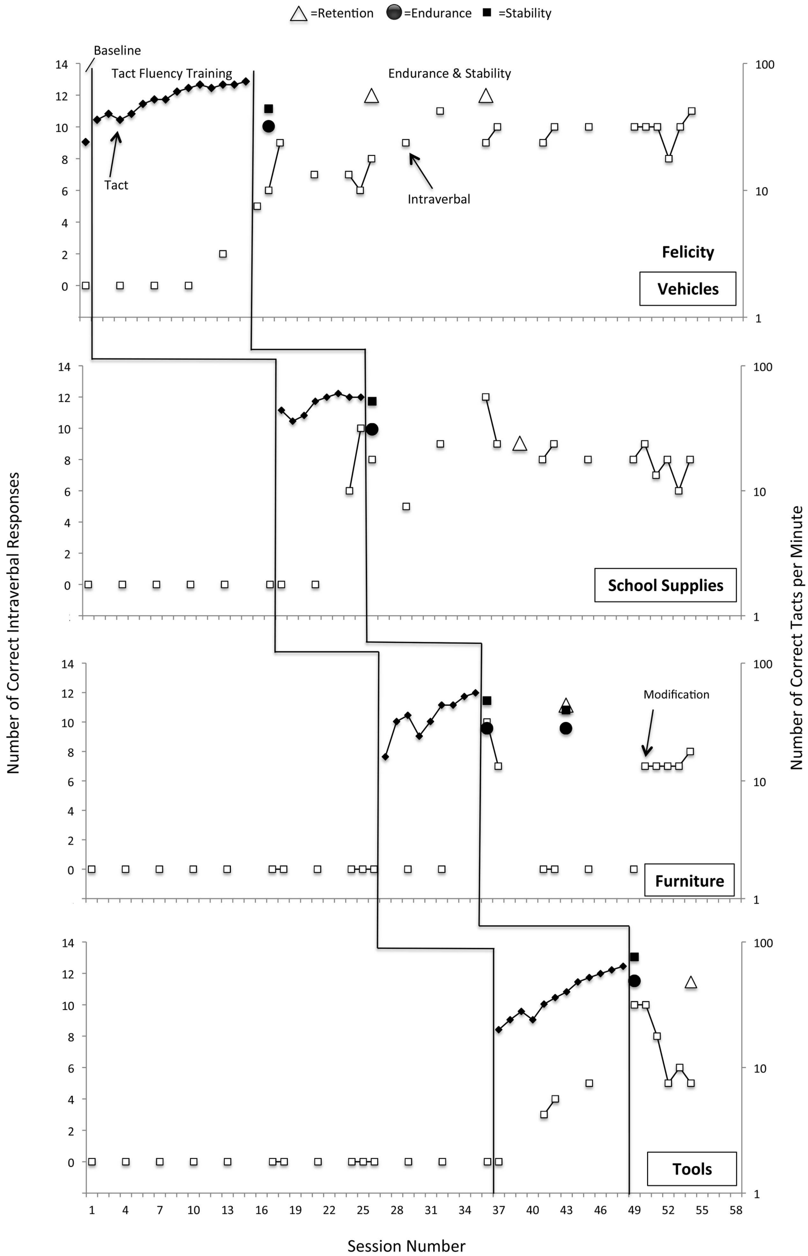

Figure 7. Tacts per minute emitted by Felicity during Tact Fluency Training charted against the *y*-axis and number of intraverbal responses emitted during Intraverbal Probes charted against the secondary *y*-axis. Retention, endurance, and stability probes charted against the secondary *y*-axis.

Tact Fluency Training condition. For example, 14 stimuli were included in the stimulus array for tools and 21 stimuli were included in the stimulus array for school supplies. These numbers should be held constant to obtain better controls to compare the number of intraverbal relations that emerge across thematic clusters. Moreover, controlling for the number of nonverbal stimuli in tact stimulus arrays may allow for the emergence of nontargeted tact relations in specific thematic clusters, for example, testing a participant who was taught to fluently tact six colors to determine if the participant would offer other correct responses, not targeted in the stimulus array, under intraverbal probe conditions.

The procedures employed in this study suggest that, at least for thematically related intraverbal relations, transfer of stimulus control procedures may not be necessary if component skills are brought to fluent levels. However, more research is needed to support this conclusion as the current study included only one participant. A worthwhile extension of Study 2 would be to determine what the relation of this procedure is with the celeration of the data, not just the level changes. Replications of Study 2 and similar investigations on other component-composite relations, perhaps with even more disparate objects (e.g., animals, trees, foods, facial expressions, etc.), should be done to investigate whether the same effect is seen across individuals and across other potential component-composite relations.

General Discussion

The results of both Study 1 and Study 2 contribute to the current research base on establishing intraverbal relations. Several studies have been conducted to determine the most efficient strategies to establish intraverbal relations (Braam & Poling, 1983; Coon & Miguel, 2012; Emmick et al., 2010; Finkel & Williams, 2002; Ingvarsson & Hollobaugh, 2010, 2011; Ingvarsson & Le, 2011; Ingvarsson et al., 2007; Luciano, 1986; Miguel et al., 2005; Partington & Bailey, 1993; Vedora et al., 2009; Watkin et al., 1989), and many of these have even offered comparisons of different prompt types or ways to transfer stimulus control from tact, echoic, or textual control to control of the intraverbal relations (Braam & Poling, 1983; Emmick et al., 2010; Finkel & Williams, 2002; Ingvarsson & Le, 2011; Vedora et al., 2009). The results of Study 1 suggest with more confidence that the textual repertoire is unlikely to enter into a component-composite relation with intraverbal responses and that pretransfer of stimulus control fluency-based instruction may not be necessary for the successful use of textual stimuli as prompts to establish simple intraverbal relations. The results of Study 2 suggest, however, that building thematically related tact repertoires to fluency might even circumvent the need for transfer of stimulus control for some intraverbal relations.

Heinicke et al. (2010) noted that the use of fluency training, a frequently included component of PT, is often promoted in autism intervention despite limited empirical support for proponents' claims (for an alternative perspective see Calkin, 2002). Yet others associated with PT have commented on the benefits of component skill fluency (Alessi, 1987; Andronis, 1983; Andronis et al., 1983; Johnson & Layng, 1992) and the potential challenges associated with cumulative dysfluency (Binder, 1996). This disconnect could be due to differences with respect to the need for current conceptualizations of steady state baseline logic when nonstandard data displays are used. For example, Cooper (2005) suggested that the lack of peer-reviewed research related to fluency-based instruction might be due to the typical increasing or decreasing trends that are expected through the use of PT, but which are not consistent with present steady state baseline logic. The data from Study 2 suggest a compromise: applying PT to the component skill (tacts) and allowing for increasing trends in the tact responses while maintaining a nontrending baseline for the composite skill (intraverbals). Twarek et al. (2010) implemented a similar experimental design to assess the effects of PT for component motor skills (Big 6 + 6) on various activities of daily living (composite skills) for three children with autism. They too were able to demonstrate steady state responding with the composite skills while applying PT to component skills.

The design used in Study 2 and by Twarek et al. (2010) offers a unique way to determine which repertoires recombine in component-composite relations. Moreover, the design allows for the use of PT on the component repertoire without regard to steady state while steady state is obtained on the composite repertoire. If experimental control is maintained, there is evidence of recombination and of a component-composite relation. Perhaps this experimental design permits more research to be conducted on PT while exploring some of the less researched claims regarding recombinative repertoires with fluency-based instruction. The identification of component-composite relations that recombine into generative repertoires without additional instruction is important to many areas of behavior analytic applications to education in which students who have fallen behind either academically or verbally need to learn more in less time. Furthermore, this analysis can be conducted in the context of interventions to establish intraverbal relations with individuals with autism, which is another area in which additional research to identify the most efficient teaching strategies is still needed.

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