Is the Source of Reinforcement for Naming Multiple Conditioned Reinforcers for Observing Responses?

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Abstract Naming refers to the incidental acquisition of word-object relations as listener and speaker without explicit reinforcement. To investigate possible sources of reinforcement for naming, we examined the effects of a procedure for conditioning reinforcement for observing responses on the emergence of naming in children who previously lacked it. The participants were three 5- to 7-year-old children with and without diagnoses of autism spectrum disorder. During the intervention, either visual or auditory stimuli were first conditioned as reinforcers for observing responses. Then, neutral visual or auditory stimuli were paired with the conditioned visual or auditory stimuli until both visual and auditory stimuli acquired reinforcing properties for observing. Following this intervention, the participants demonstrated naming of stimuli that had been used in pretests for naming, as well as on a novel set of stimuli. We observed increases in echoic responding in conjunction with the emergence of naming and conditioned reinforcement for both observing responses. We interpret the data as suggesting that listener and speaker repertoires are joined for naming only when both visual and auditory stimuli reinforce the observing responses of looking and listening simultaneously.

Keywords Naming · Higher-order conditioning · History of conditioned reinforcers

Introduction

Horne and Lowe (1996) introduced the theory of *naming*. Naming is a verbal behavior developmental cusp, the onset of which allows children to learn word-object relations

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simultaneously as a listener and a speaker without direct instruction (Greer and Longano 2010; Greer and Ross 2008; Greer and Speckman 2009; Rosales-Ruiz and Baer 1996, 1997). Horne and Lowe (1996) characterized the naming capability as a bidirectional and circular relation. Two major aspects of the naming cusp have been described in the literature (e.g., Greer and Longano 2010; Greer and Ross 2008; Greer and Speckman 2009; Horne and Lowe 1996): (a) if taught a listener response (e.g., pointing to a dog when asked “Where is a dog?”), the speaker response (saying “dog” upon seeing a dog) emerges without direct instruction, or vice versa, and (b) both the speaker and the listener responses emerge simultaneously as a result of hearing the word for an object as the child and the speaker jointly observe the object. In the latter case, a child hears an adult say “this is a dog” while looking at a dog or picture of a dog and later can point to a dog when hearing the word spoken as well as say “dog” on seeing the dog.

Considerable evidence suggests that children’s vocabulary “explodes” around the age of 3 years and that this is not a result of direct instruction (Crystal 2006; Hart and Risley 1995; Kinneally 2007). One possibility is that the explosion in language is the result of the acquisition of naming as a culturally learned verbal behavior developmental cusp (Greer and Longano 2010; Greer and Ross 2008; Greer and Speckman 2009). Indeed, some have proposed that the onset of naming, in which the behavior of speaker and listener is joined within the skin (Lodhi and Greer 1989; Skinner 1957), is necessary to being truly verbal (Barnes-Holmes, Barnes-Holmes, and Cullinan 2001; Greer and Longano 2010; Greer and Ross 2008; Greer and Speckman 2009; Hayes, Barnes-Holmes, and Roche 2001; Horne and Lowe 1996).

Research in verbal behavior has identified particular environmental conditions that give rise to the onset of naming, resulting in the identification of environmental experiences that lead to naming as a verbal behavior developmental cusp. One series of studies found that multiple exemplar instruction (MEI) across listener and speaker responses resulted in the emergence of naming for novel sets of stimuli with typically and atypically developing children (Fiorile and Greer 2007; Gilic and Greer 2011; Greer et al. 2005, 2011a; Greer, Stolfi, and Pistoljevic 2007). For example, Gilic and Greer (2011) found that naming could be induced in typically developing 2-year-old children via MEI, several months before its typical onset at 3 years. Other research suggests that naming is critical to learning in classrooms (Corwin and Greer 2014; Greer et al. 2011a). Naming may be absent in first graders who are from economically depressed communities, or children with autism, and this deficit interferes with children being successful in school. However, once naming is established, these children learn at faster rates (Corwin and Greer 2014; Greer et al. 2011a, b).

The experiments cited above followed a common experimental protocol to investigate the effects of MEI on the acquisition of naming. To test for evidence of the presence or absence of naming, the children first heard an adult say the name associated with a visual stimulus, while attending to the visual stimulus, for each of a set of stimuli. This phase was followed by a test for the emergence of untaught listener and speaker responses, which were the primary dependent measures. The participants then received MEI, which consisted of rotating instructional trials that included (a) presenting spoken words as the children performed an identity-matching task with the corresponding visual stimuli (e.g., the experimenter said “car” and the child matched a picture of a car to another picture of a car), (b) requiring the children to tact the stimuli

under pure (e.g., saying “car” when shown a picture of a car) and intraverbal (e.g., saying “car” when shown a picture of a car and asked “What is this?”) tact conditions, and (c) requiring the children to respond as listeners to the spoken words (e.g., pointing to a picture of a car when asked to do so). Presentations were arranged such that the participants could not make a correct response by simply echoing the prior response. MEI continued with a training set of stimuli until the participants emitted correct responses across response topographies at a 90 % criterion level. In the experiments cited above, all of the participants (32 across all of the published experiments to date) then demonstrated naming with untaught stimulus sets.

Other experiments (Choi and Greer 2012, submitted for publication; Pistoljevic 2008; Speckman-Collins et al. 2007) have induced naming by arranging other environmental experiences to occasion the acquisition of the verbal developmental cusp. As reported in an unpublished dissertation (Pistoljevic 2008), an intensive tact procedure, in which children received 100 instructional trials daily with five sets of unfamiliar stimuli until mastery of 100 tact responses (Greer and Ross 2008; Pistoljevic and Greer 2006; Schauffler and Greer 2006), was effective to induce naming. Speckman-Collins et al. (2007) found that the listener half of naming resulted from teaching children who could not yet speak to discriminate and match a series of auditory sounds. Choi and Greer (2012, submitted for publication) developed and tested a combined speech sounds advanced auditory-matching protocol. A series of auditory-matching responses with increasing difficulty and finer discriminations was taught. Three red circles, of equal size, appeared on the computer screen in a triangular formation with one circle above the other two. The experimenter touched each circle. As the experimenter touched each circle, a sound, a one-syllable word, a multisyllabic word, or a phrase was played. Two of the circles (the top circle and one of the bottom circles) had the exact same sound. The top circle was again pressed, and the experimenter asked the participants to match the sound with one of the two bottom circles. Increased difficulty or finer discriminations were introduced with each phase of the procedure. The protocol resulted in naming for three of seven participants and increases in untaught listener and speaker responses in the other four (Choi and Greer 2012, submitted for publication). In addition, the results suggested that voice recordings acquired conditioned reinforcing value as a result of the auditory-matching intervention. Thus, the data suggested a concomitant relation between acquisition of naming and the acquisition of conditioned reinforcement for listening to voices. This finding is particularly relevant to the experiment reported here.

Although the studies described above have traced the acquisition of naming to environmental experiences, the source of reinforcement for naming remains to be identified. Before naming can emerge and listener and speaker behavior can be joined, listener behavior and speaker behavior must be acquired as independent repertoires (Greer and Keohane 2005; Greer and Ross 2008; Greer and Speckman 2009; Horne and Lowe 1996). In Horne and Lowe’s (1996) account of the acquisition of naming, children first learn listener responses, then echoic responding. Horne and Lowe (1996), in their original theory, proposed that a history of social reinforcement for overt echoic behavior allowed for the emergence of the naming relation (p. 197–199). Then, is the source of reinforcement for the naming relation a social reinforcement history for echoic responding? Possibly yes, but it has also been suggested (Horne and Lowe 1996, p. 198; Skinner 1957, p. 64) that when an individual produces an echoic response, the

duplication of the sounds of others may potentially be an automatic reinforcer. In other words, echoic responding may produce its own reinforcer. Unless the duplication of the sounds of others is an unconditioned reinforcer in humans, experiences appear to play a role in how echoic response products come to have a reinforcement function.¹

Skinner (1957) and verbal behavior developmental theorists (Greer and Keohane 2005) have distinguished between the nonverbal and verbal functions of duplicative speech. The nonverbal function, or parroting (Greer and Longano 2010; Skinner 1957), consists of repeating a combination of sounds without any word-object relation, as when a child repeats “Mama” with no correspondence with the person. There is no relation between the emission of the speech sound and the nonverbal environment, and the reinforcement is automatic when a child is parroting. A stimulus-stimulus pairing procedure, in which unconditioned and conditioned reinforcers are paired with vocalizations, has resulted in the emission of parroting, supporting the notion that the duplicative speech response produces its own automatic reinforcer (e.g., Esch, Carr, and Grow 2009; Sundberg et al. 1996; Yoon and Bennett 2000). In these latter studies, the children emitted parroting responses that were not verbal. Nevertheless, parroting may set the stage for the development of true echoic behavior where a history of being reinforced for duplicating speech sound responding results in reinforcement from a listener. Thus, parroting may be foundational in the development of listener and speaker repertoires and later in the joining of those repertoires (Keohane et al. 2009). The verbal function of duplicative speech is true echoic behavior, when the reproduction of sounds corresponds to an object or event, and listener and speaker behavior is potentially joined.

Thus, the three interventions that have resulted in the emergence of naming (i.e., MEI, intensive tact, combined speech sound auditory matching) may have a common factor or factors. One possible factor, suggested by the findings of Choi and Greer (2012, submitted for publication), was the establishment of conditioned reinforcement for voices, or spoken auditory stimuli. The studies of Sundberg et al. (1996) and Yoon and Bennett (2000) suggest that conditioning speech sounds as reinforcers results in the emission of a duplicative response that under certain conditions could become a verbal duplicative response, or an echoic. For example, a sound such as “ch” can be conditioned using the stimulus-stimulus pairing procedure, and once the child is repeating the sound consistently, the sound can be used as an approximation for the word “chip” as an echoic with a mand function. It is possible that the MEI or the intensive tact interventions condition voices as a reinforcer for listening and the echoic response product as a reinforcer for echoing, because both procedures provide a history of reinforcement for attending to visual and spoken auditory stimuli.

It appears that one of the necessary conditions for learning the words for the names of things is listening to what is said. Possibly, the emission of the echoic extends the listening experience by allowing the listener to reproduce the word, reinforcing the speaker-as-own-listener behavior. Thus, the echoic response product as a reinforcer appears to be a viable candidate as a potential source of reinforcement for naming. But there is another stimulus involved, and that is the visual stimulus (of course, any of the

¹ Home and Lowe (1996) also described how the emission of an echoic response, either overt or covert, could potentially have a range of other reinforcing consequences (p. 198). It may sustain listener responses such as, looking for the object, reaching for the specified object, or crawling to have access to the specified object after hearing the word spoken by another. Also, the echoic, covert or overt, may reinforce speaker responding resulting in the child tacting the object in the presence of the object and a listener.

observing senses may be involved), which presumably reinforces the observing response of looking. The child must both listen to the voice and look at the visual stimulus (or contact other sensory stimuli), and reinforcement for one or both observing responses may need to be present for echoic behavior to join listener and speaker repertoires. Dinsmoor (1983), Greer and Han (2014), and Greer et al. (2011b) demonstrated that observing responses could be conditioned and that doing so increased rates of learning of related discriminations. Most notably, after 2-dimensional visual stimuli and the observing response of looking at 2-dimensional stimuli were conditioned as reinforcers, participants acquired generalized visual identity-matching repertoires and increased correct responding across listener responses (Greer and Han 2014).

In summary, we propose that both visual and auditory stimuli need to have reinforcing properties and reinforce the separate observing responses simultaneously in order for echoic behavior to join listener and speaker repertoires and induce naming. In the following experiment, we tested the effects of conditioning spoken words and visual stimuli as reinforcers on the emergence of naming. The conditioning procedure involved two phases. First, either spoken words or visual stimuli were conditioned as reinforcers via pairing with primary reinforcers (this step was omitted if either spoken words or visual stimuli already functioned as reinforcers). The second phase consisted of a higher order conditioning procedure, in which the newly conditioned spoken words or visual stimuli were paired with whichever type of stimuli (spoken words or visual stimuli) had not yet been conditioned.

Method

Participants

Three children participated: two 7-year-old males diagnosed with autism (participants E and R) and one 5-year-old female who had not been diagnosed with a developmental disability (participant T). Participants E and R were selected from a self-contained classroom, which practiced teaching based on applied behavior analysis. Participant T was enrolled in a general education kindergarten classroom that employed eclectic educational practices. The participants were selected for the study because they (a) did not demonstrate naming in pre-experimental tests and (b) had the prerequisite verbal developmental capabilities identified in *Verbal Behavior Developmental Assessment* (Greer 2008; Greer and Ross 2008; Greer and Speckman 2009), which include listener literacy, an echoic repertoire, independent mands and tacts, mands and tacts with autoclitic frames, and transformation of establishing operations across mand and tacts (Greer and Ross 2008; Nuzzolo-Gomez and Greer 2004). Also, these participants had not been exposed to MEI interventions to induce naming. In a prior experiment reported in Longano (2008), children who did not acquire naming as a result of MEI did so following the pairing procedure used in the present experiment.

Participant E had a fluent listener and speaker repertoire. He had generalized imitation and followed multistep directions. As a speaker, he tacted objects and pictures independently using three- to four-word phrases or sentences. He did not emit conversational units or exchanges with peers or adults. He learned novel verbal operants as a function of direct reinforcement and correction.

Participant R had similar skills and deficits as participant E. He was a fluent listener and speaker. He emitted tacts and mands for items independently using three- to four-word sentences that included simple autoclitics. He followed multistep directions and had an imitative repertoire. Learning occurred through direct contingencies or from observing a peer exposed to direct contingencies, but he did not learn tacts or mands without direct instruction.

Participant T, who had no formal diagnosis or classification, was exposed to two languages at home, Creole and English. According to her teacher, it was unclear if English was participant T's first or second language. The teacher described her as an "at-risk" student, who was functioning on a lower academic level than her same-aged peers. She did not appear to have any social deficits and conversed with peers and adults, but did not learn new tacts or mands without direct instruction.

Setting and Materials

We conducted the experiment in a tutoring room that contained an adult-sized desk with a computer, a child-sized desk in a corner, and a bookshelf in another corner. A second child-sized desk was brought into the room during preference assessments, and a Dell© laptop computer placed on each desk.

Two types of stimuli were used in the experiment: naming test stimuli and pairing stimuli. Naming test stimuli were different types of pasta (set a) and dry beans (set b). Each stimulus set consisted of four stimuli, and the four sets (two sets of pasta and two sets of beans) that were used in the experiment are shown in Table 1. Pairing stimuli consisted of digital drawings of shapes (visual stimuli) and objects and recordings of their corresponding spoken names (auditory stimuli). A total of four sets of pairing stimuli were used, each consisting of four visual stimuli and the corresponding auditory stimuli. Table 2 lists the stimuli in each set, and Fig. 1 shows a sample set of visual stimuli (set 1). The pairing stimuli were embedded in three types of PowerPoint © slideshows: visual stimulus slideshows, auditory stimulus slideshows, and paired stimulus slideshows. In visual stimulus slideshows, one visual stimulus was presented per slide. Upon entrance, the stimulus moved to different locations on the screen with different and changing colored backgrounds. In auditory stimulus slideshows, auditory stimuli were played one at a time, while the screen remained black. In paired stimulus slideshows, visual stimuli and the corresponding auditory stimuli were presented together.

Design

A nonconcurrent multiple-probe design (Watson and Workman 1981) was used to evaluate the effects of the independent variable on the onset of naming. Each participant was exposed to the following sequence of phases (see Table 3): (a) pretests for naming under a joint attention condition (JAC) and an incidental condition (IC) for set 1a and set 1b stimuli (see Table 1), (b) an assessment of relative preference for visual and auditory stimuli, (c) pairing of either visual or auditory stimuli with reinforcers if necessary (phase 1 of the intervention), (d) a repeated preference assessment, (e) pairing of visual and auditory stimuli (phase 2 of the intervention) immediately followed by probes for emergent tacts of the visual stimuli, (f) posttests for naming under JAC and IC for set 1a and set 1b stimuli, and (g) posttests for naming under JAC and IC with

Table 1 Naming test stimuli used in the joint attention and incidental conditions of the naming test

Participant	Set	Joint attention (a)	Incidental (b)
Participant E	Set 1	Farfalle	Great northern
		Rigatoni	Negros
		Rotini	Pinto
		Fiori	Garbanzo
	Set 2	Dumpling	Rojo
		Rotelle	Roman
		Rigate	Split pea
		Ziti	Lentil
Participant T	Set 1	Same as participant E	Negros
			Kidney
			Pinto
			Garbanzo
	Set 2	Same as participant E	Same as participant E
Participant R	Set 1	Same as participant E	Great northern
			Pinto
			Kidney
			Garbanzo
	Set 2	Same as participant E	Same as participant E

novel sets: set 2a and set 2b stimuli (see Table 1). The first pretests for naming occurred simultaneously for all participants. Participant E, who was the first participant to be exposed to the intervention, had only one pretest. The other two participants also had a second test for naming immediately before the intervention began in order to control for instructional history. If the participants passed the tests for naming after exposure to the intervention phases in the posttests, participants received training with a new set of pairing stimuli in phase 2 of the intervention. Additional sets of visual and auditory stimuli were paired until the participants demonstrated naming for set 1 and set 2 for

Table 2 Sets of materials used for the pairing of visual and auditory stimuli (independent variable)

Set	Visual and spoken auditory stimuli
Set 1	C-clamp
	Cylinder
	Scroll
	Quad arrow
Set 2	Desk lamp
	Film
	Sound
	Gears
Set 3	Engine
	Muffler
	Lures
	Spark plug
Set 4	Windmill
	Molecule
	Pulley
	Protractor

Visual Stimuli	Spoken Word (Spoken Auditory Stimuli)
Scroll
Quad-Arrow
Cylinder
C-Clamp

Fig. 1 Example of a set of visual and spoken auditory stimuli used for visual only PowerPoint, auditory only PowerPoint, the pairing of visual and spoken auditory stimuli, and during tact acquisition probes

JAC and IC. Posttests for naming using set 2 stimuli were conducted when the participant met the criterion for naming in either the JAC or the IC condition. Participant R did not require phase 1 of the intervention because visual stimuli were preferred and had reinforcing properties according to the preference assessments.

Procedure

Naming Pre- and Posttests

During tests for naming, the participant was seated at a child-sized desk facing the wall, and the experimenter sat on an adjacent side. To test for the presence or absence of naming, we arranged two experimental conditions. The JAC was designed to ensure that the participants were attending to the visual stimuli as they heard the corresponding words. Participants were first taught to match identical stimuli, using set 1a, while hearing the experimenter say the name associated with each stimulus (only prior to the first test for naming with each set). In each matching trial, the target item was placed on a desk together with a negative comparison. A third stimulus, the sample (an identical match to the target item), was given to the participant following the vocal antecedent “Match _____.” The participant was then required to place the sample piece of pasta directly next to or on top of the target piece of pasta in a field of two stimuli. Correct matching responses were reinforced with praise or edible reinforcers. Incorrect matching responses were immediately followed by a correction procedure, in which the experimenter repeated the antecedent “Match _____,” and prompted a correct response by pointing or modeling. Match instruction was continued until the child responded with 90 % accuracy across two consecutive sessions. Each session of match-to-sample instruction consisted of 20 trials, in which each of the four stimuli was presented five times in randomized order.

Approximately an hour after the mastery of the match responses or following completion of phase 2 of the intervention for each set, tests for naming were presented. Still using set 1a, tests for untaught listener and speaker (tact and intraverbal tacts) responses were conducted. We presented 20 listener trials, 20 tact trials, and 20 intraverbal tact trials. The three types of trials were intermixed in random order, and

Table 3 Sequence of phases of the procedure and sets of materials used in each phase

Dependent variable	Dependent variable	Phase 1 of independent variable	Phase 2 of independent variable
1. Test for naming JAC, set 1a	Test for naming IC, set 1b		
2. Match-to-sample instruction, set 1a	Experimenter presents tacts for set 1b		
3.		Preference assessment	
4.		Stimulus pairing procedure to condition visual or auditory stimuli (if necessary)	
5.		Preference assessment <i>*Continue this sequence until targeted stimuli are conditioned</i>	
6.			Pairing procedure to condition visual and auditory stimuli (pairing set 1) <i>*Continued to mastery was demonstrated in tact probes</i>
7. Test for naming JAC, set 1a <i>*If naming is acquired under either JAC or IC tests for naming using a novel set (set 2a)</i>	Test for naming IC, set 1b <i>*If naming is acquired under JAC or IC tests for naming using a novel set (set 2b)</i>		<i>*If naming is not acquired, set 2 of the visual and auditory stimuli is paired. Additional sets (set 3, 4, or 5) are paired until naming is acquired</i>
8. Match-to-sample instruction set 2a	Experimenter presents tacts for set 2b		
9. Test for naming JAC, pasta set 2	Test for naming IC, bean set 2		<i>*If naming is not acquired for set 2a or 2b, another set of visual and auditory stimuli could be paired</i>

each of the four stimuli in the stimulus set was presented five times. In each listener trial, two stimuli were placed on the participant's desk: the target item and a negative comparison, and the vocal antecedent "point to the _____" was provided. In tact and intraverbal tact trials, the experimenter held the target stimulus in his or her hand while facing the participant or placed the target stimulus on the participant's desk and pointed to it. In tact trials, no vocal antecedent was delivered, whereas in intraverbal tact trials, the vocal antecedent "What is this?" was delivered in conjunction with the presentation of the visual stimulus. The criterion for the presence of the naming repertoire was a minimum of 80 % correct responses for each of the three trial types.

The second naming test condition simulated natural conditions under which a word-object relation might be learned. We labeled this condition the IC. The purpose of this condition was to measure the occurrence of naming under more natural conditions. In the IC, match-to-sample instruction was not presented. Rather, the experimenter tacted each stimulus of set 1b in the presence of the participant, by saying the relevant spoken word while holding or pointing to the stimulus. Tact presentations were conducted only prior to the first probe session for each set. The participant was not required to respond,

and therefore, no consequences were delivered. The stimuli were presented when the participant was working on daily instructional tasks as part of his school curriculum. In between instructional antecedents, the experimenter placed one or more beans on the participant's desk and drew attention to them by pointing and making statements such as "look at the kidney beans," "did you see my pinto beans," or "oh, look the great northern beans fell on the floor." The spoken word was only presented when the participant was looking directly at the stimulus that was being presented. After the spoken word for each stimulus was presented five times for a total of 20 total trials, and an approximately an hour had elapsed, naming was tested with set 1b using the same procedure as in the JAC.

Preference Assessment for Spoken Words and Visual Stimuli

Multiple 5-min sessions were conducted prior to the implementation of the independent variable to determine if visual stimuli or spoken auditory stimuli functioned as reinforcers for observing responses. Preference, defined as selection and observation of visual and auditory stimuli, was assessed to test for the relative value of conditioned reinforcement for those observing responses in that moment of time under the given conditions. Two laptop computers, one displaying the visual stimulus slideshow and the other displaying the auditory stimulus slideshow, were set up on two separate child-sized desks. Other stimuli, such as toys, books, puzzles, and blocks, were displayed in bins on one of the child-sized desk alongside one of the laptops and accessible to the participants to select throughout the assessment.

The visual stimulus slideshow consisted of a combination of all the visual stimuli in all the sets listed in Table 2. The slideshow was set to repeatedly present the slides so that slides continued to be presented throughout the assessment, if necessary. In the visual stimulus slideshow, to access the visual stimuli, the space bar had to be pressed and released, after which a picture appeared and moved around the computer screen for 5 s and then disappeared. To view the next picture, the participant had to press the space bar again. If the participant held the space bar down for more than 1 s, the pictures appeared rapidly on the screen, which resulted in the participant not being able to view the stimuli. A new visual stimulus was presented each time the participant pressed and released the space bar. Therefore, if the participant pressed the space bar before the visual stimulus disappeared (before the 5 s duration), a new visual stimulus appeared.

The auditory stimulus slideshow consisted of a combination of all the auditory stimuli from all the sets listed in Table 2. The slideshow was set to repeatedly present the slides and was accessible throughout the assessment condition. For the auditory stimulus slideshow, no visual stimuli were displayed and the screen on the laptop was black. When the space bar was pressed, only the experimenter's pre-recorded voice saying a spoken word was presented. To hear the next spoken word, the participant had to press and release the space bar again. Similar to the visual stimulus slideshow, if the participant held the space bar down for longer than 1 s, the spoken auditory stimulus was not presented.

Prior to beginning the assessment, we modeled and showed the participant how to use both PowerPoint® slideshows. The participant was also shown the toys and books that were available. A child-sized chair was placed in the center of the room. The participant was told that he or she could sit and move his chair to the station or desk of his or her choice. An experimenter stood in the doorway of the room to observe. An arbitrary criterion of 70 % response allocation to either visual or auditory stimuli for

two of the three assessment sessions was taken to indicate that these stimuli functioned as conditioned reinforcers for observing.

If the participant did not select either visual stimuli, auditory stimuli, or both for at least 70 % of two of three assessment sessions, it was concluded that the stimuli did not function as conditioned reinforcers, and a stimulus pairing procedure (Greer, Becker, Saxe, and Mirabella 1985; Greer et al. 1973a, b, 2011a, b; Greer, Dorow, and Randall 1974; Longano and Greer 2006; Nuzzolo-Gomez et al. 2002; Tsai and Greer 2006) was implemented to condition either visual or spoken auditory stimuli as reinforcers.

The data suggested that for participant R, visual stimuli functioned as a conditioned reinforcer. He selected visual stimuli for 91.7 % of the first assessment session and 83.4 % of the second assessment session, meeting the predetermined criterion. Participants E and T did not meet the criterion for either visual or spoken auditory stimuli. In the three pre-assessments, participant E selected visual stimuli for 8.3 % of the first and 0 % of the second and third assessments. He selected spoken auditory stimuli 25, 68.3, and 51.7 % of the first, second, and third assessments, respectively. Participant T selected to observe visual stimuli for 100 % of the first assessment session and 0 % of the second and third assessment sessions. She selected spoken auditory stimuli for 0 % of the first and second assessment sessions, but selected to listen to the spoken auditory stimuli for 95 % of the third assessment session.

Independent Variable: Conditioning Visual and Spoken Auditory Stimuli as Reinforcers

We implemented two stimulus pairing procedures to condition both visual and auditory stimuli as reinforcers for the simultaneous observing responses of looking and listening. If a participant's preference assessment did not suggest that either visual or auditory stimuli had reinforcing properties (participants E and T), we paired either visual or auditory stimuli with reinforcers in phase 1 until additional preference assessments suggested a strong preference for that type of stimuli. In phase 2, we paired visual and spoken auditory stimuli with one another, working under the assumption that at least one type of stimulus already functioned as a conditioned reinforcer for each participant and, thus, could transmit its reinforcing value to the other type of stimulus. During phase 2, the participant sat at an adult-sized desk and interacted with PowerPoint® slideshows displayed on a computer.

Phase 1: Pairing Visual or Auditory Stimuli with Reinforcers Auditory stimuli were paired with reinforcers for participant E and visual stimuli were paired with reinforcers for Participant T. The stimulus pairing procedure involved the rotation of pairing and test trials. During the pairing trials, we used a classical conditioning procedure to pair reinforcing stimuli (edibles and/or tickling, pats on the back, and some vocal approvals such as hooray, wow, oh, nice, great) with the presentation of the visual or spoken auditory stimuli and the corresponding observing response (looking at the visual stimuli or hearing the auditory stimuli). The visual and auditory slideshows used in this phase were the same visual stimulus or auditory stimuli slideshows used during the assessment conditions. Slideshows were set to repeat and continued for the duration of the pair/test sessions. The number of stimuli and slides presented varied depending on total duration of each pair/test session. Pairing trials began when the participant was appropriately using the equipment and slideshow. Reinforcers were delivered to the participant two to three times during the pair trial with the targeted

stimuli. If the participant observed the targeted stimuli presented on the slideshow appropriately for the entire pairing trial, a test trial was implemented. If not, we redirected the participant to observe the slideshow once again and restarted the pairing trial and again paired reinforcers with the targeted stimuli and corresponding observing response. A pairing trial was only considered complete when the participant observed the target stimuli for the set duration of the pair trial, which was then followed by the test trial. We observed the participant during the test trial to determine if the participant continued to observe the targeted stimuli in the absence of reinforcer delivery. The duration of pair/test intervals, the duration for which pair and test trials were presented, was set at 5 s in the first phase. A pair/test session was completed after 20 test trials were conducted. A predetermined criterion was set for 90 % observing behavior during 100 % of test trials for two consecutive sessions. When this criterion was met, we repeated the preference assessment for visual and auditory stimuli using the same materials and presented in the same fashion as the initial preference assessments. If the assessment did not suggest a preference for the targeted stimuli, we returned to the stimulus pairing procedure and increased the duration of the pair/test intervals by 5 s. Participant E met the criterion for preference for auditory stimuli after two phases of the pair/test procedure, following which he interacted with auditory stimuli 60, 80, and 72 % of the time in three consecutive preference assessment sessions. Participant T met the criterion for preference for visual stimuli after one phase of the pairing procedure, following which she interacted with visual stimuli 90 and 100 % of the time in two consecutive preference assessment sessions.

Phase 2: Pairing Visual Stimuli with Auditory Stimuli Both auditory and visual stimuli were presented together in this phase, using the different paired stimulus slideshows (see Table 2) in which visual and auditory stimuli were presented simultaneously. Upon pressing the space bar, a visual stimulus appeared and moved around the computer screen, and at the same time, a pre-recorded voice saying the spoken word for the picture was presented. If the participant was not observing or looking at the visual stimuli, we prompted him or her to look at the computer screen. If the participant did not press the space bar to view the next presentation of stimuli, a verbal prompt to do so was provided (“press the button”). Also, when the participant did not press the space bar correctly or appropriately, the slideshow was restarted and the last presented stimuli were represented. Set 1 was first used for each participant. In each session, the four stimuli in the set were presented five times each (four stimuli per slide for total of five slides). Subsequent sets (set 2, 3, or 4) were used if the participant did not pass tests for naming. During the slideshow sessions, we prompted the participant to attend to or use the equipment properly one to two times per session when necessary. Intermittent reinforcement, in the form of vocal praise, was delivered for appropriate observing behavior and manipulation of the space bar to view the slideshow. Instances of echoic behavior were recorded, but reinforcement was not delivered contingent upon echoic behavior. For participant E, for whom auditory stimuli had been conditioned as reinforcers in phase 1, prompts were not effective in increasing looking at the visual stimuli, and therefore, a training procedure was implemented prior to pairing with the third stimulus set.

Each pairing session consisted of five presentations of each of the four stimuli in one stimulus set (i.e., a total of 20 trials). No test trials were conducted in this phase; however, each pairing session was followed by a tact probe (see below) and performance

in these probes determined for how long pairing sessions with that stimulus set continued. Mastery in tact probes was followed by tests for naming under JAC and IC with set 1a and Set 1b. If the participant did not demonstrate naming in these probes, additional pairing sessions were conducted with a new stimulus set from Table 2.

Tact Probes

Following each session of pairing auditory and visual stimuli, we presented the participant with a block of 20 opportunities to tact the visual stimuli used in the pairing session (five trials per each of four stimuli). Each tact probe began with the presentation of a flashcard containing a visual stimulus from the paired stimulus slideshow. Correct tacts were defined in the same manner as in tests for naming. No consequences were delivered for correct or incorrect responses. The criterion for tact mastery was 100 % accuracy in a single 20-trial probe session. If this criterion was not met in one session, the participant returned to pairing of auditory and visual stimuli for that set of stimuli, followed by another tact probe session. When the mastery criterion was met, naming was tested under the JAC and IC.

Data Collection and Interobserver Agreement

Primary Dependent Measure

The primary dependent measure was the occurrence of untaught listener and speaker responses (tacts and intraverbal tacts) during pre- and posttests for naming. Correct listener responses were defined as the participant pointing to or selecting a target item from an array of two stimuli (the target item and a negative comparison) given the vocal antecedent “Point to the [name of target item].” If the participant pointed to an incorrect item or did not respond within 3 to 5 s of the presentation of the antecedent, an incorrect response was recorded. A correct tact or intraverbal tact response was recorded if the participant said the spoken name of the object presented, either in the presence (intraverbal tact) or the absence (tact) of the vocal antecedent “What is this?”. Any other response or no response was recorded as an incorrect response.

Matching instruction was presented prior to tests for naming under JAC. A correct matching response was defined as placing a sample item next to or on top of an identical comparison within a field of two stimuli. An incorrect response was defined as placing the sample item anywhere other than on the identical comparison or no response.

Interobserver agreement (IOA) was assessed for 82 % of naming pre- and posttests by a second trained independent observer. Point-by-point agreement was calculated by dividing the number of agreements by the total number of opportunities, and multiplying by 100. For participant E, mean agreement was 99.6 % (range of 95–100 %) across tests. Interobserver agreement ranged from 90 to 100 % with a mean of 99.5 % for participant T across tests and from 90 to 100 % with a mean of 99.2 % for participant R across tests.

Additional Measures

During the preference assessments, 5-s partial interval recording was used to measure the selection of stimuli and the corresponding observing responses (for example, if a

child picked up a book and emitted the observing response of looking at the book), and 5-s whole interval recording was used to measure the participants' appropriate use of the equipment and observing of the stimuli. Selection of stimuli was defined as the object or item the child was touching and looking at, or the object the child was interacting with. The use and observing of the PowerPoint® slideshows was considered correct if the participant pressed and released the space bar, observed the stimuli (for visual stimuli, tracking the pictures with eye movements that followed the picture's movement around the computer screen; for auditory stimuli, the presentation of the sound for the total duration of each auditory stimulus), and pressing and releasing the space bar again to access the next stimulus. Appropriate use and observing of other stimuli (toys, books, or blocks) during the preference assessments was recorded if the participant used the items as they were intended to be used (playing with the toys, looking at books, pointing to the pictures in the books, textually responding to words in the books, building with the blocks, disassembling block structures, taking blocks from the bins, and putting blocks away). Incorrect responses and observing of these items were recorded if the participant banged the items on the desk, threw the items, pushed items off desk onto floor, and other such behaviors. Instances of stereotypy (nonfunctional repetitive movements) in conjunction with the selection of an item or in isolation without selecting an item also resulted in the scoring of incorrect responses and observing. IOA was assessed for 50 % of the assessment sessions for participant E and ranged from 92 to 100 % with a mean of 95.8 %. For participant T, IOA was assessed for 80 % of the assessment sessions and was always 100 %. IOA was assessed for 100 % of the assessment sessions for participant R and ranged from 92 to 100 % with a mean of 96 % agreement calculated.

Observing behaviors corresponding to visual or auditory stimuli were measured during the implementation of the independent variable. Correct responses for slideshow use were the same as described above with the exception that all other responses were considered incorrect, as was no response. During the pairing phases, participants were only presented with slideshows, and no other stimuli were presented for the participants to choose. In phase 1, a second independent observer recorded data for 33 % of all sessions for participants E and T. Interobserver agreement was 100 %. In phase 2, data were recorded on observing behavior (defined as previously described) and instances of echoic behavior. Echoic behavior was recorded if after hearing the spoken word for the picture presented during the pairing procedure, the participant immediately vocalized the same word. Following each session of phase 2, we conducted tact acquisition probes. A correct tact was defined using the same definition as described above. Across pairing sessions for the three participants, a second independent observer recorded data for 41.5 % of phase 1 sessions and for the tact acquisition probes. In all sessions, 100 % interobserver agreement was recorded for echoic behavior, observing behavior, and tacts.

Results

Tests for Naming Under JAC and IC

Figures 2 and 3 show data from naming test sessions in the JAC and the IC, respectively. One pretest was conducted for participant E in each condition using test stimuli: set 1a in JAC and set 1b in IC. His number of correct responses in listener, tact,

Fig. 2 The number of correct untaught listener, tact, and intraverbal responses emitted during tests for naming under JAC across participants

and intraverbal tact trials, respectively, was 14, 5, and 5, in the JAC and 9, 3, and 3 in the IC. Table 4 shows the number of pairing sessions that were conducted with each set of pairing stimuli. Following training with the first two sets of pairing stimuli, participant E failed naming posttests in both JAC and IC. Following training with the third set, participant E passed the naming test in IC, with 20, 19, and 20 correct listener, tact, and intraverbal responses, respectively. However, he continued to fail in JAC. Participant E was next tested with novel naming test stimuli: set 2a in JAC and set 2b in IC. In JAC, he passed the test with 20, 19, and 20 correct listener, tact, and intraverbal responses, respectively, but he did not show passing performance with set 2b in IC. After exposure to pairing sessions with a fourth set of pairing stimuli, participant E was retested with the set 1a test stimuli in JAC and with the set 2b test stimuli in IC. He did not show passing performance in the speaker responses but clearly showed an effect, with 18 correct listener, 14 tact, and 17 intraverbal tact responses in JAC, and 20, 17, and 16 correct responses in the respective trials in IC. Although he did not emit 80 % accuracy for the tact responding under JAC, his overall performance across listener and speaker behavior met the 80 % criterion, which we also considered a passing performance.

Fig. 3 The number of correct responses for taught listener, tact, and intraverbals emitted during tests of naming under natural incident condition across participants

Table 4 Mean echoic responses recorded during the pairing of visual and spoken auditory stimuli per session and number of pairing opportunities

Participant	Set of stimuli	No. of pairing sessions	Pairings to criterion for tact acquisition per set	Mean number of echoic responses per session
Participant E	1	4	80	0
	2	9	180	4.8
	3	8	160	2.75
	4	12	240	10.75
Participant T	1	21	420	5.8
	2	7	140	6.1
	3	9	180	13.4
Participant R	1	14	280	11.2
	2	10	200	12.8

Two pretests were conducted for participant T in each condition with set 1a and set 1b, with the second set of tests occurring after the first posttests for participant E. In the first pretests, her number of correct listener, tact, and intraverbal responses was 19, 1, and 1, respectively, and 13, 2, and 0 under IC. In the second pretests, she emitted 14, 0, and 1 correct responses for listener, tact, and intraverbal responses under JAC and 12, 0, and 0 correct listener, tact, and intraverbal responses under IC. Participant T failed posttests for JAC and IC after two sets of stimuli were paired. She passed the posttests following training for a third set of stimuli for JAC with 20, 20, and 20 correct listener, tact, and intraverbal tact responses, respectively. Under IC, her number of correct responses was 18, 13, and 14 for the respective trials. Table 4 shows the number of pairing sessions for each set. Posttests for naming with a novel set of stimuli (set 2a and set 2b) were then conducted. She emitted 19 correct listener and 16 correct tact and intraverbal tact responses under JAC and 19, 13, and 15 correct responses for listener, tact, and intraverbal tact responses for IC. Participant T passed posttests under JAC with the original and the novel set, but did not pass with either set under IC. However, increases in untaught listener and speaker responses were observed in posttests with the novel set.

For participant R, two pretest probes with set 1a and set 1b were conducted with the second occurring when the first posttests were conducted for participant T. On the first pretest under JAC, he had 17, 0, and 8 correct listener, tact, and intraverbal tact responses, respectively, and 10, 8, and 8 listener, tact, and intraverbal tact responses under IC. In the second pretests, participant R emitted 16, 10, and 9 correct listener, tact, and intraverbal tact responses under JAC and 11, 3, and 3 listener, tact, and intraverbal tact responses under IC. Participant R passed the posttest under JAC for set 1a after training for one set of stimuli with 19, 17, and 16 correct responses for listener, tact, and intraverbal tact responses. He did not, however, pass the posttest under IC for set 1b (see Fig. 3). We then tested for naming using novel sets of stimuli for JAC and IC. In the first posttests with the novel stimuli, participant R passed naming test under IC for set 2b with 19, 15, and 16 correct listener, tact, and intraverbal tact responses, respectively. However, he failed the test with novel stimuli under JAC. Set 2 (see Table 2) was then paired in the training condition. Following the training, posttests were conducted for the sets of stimuli he had previously failed (set 2a under JAC and set 1b under IC). He passed both posttests with 19, 17, and 17 correct listener, tact, and intraverbal tact responses with set 2a under JAC and 19, 15, and 17 correct listener, tact, and intraverbal tact responses for set 1b under IC (labeled as “Return to Set 1” in Fig. 3).

Echoic Behavior and Tact Acquisition

Table 4 shows the mean number of echoic responses per session during the pairing of visual and spoken auditory stimuli and the number of pairings each participant was exposed to before passing tact probes with each set of pairing stimuli. Four sets of visual and spoken auditory stimuli were paired for participant E. He acquired the tacts for the first set after four sessions of pairing, the second set after nine sessions, the third set after eight sessions, and the fourth set after 12 sessions. Across all sets, he was exposed to a total of 660 pairings before demonstrating naming in both JAC and IC with naming test sets 1 and 2. For the first set of stimuli, participant E did not emit any

echoic responses. The highest levels of echoic responding were recorded during the pairing of the fourth set of visual and auditory stimuli. He emitted a mean of 16.3 echoics (20 total opportunities) per pairing session (Table 4). A visual training procedure was implemented to teach participant E to look at the stimuli during pairing. This procedure was implemented prior to pairing with the third set of visual and auditory stimuli.

Three sets of visual and auditory stimuli were paired for participant T. For the first set of stimuli, she acquired tacts after 21 sessions. She acquired the tacts for the second set of stimuli after seven sessions and acquired tacts for the third set of stimuli after nine sessions. A total number of 710 pairing opportunities were presented for the acquisition of naming for pasta set 1 and pasta set 2 under JAC. Participant T emitted a mean of 5.8, 6.1, and 13.4 echoic responses for the first, second, and third sets of stimuli, respectively (Table 4).

Participant R acquired naming after two sets of visual and auditory stimuli were paired. He emitted high levels of echoic behavior during the conditioning procedure for both sets of visual and auditory stimuli (mean of 11.3 for set 1 and mean of 12.8 for set 2). A total of 480 pairing opportunities were presented before the acquisition of naming under JAC and IC for sets 1 and 2 (Table 4).

General Discussion

The conditioning intervention was sufficient to result in the emergence of naming. All three participants required pairing of visual and auditory stimuli with more than one set of stimuli to acquire full naming under both JAC and IC. We hypothesize that the history of such pairings occasions the joining of listener and speaker behavior as a function of echoic behavior and that naming can emerge only when both types of stimuli acquire reinforcing properties and occasion observing responses for both. Interestingly, in the final pairing sets for both participants T and E, we observed a large increase in echoic behavior during the pairing procedure compared to previous sets. This finding supports Horne and Lowe's (1996) theory of the role echoic behavior plays in the acquisition of naming, as well as our proposal that echoic behavior can function to join listener and speaker repertoires only when both visual and auditory stimuli reinforce the observing responses of looking and listening. Thus, naming may be controlled by multiple conditioned reinforcers for observing responses. Horne and Lowe describe a history of social reinforcement for echoic behavior. It is possible that this history of reinforcement for echoic behavior functions to condition visual and auditory stimuli as reinforcers that reinforce the observing responses of looking and listening, which appear to be necessary for the joining of listener and speaker behavior and the naming relation.

Our data may also suggest that acquisition of conditioned reinforcers for both visual and auditory stimuli provides the foundation for the naming capability. We propose that visual and auditory stimuli may have reinforcing properties separately, but for naming to emerge, the two types of stimuli must simultaneously act to select out the observing responses of looking and listening. We do not suggest that multiple exemplar instruction and experiences are unnecessary for naming, but rather, that without visual (or other sensory stimuli) and auditory stimuli functioning as reinforcers, the joining of

listener and speaker repertoires may not be possible. Alternatively, multiple exemplar experiences, auditory matching, or intensive tact instruction may set the occasion for the conditioning of visual and auditory stimuli as reinforcers, resulting in the emergence of naming. As mentioned previously, Choi and Greer (2012, submitted for publication) found that spoken auditory stimuli were conditioned as reinforcers as a function of the auditory-matching procedure. Also, in a pilot study, we implemented the pairing procedure to condition spoken auditory and visual stimuli, for a participant who had been exposed to MEI but did not acquire naming as a function of MEI. He did, however, acquire naming following the pairing procedure, supporting our hypothesis that the conditions for naming were not present until those stimuli (visual and auditory) functioned as reinforcers and selected out the observing responses of looking and listening.

Higher levels of correct responses for untaught listener behaviors than speaker responses were recorded prior to the conditioning of visual and spoken auditory stimuli. Do these data suggest that conditioned reinforcement for observing responses does not play a role in listener half of naming? We do not believe so, because the observing responses for the listener half of naming, observing the visual and auditory stimuli, are the same that are necessary for full naming. The participants emitted higher levels of correct untaught listener responses under the JAC condition compared to IC, which was arranged to set the occasion for joint attention to visual and auditory stimuli, which may have resulted in the higher level of responding for untaught listener responses prior to conditioning. Also, under the JAC condition, participants had more opportunities to see and hear the names of the stimuli during match instruction. Participants were exposed to at least 40 matching instructional trials (each stimulus presented 10 times), whereas under IC, the participants only heard the name of the stimuli 20 times (5 five presentations of each stimulus). We hypothesize that untaught speaker responses did not emerge prior to the conditioning experience because speaker and listener responses were not joined as a function of echoic behavior.

According to the verbal behavior developmental theory (Greer and Keohane 2005; Greer and Longano 2010; Greer and Ross 2008; Greer and Speckman 2009), conditioning of spoken auditory stimuli as reinforcers begins to take place even before a child is born and continues to take place after the child is born (DeCasper and Spence 1986; DeCasper et al. 1994; Rheingold et al. 1959; Spence and DeCasper 1987). Potential pairings occur in utero and after birth with the pairing of the mother's voice with feeding. The mother's voice becomes a potent conditioned reinforcer, which is first paired with her face, and then, as the child grows, with other visual stimuli (Greer and Ross 2008). The mother's voice occasions observing as a listener and as a visual observer. When the child repeats the phonemic sounds that the mother has said, automatic reinforcement occurs. At this point, the repetition, or what Skinner (1957) referred to as parroting, is automatically reinforcing (Vaughan and Michael 1982). Once the parroting contacts the verbal community, it acquires the echoic function and can later lead to independent mands and tacts (Sundberg et al. 1996; Tsiouri and Greer 2003/2007; Yoon and Bennett 2000).

It has been suggested that the emission of a tact by a caregiver while the caregiver and a child are attending to the same stimuli occasions the child's emission of an overt echoic initially (Horne and Lowe 1996). We propose that the repetition of the spoken word, the overt echoic, initially is a function of the conditioned reinforcement value of

voices, as the child can simply provide his/her own reinforcement by repeating the word sounds. When words occur in conjunction with stimuli that are also visual reinforcers for looking, the initial conditions for naming are present. Thus, a child with naming will attend to visual stimuli (Greer and Han 2014; Greer et al. 2011a, b), a caretaker's words, and the repetition of the words paired with the visual stimuli, allow for the joining of the listener and speaker repertoires. We suspect that Horne and Lowe's (1996) suggestion about the role of the echoic is accurate; however, the auditory stimulus (either the caregiver's or the child's own voice) that elicits an echoic may not function as a conditioned reinforcer for all children. Moreover, attention to the stimuli that the caregiver is tacting may also be absent, perhaps due to failure of visual stimuli to reinforce looking. Whether it is as a function of classical conditioning, as we propose, or operant conditioning procedures, both visual and auditory stimuli have reinforcing properties that, according to our hypothesis, allow for the naming relation to emerge. Our data suggest that both types of reinforcement can be conditioned for children like those we studied, resulting in the onset of naming if the effect of the procedure holds up across further replications.

Several limitations should be noted. First, the experiment involved only three participants. Thus, additional replications are needed within our laboratory and replications from other laboratories. Second, the procedures we used for determining "preference" or conditioned reinforcement for observing responses was complex and computer software to present the stimuli should be developed such that a single computer can be used rather than two computers. However, we believe the series of assessments that were utilized provided valid data to determine if spoken auditory or visual stimuli acquired relative reinforcing properties as a function of the stimulus-stimulus pairing procedure in that moment in time under those specific conditions. Given several choices, we observed which stimuli the participants selected to engage with and inferred that a high allocation of session time to a particular type of stimulus indicated a reinforcement function. Participants had the opportunity of choosing both visual and auditory stimuli simultaneously during the preference assessments, but only if they pressed the two separate slideshows simultaneously. In future studies, an assessment to test for conditioned reinforcers for observing responses following the independent variable would be useful to show if the second phase of the intervention did truly condition both visual and auditory stimuli as reinforcers and when both acquired reinforcing properties in relation to the acquisition of naming.

A third limitation is that by conditioning auditory rather than visual stimuli for participant E, prompts for observing the visual stimuli were delivered in phase 2 of the intervention. After two sets of auditory and visual stimuli were paired without the participant passing naming tests, we identified the problem as a lack of observing visual stimuli and implemented a training procedure to teach attending to visual stimuli. Following training, he did not require prompting during the pairing procedure.

From an applied perspective, the development of tools to induce the naming cusp and capability is a critical advance toward providing children with language delays the wherewithal to learn verbal behavior incidentally. Naming also appears to predict success in inclusion instruction for some children (Corwin and Greer 2014; Greer et al. 2011a, b). From the point of view of a basic science of verbal behavior and language development, the identification of environmental histories that lead to learning the words for things incidentally provides still additional evidence of the role of

ontogeny interacting with phylogeny in how humans acquire language. One might also argue that it suggests why they do so, possibly as a function of culturally learned reinforcement functions.

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