How Kids Learn to Say the Darnedest Things: The Effect of Multiple Exemplar Instruction on the Emergence of Novel Verb Usage

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We report experiments using time-lagged pre- and postintervention designs with (a) 4 first graders with learning delays, and (b) a systematic replication with 3 preschoolers with learning delays. Both experiments tested the effects of multiple exemplar instructional procedures (MEI) on the emergence of untaught past tense emission of novel regular verbs (e.g., *jumped* derived from *jump*) and grammatically inaccurate but experimentally correct usage of irregular verbs (e.g., *singed* derived from *sing*). Prior to the MEI, none of the children could produce regular or irregular past tense forms to pictures that provided simulated contexts (pictures with backgrounds for past and present tense). MEI provided across the picture contexts for past and present tense used separate training sets of verbs to teach children to form regular past tense. After either 1 or 2 MEI training sets, the children emitted accurate past tense forms of the untaught regular and inaccurate, but experimentally correct irregular verbs. These findings provided an instructional history that resulted in the children's acquisition of past tense for untaught regular past tense verbs and "creative" errors with irregular tenses. Results are discussed in terms of the research on experimentally induced sources for novel verbal behavior and related interpretations.

Key words: novel verbal behavior, grammar, emergent behavior, productive verbal behavior, multiple exemplar instruction, multiple exemplar training

The fact that young children emit novel irregular verbs using the regular past tense suffix (e.g., *bleeded* and *singed*) has been a major source of the claim that language is "acquired by a neural network" independent of contact with contingencies. The following quotes illustrate the prominence of this argument:

Children's errors with irregular verbs... have been prominent in debates on the nature of language and mind. The Neurologist Eric Lennenburg pointed to the errors when he and Noam Chomsky first argued that language was innate, the psychologists David Rumelhart and James McClelland set them as a bench mark when they first argued that that language could be acquired by a generic neural network. (Pinker, p. 190)

...Children are never given grammar lessons presenting *-ed* or *-s* with lists of stems

to conjugate or decline; they must mentally snip the suffixes out of the full, inflected words they hear in conversation. (Pinker, p. 192)

Pinker, and some other linguists who hold to the theory that language is a function of a mental language acquisition device, criticized Skinner's (1957, 1992) extrapolation of the basic principles of behavior to language on the basis that children's use of novel forms of verbal behavior cannot be attributed to histories of reinforcement (Chomsky, 1959; Chomsky & Place, 2000, MacCorquodale, 1970; Pinker, 1999). However, recent research in behavior analysis has identified instructional histories that lead to some novel forms of verbal behavior: instructional histories anchored to well-established principles of behavior. This body of work identifies environmental sources for several types of emergent verbal behavior and the novel production of verbal behavior.

Several types of either abstractions or emergent verbal behavior have been tied to prior multiple exemplar instruction (MEI). For example, learning a subset of exemplars for phonemic textual responding leads to the emission of accurate textual responses to novel words

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containing different arrangements of phonemes (Becker, 1992). There is a substantial body of research showing that the provision of MEI, involving the teaching of essential stimulus control for minimal units results in abstract stimulus control for novel stimuli, ranging from emission of novel textual responses (Becker, 1992), or visual categorization (Fields et al., 2003) in humans, to abstract control by novel and complex auditory stimuli in humans and pigeons (Greer & Lundquist, 1976; Porter & Neuringer, 1985).

However, the types of MEI identified as the source of the production of novel verbal responses, at least for some children, is somewhat different in that the exemplar experiences have involved rotated responses to single stimuli (Greer, Stolfi, Chavez-Brown & Rivera-Valdes, 2005; Greer, Stolfi, & Pistoljevic, 2007; Greer, Yuan, & Gautreaux, 2005). In these studies, responses were rotated to a single stimulus. That is, rather than rotating different stimulus conformations for a single response, as in the case of abstractions such as phonemic responding in novel words, in these studies the independent listener and speaker responses are rotated for a single stimuli. For example, the experimenter alternates instructional presentations to tact a stimulus (an eagle as one of a category of birds) with presentations to respond as a listener ("Point to a sparrow"). The alternating presentations across the speaker and listener responses are counterbalanced to ensure that the visual stimulus controls the response rather than the prior listener or speaker response. Thus, stimuli for listener and speaker responses to the same stimulus cannot be presented in immediate proximity.

Greer Yuan et al. (2005) found that MEI was functionally related to the emergence of correspondence between writing and saying as responses to dictated words. Children, for whom vocal spelling and written spelling were independent, acquired correspondence between saying and writing as a function of MEI. Naming is another type of responding that involves the joining of two different responses that are initially independent. The Naming capability is a developmental verbal phenomenon whereby children acquire both tact and listener responses from observing another tact—a stimulus without direct instruction. In the initial study on Naming and MEI, Greer and Stolfi et al. (2005) showed the emergence of corre-

spondence between listening and speaking in which MEI was found to be sufficient for the emergence of Naming. Greer, Stolfi, et al. (2007) replicated the Naming effect from MEI and also found that the rapid alternation of different responses to the same stimulus via MEI was both necessary and sufficient for the emergence of Naming. That is, the same amount of instruction presented in isolated format (i.e., listener responses taught separately from speaker responses) did not result in Naming, while rapid alternation of speaker and listener responses as MEI did. These studies also included multiple exemplars of stimuli to provide abstraction across irrelevant visual components. However the key application of MEI in these studies was multiple exemplars across response types.

Hayes, Barnes-Holmes, and Roche (2001) catalogued numerous empirical demonstrations of emergent and novel match-to-sample responding, and they suggested that certain multiple exemplar experiences created higher order operants or frames that allowed the emission of novel behavior as a function of the novel behavior having joined a class of stimulus control (e.g., Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001a, 2001b). A more recent case study demonstrated the emergence of novel visual match-to-sample responding in a young child (Luciano, Gomez, Lopez, Martin, & Barnes-Holmes, 2007).

Barnes-Holmes, Barnes-Holmes, and Cullinan (2000) proposed that in order for behavior to be truly verbal, the behavior must be novel.

...It is the presence of arbitrarily applicable relational responding either with or without other behavioral processes, that defines a verbal relation. (Barnes-Holmes, et al., 2000, p. 73).

They also proposed that reinforced multiple exemplar experiences, which occur by design or incidentally, provide the contact with the basic principles that result in relational responding that makes novel behavior possible. They described how locating the source of novel verbal behavior in experience involving the basic principles of behavior eliminated the need for intervening psychological constructs to explain complex human behavior. In their view "Naming" and other types of novel verbal behavior distinguish verbal from nonverbal behavior.

Naming as used in the verbal developmental literature is not the same as labeling or tacting (Catania, 2007; Gilic, 2005; Greer & Ross, 2008; Horne & Lowe, 1996, 1997; Horne, Lowe, & Randle, 2004; Lowe, Horne, Randle, & Harris, 2002; Lowe, Horne & Hughes, 2005). Often *naming* is used synonymously with *tacting* or *labeling*, and lower case is used here to distinguish it from the verbal developmental phenomenon of Naming. The term *Naming* refers to the developmental phenomenon whereby a child acquires both listener and speaker responses without direct instruction as a result of observing stimuli as they are tacted by another. Consistent with Barnes et al. (2000), several studies have reported Naming to emerge as a result of a type of MEI (Fiorile & Greer, 2007; Horne & Lowe, 1996; Greer & Ross, 2008; Greer, Stolfi, et al, 2005, 2006).

In another demonstration of MEI as the source for the emergence of a different type of novel verbal behavior, children who were taught to spell either vocally or in written form, but who could not spell in the untaught form (either written or spoken), acquired that capability as a function of training a subset of stimuli using MEI (Greer, Yuan, et al., 2005). In the latter studies, the stimulus control for dictated words was transformed from control of a single response (either writing or saying) to control over untaught responses by novel stimuli. This was an example of the joining of two different responses such that dictation came to control both (Skinner, 1957).

In another but somewhat different application of MEI, Nuzzolo-Gomez and Greer (2004) found that MEI across establishing operations with a subset of responses led to the untaught usage of vocal mands or tacts with children for whom the tact and mand functions were independent prior to the MEI intervention. In this case, single responses came to be controlled for novel production as a function of the establishing operations tied to different verbal functions. That is, once the children mastered instructional sets using the same topography in different functions, according to the contextual control of the relevant establishing operations for each function, learning a novel response in either a mand or a tact function resulted in the emergence of the untaught functions of the response. This finding was replicated by Greer, Nirgudkar, and Park (2003). Some evidence suggests that the independence of

mands and tacts for typically developing children may be short-lived (Petursdottir, Carr, & Michael, 2005). Nevertheless, in the Nuzzolo-Gomez and Greer and the Greer, Nirgudkar, et al. studies with children for whom mands and tacts were independent, the provision of a particular experimentally controlled history was found to be sufficient in producing the untaught usage.

In addition to the research described above, recent research found functional relations between multiple exemplar experiences and the abstraction of suffixes as autoclitics (Speckman-Collins & Greer, 2006). The untaught emission of such suffixes is still another example of novel verbal behavior. Early studies in applied behavior analysis, such as those by Schumaker and Sherman (1970), Guess, Sailor, Rutherford, and Baer (1968), and Baer and Guess (1971) involved MEI types of interventions with suffixes and were similar to the Speckman-Collins and Greer (2006) study and the present study, although the emergent behavior reported in the early studies predated the identification of the role of MEI as a possible source of the effect. Given the evidence for the effectiveness of the different types of applications of MEI in generating novel verbal behavior, it was postulated that children's production of past tense forms in autoclitic functions, like those characterized by Pinker (1999) in the quotations at the beginning of this paper, was also traceable to certain MEI reinforcement histories. Specifically, we tested the theory that provision of multiple exemplar experiences with a subset of verbs, used in an autoclitic function under the contextual control of pictures, would result in the production of unreinforced past tense usage with novel verbs, including the production of regular past tense and "creative" usage of irregular past tense forms in children initially missing the repertoire.

EXPERIMENT 1

METHOD

Participants

Four students from 6 to 7 years old who were enrolled in an elementary school participated in the study. They were classified with language delays, health impairments, developmental delays, and autism. Participants A, B, and C were 6-year-old males, and Participant D was a

Table 1
Description of Participants A, B, C, and D in Experiment 1

Participants	Level of verbal behavior	Social repertoire	Standardized testing scores
Participant A	Listener, speaker, beginning reader (textually responds to simple sentences), beginning writer (writes name and transcribes simple words)	Engaged in parallel and cooperative play Participated in conversation as a listener and a speaker	<i>Stanford-Binet Intelligence Scale</i> (verbal score 71, performance score 75 full score 76)
Participant B	Listener, speaker, beginning reader (textually responds to simple sentences), beginning writer (writes name and transcribes simple words)	Engaged in parallel play Answered questions Did not participate in conversations	<i>Vineland Adaptive Behavior Scale</i> (adaptive behavior composite score 73, (adaptive behavior composite score 73, communication domain score 68, daily living score 85)
Participant C	Listener, speaker, beginning reader (textually responds to simple sentences), beginning writer (writes name and transcribes simple words)	Engaged in parallel and cooperative play Participated in conversation with prompts	<i>Vineland Adaptive Behavior Scale</i> (adaptive behavior composite score 73, communication domain score 68, daily living score 85)
Participant D	Listener, speaker, beginning reader (textually responds to simple sentences), beginning writer (writes name and transcribes simple words)	Engaged in parallel play Answered questions Participated in conversations with prompts	<i>Expressive One-Word Picture Vocabulary Test</i> (communication 50, auditory comprehension 57, total score 66)

7-year-old female. Table 1 describes the students’ level of verbal behavior, their social repertoire according to the *CABAS® Curriculum and Inventory of Repertoires for Children from Pre-School through Kindergarten and First Grade* (Greer & McCorkle, 2003), *The New York State Standards: Grades K-2*, and stan-

dardized diagnostic test scores for the *Vineland Adaptive Behavior Scale*, *The Expressive One-Word Picture Test*, and the *Stanford-Binet Intelligence Scale* (Brownell, 2000; Roid, 2004; Sparrow, Balla, & Cicchetti, 1984). These participants were also selected because they specifically lacked the repertoire

Table 2

Verb Sets Used during Pre- and PostIntervention Probes, Single Exemplar Baseline Instruction, and Multiple Exemplar Instruction for Participants A, B, C, and D in Experiment 1

Stimulus set	Assignment to participants
Regular verbs: pull, climb, dig, lick, dress wave, brush, kiss, jump, wipe open, splash, knock, drill, hug lift, skate, spill, hug, clap	Set 1 for participants A and C Set 1 for participants B and D Set 2 for participants A and C Set 2 for participants B and D
Irregular verbs: sit, sleep, blow, read, sweep draw, eat, drink, hold, run	All participants All participants

of emitting past tense for either regular or irregular verbs under the context of present and past events.

Setting

The study was conducted in a special education self-contained classroom within a public elementary school for children with and without disabilities. There were eight students, one teacher, and two teaching assistants in the classroom while the experiment was conducted with each child individually at a table in the classroom. During the experiment, the teaching staff also conducted instructional programs with the other students who received the range of communication, academic, and self-management domains for all students per the curricula cited above. The responses to all instruction by the children who were not in the experiment were measured as responses to learn units (Greer, 1994) and probe trials in the same manner as were the responses to the dependent and independent variables for the children in the experiment.

For purposes of the experiment, single instructional or probe sessions were conducted daily in the classroom. The experimenter sat next to the participant at child-sized table, and the independent observer in an adjacent chair. Both the experimental probes and the instructional sessions were conducted during daytime in the same classroom with the children individually, while the classroom teacher and teacher assistants conducted instruction with other children in both individual and small group settings. The classroom had an arrangement of three different instructional centers

that included a group center, independent work center, and a one-to-one instruction center.

Stimulus Materials

The context for past and present tense was arranged by using pictures of children engaged in the activities for the verbs. The tense stimulus for the pictures consisted of the background for the action pictures: a background with a prominent sun and blue clouds represented present tense, while a dark sky and a prominent moon represented past tense. The pictures were identical for the past and present tenses for each verb except for the backgrounds that were painted by the experimenters. In addition to the pictures, each page had printed textual statements with a blank for the verb that was to be inserted by the participants. The printed statements consisted of either "He/she _____ last night," or "Today he/she _____," with contextual backgrounds for the present and past tense respectively. The pictures showed either a child engaged in an action in the daytime context that represented present tense, or a picture of a child engaged in an action in the nighttime that represented the past tense context. The pictures were color photocopied on standard 216mm x 279mm copy paper. Three sets of five regular verbs and two sets of five irregular verbs were chosen for each of the participants and teaching and probe sets were counterbalanced across participants (Table 2).

Data Collection

Dependent variable: Untaught responses to probe trials. The dependent variable consisted

of probe trials for untaught regular and irregular past tense verbs prior to, and following, MEI on teaching sets of verbs. During the probes, the experimenter first presented a textual stimulus printed on a page (either "He/she _____ last night" or "Today he/she _____") and then presented a picture for either present or past tense. Correct responses for the regular past tense required the participant to insert the verb consistent with the picture in the appropriate tense. Examples of correct regular past tense responses were "He painted last night," or "She skated last night." Examples of correct irregular verbs responses were "She singed last night," or "He dranked last night." Correct responses for the present were "She sings today," or "He drinks today." Although the irregular past tense responses were grammatically incorrect, they were experimentally correct. Incorrect responses consisted of responses that did not include *-ed* for either regular or irregular verbs, the emission of the wrong verb, or omissions of responses. Correct responses for the present tense were the grammatically correct responses for present tense such as "She skates today."

For the dependent variable, the experimenter recorded the participants' responses to the probe trials using pencil and paper. Independent observers for the pre- and postexperimental probes also collected data periodically on untaught past tense regular and irregular verb responses and for the instructional sessions. There were no consequences delivered during probe trials. The pre- and postexperimental probe trials consisted of opportunities to emit correct or incorrect responses on regular and irregular verbs (i.e., words ending with *-ed*).

Interobserver agreement. An independent observer simultaneously but independently collected data on 40% of the probe trials and 40% of the instructional presentations across all participants to determine interobserver agreement. Interobserver agreement was calculated for each session by dividing the total numbers of point-by-point agreements for the participants' responses to both learn units and probe trials by the number of agreements plus disagreements and multiplying by 100. The interobserver agreement for all probe sessions and instructional sessions was 100% for all participants' responses. The accuracy of the experimenter's presentations for the probe trials and learn unit sessions was 100%.

Procedure

Design. A time-lagged multiple probe design across participants was used in the study. The design sequence was as follows: (1) students were probed for past tense regular and irregular verbs across all sets to ensure that the responses were not in students' repertoires; (2) single exemplar instruction (SEI) was presented to teach Set 1 regular present tense verbs and past tense verbs separately to mastery; (3) students were probed for untaught Set 2 regular and Set 1 and Set 2 irregular past tense verbs; (4) when the prior probe showed that the participants did not form past tenses, the experimenter presented MEI to teach both present and past tense with another regular verb teaching set until the participant mastered the set; (5) the participants were probed again for the emergence of untaught regular and irregular verbs with the original set. If needed, additional sets of MEI were taught, followed by probes of the original set. Each of these phases was time-lagged across participants to control for maturation and instructional histories outside of the experimental conditions.

Pre-intervention probe trials. The pre-SEI, post-SEI, and post-MEI probe sessions consisted of five trials per session for each regular and irregular verb set (five probe trial sessions for the present and 5 for the past). The past and present trials were conducted separately. There were four trials for each of the five verbs in the sets for the present tense and for the past tense in each of the regular verb sets. The students were required to say "Today he/she _____" while viewing the picture for the present tense or "He/She _____ last night" while viewing the picture for the past tense. Participants were not given feedback on correct or incorrect responses.

None of the participants emitted any correct responses prior to the SEI baseline instruction. Subsequently, the baseline instructional condition was completed using single exemplars. The pre-SEI probe trials were conducted following the SEI baseline instruction and then again after the MEI intervention (Figure 1).

Baseline condition with single exemplar instruction and probe. During this phase, the students were taught to say the correct present and past tense with Set 1 regular verbs separately to mastery. The students were taught the correct present tense first to mastery in massed

Figure 1. Numbers of correct responses to untaught regular and irregular verbs during pre- and post-multiple exemplar instruction for Participants A, B, C, and D for Experiment 1.

learn unit format, and then the correct past tense to mastery in massed learn unit format (see the first phase of Figure 3). Mastery was defined as emitting a minimum of 90% correct responses for two consecutive sessions of 20 learn units. During this phase, students were reinforced for correct responses or corrected for incorrect responses per the learn unit protocol. Learn unit presentations require reinforcement for correct responses and corrections for incorrect responses. When the participant responded incorrectly, the experimenter provided the correct response and the student was required to repeat the correct response while attending to the picture.

After the students mastered Set 1 present and past tense with regular verbs, probes were conducted on the past tense for Set 2 regular

and Set 1 and Set 2 irregular verbs to test for the emission of untaught responses (Post-SEI and Pre-MEI Phases Figure 1 Phase 1). This phase consisted of five trials per session for the untaught regular and irregular verb sets, and students were not reinforced for correct responses, nor were they corrected for incorrect responses; rather, the next trial was presented. These probes tested for the participants' emission of past tenses under the control of the contextual stimuli derived from learning subsets of regular past tense suffixes when each tense was taught separately (SEI). Although emissions of irregular verb forms ending with *-ed* are grammatically incorrect, they were experimentally correct. None of the students emitted a grammatically correct irregular past tense at any point in the experiment.

Multiple exemplar instruction. During this phase, the MEI intervention, each participant was taught an instructional set of regular verbs as shown in Table 2. The procedures for MEI consisted of rotating learn unit presentations across present tense and past tense for the regular verbs. Rather than teaching the present tense separately in one session of massed learn units and the past tense in another separate session per the prior SEI phase, the present tense and past tense presentations were rotated or juxtaposed. For example, the experimenter presented a learn unit for the student to say "Today he/she walks" with a picture of a child emitting a verb action in the daytime immediately followed by a learn unit for "He/She dressed last night" with a picture of the same child emitting a different verb action at night with the moon and a dark sky. Verbs used to teach the past tense immediately after the same present tense verb were not presented, in order to avoid intraverbal control of the responding. The child could not simply add an *-ed* to the verb emitted for the prior presentation, rather, the child had to respond by tacting the tense form per the context. Each correct response was reinforced by praise, edibles, or tokens based on the effective reinforcers for learning for each participant and each incorrect response was corrected per the learn unit protocol. Corrections in the learn unit protocol require the experimenter to provide the correct response, after which the participant must repeat the correct response while attending to the potential S^D. Correction responses are not reinforced.

The instructional sets were considered as mastered when the student emitted 90% accuracy for two consecutive sessions of 20 learn units. All participants mastered two sets of verbs. However, Participants A and B were probed following the first set and the probed again following the second set, while Participants C and D were not probed until they completed two sets of verbs to mastery. Probes were dropped following mastery of the first set of verbs for Participants C and D because Participants A and B required two sets of instruction to acquire significant changes in responding to the untaught verb forms. Following the mastery of the two MEI instructional sets, the untaught sets were probed again, as done prior to the MEI instruction and after the SEI instruction as described above.

RESULTS

Figure 1 shows that following baseline SEI, none of the participants emitted correct responses to the untaught irregular verbs as shown in Figure 2. Following one set of MEI instruction, Participant A emitted no correct responses on the Set 2 regular and Set 1 irregular verbs and one correct response on the Set 2 irregular verbs and Participant B emitted two correct responses on the Set 2 regular verbs and three correct responses on the untaught Set 1 and Set 2 irregular verbs. Because the outcomes for Participant A and Participant B's performances were weak, Participants A and B received a second set of MEI instruction. That is, it appeared that one set of exemplars was not sufficient. In prior studies that demonstrated emergent verbal behavior, some participants required mastering more than one set of MEI instructional sets in order for the behavior to emerge (Fiorile & Greer, 2007; Greer, Stolfi, et al., 2005, 2007; Greer, Yuan et al., 2005). After mastery of the second MEI set, Participant A emitted four correct responses for the regular verbs and three correct responses for the Set 1 and 2 irregular verbs. Because it appeared that mastery of one set of MEI did not provide adequate exemplar instruction, the decision was made to conduct two sets of MEI before probing Participants C and D. Following the two sets of MEI instruction, Participants C and D emitted either four or five correct responses for the untaught irregular and regular verbs.

Figure 2. Numbers of correct responses to untaught regular and irregular verbs during pre and post multiple exemplar instruction for Participants A, B, C, and D for Experiment 1.

Figure 2 shows the correct responses to instruction for the single and multiple exemplar conditions. Participant A mastered the SEI for the present tense in three sessions (Phase 1) and the past tense in two sessions (Phase 2). Participant B required four sessions for the present tense and three sessions for the past tense. Participants C and D required three ses-

Table 3
Description of Participants E, F, and G in Experiment 2

Participants	Level of verbal behavior	Social repertoire	Standardized testing scores
Participant E	Listener, speaker, emergent reader, emergent writer	Engaged in parallel and cooperative play Participated in conversation as a listener and a speaker	<i>Stanford-Binet Intelligence Scale</i> (verbal score 71, performance score 66 full score 83)
Participant F	Listener, speaker, reader, emergent writer	Engaged in parallel and cooperative play Participated in conversation as a listener and a speaker	<i>Vineland Adaptive Behavior Scale</i> (adaptive behavior composite score 54, communication domain score 60, daily living skill score 52)
Participant G	Listener, speaker, emergent reader, emergent writer	Engaged in parallel play Participated in with prompts	<i>Preschool Language Scale</i> (auditory comprehension 57, expressive communication 72)

sions to master the present and past tenses respectively. In the first MEI (Phase 2, Figure 2), Participant A mastered the present and past tense in five sessions, Participant B required four sessions to master both tenses with MEI, Participant C mastered the tenses in three sessions and Participant D mastered the tenses in two sessions. During the second set of MEI, Participant A required three sessions to master both tenses and Participants B, C, and D required two instructional sessions.

DISCUSSION

The objective of this experiment was to test whether the regular and irregular past tense verbs would emerge as a function of MEI. The results showed that none of the participants emitted correct responses following SEI for untaught past and present tenses. After MEI with two training sets of verbs all of the par-

ticipants emitted *-ed* endings to untaught regular and irregular verbs. Participants A and B showed the weakest effects and Participants C and D the strongest effects.

Following two sets of MEI instruction, all participants showed increased accuracy for the untaught past tenses for Sets 1 and 2. These data suggested that the source for these participants' emission of untaught past tense responses were attributable to a particular exemplar instructional history.

In the second experiment, the experiment was repeated with preschool children to test for the reliability of the findings and to extend the test to preschool age children. In the second experiment each participant was probed for the emergence of the untaught responses following each MEI intervention. Criterion for demonstrating emergence was set as a minimum of 80% accuracy for each probe set as a means of determining whether or not additional sets of MEI were needed.

EXPERIMENT 2

METHOD

The procedures for Experiment 2 were the same as Experiment 1 with a few minor changes, including the use of younger participants and the establishment of a criterion for whether or not additional sets of MEI were warranted. That is, probes were conducted on the untaught responses for all participants following their first MEI intervention and a second MEI was conducted only if the results warranted a second exposure based on whether or not the participant achieved 80% accuracy on post-MEI probe (four correct responses out of five probe trials). These differences are described in detail in the following sections.

Participants. Three students enrolled in a preschool participated in the second experiment—Participants E, F, and G. The students were diagnosed with developmental delays and were two or three years younger than the participants in Experiment 1. All 3 students were 4 years old and were selected for this study because they did not form past tense regular and irregular verbs under contextual control. Table 3 describes the participants' levels of verbal development, assessments of social repertoires, and standardized diagnostic test scores.

Setting. The study was conducted in a classroom in a privately run, publicly funded preschool for children with and without disabilities that used a comprehensive behavior analytic approach to instruction. All of the other components of the setting were the same as described in Experiment 1.

Materials. Three sets of regular verbs and two sets of irregular verbs were chosen for each of the participants as was done in Experiment 1 (Table 2). The same contextual pictures were applied to the sets of action pictures as was done in Experiment 1.

Design. The same design from Experiment 1 was repeated in the second experiment. The single exception was that in the second experiment, all students were probed for the emergence of untaught responses following each MEI intervention as described above.

Interobserver agreement. Interobserver agreement was assessed by having two observers simultaneously but independently collect data on 25% of the probe sessions across

pre- and postexperimental conditions and 25% of the instructional sessions. The mean interobserver agreement for probe sessions was 97% (range 95% to 100%). Interobserver agreement was 100% for the instructional sessions for all participants. The accuracy of presentations for learn units and probe trial was 100%.

RESULTS

Figure 3 shows correct responses to probe trials for the untaught irregular and regular past tense verbs for Participants E, F, and G following SEI and following MEI. The results show that following SEI and prior to the MEI intervention phase, all three participants emitted low numbers or no correct responses to the untaught irregular and regular verbs. After the first MEI, the numbers of correct responses were either 80% or 100% (four or five correct responses out of five trials) for Participants E and F. Following the first MEI intervention, Participant G emitted no correct responses for the regular verbs and one correct response out of five trials for the irregular verbs. Participant G received a second MEI intervention after which he emitted four correct responses for the regular verbs and five correct responses for the irregular verbs. They emitted *-ed* endings to untaught verbs. This occurred for two participants following mastery of one MEI training set, while one participant required two training sets.

Figure 4 shows the correct responses of Participants E, F, and G to SEI instruction (the first phase for each participant) and MEI instruction (the second phase for Participants E and F and the second and third phases for Participant G). For the SEI present tense instruction that was taught first, Participant E met the criterion for mastery in two sessions and Participants F and G each required three sessions. Participant E mastered the past tense in six sessions, Participant F in four sessions, and Participant G in three sessions. During the MEI phase, Participants E and G met criterion in four sessions and Participant F in three sessions. Participants E and F required mastery of only one instructional set of MEI verbs for the emergence of the suffixes with novel verbs, while Participant G required two sets. Participant G met the criterion for the second MEI instructional set after three sessions.

Figure 3. Numbers of correct responses to single and multiple exemplar instruction across Participants A, B, C, and D for Experiment 2.

DISCUSSION

The MEI intervention resulted in the emergence of correct usage of untaught regular verbs or abstractions of the *-ed* endings to past tenses for the 4 first graders in Experiment 1 and the 3 preschool participants in Experiment 2. In addition, the participants acquired abstrac-

tions of *-ed* to irregular verbs (e.g., *sing* to *singed*). While the latter were grammatically incorrect, the emission of these demonstrated that multiple exemplar experiences resulted in the emission of what some linguists have described as responses that could not be attributed to a particular instructional experience. In fact, the source of the “creative” responding

Figure 4. Numbers of correct responses to untaught regular and irregular verbs during pre- and post-multiple exemplar instruction for Participants E, F, and G for Experiment 2.

was MEI with a subset of regular verbs. Thus, the subset of verbs that were taught created what might be characterized as a higher order class of responding. While this experiment does not necessarily demonstrate that all children acquire the emission of novel past tense usage as a function of exemplar experiences with a subset of verbs, the results do show that for children like those studied, the exemplar experiences were sufficient to result in the emission of past tense forms with novel verbs. The responses would appear to meet the criterion for autoclitics with tacts, since the contrived

contextual pictures functioned as the controlling stimuli for the responses.

The rotating contextual conditions were the target conditional stimulus control taught by the MEI condition. The juxtaposition of learn units for the different backgrounds, relevant to the different suffixes, resulted in the essential control for the emission of tense suffixes with novel verbs. The participants learned that regardless of particular verbs that they encountered the context determined the suffix. In some MEI applications the context is to be disregarded, as in the abstraction of phonemes for

textually responding to novel words where the phoneme exerts control for saying the sounds regardless of the context, while in other cases, the context can come to control the emission of the different suffixes of past and present. In the former case what is learned is that regardless of the context one says the phonemes; whereas, in the latter case, regardless of the verb, the context controls the suffix.

Certainly the use of the contextual control simulated by the pictures does not mean that the children in our experiments learned to use past tense in other and nonexperimental contexts for past and present tense such as the discrimination of one's own past and present behavior—this was not tested during the course of the experiment. However, it is possible that exemplar instruction across “naturalistic” settings for one's own past and present tense behavior could lead to the formation of that repertoire. This should be tested in future experiments. It was not the intention of this experiment to test for that particular abstraction or relational responding; rather, the focus was to test whether the provision of an instructional experience with a subset of verbs under contextual control could result in the formation of untaught past tense usage, thereby testing the theory that such formations were not traceable to reinforced experiences, as Pinker (1999) argued.

When the results of these experiments are combined with those of experiments described in Speckman-Collins and Greer (2006), the evidence suggests that the emission of untaught forms of autoclitics for suffix endings of either *-s* or *-ed* could result from reinforced exemplar experiences with a subset of responses brought under contextual stimulus control. Pinker asserted that “Children are never given grammar lessons presenting *-ed* or *-s* with lists of stems to conjugate or decline; they must mentally snip the suffixes out of the full, inflected words they hear in conversation.” (Pinker, p. 192). In fact, for the children studied, contact with reinforced responses to a subset of contextual exemplars were sufficient to result in the emission of untaught forms for autoclitic functions. It would appear that the exemplar experiences were grammar lessons enough—no “mental snips” were observed. The implication is that the emerged responses were the result of the verb endings joining a class of responding. Thus, these grammatical forms and their potential for autoclitic

functions are a result of reinforced exemplar experiences. Clearly, novel forms of verbal behavior like these can be traced to reinforcement histories, at least for children like those studied. In fact, it could be argued that these are in fact *not* novel forms of behavior; rather, the behavior is simply part of a class of responses that have been learned as a function of a particular instructional history.

Several programs of research in behavior analysis have identified sources for “novel” verbal behavior and categorization in addition to the extensive research in Relational Frame Theory (Hayes et al., 2000). Becker (1992) presented extensive evidence that novel textual response emerged as a function of MEI from subsets of phonemic stimulus control. Others found that MEI produced complex auditory abstractions in humans and pigeons (Greer & Lundquist, 1976; Porter & Neuringer, 1985), and novel categorization of visual stimuli in humans (Fields, et al, 2003). These latter MEI procedures dealt with MEI for stimuli rather than MEI across responses to stimuli. Still other work has shown that histories of exemplar experiences across responses can result in the emergence of joint stimulus control across saying and writing (Greer, Yuan, et al., 2005), emergence of joint stimulus control across listener and speaker responding in Naming (Fiorile & Greer, 2007; Greer, Stolfi, et al., 2005; Greer, Stolfi, et al, 2007), and emission of untaught mand or tact responses as a function of histories of MEI across establishing operations (Nuzzolo-Gomez & Greer, 2005). The present studies and Speckman-Collins and Greer (2006) suggest that “novel” suffix responses can also result from multiple contextual exemplar instruction.

While characterizations of the phenomenon vary to some degree across research programs, perhaps due to the idiosyncrasies of different procedures, the body of work in experimental tests of the relation of exemplar experiences to novel verbal responses does locate one source of the novel behavior to experience with the basic principles: historical reinforcement of a subset of responses. Just as the joining of antecedent, behavior, and consequences accrue from reinforcement and corrections that lead to new operants, perhaps the reinforcement and corrections of classes of responding or minimal units leads to higher order operants. It appears that the evidence does seem to expand the range of the effect of those basic prin-

Table 4

Verb Sets Used during Pre- and PostIntervention Probes, Single Exemplar Baseline Instruction, and Multiple Exemplar Instruction for Participants

Stimulus set	Assignment to participants
Regular verbs: wave, lift, brush, skate, kiss jump, hug, wipe, clap, spill pull, open, climb, splash, dig lick, drill, dress, hug, knock	Set 1 Participants A and C Set 2 Participants A and C Set 1 Participants B and D Set 2 Participants B and D
Irregular verbs: slept, blew, read, swept, sat drew, ate, drank, held, ran	Set 1 All Participants Set 2 All Participants

ciples to incorporate histories of instruction that lead to what Catania (2007) called “higher order classes.” Of course, the findings described herein need to be replicated by others.

There is a great deal remaining to be explained about stimulus control for the topography of verbs that have autoclitic functions. For example, at some stage, children do cease the ungrammatical usage of *-ed* for irregular verbs and apparently they do so without direct instruction. Some linguists point to this fact as even stronger grounds for the untaught source for grammar (Pinker, pp. 144, 195). In answer to this, we argue that the learning history for the “emergence” of the accurate irregular usage may not differ significantly from the source for exceptions to phonemically-controlled textual responding in the English language (Becker, 1992; McGuiness, 2004). That is, many words in the English language involve phonemic exceptions, yet children who are taught to textually respond as a function of mastery of phonemics do learn to textually respond accurately to the exceptions. Learning these exceptions is a part of learning to textually respond and according to McGuiness (2004), exemplar instruction, rather than the learning of rules, is the most effective way to teach this. It is not unreasonable to posit that instances of irregular verb usage are learned incidentally through exemplar experiences as exceptions, just as the exceptions to phonetic control for textually responding are learned. This is a possible avenue for future research.

The term *single exemplar instruction* may not be the most apt term to describe the instruction style used in this experiment. That is, the single exemplar instruction might best be

described as the separate teaching of simple discriminations for past and present tense. The single tense was taught as a simple discrimination and the past tense also as a simple discrimination. This sequence, however, showed that the separate mastery of these did not result in novel usage. By using the essential components of the contextual stimulus (i.e., the dark and sunny pictures) MEI did result in the abstraction because the context controlled responding regardless of the verb encountered. This suggests that MEI across the tense contexts is sufficient to form the higher order class, while teaching the single discriminations separately is not. In a related MEI and SEI comparison study, Greer, Stolfi, and Pistoljevic (2007) found that the rotation component of MEI was both sufficient and necessary in the emergence of Naming. In that study, as in this one, SEI for listener and speaker responses separately in a control group did not result in the joining of listener and speaker responding in Naming. The same numbers of MEI instructional presentations for an experimental group did result in Naming. In addition, the control group that did not receive MEI but received SEI subsequently received MEI, and Naming emerged for them also. The current study, together with Greer, Stolfi, and Pistoljevic (2007), provides additional evidence that emergent verbal behavior is a higher order class of responding that is learned.

We suggest that the instructional intervention involving multiple exemplars is a possible simulation of the incidental experiences that result in the “untaught” emergence of novel past tense verbs or other emergent verbal behavior such as Naming in typically developing

children (Gilic, 2005), the joining of saying and writing (Greer, Yuan et al., 2005), or the contextual control for suffixes as in the present study. Thus, it is possible that incidental multiple experiences lead to higher order verbal operants for most children and that controlled experiments that provide direct MEI simulate that process. Direct tests of whether or not incidental multiple exemplar experiences do in fact occur naturally would involve descriptive longitudinal studies. While such studies might provide external validity for multiple exemplar "experiences," as distinguished from instruction, as the source of these types of emergent verbal behavior, the lack of experimental control or internal validity in longitudinal studies can not affirm the argument. Thus, while the possibility exists that MEI is a test of incidental multiple exemplar experiences, that relation cannot be definitively determined at present.

The term *multiple exemplar instruction* was used extensively in early research on "concepts" and abstraction (Becker, 1992; Fields et al., 2003; Greer & Lundquist, 1976) and has been used in the research on emergent verbal behavior (Fiorile & Greer, 2007; Greer, Stolfi, et al., 2005, 2007; Greer, Yuan et al., 2005; Nuzzolo-Gomez & Greer, 2004). The term *multiple exemplar training* is also used in a significant body of research (Barnes-Holmes, et al., 2001a, 2001b; Luciano et al., 2007). Fields described a similar intervention using the term *training with multiple domains, samples, and comparisons*. The terms refer generally to similar operations. Some possible differences are that in both the MEI research described by Becker (1992) and in the research on the emergence of Naming (Fiorile & Greer, 2007; Greer, Stolfi et al., 2005, 2007), the emergence of tacts from learning mands and vice versa (Nuzzolo-Gomez & Greer, 2004), and the emergence of writing from saying and vice versa (Greer, Yuan et al., 2005) consistently used the correction component of the learn unit (Ingham & Greer, 1992); whereas, in the multiple exemplar training this may have not been the case. Moreover, the MEI used in the studies on Naming and the joining of saying and writing involve MEI across response types along with MEI for the visual stimuli.

There are alternative possible explanations for the reported findings. The textual prompts may have in some way have played a part. Those prompts were simply used to set the occasion for the opportunity for the visual

stimuli to control the verbal responses, and after a few trials, it appeared that the participants ignored the text and directly responded to the picture. However, how that component may have played a part, and the degree to which it did, is unknown and suggests further research. There may also be some artifacts of the experiment's design or procedures that were responsible for the results that have not yet been detected. Future research may also identify key variables currently unidentified.

Much recent work devoted to detecting the environmental sources of "novel" behavior suggests that the behavior is not really novel; rather, the behavior is learned and the sources uncovered. The study of other types of "creativity" may benefit from expanding Skinner's initial theoretical analyses of creativity (Skinner, 1953) through experiments that manipulate exemplar experiences in ways not unlike the experiments described above. Perhaps other types of creative responding or emergent relations (e.g., adduction) may also be a function of certain exemplar experiences, but that remains for future investigations.

There are numerous aspects of emergent verbal behavior that require investigation. One such aspect involves the joining of "see and do" with "hear and say" and some research suggests that multiple exemplar experiences across these two different response classes may result in a single higher order class of duplic responding (Vargas, 1982) that result in first instances of echoics, mands, and tacts (Ross & Greer, 2003; Tsiouri & Greer, 2003).

It also appears that exemplar experiences may not be the only instructional history experiences that lead to novel verbal behavior or accelerated learning of listener or speaker responses, as in the case of the development of vowel-consonant control over listeners (Greer, Chavez-Brown, Nirgudkar, Stolfi, & Rivera-Valdes, 2005) or a history of conditioned reinforcement that accelerates textual stimulus control (Tsai & Greer, 2006). That is, the induction of certain prerequisite repertoires, including the conditioning of stimuli via stimulus-stimulus pairing that is associated with observing or vocal responses, have been shown to result in the acquisition of stimulus control in cases in which instruction did not work prior to the provision of the prerequisite capabilities (Greer & Ross, 2008; Longano & Greer, 2006; Sundberg, Michael, Partington, & Sundberg, 1996; Tsai &

Greer, 2006). Thus, exemplar experience may be only one of several instructional histories that result in new verbal capabilities.

There is an extensive theoretical linguistic literature for the innate theory as illustrated by the quotations at the beginning of this paper, but the evidence for that theory has been largely descriptive and anecdotal. The research reported in this paper, along with the related research described herein, has been either experimental studies or demonstration studies. Moreover, related computer simulations seem to replicate the experimental work (Elman, 2006). Taken together, this evidence appears to point to contact with the basic principles as the environmental sources for complex forms of human verbal behavior. Thus, the basic principles appear to be more widely applicable in that instructional histories of contact with the principles apply to wider response classes or stimulus classes. In such cases, the contact with the principles occurs in more remote but experimentally testable instructional histories. In any case, these results suggest one way that kids can learn some of the darnedest things.

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