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WHEN THINGS ARE NOT THE SAME: A REVIEW OF RESEARCH INTO RELATIONS OF DIFFERENCE

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Responding to stimuli as same and different can be considered a critical component of a variety of language and academic repertoires. Whereas responding to "sameness" and generalized identity matching (i.e., coordination) have been studied extensively, there appears to be a significant gap in behavior analytic research and educational programs with regard to nonmatching relations or relations of difference. We review research on difference relations from a variety of domains, including comparative psychology, as well as experimental, and translational behavior analysis. We examine a range of studies, including research on the perception of difference and oddity responding, as well as investigations on establishing relational frames of distinction. We present suggestions for future research and describe potential methods for teaching skills related to relations of difference.

Key words: frame of distinction, same/different, relational frame theory, autism, difference

One of these things is not like the others,
One of these things just doesn't belong.
Can you tell which thing is not like the others
By the time I finish my song? —Sesame Street (Raposo, Stone & Hart, 1970, track A7)

Behavior analysts charged with developing individualized intervention programs for clients with developmental disabilities, including autism spectrum disorders (ASD), have long relied on the concept of behavioral cusps (Bosch & Fuqua, 2001; Rosales-Ruiz & Baer, 1997). A behavioral cusp has been defined as any behavior change that allows an organism to come into contact with new contingencies that have broad and significant effects with respect to establishing and maintaining other new behaviors (Rosales-Ruiz & Baer, 1997). One such behavior change occurs when individuals learn to make generalized same/different judgments (McIlvane et al., 2011).

Identifying stimuli as being different from one another is considered by cognitive, developmental, comparative, and educational psychologists to be fundamental to cognition (e.g., Addyman & Mareschal, 2010; Thompson & Oden, 1995). Using abstract language concepts, particularly those of "sameness" or "difference," to classify the relations among objects and events has been described as being the "hallmark of human intelligence" (Blaisdell & Cook, 2005), the "very keel and background of our thinking" (James, 1981/1890, p 434). One of the main lines of research in comparative psychology for decades has been to determine whether nonhuman subjects are capable of same/different responding, long considered to be evidence of "conceptually-mediated" behavior (e.g., Nissen, Blum, & Blum, 1948). Finally, within educational psychology, identifying similarities and differences between stimuli or concepts has been highlighted as having a particularly powerful impact on student achievement (Marzano, Pickering, & Pollock, 2001).

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Same/different responding features prominently in academic curricula. At the preschool level, important milestones for 48-month-old children include showing interest in how people are the same and different, and describing simple relations between objects such as pointing to pictures of two different animals and saying that they are "different" (e.g., see California Department of Education, 2008). At 60 months, preschoolers are expected to describe differences between items based on informational text, such as by "communicat[ing] important differences of jet airplanes and propeller planes after being read a story about airplanes and airports" (California Department of Education, 2008, p. 68). Marzano, Pickering, & Pollock (2001) noted that identifying similarities and differences is the foundation of numerous effective instructional activities at all academic levels and across subjects involving comparing, classifying, and creating metaphors and analogies. Identification of similarities and differences, including comparing/contrasting, are also clearly recognized academic standards across multiple grades and subjects within the widely adopted Common Core curriculum (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

In light of the emphasis on both sameness and difference within the broad educational literature, it is somewhat surprising that there is relatively little explicit emphasis on teaching *differences* (as opposed to sameness) in behavior analytic intervention programs for children with autism and other developmental disabilities. Programs based on an analysis of verbal behavior (e.g., Partington, 2006; Sundberg, 2008) place little to no emphasis on identifying differences, considering it to be too complex for early language intervention programs (e.g., autoclitics, see Sundberg, 2004). A more recent curriculum (Promoting the Emergence of Advanced Knowledge [PEAK]; Dixon, 2014a, 2014b, 2015) includes some potentially relevant lessons such as selecting an item that does not belong from an array of otherwise identical items and picking out objects that do not share a feature, function, or class with a named object. However, this is still a relatively limited sampling of difference responding. More traditional programs often include some lessons on difference (e.g., Center for Autism and Related Disorders, 2013; Leaf & McEachin, 1999; Maurice, Green, & Luce, 1996), which vary in comprehensiveness. The most detailed includes a number of lessons sequenced from matching same/different through identifying items as being the same or different and identifying how two presented items are the same or different (i.e., in terms of their attributes or categories; Center for Autism and Related Disorders, 2013). However, even these programs provide a relatively limited task analysis of training procedures, given the potential range from very simple to very complex same/different skills.

The emphasis on relations of sameness within the behavior analytic basic and applied literature (e.g., Dube, McIlvane & Green, 1992; Leaf & McEachin, 1999; Lovaas, 2003; Serna, Dube & McIlvane, 1997) may suggest that when teaching "same," we are inherently also teaching "different," as the two concepts cannot exist except in contrast to one another (i.e., if something is not same, it is necessarily different, and vice versa). However, there are a number of reasons why focusing on relations of difference is important. First, although it might seem logical to assume that if a person responds to same, then they also respond to different, empirical evidence suggests that this is not the case. As we will discuss further, research with individuals with developmental disabilities has shown that individuals who respond accurately during identity matching tasks may not necessarily respond accurately during oddity matching (e.g., selecting a comparison different from a sample), and vice versa (e.g., Mackay, Soraci, Carlin, Dennis & Strawbridge, 2002; Soraci et al., 1987). A similar argument can be made in response to the suggestion that teaching other types of relations (e.g., comparison) might implicitly teach relations of difference by virtue of the fact that a difference along any relational dimension (e.g., being more than something) automatically implies a difference in absolute terms. Although the latter might be true in a logical sense, this does not imply that it would be true at the psychological or behavioral level. Responding in accordance with relations of difference is a particular pattern of behavior that likely requires specific contingencies for its development (e.g., see Hayes, Fox, et al., 2001).

Second, explicitly training the relation of difference as a contrast to sameness necessitates the use of discriminative (or discriminative-like) control in order to differentiate the two. The teacher must use cues such as "same" (or "match") and "different" (or "not same") to differentiate the tasks. Use of discriminative control such as this means not only that the student is learning a new relation, but also that by switching between the two cues, his or her behavior can come under discriminative control of more than one relation within the same task. Establishing such control is also necessary for responding to same versus different along alternative physical dimensions (shape, color, size etc.) as well as for responding in accordance with patterns of abstract sameness and difference unsupported by physical features. Both of these skills are prerequisites for categorization (e.g., responding to category-related questions such as, "How is a dog like a cat?" or, "How is a cow different from a bird?"). Hence, by bringing behavior under the control of cues for same and different at an early age we are establishing a foundation for critically important repertoires.

No published behavior analytic programs describe a comprehensive and conceptually systematic curriculum for teaching same/different skills. This may be because responding to differences has been viewed as a variety of distinct types of skills (e.g., visual performance, listener responses, complex conditional discriminations, autoclitic tacts, multiply controlled intraverbal responding). We argue that a relatively coherent methodology may be provided by approaching responding to similarities or differences between events fundamentally as a form of *relational* responding. We suggest that taking this view leads to conceptually systematic curriculum development.

RELATIONAL RESPONDING

Relational responding involves responding to one stimulus in terms of another (e.g., Hayes, Fox et al., 2001; Stewart & McElwee, 2009). Identity matching is an example of relational responding, as is tacting an item as being bigger or smaller than another. In these examples, the response is generalized and based on the relation between items (i.e., identity and bigger/smaller, respectively) rather than any specifically taught conditional discrimination. Furthermore, such responding is often under the control of a specific discriminative (or discriminative-like) stimulus (i.e., contextual cue[1]). For example, in the case of a difference relation, one might be asked to "Pick up some takeout dinner on the way home from work, but get something *different* from last time — I'm tired of Thai food." Based on the inclusion of the cue "different," this request would likely evoke the selection of takeout dinner that is other than Thai food, whether or not that particular selection had been tried before. Social contingencies might further

[1]In this paper, we will be adopting a Relational Frame Theory (RFT) framework for our discussion of relevant research. With regard to the label for a stimulus that controls the type of relational response (e.g., same vs. different vs. comparative, etc.), RFT uses the term *contextual cue* rather than *discriminative stimulus* because the latter term refers to stimuli that acquire their functions through direct training only whereas RFT wishes to refer to stimuli that acquire functions not just through this means but also through derived relations; hence a distinct technical term is used. As such, in this paper we will use *contextual cue* in this situation from here onwards.

condition responding; for example, delivery of Thai food might result in criticism and an argument, whereas delivery of something other than Thai food might be met with approval.

Relational Frame Theory (RFT; Dymond & Roche, 2013; Hayes, Barnes-Holmes, & Roche, 2001) provides a useful foundation for analyzing research into the emergence and development of difference relations, and thus we will use it as a framework in our review. One key distinction is that between nonarbitrary and arbitrary relations.

Arbitrary versus Nonarbitrary Relations

There are two fundamentally different types of relational responding: *nonarbitrary* and *arbitrary* (or *arbitrarily applicable*). Nonarbitrary relational responding is based on physical characteristics of stimuli. An example of nonarbitrary sameness responding would be selecting a triangle as the comparison in the presence of a triangle as the sample (i.e., identity matching). Another example would involve selecting an item that is physically different from a sample (i.e., oddity matching). The type of response (selecting same or different) required in a given circumstance may be determined by the contextual cue, such as the words *same* or *different* (as in, "Select same."). However, despite the fact that contextual control can determine which physical relation is appropriate, nonarbitrary relational responding is always based to at least some extent on the physical characteristics (e.g., color, shape, etc.) of the stimuli being related.

In the case of arbitrary (or arbitrarily applicable) relational responding, by contrast, physical features of the stimuli being related are no longer a defining feature. It is the contextual control that determines the relational response. Stimulus equivalence provides an example of this for a relation of arbitrary sameness (e.g., McLay, Sutherland, Church, & Tyler-Merrick, 2013; O'Donnell & Saunders, 2003; Rehfeldt, 2011; Sidman, 1971, 2009). For example, if a child is told that the sound *lemur* (A) is the name of the animal in the picture (B) and also that the written name for *lemur* is the textual stimulus *lemur* (C), she may then respond as if the three stimuli A, B and C were substitutable or equivalent, despite the fact that they are not physically similar. This pattern might be cued by words such as *is*, *called*, or *name of*, as well as by more subtle cues such as the use of a matching-to-sample (MTS) procedure (which has been employed to study this pattern in the laboratory). In other words, these features of the context are what determine the relational response, not the topography of the stimuli being related. Arbitrary relational responding in accordance with difference involves responding to two stimuli under the control of a cue for a pattern of distinction. For example, when discussing with one child how other children in her class compare and contrast in terms of their likes and dislikes, she or he might learn that Johnny likes the same food as Susie, but different food from Alan. In such a case, despite there being no immediately physically obvious same or different dimensions of the individuals being related, the child may identify that Susie and Alan like different food from each other (Dymond & Roche, 2013). In this case, again, cues such as the words *same* and *different*, which are used to compare the preferences of Johnny and Susie and of Johnny and Alan, respectively serve as the determinant for the response.

In the next sections, we will consider both nonarbitrary and arbitrary difference relations as investigated from a number of different theoretical perspectives. We will describe a sample of the available literature, with the intent to provide a logically and conceptually systematic organization to stimulate applied research. Towards this end, a variety of search terms were used (e.g., identity and nonidentity matching, oddity, difference responding, distinction, same-different responding), which were assembled organically[2] over the course of the project rather than beginning with a predefined set of search terms and methods.

A variety of terms for specific response forms relevant to difference relations were identified, depending upon theoretical orientation. For consistency, we have chosen to use a specific set of terms, as follows (also see Miguel et al., 2015): We will use the term *relational matching* to describe pair matching on the basis of the relation exemplified by the pairs involved (e.g., matching AB [different] with XY [different] rather than ZZ [same]). We will term the selection of comparison stimuli in a MTS format, under the control of a specific relational cue (such as, "Find different.") as *relational listener discriminations*. Finally, we will term production or selection of the name of a relation (e.g., "different") in response to two stimuli in a pair (e.g., two physically dissimilar stimuli) as *relational tacting*, whether the response is topographical (such as saying "different") or selection-based (such as selecting the textual stimulus *different*).

As noted, we will structure this review around core elements of relational responding as identified by RFT. We will thus begin with early nonarbitrary relational responding and proceed to arbitrary (arbitrarily applicable) relational responding. As we do so, we will provide recommendations for future applied research, as well as clinical practice (when there is sufficient basis in the literature to do so).

NONARBITRARY RELATIONAL RESPONDING

Nonarbitrary same/different relational responding has been studied in the comparative psychology literature with a variety of species, and early types of nonarbitrary relational responding—identity and oddity—have also been well studied with humans (e.g., Mackay et al., 2002; Serna et al., 1997; Soraci, Carlin & Bray, 1992; Soraci et al., 1987). As noted above, nonarbitrary relational responding in accordance with a relation of sameness or distinction can include matching pairs of stimuli (e.g., matching two cows to two dogs rather than to a cat and horse; relational matching); selecting an item that is the same as, or different from a sample (relational listener discriminations); or producing/selecting the name of a relation in response to items either physically different or the same as each other (relational tacting). Furthermore, the experimental literature would suggest that prior to acquiring any of these repertoires, organisms must first demonstrate responses relevant to perception of difference relations (such as orienting towards stimuli that are different from those previously seen) and learn to discriminate different stimuli based on a history of training rather than based on contextual cues (i.e., oddity matching).

The literature related to responding to nonarbitrary relations of difference includes: a) perception of sameness/difference and nonarbitrary difference responding that is not controlled by a specific relational cue (oddity matching or nonmatching to sample); b) nonarbitrary relational matching; c) nonarbitrary contextually controlled relational listener discriminations; and d) nonarbitrary relational tacting.

Perceptual Responses and Oddity Matching

Visual discrimination is important for learning that involves visual stimuli; individuals must observe the relevant features of stimuli and the relations between them, presented in such a way as to differentially respond given the requirements of a particular task (Carlin, Soraci, & Strawbridge, 2003; Soraci et al., 1992). Researchers from a cognitive perspective have tested for perception of physical relations

[2]Google Scholar searches were first conducted, with related searches then conducted in PubMed, including searches for articles that cite already-identified articles as well as reviews of literature cited by already-identified articles.

of difference versus sameness among a variety of nonhuman species, as well as among human infants. For example, research has found that 7- to 8-month-old human infants, but not younger, and infant chimpanzees as young as 9 months, differentially respond to novel stimuli (i.e., those different from previously seen stimuli), as well as to matching versus nonmatching pairs of stimuli measured by how long they look at the stimulus, and by anticipatory eye movements (Addyman & Mareschal, 2010; Oden, Thompson, & Premack, 1990; Tyrrell, Stauffer, & Snowman, 1991). Such results indicate that responding to relations of sameness and difference starts to be shaped early on, and that systematic training might benefit young individuals.

One very early type of discrimination that is based on a relation of difference is oddity matching—selecting the item that is different from the others in an array. Responding on the basis of oddity relations has been trained in a variety of nonhuman species, including pigeons (e.g., Zentall, Edwards, Moore, & Hogan, 1981), corvids (e.g., Smirnova, Lazareva, & Zorina, 2000), rats (e.g., April, Bruce, & Galizio, 2011), bees (Avarguès-Weber, Dyer, Combe, & Giurfa, 2012), sea lions (e.g., Hille, Dehnhardt, & Mauck, 2006), and various primates (e.g., Davis, Leary, Stevens, & Thompson, 1967). In these studies, subjects are trained to respond to a MTS task in which selecting the comparison stimulus that is different from the sample is reinforced, and then generalization to novel stimuli is tested.

Although early research on oddity with humans seemed to indicate that responding to oddity tasks was very difficult for individuals under 4 years of age (e.g., Ellis & Sloan, 1959; House, 1964), other early researchers considered oddity to be a prerequisite for identity matching (e.g., Fellows, 1968). More recent studies, moreover, have been successful in training oddity with young children and individuals with developmental disabilities (e.g., Soraci et al., 1987). Even though several factors may influence performance at early developmental levels of functioning, some authors (Carlin et al., 2003; Soraci et al., 1992) suggest that difficulty in establishing successful oddity matching may be due to the complexity of the task requirements. For example, it may be more difficult for individuals at early developmental or chronological ages to perform correctly in an oddity task involving a small array of stimuli in which the odd stimulus is similar in some dimension or feature to the other stimuli. In addition, performance on some oddity tasks requires attending both to the oddity relation itself (i.e., responding to the difference between stimuli) and to a specific dimension along which the stimuli differ (e.g., form, color, or size). Children may have a predisposition to attend to one dimension more than another, with younger children demonstrating a dimensional preference for color, and older children for form (e.g., Suchman & Trabasso, 1966). Thus, increasing the salience of the relevant relations between stimuli (e.g., making the different stimulus more distinct, such as one elephant among many mice) and/or the relevant dimensions of stimuli could be expected to facilitate oddity (and identity) matching.

As mentioned, one general method of increasing the salience of interstimulus relations involves organizational manipulations of the array, including (a) increasing the number of nonodd stimuli and (b) increasing stimulus contiguity (see Figure 1). For example, Zentall, Hogan, Edwards, and Hearst (1980) found that increasing the number of nonodd stimuli from two to eight not only facilitated acquisition of oddity learning in pigeons, but also facilitated transfer of their performance to an array of only two nonodd and one odd stimuli. Soraci et al. (1987) found similar results with young children identified as at risk for developmental disabilities. Increasing stimulus contiguity (i.e., eliminating space between stimuli) has also been found to facilitate oddity learning with either small (e.g., three nonodd stimuli) or large (e.g., eight nonodd stimuli) arrays (Soraci et al., 1992).

Soraci et al. (1992) also described two methods of increasing the salience of the relevant dimensions (e.g., color vs. form) of the matching stimuli. The first is to assess individual dimensional preferences by using stimuli that vary in both color and form and determining which dimension is attended to in a matching task (e.g., given a red airplane as a sample, and a red car or a blue airplane as the comparisons, which comparison does the child choose?). A second method is to specifically train attending to the relevant dimension, by reinforcing identity matching on the basis of the relevant dimension (e.g., one could reinforce matching on the basis of color rather than form, such as by matching a red car and a red airplane) before testing oddity on that dimension.

Finally, Soraci, Deckner, Baumeister, and Bryant (1991) found that pairing a tone with visual stimuli during oddity tests (such as using an array consisting of several bells—with that sound—and one rattle—with its sound) facilitated oddity performance. In this study, preschool children who had previously failed oddity tasks with visual stimuli alone were able to pass using the paired stimuli, and that skill transferred to oddity tasks using novel visual stimuli alone. Using stimuli in this way might be a useful remediation for students who show difficulty with oddity responding.

By increasing the salience of the relevant variables, children with and without developmental delays have been taught to perform accurately during identity and oddity tests. Mackay et al. (2002) worked with children who had failed a test of two-choice identity matching (the cohort included individuals with developmental disabilities, as well as typically developing 3- to 4-year-old children). Participants were trained in an identity MTS task that first used a comparison array of eight incorrect comparisons (all identical to each other but different from the sample), and one correct comparison (identical to the sample, but different from the other comparisons) to guide attention

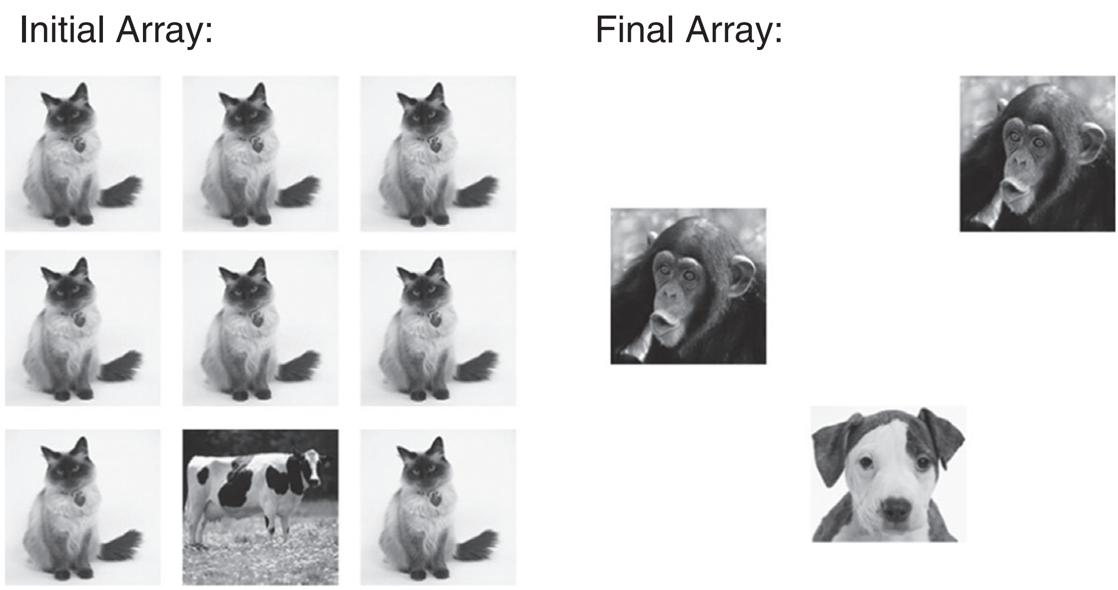

Figure 1. Types of arrays used for oddity tasks, progressing from large arrays of stimuli in close proximity to small arrays in less proximity, using MET with different stimulus sets on each trial.

to the correct comparison. Initially, the children could make a correct selection on the basis of oddity alone, within the comparison array. Over time, the size of the comparison array was gradually reduced, until the array consisted of only one correct and one incorrect comparison stimulus. Using this procedure, children with and without developmental delays passed the identity matching test which they had previously failed.

Previous work on identity matching may also serve to guide research on oddity matching (e.g., Green, 2001; McIlvane, 2009). For instance, Serna et al. (1997) described critical variables to consider when teaching individuals to respond to tasks requiring identity matching. These include whether the MTS task is nonconditional (i.e., the S+ and S- stimuli do not change across trials) or conditional (i.e., the S+ stimulus on one trial could change to be an S- stimulus on another trial). Their recommended teaching sequence is to proceed from simple discrimination to nonconditional to conditional identity matching; preverbal toddlers (16-21 months) have also been successfully trained in identity matching using this sequence (de Alcântara Gil, de Oliveira, & McIlvane, 2011). Even though this sequence has not yet been studied with oddity matching, it might be a reasonable one to further examine.

Although there is insufficient evidence to determine whether oddity and identity training should proceed simultaneously or in a particular sequence, research by Mackay et al. (2002) suggests that identity and oddity are indeed separable at the level of behavioral repertoires and thus an individual might learn one before learning the other. As such, future research might examine whether these repertoires should be trained sequentially or simultaneously.

Nonarbitrary Relational Matching

Relational matching involves selecting an item pair that exemplifies the same type of relation as a sample (see Figure 2 for examples). For instance, such tasks might require matching a pair of squares (same) to a pair of triangles (same) rather than a pair that contains both a circle and a star (different), or matching a pair containing a cow and a pig (different) to a pair containing a horse and a duck (different) rather than a pair of cats (same). This type of responding might be seen as a simple (or precursor) form of analogy, which in turn is seen as an important skill in itself as well as a measure of intellectual performance (e.g., Ortony, 1979; Sternberg 1977).

There are several decades of research into this type of relation with primates (e.g., Thompson & Oden, 1995, 2000), as well as more recent research with corvids (Smirnova, Zorina, Obozova, & Wasserman, 2015). For example, Thompson, Oden, and Boysen (1997) demonstrated that chimpanzees with a history of training to select a specific token (triangle) when shown a "same pair", and a different token (diagonal) when shown a "different pair" could match a same pair to another same pair, and a different pair to another different pair. Meanwhile, a chimpanzee without similar training did not do so. Thompson and Oden (1995, 2000) concluded that organisms must be trained to emit a relational tact in order to perform a relational match. However, more recent research indicates that some primates and pigeons can be trained to perform nonarbitrary relational matching without such a history, given sufficient training exemplars and sufficiently individualized stimulus presentations (e.g., small or large array size; Cook, Kelly & Katz, 2003; Flemming, Beran, Thompson, Kleider, & Washburn, 2008; Truppa, Piano Mortari, Garofoli, Privitera, & Visalberghi, 2011; Vonk, 2003).

To date, there appears to be little or no research on teaching nonarbitrary relational matching to humans that parallels the type of relational matching of same and different relations seen in the nonhuman literature. Most

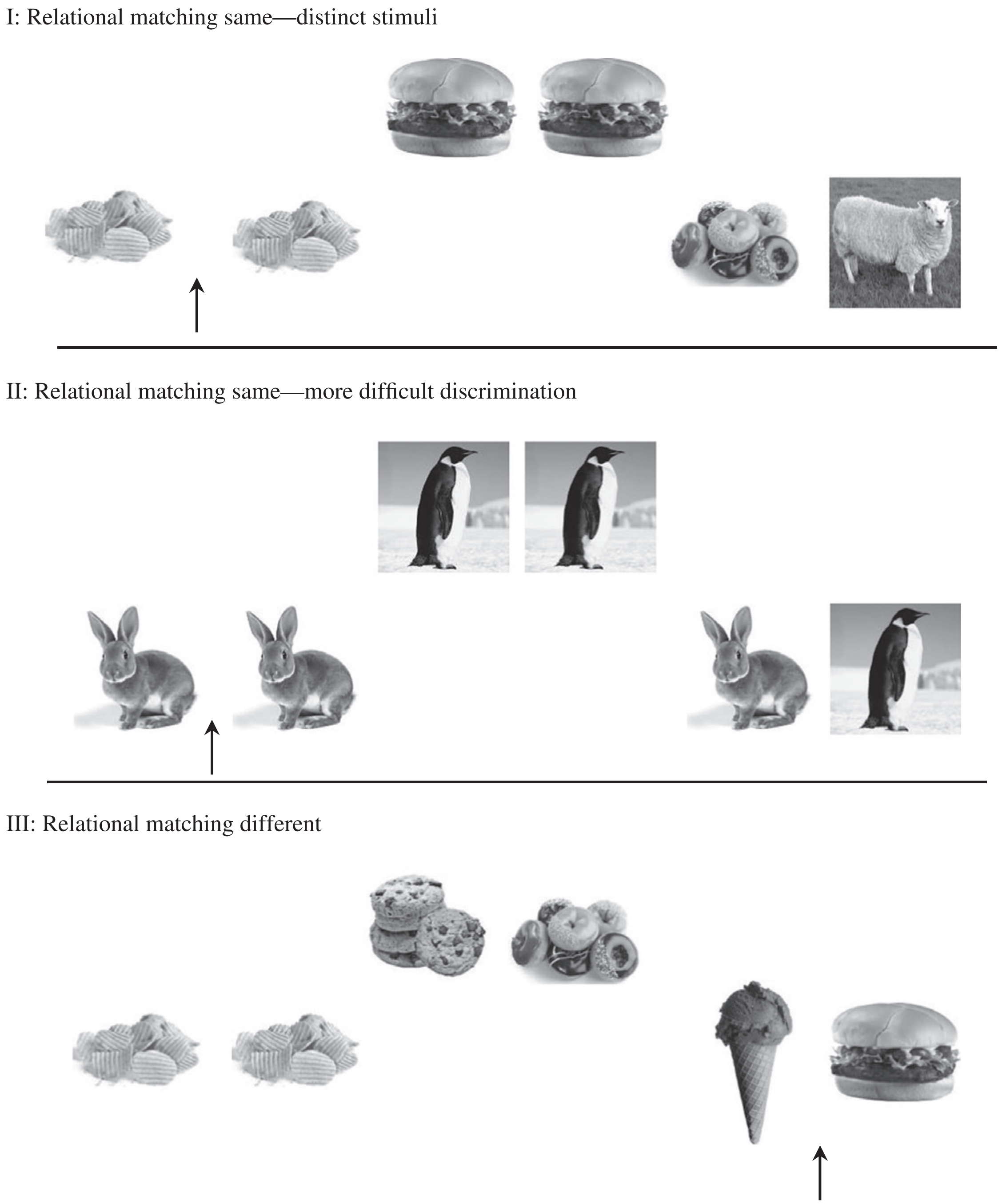

Figure 2. Examples of nonarbitrary relational matching tasks. I: Relational matching same—distinct stimuli. II: Relational matching same—more difficult discrimination. III: Relational matching different.

research with humans has focused on analogy based on arbitrary relations. This seems to be a significant gap, as it would appear to be a potentially important element of a generalized repertoire of responding to differences, as well as a potentially important precursor to analogy. A number of different issues might be examined. One question concerns the stage in the typical developmental sequence at which nonarbitrary relational matching begins to be seen in children. For example, does relational matching typically precede or follow relational tacting and/or listener behavior, and might this order be changed based on targeted training? A second question concerns the best methods by which to establish and strengthen this repertoire. For instance, how might training of related repertoires such as relational tacting and/or listener training compare, or interact with multiple exemplar training (MET) of the repertoire itself as a means of establishing or strengthening this capacity? Might training involving the matching of a range of different varieties of relations be better than training involving a more limited set? How effective might the use of stimulus arrays similar to those used in establishing oddity selection (e.g., a comparison array of many same pairs and one different pair, with a different pair as sample, or vice versa) be? A further issue concerns the effect of training nonarbitrary relational matching on the emergence of arbitrary relational matching (the form of behavior to which the label "analogical reasoning" is most frequently applied) and/or other arbitrary relational (i.e., relational framing) abilities as well as on intellectual performance more generally.

Nonarbitrary Relational Listener Discriminations and Relational Tacts

Nonarbitrary relational listener discriminations require selecting a comparison under the control of relevant contextual cues—stimuli discriminative for either same or different matching responses (e.g., given a sample of a picture of a banana and the vocal or textual cue "same," selecting another picture of a banana rather than an orange, and vice versa given the vocal or textual cue "different"). This is a similar task to the previously described oddity matching tasks in that it involves the selection of a stimulus that is different from another stimulus; however, in the case of nonarbitrary listener discriminations, the response is under the specific—and changing—control of the contextual cue of either same or different. In oddity matching, the task does not change between selection of same and different—only the different item must be selected from the array. Nonarbitrary relational tacts require identifying the relation between items, either through a topographical response (e.g., emitting a vocal or sign-based response of "same" or "different" when shown two bananas vs. a banana and an orange) or selection of the appropriate relational name (e.g., selecting a text or symbol card indicating same vs. different when shown a pair of identical vs. nonidentical stimuli).

Relational tacts and listener responses involve responding to identical versus nonidentical items as the same or different, as well as responding on the basis of *how* two items might be the same or different from one another. Examples abound not only in preschool worksheets, but also in other arenas, such as training musical listening skills by requiring learners to listen to two tones and identify if they are the same or different (e.g., EarTrainingandImprov.com, 2012). The classic Sesame Street game of "One of these things is not like the others" (Raposo, Stone & Hart, 1970, track A7) is a good example of these kinds of tasks at a slightly more advanced level—that is, having to identify an item as being different from the others on the basis of features other than simple identity/oddity (see Figure 3 for examples). Examples at the early elementary level include Common Core Math standards that require students to "analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/ "corners") and other attributes (e.g., having sides of equal length)," and Common Core Literacy standards that require students to "identify basic similarities in and differences between two texts on the same topic (e.g., in illustrations, descriptions, or procedures)" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Nonarbitrary relational listener discriminations have been studied and demonstrated with a number of primate species, both in a MTS format in which either an identical or nonidentical comparison is selected (e.g., Burdyn & Thomas, 1984; Robinson, 1955; Thomas & Kerr, 1976), and in which an identical or nonidentical comparison pair is selected, depending on a cue (e.g., Flemming, Beran, & Washburn, 2007). Depending on the cue displayed (e.g., colors or patterns), selecting one or the other of the comparisons is reinforced. Such tasks might require responding on the basis of a single dimension (e.g., shape) throughout, or might require a more complex level of responding such as selecting among multidimensional stimuli for an item that is the same or different with respect to a specific dimension; for example, same color or different size (e.g., Vonk, 2003; see Figure 4 for examples).

There is also substantive data from nonhuman research that has investigated nonarbitrary same/different relational tacting. Using discrimination training and MET, a variety of species have been taught to identify pairs of items as being the same or different (e.g., Blaisdell & Cook, 2005; Flemming et al., 2007; Katz & Wright, 2006; Mercado, Killebrew, Pack, Mácha, & Herman, 2000; Pepperberg, 1987, 1988). Though required response topographies have varied (e.g., token selection, key press, paddle press), in all instances, the subjects were successfully trained to make one response in the presence of two same novel items, and another response in the presence of two different novel items. For example, Katz and Wright (2006) taught pigeons to peck an upper picture as the sample, which brought up two comparisons: another picture and a white rectangle. The pigeons were taught to peck the comparison picture if it was the same as the sample, and to peck the white rectangle if the two pictures were different.

Pepperberg (1987, 1988) trained an African Grey parrot (Alex) in several more complex tasks requiring second order same/different relational tacting. As Alex had been previously trained to identify abstract categories of color, shape, and material, these categories were used for training him to tact what properties of two items were either the same or different, or if no properties were same or different. After multiple exemplar training with various pairs of items with the questions, "What's same?" or, "What's different?" Alex correctly responded to pairs of novel objects by vocally tacting same/ different relations with respect to color, shape, material, or stated that none of the properties were the same or different.

Relevant to relational tacting of same/different, Serna et al. (1997) described research on developing nonvocal procedures for humans that are very similar to some of the procedures used with nonhuman subjects as described above. A "blank comparison" procedure allows nonvocal individuals to identify (i.e., tact) whether or not a comparison is the same as the sample. With these procedures, an individual can be taught to press a matching comparison if it is the same as (or similar to) the sample, and to press a blank comparison if not.

Training nonarbitrary relational listener and tacting skills with humans could reasonably be guided by procedures used in the nonhuman literature in addition to procedures commonly used in language intervention programs for other types of tacts and listener behaviors

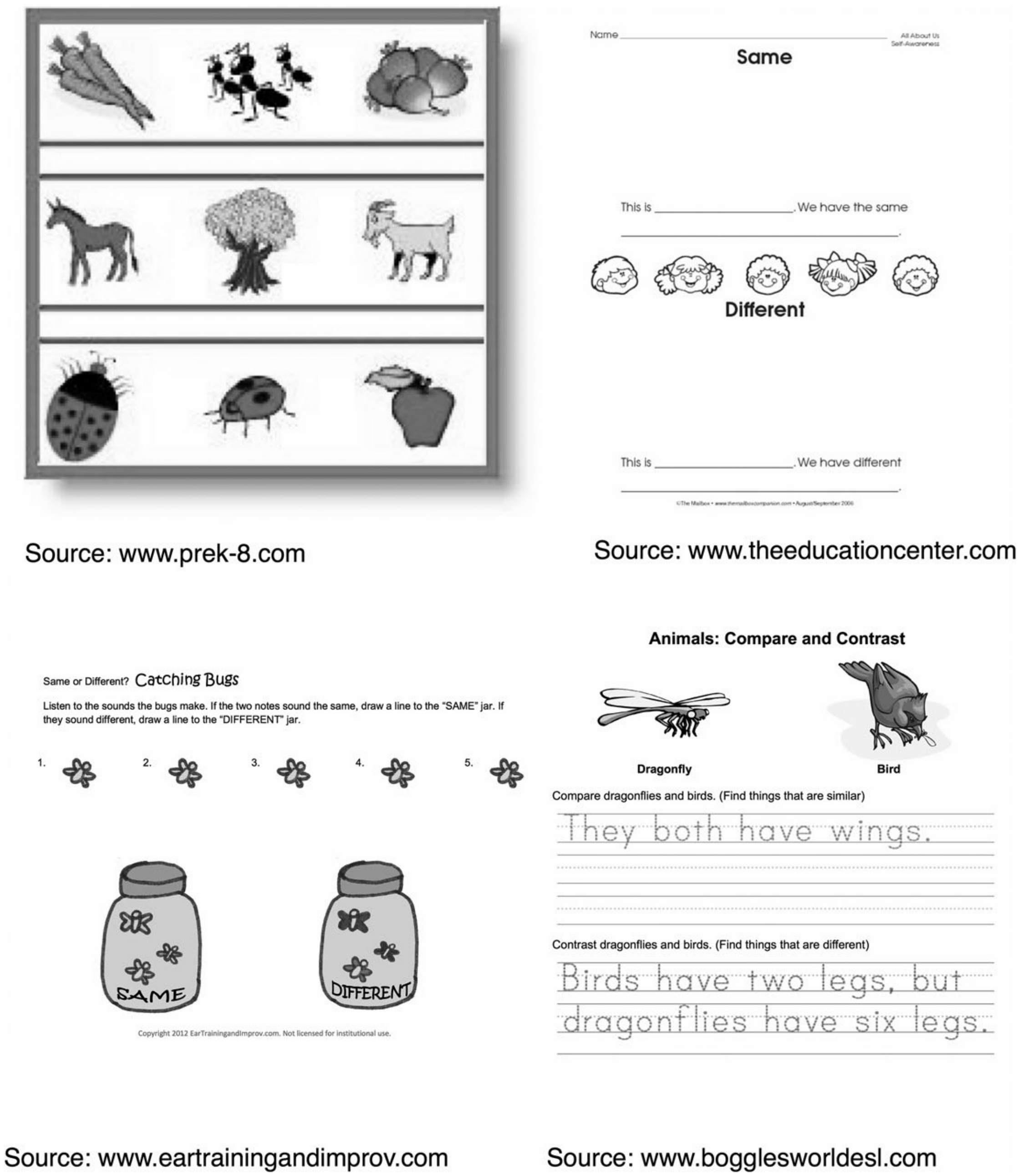

Figure 3. Nonarbitrary relational responding—educational activities.

(e.g., Sundberg & Partington, 2010). However, we have not found any studies examining teaching nonarbitrary relational same/different listener discriminations with humans, despite this task being present in several curricula for children with autism (e.g., Center for Autism and Related Disorders, 2013; Leaf & McEachin, 1999; Maurice et al., 1996; Partington,

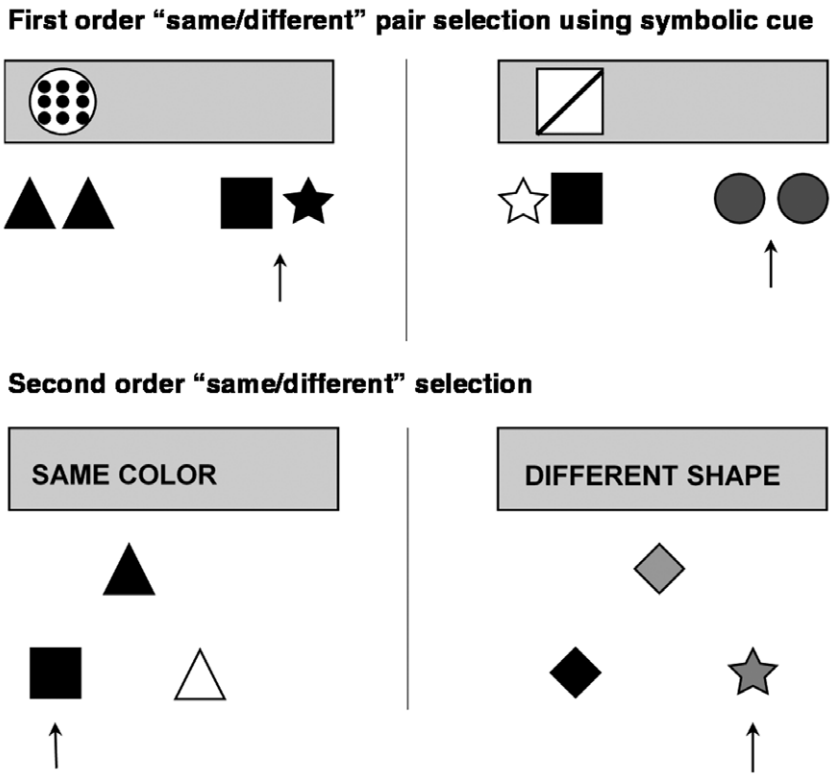

Figure 4. Contextually-controlled "same/different" nonarbitrary listener discriminations.

2006). Obvious directions for future research, therefore, might involve assessment and where necessary, training of these skills in both typically developing and developmentally delayed children. This work might involve assessing and training listener and tacting repertoires using protocols similar to those previously employed in nonhuman work, and perhaps comparing them in terms of their efficacy. It is also important to investigate at what point arbitrary (rather than nonarbitrary) responding to relations of difference should be introduced. Research has found that training nonarbitrary responding can provide an important foundation for arbitrary responding (e.g., Barnes-Holmes, Barnes-Holmes, & Smeets, 2004; Berens & Hayes, 2007). Similarly, yes/no responding with nonarbitrary stimuli in relations of same and different might also be investigated as a foundation for later arbitrary yes/no responding. This would involve identifying whether a pair of items is or is not same or different with nonarbitrary stimuli (e.g., responding to the question, "Are these the same?" or, "Are these different?" with physically identical vs. different items), or finding an item that is not the same or not different (e.g., see Hayes, Stewart, & McElwee, in press). Students who have difficulty with this task might benefit from the procedures described by Serna et al. (1997) and similar procedures used with nonhumans—that is, procedures in which the learner is taught to select a matching comparison or to select a blank card (or make some other response) if the comparison is different from the sample. It would be informative to determine if nonarbitrary yes/no responding is facilitative or necessary for arbitrary yes/no relational responding. At the arbitrary level, an example of such responding would use picture-name combinations (e.g., “Is this a cat?” or, “Find the one that is not a cat.”), in which the relation is based on social convention (the word is the name of the picture) rather than physical attributes. Parenthetically, we would note that many programs for children with autism teach such yes/no tacting and listener discriminations without necessarily testing for generalized responding with yes/no at the earlier, nonarbitrary level of physical identity/difference (e.g., Center for Autism and Related Disorders, 2013; Leaf & McEachin, 1999; Partington, 2006). Research on this issue might be extremely helpful for developing intervention curricula.

In summary, nonarbitrary difference relational responding has been demonstrated with a variety of species across several types of relational responses, and there are well-documented experimental procedures in the literature. However, there appears to be a significant gap with respect to using these procedures with children who have skill deficits in this area, and there is no clear evidence for a particular sequence or hierarchy of teaching relational tacting, listener discriminations, or matching. Relevant research into assessment, training, and interaction of these skills is needed, including, for example, exploring which ones might most efficiently facilitate the others, and thus be targeted first, as well as what effect this might have on arbitrary relational responding within frames of difference and beyond.

ARBITRARY RELATIONAL RESPONDING

As discussed earlier, relational responding can be either nonarbitrary or arbitrary. In arbitrary relational responding (also called relational framing; Hayes, Barnes-Holmes & Roche, 2001), stimuli are related (e.g., as the same as or different from each other) based on contextual cues rather than physical properties. For example, imagine that we tell a child that we have three foreign coins (A, B and C) and that A is the same as B and B is different from C. If we next ask her whether A and C are same or different, she may be able to tell that they are different, even though she hasn’t seen any of the coins. She can do this based on a learning history involving the contextual cues *same* and *different*, rather than on physical properties.

Responding to stimuli in arbitrary same/different relations such as this facilitates rapid learning and generativity to an extent that neither nonarbitrary relational responding nor direct operant training can (e.g., Stewart & Roche, 2013). Of particular importance, such skill likely provides the foundation for further key repertoires including classifying objects and events together and distinguishing them across multiple different verbal dimensions (see, for example, Hayes, Gifford, Townsend & Barnes-Holmes, 2001; Gil, Luciano, Ruiz & Valdivia-Salas, 2012; Slattery & Stewart, 2014). Furthermore, recent empirical evidence of substantial improvements in reading comprehension based on MET of arbitrary same and different relations would appear to cohere with this conclusion (Newsome, Berens, Ghezzi, Aninao, & Newsome, 2014).

Arbitrary relational responding of difference/distinction might also involve listener responses, relational tacting, or relational matching. The common factor in all cases is that responses would be primarily controlled by contextual cues (e.g., *different*) and involve arbitrarily designated relations of difference (e.g., food or music preferences, the coins mentioned above, or that *cat* is the same as *gato* but different from *chien*). Moreover, such responding can involve the emergence of a new response on the basis of taught relations (i.e., a derived response, as when stimulus equivalence is demonstrated for a relation of sameness, or as when the child in the example above could tell that coins A and C were different; see also Ming, Moran, & Stewart, 2014). In the sections to follow, we will consider behavior analytic research relevant to this type of responding, beginning with possible precursors to arbitrary difference relational responding and then arbitrary difference relational responding itself, including arbitrary relational tacts, listener discriminations, and relational matching. We will start with precursors to arbitrary difference relations.

Precursors to Responding to Arbitrary Relations of Difference.

There are two repertoires that can be argued to be precursors to, or at least skills supportive of, arbitrary difference relations: exclusion and yes/no responding. The phenomenon of exclusion is seen when, given a history of well-established MTS performance with a set of arbitrarily related stimuli, a novel unfamiliar comparison stimulus is selected in the presence of a novel unfamiliar sample stimulus without additional training. As such, exclusion procedures can lead to matching of arbitrary stimuli in the absence of any explicit reinforcement (emergent matching; see Wilkinson, Dube, & McIlvane, 1998, for a review of this research). Exclusion seems relevant to arbitrary relations of difference because it appears to involve responding influenced by perceived incongruity. In fact, some theorists have suggested that performance on arbitrary MTS tasks may involve not simply selecting (i.e., responding towards) the correct comparison (S+) but also excluding or rejecting (i.e., responding away from) the incorrect comparison(s) (S-; e.g. Carrigan & Sidman, 1992; Dixon & Dixon, 1978; Stromer & Osborne, 1982). In any event, testing for, and if necessary training exclusion might be important for ensuring a well-established arbitrary MTS repertoire prior to assessing and training arbitrary difference relations.

Exclusion and derived relational responding (DRR) may also be examined in combination. For example, Lipkens, Hayes, and Hayes (1993) showed two versions of exclusion when recording instances of DRR in the behavior of a young infant. The first version, which was first recorded at 16 months of age, involved selecting a novel versus known animal picture given a novel name (i.e., the straightforward version of exclusion described in the previous paragraph). The other, which was first recorded at 23 months of age, was a version in which responding was based on a combination of both exclusion and derived relational responding. More specifically, in this case the child had to not only select the novel animal, but also tact that animal without further training. This latter performance, which might be referred to as derived exclusion, might seem particularly relevant as a precursor to demonstrating derived relations of difference.

Although the exact importance of exclusion in both its basic and derived forms to difference responding remains to be investigated, exclusion is an important skill for the establishment of emergent matching (Wilkinson et al., 1998). Thus, one important area for future research is to develop and test procedures for establishing basic and derived exclusion with individuals who do not yet readily demonstrate them. In this regard, MET with novel sets of stimuli may be an avenue to explore (that is, by training the exclusion response with one set of stimuli and then testing with a novel set of stimuli, and repeating as necessary). Another important direction for future research would be to determine any potential importance of demonstrating both basic and derived exclusion, from the perspective of whether either of these abilities is correlated with, or might support the learning of, nonarbitrary and arbitrary difference relations. For example, research might investigate whether children taught to perform nonarbitrary and/or arbitrary relational responding in accordance with difference (such as relational listener discriminations or tacts of difference) can also readily show derived exclusion, or whether teaching derived exclusion speeds up the learning of such repertoires.

Another potential precursor to arbitrary relations of difference is responding to yes or no questions about arbitrary sameness relations. Relevant to a yes/no repertoire, "go/no-go" procedures (e.g., Debert, Amelia Matos, & McIlvane, 2007; Modenesi & Debert, 2015) have been used to train responding (e.g., clicking a mouse) only when a pair of stimuli have been arbitrarily established as "going together" either in training or through equivalence relations (and not responding if they have not)—this can be seen as analogous to identifying the pair of items as being the same or different from each other. What would generally be termed descriptive autoclitic tacts of assertion and negation (Skinner, 1957) involve similar responses. In this case, negation would imply not-same or different. For example, when answering the question, "Is this a cat?" when presented with a dog, saying "no" would require the student to identify the item presented as being not the same as, or different from, the word *cat*. As an intraverbal response, answering the question, "Does a cat say woof?" requires the student to identify that *cat* and *woof* don't belong together or that they relate to different things. In these cases, the relation of the stimuli *cat*, *dog*, or *woof* to each other is arbitrary. Similarly, selecting an item on the basis of its (arbitrarily designated) difference from a sample could also include identifying an item that is not the same as a sample—such as in common teaching procedures for negation (e.g., Leaf & McEachin, 1999), in which a student is asked, for example, to find the stimulus that is not a cat from an array that includes a cat and a dog.

There is little applied research on teaching individuals such arbitrary conditional discriminations with respect to yes/no responding to relations of sameness when they do not already do so. Two studies have attempted to teach participants to say "yes" or "no" as tact or intraverbal responses, using discrete trial teaching procedures. In the first of these, Neef, Walters and Egel (1984) examined teaching procedures for teaching yes/no mand and tact responses. Children with developmental delays (ages 4-6 years old, with assessed age-equivalencies on standardized IQ tests between 2 and 3 years old) were taught yes/no mands through embedded instructional procedures (mand training). However, this skill did not generalize to yes/no tacts; the latter were only acquired when the teaching procedures included specifically programming alternating trials of tacts and mands. Shillingsburg, Kelley, Roane, Kisamore, and Brown (2009) examined procedures for teaching children with autism yes/no mands, tacts, and intraverbals, with a focus on determining the functional independence of these responses. They found that responses of yes/no could be taught to children as mands (e.g., "Do you want a chip?"), tacts (e.g., "Is this a cup?"), and intraverbals (e.g., "Does a dog say moo?") and generalized within but not across operants. We would note that additional information about participants' other relational responding skills at both nonarbitrary and arbitrary levels (for example, relational listener discriminations and tacts of nonarbitrary same and different relations; arbitrary sameness [equivalence]) might be helpful in determining factors that could potentially facilitate such generalization (see also Stewart, McElwee & Ming, 2013).

A critical direction for future research is to identify any relation between arbitrary yes/no responding and both nonarbitrary and arbitrary difference responding. For example, arbitrary yes/no responding with respect to sameness (e.g., saying "yes" or "no" in response to the question, "Are these cups?") might facilitate arbitrary difference responding (e.g., selecting a quarter rather than two nickels when asked to find an amount different from a dime). Responding to yes/no questions with respect to nonarbitrary sameness/difference (e.g., answering "no" to the question, "Are these different?" when shown a pair of identical items) might facilitate responding to yes/no questions about arbitrary relations (e.g., answering "no" when shown five dimes and asked, "Are these different from two quarters?"), or to other forms of arbitrary difference responding. Future research might also examine the use of yes/no procedures as a means of training both nonarbitrary and arbitrary relational responding, as discussed previously with respect to nonarbitrary relational tacts and listener discriminations.

Deriving Arbitrary Relational Listener Discriminations And Relational Tacts: Relational Framing

As we have explained previously, arbitrary relational responding is based on contextual control rather than physical properties of stimuli. As such, if appropriate contextual cues are used with respect to arbitrary stimuli and a relational pattern is established (e.g., A = B and C ≠ B, as in our earlier example involving the child and the coins), then additional responses may emerge without further training. These untrained responses can be seen as derived relational listener discriminations or derived relational tacts, dependent on the topography of the response, but all can be viewed as part of the generalized operant of *relational framing*. For example, if a child is taught to tact coin A when shown coin B as being the same and to tact coin C when shown coin B as being different and can then tact coin A when shown coin C as being different, she will have demonstrated a derived relational tact. If, on the other hand, she has been taught to select various coins given a sample and the contextual cue of *same* or *different*, and can then select coins based on combining taught relations (e.g., selecting coin A when shown C and told to "find different"), then she would be demonstrating a derived relational listener response. More importantly, both of these response topographies involve deriving a new arbitrary relational response and can be considered examples of relational framing in accordance with distinction. There is very little research on how to establish a repertoire of derived difference relational responding. Most research into derived relations with very young children and children with developmental delays has focused on derived sameness (i.e., stimulus equivalence; Luciano, Gomez Becerra, & Rodriguez Valverde, 2007). Nonetheless, a few studies have examined the emergence of untrained (derived) difference relations. O'Connor, Barnes-Holmes, and Barnes-Holmes (2011) investigated relational responding in typically developing children and children with autism. Using a two-comparison MTS task, contextual control was established for emitting either the symmetrical response (i.e., train A1-B1, test for B1-A1; e.g., Sidman, 2009) or the alternative asymmetrical response (i.e., train A1-B1, test for B2-A1; see also Boelens & van den Broek, 2000). The cues used in this protocol were blue or red circles, which might be interpreted as the same and not the same, respectively. In this series of experiments, children were first taught to read nonsense words (e.g., saying "vug" [A1] when presented with the text card VUG [B1; A1-B1] or saying "lup" when presented with LUP [A2-B2]). They were then trained to select the related (same) comparison when presented with the sample and a blue circle, and to select the unrelated (not same) comparison when presented with the sample and a red circle. Thus, upon hearing "vug" in the presence of the red circle, the participants were trained to select the LUP text (B1-A2). The red circle might be described as cuing selection of "not the same" or "different from" stimuli. Once contextual control was established over trained same and not same relations, the typically developing children demonstrated generalized and derived contextually controlled relational responses to novel stimulus sets. Not all the children with autism did so initially, but for these children, MET resulted in contextual control over the derived responses. This could be described as an example of MET-based establishment of contextually controlled derived same and not same relational listener discriminations. In addition to derived relational responses, empirical research has shown that the functions of a stimulus in a given context may be influenced (transformed) by being in a relation with another stimulus. In the case of difference, if B is different than A in a given context, and A has some function in that context, then it might be predicted that B will not have that function or will have a different function (Hayes, Barnes-Holmes & Roche, 2001, p. 36). For example, if I am told that Sam is someone who likes country music and that Alan has completely different taste from Sam, then I will likely derive that Alan will like something other than country music. In this way, Alan has acquired a new function through derived difference relations. Although transformation of function through derived relations has been investigated with a number of relations, including same, opposite, comparison, and hierarchy (e.g., Dymond, Roche, Forsyth, Whelan, & Rhoden., 2007; Gil et al., 2012; Murphy & Barnes-Holmes, 2010), there is little to no research focused specifically on transformation of functions through difference. In our own work, we have been assessing transformation of food preference functions through same and difference relations in children with autism (Ming, 2015). More specifically, we first trained arbitrary relations of sameness and difference in a context of food preference of different animals (e.g., "The lion likes the same food as the bear but different food from the zebra"). We then assessed for derived relations (e.g., by asking, "Does the bear like the same as or different from the zebra?") and transformation of functions through derived relations (e.g., given pictures of ice cream and chocolate as selection options, and the information that the bear likes ice cream, the task might be to specify what the lion likes and what the zebra likes). In an initial study with two children with autism, the participants did not respond correctly when required to make food selections based on any of the relations between animals, despite tacting those relations—for example, even if they had tacted the relation correctly that the lion liked different food from the zebra, they would not necessarily pick a different food for the zebra than the lion. Multiple exemplar training of different food stimulus sets was then used to successfully train transformation of function for these two children. Although this task may appear somewhat artificial, it controls for any previous history with the stimuli while also allowing a focus on learning only the new relation (who likes what) rather than having to teach any tacts of novel stimuli (and anecdotally, the children also enjoy the novelty of the task). The focus here is on teaching the appropriate pattern of relational responding itself, rather than any particular content, but other more "real" contexts may of course also be used in training (e.g., identifying which students in the class like particular toys or holidays or foods).

Training distinction as a new relational framing repertoire (for example, when an individual already demonstrates derived relations of sameness or equivalence) also necessarily entails promoting flexibility of relational responding—that is, fluency of performance under conditions of changing contextual control over relational responding—which is also an important factor in teaching language skills. For example, O'Toole and Barnes-Holmes (2009) found that speed and flexibility of same/different relational framing was correlated with intelligence as measured by a standardized intelligence quotient (IQ) test. Recent research (Newsome et al., 2014) on training fluency of responding to relations of distinction and coordination provides an excellent example of the importance of such skills, as well as suggesting the importance of a repertoire of responding to same/different relations with respect to more complex repertoires such as categorization. Newsome et al. argued that arbitrary relational responding is critical to reading comprehension, and that responding in terms of both distinction and coordination is foundational for skills such as comparing and contrasting, making predictions, and integrating concepts found in text. In this study, explicit training was provided in relating stimuli on the basis of similarity or difference. Following training in identifying the categories, features and functions of a variety of common stimuli, participants were next trained to fluency in several different relational tasks involving distinction and coordination. For example, participants might be asked to identify how a bus and a dog are the same or different. Participants were also asked questions about activities, such as, "How is playing in the park like [or different from] swimming in the pool?" This protocol improved both responding on similar relational tasks with novel stimuli and performance on standardized measures of reading comprehension.

As noted, there is little research on establishing a repertoire of responding to arbitrary relations of difference, and thus much further investigation is needed. Luciano et al. (2009) made a number of general suggestions for teaching the earliest frames of relational responding, including coordination and distinction, such as using MET in the specific pattern of relational responding, mixing different relations to improve flexibility, using specific and consistent cues for the relations being trained, and beginning with nonarbitrary relations before transitioning to arbitrary relations. With respect to distinction, these suggestions require further empirical investigation, although the results of O'Connor et al. (2011) with respect to symmetrical/asymmetrical responding, and Ming (2015) with respect to transformation of function in combined relations of coordination and distinction would certainly suggest that MET in the relevant relational patterns may be successful.

Another worthwhile avenue to investigate with respect to possible procedures for establishing responding in accordance with distinction would be to use procedures for establishing yes/no responding that have been developed with the Relational Evaluation Procedure (REP; Barnes-Holmes, Hayes, Dymond & O'Hora, 2001; Cullinan, Barnes, & Smeets, 1998; Cullinan, Barnes-Holmes & Smeets, 2000, 2001) and the Implicit Relational Assessment Procedure (IRAP; see Barnes-Holmes, Barnes-Holmes, Stewart, & Boles, 2010). As the names suggest, the aim of these procedures is to test and train participants to evaluate stimulus relations (both nonarbitrary and arbitrary) using relational tacting procedures. For example, the IRAP has participants respond to relations between natural language stimuli through time-pressured selection of natural language cues (i.e., the actual words *yes*, *no*, *same*, *different*, etc.) when presented with pairs of stimuli and a relational cue (see Figure 5 for examples).

In applying this procedure to establishing a repertoire of arbitrary difference responding, for example, one might present a picture, a text stimulus, and a same or different stimulus, and require a yes/no response—for instance, if a picture of a cat is paired with the text *dog* and the word *different* (or the student is asked, "Are they different?"), then the required response would be "yes." Training could also be directed at establishing and strengthening second order contextual control over arbitrary relations (e.g., same or different according to specified features, functions, or categories, and identifying how stimuli are the same or different; e.g., Newsome et al., 2014). For example, a game might be devised with key vocabulary words (such as from passages in a remedial reading text), and the teacher might ask the student to sort them in particular ways or identify how they are related. Given a selection of animals, questions might include finding something that lives in the same/different place as (than) another, or has the same/different number of legs, and so on.

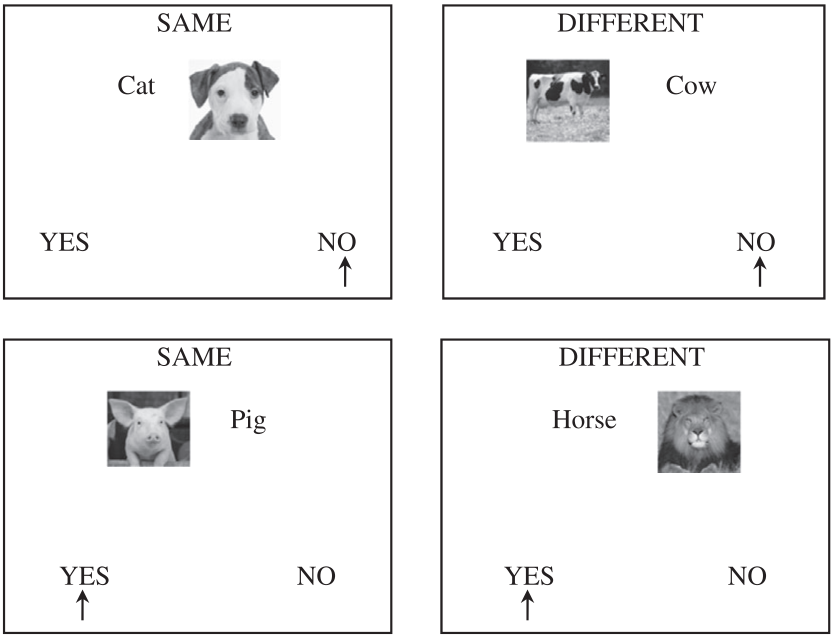

Figure 5. IRAP-type relational responding tasks. Tabletop versions could use text cards for the names, and the teacher could ask the relevant question, for example, "Are they different?".

Beginning with familiar stimuli, and establishing new, arbitrary relations under the contextual control of cues for same/different, and testing for transformation of function might also provide a foundation for the more complex relational responding required at the level of deriving responses in frames of distinction and provide another avenue for future research. At first, this is likely best accomplished in combination with coordinate relations, because identification of a relation as unspecified—that is, if A is different from B, and C is different from B, we cannot know what the relation is between A and C—is relatively difficult even for typically developing adults (see, for example, Vitale, Barnes-Holmes, Y., Barnes-Holmes, D., & Campbell, 2008). For instance, the food preference protocol described earlier involved testing correct derivation of an untrained food preference based on the combination of same and difference relations. One more advanced test within this protocol might be to look for the combination of difference relations. For example, if the lion likes different food from the zebra and the zebra likes different food from the frog, then the student could be asked whether the lion and the frog like the same or different. The correct answer is that we do not know. Another way of proceeding might of course be to look for generalization of either combined same/different or different/different relations to a novel context; for example, one could teach that a cow and a horse live in the same place, but a cow and an axolotl live in different places, and then ask if a horse and an axolotl live in the same place or in different places.

Relational Matching

We will conclude by examining relational matching, or analogy, involving arbitrary relations of difference. A number of behavior analytic studies have modeled analogy as the derivation of relations between derived relations, including both equivalence relations and nonequivalence relations. For example, Barnes, Hegarty, and Smeets (1997) first trained and tested participants (typically developing adults) for the formation of four three-member equivalence relations (which can be designated as A1-B1-C1, A2-B2-C2, A3-B3-C3, A4-B4-C4), and then showed that, without further training, they matched compound stimuli composed of stimuli in an equivalence relation to each other (e.g., B1C1 to B3C3; referred to as equivalence–equivalence responding) and that they also matched compound stimuli composed of stimuli not in an equivalence relation to each other (e.g., B1C2 to B3C4; referred to as nonequivalence–nonequivalence responding). The latter phenomenon of matching nonequivalence relations to nonequivalence responding can be considered an example of matching arbitrary relations of distinction and a number of other studies since have replicated this phenomenon (e.g., Carpentier, Smeets & Barnes-Holmes, 2002, 2003; Stewart, Barnes-Holmes, Roche, & Smeets, 2001, 2002; Stewart, Barnes-Holmes, & Roche, 2004).

Recently, Miguel et al. (2015) combined the use of relational tacting with analogy procedures. In these studies, college students were trained to tact abstract stimuli belonging to the same class with a common name and then to tact the relations between pairs of stimuli as *same* or *different*. Following this training, participants tacted novel pairs as *same* or *different* and accurately matched pairs that were same or different (e.g., A1C1 to A2C2 or A1C2 to A2C1). Participants who failed tests of relational tacting also failed the matching (analogy) tests.

Finally, most of the work carried out so far has involved typically developing individuals. However, this research provides an important foundation for work with populations with developmental delays. Stewart, Barnes-Holmes, and Weil (2009) describe protocols for assessing and training analogy on the basis of equivalence relations that might be investigated from the perspective of establishing analogical responding with individuals who do not yet demonstrate such skills. These protocols proceed from training baseline conditional discriminations (e.g., A1-B1, A2-B2, A1-C1, A2-C2) to training and testing relations between both matched (e.g., A1B1-A2B2) and unmatched (e.g., A1B2-A2B1) pairs of stimuli, and then testing for derived relational responding with respect to relations between both matched and nonmatched pairs (e.g., B1C1-B2C2, C1B2-C2B1). In line with these recommendations, matching pairs of stimuli that have been trained in arbitrary relations of either same or different might be an important step in teaching frames of distinction as well as establishing analogy. For example, if a student is taught to identify sets of animals as liking particular foods (e.g., the bear, lion, and tiger like popcorn, and they like different food from the giraffe, zebra, and elephant, which like cake) a task might be to match on the basis of whether particular pairs of animals represent the same relation. For example, a pair composed of the lion and giraffe (different) should be matched to a pair involving the bear and zebra (different) rather than a pair involving the lion and tiger (same). This type of activity could be conducted first with taught relations as the elements making up the pairs, and subsequently with derived relations in the pairs. Again, research is necessary to determine an appropriate sequence of such training in relation to the other skills described in this section as well as to determine the most effective set of procedures for establishing this repertoire when it appears to be absent.

CONCLUSIONS

As noted earlier, comparing/contrasting and identifying similarities and differences are prevalent in curricular standards, and teaching activities that focus on these skills have been singled out as having particularly important impacts on academic performance (Marzano, et al., 2001).

In addition, recent research supports the importance of same/different relational responding in various contexts. Performance on relational tasks that include derived responding to same and different relations has also been correlated with the vocabulary and arithmetic subtests of the Wechsler Adult Intelligence Scale–Third Edition (O'Hora, Pelaez, & Barnes-Holmes, 2005) and with the verbal subtest of the Kaufmann Brief Intelligence Test (O'Toole & Barnes-Holmes, 2009), and activities that capitalize on deriving arbitrary relations of sameness and difference have been shown to improve reading comprehension (Newsome et al., 2014). O'Toole and Barnes-Holmes further suggest that fluent responding to congruent and incongruent relations under contextual control may be a key indicator of relational flexibility, which has itself long been regarded as a critical component of cognitive ability (e.g., Premack, 2004).

Even though there are no studies examining how best to establish frames of distinction when individuals cannot demonstrate such untaught relational responses, this skill is clearly important to language development as well as many academic skills and cognitive development more generally (Marzano et al., 2001; McIlvane et al., 2011; O'Toole & Barnes-Homes, 2009). We argue that by conceptualizing same/different responding as a continuum of responding from nonarbitrary to arbitrary distinction relational responding, a path becomes clear for research (and future curriculum development) on a likely hierarchy of component/composite skills as well as teaching procedures. Considerable research is warranted to investigate the influence and optimal sequencing of these skills and the most effective teaching procedures for establishing each of them.

In summary, in this paper we attempted to organize existing literature on same/different relational responding from comparative psychology, experimental behavior analysis, and applied behavior analysis both to stimulate applied research and to encourage practitioners to consider relations of difference more systematically in their programming. Practitioners might begin to incorporate this work by using existing research protocols (such as for oddity and relational matching) and considering difference responding as a continuum from nonarbitrary to arbitrary relational responses as they develop teaching plans. There are clearly many gaps to be filled, however, as there is very little applied research with humans who do not yet demonstrate either arbitrary or nonarbitrary responding in accordance with difference. Additionally, there is little in the way of curricula advising how to teach difference responding to children with autism. As Rehfeldt (2011) has also noted, it is critical for the field to move beyond relations of sameness and apply the derived relational responding paradigm to other relations if we are to develop practical teaching procedures for the many complex language and cognitive skills that are necessary for academic success. We hope that the summaries and suggestions in this review will stimulate such research with regard to relations of difference and that a more conceptually systematic and empirically validated set of curricular recommendations might develop in tandem with such work.

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