Discrete Trial Teaching and Discrimination Training

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Discrete trial teaching (DTT) and discrimination training are among the most supported components of early and intensive behavioral intervention (EIBI). DTT is a highly structured procedure for presenting learning opportunities to the child, and discrimination training concerns how these opportunities are structured to optimize learning. This chapter starts with a description of the elements of DTT, followed by a brief description of other teaching procedures often used in conjunction with DTT. Subsequently, we describe the areas in which DTT has been applied and the scientific support it has received. In the next section, we provide a detailed description of the most common discrimination training procedures, together with other more systematic and incremental procedures used when the more traditional approaches have been unsuccessful. In the last section of this chapter, we discuss other strategies and procedures that can be used to optimize and individualize DTT and discrimination learning.

Discrete Trial Teaching

Background

Discrete Trial Teaching (DTT) is a behavior analytic procedure designed to improve the developmental and educational outcomes of individuals with autism and other developmental delays (Smith 2001). Although DTT was developed in the 1960s (Green 2001), it is still a chief component of contemporary early and intensive behavioral intervention (EIBI) programs (Eikeseth 2011).

The purpose of DTT is to help individuals to learn skills that have not been acquired spontaneously, or have not been learned from regular education or special education. Hence, DTT has *not* been designed to help individuals with a specific psychiatric diagnosis such as autism. Also, DTT has *not* been designed specifically for children. It can be used to teach individuals of any age who benefit from a highly structured teaching environment when learning new skills. For a comprehensive overview of how DTT can be used in primary and secondary schools, see Smith (2012).

Most individuals with developmental delays have a history of failed attempts in teaching situations. Typically, parents and teachers will try to teach children skills they perceive that the child has failed to learn spontaneously. Although

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laudable, this also means that children have experienced frustration from failure and from tasks that are too demanding. DTT is a specific type of one-to-one, teacher–child directed instruction that individualizes, simplifies, and structures teaching in a specific way to maximize learning. This is done in several ways:

Firstly, learning targets are carefully matched in difficulty to the child's current level of functioning. The targets selected for teaching are operationally defined and judged to be relatively easy for the child to acquire. As the child acquires these targets, they are either combined with other acquired targets into more complex tasks or the complexity of the targets is gradually increased in a stepwise manner.

Secondly, a technique known as *prompting* is used. Prompting is a specific type of help provided by the teacher to guide the child to correctly perform the target response. Prompts can be anything from physically guiding the child to the target response (e.g., taking the hands of the child and putting them together for the child to clap) to modeling a correct verbal response to a question ("What color is a tomato? Say 'Red'"). Over successive presentations of the learning task, the teacher gradually makes the prompt less and less salient, so that the child eventually responds correctly to the task without any prompt. Such prompting techniques result in a high degree of error-free learning, which by itself makes it easier for the child to learn the tasks. In addition, learning with few errors may keep the child's motivation high.

Thirdly, DTT involves the systematic use of consequences and the systematic repetition of tasks until particular targets are mastered. The consequences provided for correct answers are any item or activity that is likely to be a positive reinforcer for that child, such as praise, happy faces, stickers, brief access to favorite toys, blowing bubbles, a small piece of a favorite food, listening to music, or watching YouTube films for a minute or two.

Components of Discrete Trial Teaching

DTT consists of five main elements. What follows is a description of each of these elements, beginning with the trial.

Trial DTT consists of a series of *trials,* each lasting for approximately 5–15 s. Each trial starts with the teacher presenting the child with a task (the *Antecedent Stimulus)*. If it is unlikely that the child will respond correctly, presenting the task is followed immediately with an additional stimulus, the prompt, designed to help the child to perform the target response correctly. For example, if the task is color identification, the prompt might be that the teacher points to the red stimulus card on the table after saying "Give me red." Immediately after the child has responded, the teacher provides the child with feedback on his/her response. In the case of a correct response, the teacher immediately provides the child a *reinforcer* (S^R). The reinforcer may be praise, brief access to a favorite toy, a game or an activity, a token, or something to eat or drink. The reinforcer is typically available for only 3 to 10 s (in the case of food or drink it should be consumed within a few seconds) so that the next trial can be started. If the child responds incorrectly, the consequence could be nothing at all, or verbal feedback communicating that the response was incorrect (such as teacher saying "Try again," "Almost," or "Nice try") (Smith et al. 2006).

One of the chief benefits of DTT is that the trials can be kept short and simple, and be frequently repeated in a highly systematic way. Up to 10–15 trials are presented per minute. Ideally, the child works on a particular target (e.g., color identification) in blocks of 2–5 min, and subsequently, the child is given a 2–3 min play break. After this play break, the child restarts DTT for 2 to 5 min, typically on a different target (e.g., answering Wh-questions). This is again followed by a brief play break and another DTT session. These DTT sessions (i.e., DTT interspersed with play breaks) last no less than 10–15 min and usually do not exceed 1–2 h. Whether the DTT sessions last for 10 min or 2 h depends on the age of the child and what type of skills the child needs to learn. Trials on a particular target are repeated until the child produces the target response correctly and without prompts for 80–90% of the time the task is presented to the child.

Between the DTT sessions, the child and the teacher typically leave the teaching room and participate in play, leisure activities, or natural

environment teaching (see chapter on naturalistic teaching strategies in this volume). If the child is in a preschool or kindergarten, the child can participate in play, educational, or social activities with other children in the class between the DTT sessions. Sessions of DTT might be repeated several times during the day, as some children may do up to 3–6 h per day of DTT. Typically, the child works on up to 12 different targets (programs) during DTT sessions, and interventionists rotate between the different programs by, for example, starting a new program after each play break. Frequently rotating between different programs likely helps keep the child motivated.

Before starting DTT, the teacher should:

1. Organize the teaching room so there are no unnecessary distractions for the child
2. Organize the teaching room so it is comfortable for the child and for the teacher
3. Know the exact goal for each program
4. Know exactly which instructions to give to the child
5. Know exactly what constitutes a correct response
6. Know exactly what teaching materials to use
7. Have teaching materials ready, well organized and within the teacher's reach
8. Select a number of reinforcers to use during teaching and have them within reach

Antecedent Stimulus (the Task) Each trial starts with the presentation of the antecedent stimulus. The antecedent stimulus consists of the interventionist presenting an instruction and some sort of task to the child. For example, the teacher shows the child a car and asks "What is it?" The question and the car together constitute the antecedent stimulus, and this antecedent stimulus is meant to evoke a particular answer from the child. The antecedent stimulus need not include a verbal question; it can be any situation which the child needs to respond to, such as seeing some other children playing a game (then the response could be to ask to join) or seeing some crayons and paper (for which the response could be to draw).

For each exercise, the antecedent stimulus is always carefully defined and it should be explicitly written as a part of the child's program description. Moreover, if stimulus cards are used, sometimes it is helpful to write the instruction that the teacher is supposed to give to the child on the back of each stimulus card. For example, if teaching the child to name colors, the teacher shows the child a blue color card, and asks, "What color?" The instruction "What color?" could be written on the back of the color card so that the teacher remembers to say, "What color?" instead of, for example, "What color is the card?" or "What color do you think this is?"

When presenting an antecedent stimulus, the teacher should:

1. Simplify the language used as the instruction to match it to the child's language level. For example, for early learners, "Car" or "Give me car," instead of "Can you give me the car?" or "Do you know which one is the car?"
2. Present tasks that are appropriate for the child's skill level (i.e., ensure prerequisite skills are already in place)
3. Use a natural, friendly, and clear voice
4. Use the exact type of stimulus material and wording that has been decided for the particular task being taught
5. Give the child 3–5 s to respond before any consequences are given
6. Present the instruction only once within each trial

Prompt The purpose of the prompt is to help the child produce the correct response after the antecedent stimulus has been presented (MacDuff et al. 2001). For example, the teacher might say "Clap," and then manually guide the child's hands to produce a clap. This is known as a physical prompt. If the antecedent stimulus is a question requiring a verbal answer, the teacher could model the correct answer so that the child can imitate it. For example, the teacher would present a doll and ask, "What is this?" and a verbal prompt would be to say "Say doll" immediately after saying "What is this?" Obviously, this prompt requires that the child is already able to imitate speech. Other types of prompts include pointing prompts (e.g., pointing to the object car after saying "Touch car"), position or proximity prompts (e.g., putting the car closer to the child than the other stimuli), time delay (e.g., across

trials gradually delaying the onset of the prompt after providing the S^D, with the hope that the child might produce the correct response before the prompt is given), and modeling prompts (e.g., the teacher shows the child the correct response).

All prompts must eventually be faded so that the target response is produced by the antecedent stimulus only. For example, initially the teacher might manually guide the child to clap, but then over successive trials the teacher can let go of the child's hands earlier and earlier until the child can clap independently. Such fading of prompts is one of the cornerstones of effective DTT.

When prompting the teacher should:

1. Provide the prompt as specified in the teaching program, which typically means that the prompt is presented immediately after the S^D. However, other strategies for prompting can be used, such as presenting the prompt together with the S^D or gradually, over successive trials, increasing the time between the S^D and the prompt
2. Use the least intrusive prompt necessary to produce the correct response
3. If a particular prompt is not effective, use a more intrusive prompt in the next trial
4. Refrain from using non-intentional prompts such as always looking at the correct stimulus, orally mimicking the correct verbal response, or always leaving the correct stimulus in the same place, etc.

Response It is important to remember that responses are meaningful *only* in combination with a specific antecedent stimulus. For example, it would be pointless to teach a child to simply clap randomly in all situations. What is important, however, is that the child can clap as a response to other children clapping or when someone is asking him/her to clap.

The target response is always defined in observable behavioral terms, as precisely as possible, and written down as part of the child's program description. During DTT, the child's response can be:

a. Correct: A correct response *without* prompt occurs within 3–5 s of the presentation of the antecedent stimulus.
b. Prompted: A correct response *with* prompt occurs within 3–5 s of the presentation of the antecedent stimulus.
c. Incorrect: The child's response does not meet the criteria required in the response definition, or it occurs more than 5 s after the presentation of the antecedent stimulus.
d. No response: The child does not respond to the antecedent stimulus in any particular way. This can be due, for example, to lack of motivation or lack of attention. No response does not necessarily indicate that the child cannot perform the task.

The teacher should:

1. Allow the child 3–5 s to respond
2. Observe if the response is correct, incorrect, prompted, or if it is a no response
3. Refrain from repeating the instructions or talking about other things while waiting for the child to respond

Reinforcer, S^R (the Consequence) To increase the likelihood that the child will produce the target response given the specified antecedent stimulus, responses are differentially reinforced. This means that the child is presented with a desired item or activity as quickly as possible after the target correct response has been performed. Reinforcers can be verbal praise, tickling, favorite toys, games, or snacks. Which stimuli function as reinforcers depends on the child's interests, and hence may vary greatly across children. Some children may like to watch YouTube movies while others prefer bouncing on the trampoline. Moreover, the extent to which a particular stimulus functions as a reinforcer also depends on motivational variables such as deprivation and satiation. Therefore, which stimuli function as reinforcers for each child will vary from time to time. For example, if the child has not played with bubbles for a while (deprivation), blowing bubbles might be highly reinforcing. However, after blowing bubbles a number of times (satiation), bubbles might temporarily lose their reinforcing properties until the child has again not seen the bubbles for a while.

There are a number of different ways to identify reinforcers for a particular child, such as (a) asking the parent and teachers what the child likes to do (e.g., Fisher et al. 1996); (b) observing what the child is playing with or doing when he/she participates in an unstructured activity; and (c) letting the child sample different items, by, for example, presenting various items to the child and observing which items he/she chooses (Roane et al. 1998; Cote et al. 2007). An ideal procedure is to provide the student with an opportunity to make a physical choice between two or more reinforcers at the beginning of each block of trials and to use the chosen stimulus as the reinforcer for that block of trials.

Sometimes reinforcement needs to be given when the child produces approximations of the target response. This is called *shaping* and is a technique from behavior analysis that teaches the child the target response by reinforcing successive approximations to it. For example, if the child is learning vocal imitation of the sound "Ah," then initially any kind of vocalization on the part of the child is reinforced. Gradually, over successive trials, only vocal sounds are reinforced, and when the child reliably emits vocal sounds during 80–90 % of the trials when the discriminative stimulus (S^D) "Ah" is presented, only those sounds that approximate the sound "Ah" are reinforced. Finally, only the sound "Ah" is reinforced, and this continues until the child emits the sound "Ah" during 80–90 % of the trials where the S^D "Ah" is presented.

Social stimuli such as a smile and praise are almost always a powerful reinforcer for the behavior of typically developing children. One of the characteristics of children with autism spectrum disorder (ASD) is that many such social stimuli do not function as reinforcers, and this probably affects their learning and development in a negative way. To establish (or strengthen) social stimuli as reinforcers for the behavior of children with ASD, the presentation of tangible reinforcers (e.g., favorite toys, snacks, or activities) is always paired with the presentation of social stimuli such as verbal praise (e.g., "Good job!") and smiles. The rationale is that social stimuli alone will eventually become reinforcing through a process called *classical conditioning*.

To avoid the child satiating on reinforcers and losing his/her motivation for learning, it is important that the teacher identifies a number of different reinforcers for each individual child, and that the teacher presents different reinforcers on successive trials (i.e., the teacher varies the way he/she praises the child across trials and the teacher uses different tangible reinforcers across successive trials). In addition, it is important to save the stimuli that are likely to be the strongest reinforcers for when the student performs a particularly difficult task.

Another way to avoid satiation can be to use a token economy system. In a token economy, correct responses produce tokens. Tokens can be check marks, stickers or happy faces, and the like. Whenever the child has collected a set number of tokens (e.g., ten tokens) the child can exchange the tokens for a backup reinforcer. The backup reinforcer must be a very potent reinforcer, such as watching a video for a few minutes, eating a favorite snack, or playing a favorite game.

It is important to note that behaviors taught in DTT are of little use if the child does not use them outside of the DTT setting. During DTT, the behaviors are usually maintained by arbitrary reinforcers; that is, by reinforcers that are not related to the behavior being taught (e.g., the child is reinforced with small bites of a cracker for playing with a doll in a specific way). Moreover, in DTT these reinforcers are typically delivered at a high frequency. This type of reinforcement is not provided in natural settings, and hence, the child may fail to perform newly learned skills in everyday life if specific measures are not taken to ensure generalization and maintenance.

To help the child transfer skills learned in DTT to natural settings, the teacher can:

a. Reduce the frequency of artificial reinforcers used in DTT after the child has begun mastering a particular skill.
b. Observe whether or not a particular behavior learned in DTT is maintained by natural reinforcers in natural settings. For example, if the other children in the preschool play a particular game

and the child in treatment finds interaction with peers reinforcing, then playing that particular game after learning it in DTT will likely be naturally reinforced by the other children.

c. Whenever a behavior learned in DTT is *not* performed or maintained in the natural settings, the teacher must design a system for presenting the artificial reinforcer, at least for a while, to ensure that the behavior is performed and maintained in this setting. Often, a token economy system is used for this purpose, where the child receives tokens for performing specific behaviors in the natural setting. These tokens can later be exchanged with favorite activities such as playing a computer game, etc.

For more thorough discussions of reinforcement, see the chapter dedicated to variables that impact reinforcer effectiveness and for a thorough discussion of teaching and generalizing skills in the natural environment, see the chapter dedicated to natural environment training in this volume.

When using reinforcers (S^R) the teacher should:

1.	Present the S^R as quickly as possible after the correct response occurs
2.	Observe the child to see whether he/she is "enjoying" the S^R, as indicated by consuming and/or interacting with it. If not, alternative reinforcers should be considered
3.	Pair tangible S^R with social stimuli such as praise and smile
4.	Vary the tangible S^R across trials
5.	Vary the social S^R across trials

Generalization After the child has learned a particular skill, generalization occurs when the child uses the new skill in a somewhat different way than the way it was taught. For example, generalization has occurred if the child names all dogs that he or she meets as "Dog" and not the specific examples of dogs that were used during teaching. If the child does not generalize, which is often the case, then generalization must be explicitly taught. This is done by expanding, one by one, the examples of dogs that function as antecedent stimuli for saying "Dog," until the child generalizes to all dogs. This procedure is called multiple exemplar training or "training sufficient exemplars" (see chapter on teaching cognitive skills in this volume). When the student is able to exhibit the skill in the presence of untrained stimuli (e.g., new examples of dogs that were never taught), it is called stimulus generalization. In addition, the child must learn to generalize across settings (or situations). That is, the child must learn to use the word "Dog" outside the teaching room, such as in other rooms and places in the preschool, at home, at the playground, in the car, etc. Moreover, the child must also use the label "Dog" when with other teachers, with parents and siblings, and with other children, which is called generalization across people. Finally, the child must be able to maintain (remember) the skill over time, and this often requires the skill to be occasionally rehearsed (e.g., once a week or once a month).

It is particularly important to address generalization when using DTT. Although DTT is highly effective in teaching new skills, the particular structure of this teaching procedure differs in many ways to how the child learns and behaves in real life settings. These differences may challenge generalization, and hence the teacher must not assume that the child will automatically perform new skills learned in DTT in other places and with other people. It is possible that the child will learn a number of new skills in the one-to-one setting with a particular teacher in the room where the teaching takes place, but subsequently fail to use these skills at home, with parents or siblings, playing with other children or even with other preschool teachers. With careful planning and monitoring of generalization, the child can learn to respond adequately to the full range of naturally occurring situations.

When using DTT, generalization should be addressed by:

1.	Assessing whether the child can perform the new skill when exposing him/her to other materials found in daily life (e.g., different pictures or different objects of an item learned)
2.	Assessing whether the child can perform the new skill in new places (e.g., home, playground, other places in the preschool, etc.)
3.	Assessing whether the child can perform the new skill for other adults (e.g., different teachers and parents)
4.	Assessing whether the child can perform the new skill for other children
5.	Assessing whether the child can maintain the skill over time

Other Teaching Procedures Often Used in Conjunction with DTT

In addition to DTT, children typically participate in other types of instructional or play activities, performed in groups or individually, depending on the child's needs. Since the skills learned in DTT are initiated by the teacher, DTT has been criticized for making the child passive and teacher dependent, resulting in generalization difficulties and lack of spontaneity. This criticism is valid in the sense that DTT is not the most effective way to teach all type of skills. For that and other reasons, two other behavior analytic teaching procedures called incidental teaching and natural environment teaching are often used in conjunction with DTT. Virtually all contemporary comprehensive EIBI programs for children with autism implement a combination of DTT and naturalistic behavioral teaching strategies (see chapter on naturalistic teaching strategies in this volume for a thorough treatment of the topic).

Areas of Application and Scientific Support

Many intervention packages for children with developmental delays, especially autism, include DTT together with other behavior analytic techniques (Eikeseth 2009). Much of the support for DTT is indirect in the sense that those programs that have received much research interest and have been shown to be highly effective in teaching children language skills and adaptive behaviors (Reichow 2011) have used DTT alongside other techniques. An example of this is EIBI, which was pioneered by Dr. O. Ivar Lovaas (Lovaas 1987, 2003). A recent meta-analysis analyzing nine peer reviewed, controlled outcome studies on EIBI, found a large effect size (1.10) for change in IQ scores and a moderate effect size (0.66) for change in adaptive behavior scores (Eldevik et al. 2009).

Although these findings are based solely on children with autism, there are indications that EIBI including DTT might be effective for children with intellectual disabilities (Eldevik et al. 2010), and for children with severe intellectual disabilities and pervasive developmental disorders (Smith et al. 1997).

Intensity of DTT There is an extensive and ongoing debate about what constitutes the optimal intensity of DTT. Most likely, the optimal intensity or amount of DTT for a particular child will depend on several factors, including the child's level of functioning. Children with little or no language or who lack basic skills such as motor or vocal imitation need more DTT than children who need to learn more subtle social skills such as peer interaction. Having said this, it should be noted that intervention programs that have included a large portion of DTT combined with other one-to-one behavior analytic teaching procedures have yielded the largest effects (Eldevik et al. 2010).

Imitation One of the skill areas most commonly and successfully taught using DTT is imitation (e.g., Coe et al. 1990; Lovaas et al. 1966, 1967; Young et al. 1994). This entails gross motor imitation (e.g., clapping when someone else claps), fine motor imitation (e.g., copying a sign-language sign), vocal imitation of phonemes (e.g., repeating consonant-vowel combinations), words and phrases (e.g., repeating novel words and sentences), as well as imitation of complex play skills (e.g., playing like other children). Imitation is gradually made more difficult by moving, for example, from clapping to imitating various play behaviors, such as filling a car with gas. Imitation skills in each area (such as gross and fine motor imitation) are taught until the child achieves generalized imitation (i.e., the child imitates novel movements or sounds on the first attempt without prior practice on that specific imitation). Imitation is not only useful in natural settings, such as when learning new words and behaviors from peers and adults, but is also used as an effective prompt in other DTT exercises.

Language DTT can be used to teach both receptive and expressive language (also see chapter on verbal behavior in this volume). Receptive

language includes responding to and the comprehension of verbal instructions (Lovaas 2003). Examples of this could be to point to different objects when they are named, or following instructions such as "Clap" or "Jump." Receptive language is usually built up from simple discriminations such as these to more complex instructions such as "Get the big red ball from the living room." The effectiveness of using DTT to teach receptive language has been shown in multiple studies on a wide range of language skills (Lovaas 1977; Risley et al. 1972).

There is often a need to teach the child to *use* words, even if he/she can understand them when they are spoken by someone else. Expressive language is the production of verbal statements, such as naming objects or answering questions. As with receptive language, expressive language is first taught at a simple level and is then made gradually more difficult, up to telling stories, asking questions, or engaging in small talk (McGee et al. 1984). DTT can also be used to teach children grammar. For instance, the child can be taught to correctly use plurals (Baer et al. 1972), grammatical tense, pronouns (Lovaas 1977), adjectives (Risley et al. 1972), and answering Wh-questions (Jahr 2001). It should be noted that all the techniques that are used to teach children spoken language can just as easily be used to teach sign language (Carr 1979).

Vocal imitation is a necessary prerequisite to teaching expressive language, as this is frequently used as a prompt to help the child produce the target verbal response (Baer et al. 1972; Risely et al. 1972). As with receptive language, many studies have shown the effectiveness of using DTT to teach expressive language (Lovaas 1977; Howlin 1981).

Play skills Teaching children play skills is often an area of high priority. Enabling a child to play is important because it makes social interaction with peers both easier and more rewarding for the child, and it also decreases time spent in stereotypic behaviors (Lovaas 2003). Children with autism very often lack basic skills for cooperating with peers, but this may be taught (Downs and Smith 2004). Play skills are taught like any other skills, by presenting the child with an antecedent stimulus (usually the play materials) and prompting a target response. When presenting the child with a new game or new play material, this novel activity is usually not rewarding to the child by itself, and it is important that the teacher uses reinforcers when teaching the child the play behaviors. Eventually, some play activities may become intrinsically reinforcing to the child and are thus maintained without the use of other types of reinforcers.

Most play activities require a large number of independently taught responses, both verbal and nonverbal. Playing with dolls can be broken down into a number of smaller responses such as dressing, feeding, and talking with the doll (and countless more). The child is taught each of these responses separately through prompting and differential reinforcement. Subsequently, they are chained together so that, for example, putting on one sock is an S^D for putting on the other sock, which in turn is the S^D for putting on the dress, etc.

The type of play skills usually taught initially includes playing with cars, trains, and dolls, doing insert and jigsaw puzzles, lotto, drawing, and ball games. It is important to include typically developing peers in the play activity as quickly as possible after the child has learned to perform the play activity with the teacher. The child must also be taught how to initiate play with other children, comment on what their peers are doing, and take on different roles in pretend play.

Two studies have reported on the effectiveness of teaching children play using DTT alone. Coe et al. (1990) reported successful teaching of a simple ball game to three children with autism or Down's syndrome. Jahr et al. (2000) taught cooperative play to six children with autism, all of whom mastered cooperative pretend play and generalized to novel settings and peers.

Daily living skills Another high priority in DTT programs is to teach the child age appropriate self-help skills (also see chapter on independent living skills in this volume). As with play, these skills can be broken down into component behaviors which are taught independently and

subsequently chained together to form a particular self-help skill. Common daily living skills that can be taught with DTT include: using utensils, drinking from a cup, dressing and undressing, and washing hands. As in the play exercises described above, the child is presented with an antecedent stimulus in the form of a situation requiring action or an instruction. The child is then prompted, verbally, manually, or by modeling, to perform the target behavior. The prompts are slowly faded until the child responds correctly without help. Some daily living skills may become automatically reinforcing and maintain themselves (such as undressing to go to bed and listen to a story), while others (such as cleaning one's room) often require continued reinforcement from a teacher or parent.

Matson et al. (1990) taught a number of different self-help skills (tying shoes, brushing teeth, combing hair, putting on pants, shirt, and socks, and eating and drinking) to four children with mental retardation, three of whom also had autism. A majority of the skills were successfully mastered by the children and maintained at follow up several months later. The authors note that mastering the complete sequence of skills most likely helps maintain the sequence because of naturally occurring positive consequences (i.e., tying shoes to go outside to play).

Reducing stereotypic and problem behaviors Many children with developmental delays exhibit stereotypic and maladaptive behaviors, sometimes dangerous to themselves or to peers. DTT may concomitantly decrease problem behaviors in the child, by both strengthening incompatible behaviors and by making teaching situations highly rewarding (Dib and Sturmey 2007). In addition to this, DTT aims to increase communicative skills in children, which in turn might decrease problem behaviors by giving the child more adaptive alternatives to tantrums or problem behaviors to get what he/she wants (Matson et al. 1996; Smith 2001).

Other curriculum skills DTT must be combined with an appropriate and comprehensive curriculum for the child to make maximum gains. The content of the curriculum is comprehensive and addresses all areas of deficit and must be individually tailored for each child's needs. The key components of the curriculum are described elsewhere (Leaf and McEachin 1999; Lovaas 1977, 2003; Lovaas et al. 1981; Maurice et al. 1996, 2001; chapter on linking curriculum to assessment in this volume), and are only summarized below.

Beginning curriculum Each child's curriculum is individualized and comprehensive, teaching skills in all areas of development. Beginning skills included prerequisites in the areas of attention, communication, social initiations, and play. Examples include sitting in a chair, responding to simple instructions such as "come here" and "wave bye-bye," requesting favorite items, pointing, joint attention, matching identical objects, imitating gross motor actions or imitating actions with objects, imitating sounds and words, identifying and naming objects, playing independently with toys, and basic interactive skills such as rolling a ball to and from an adult.

Intermediate curriculum Intermediate skills include further language training such as identification and naming of abstract concepts, parallel play, turn taking, imitating sentences, early academic skills such as identifying letters and numbers, drawing imitation and tracing, and self-help skills such as dressing and undressing, toilet training, drinking from an open cup, and increasing the range of food and drink taken.

Advanced curriculum Once these skills are acquired, more advanced skills are addressed, such as conversation and asking questions, advanced pretend play and cooperative play, social-emotional skills such as theory of mind and perspective taking, advanced academic skills, self-management and self-control skills, observational learning, and learning in the classroom environment.

Alternatives to DTT DTT differs from another commonly used behavior-analytic technique known as pivotal response training (Koegel &

Koegel 2006). DTT stresses the need to build a complete behavioral repertoire in a systematic and incremental manner, behavior by behavior, while pivotal response training aims to identify and teach key (pivotal) behaviors which are assumed to automatically lead to spontaneous learning. Pivotal response training is designed as an alternative to DTT and hopes to achieve similar results with less intervention (Koegel & Koegel 2006).

Pivotal response training differs from DTT in that it is less structured, both in regard to where the training takes place and what is being taught. Pivotal response training is more dependent on initiations from the child in natural settings. This takes advantage of the momentary motivation of the child (e.g. wanting a cookie or a specific toy) and teaching a relevant response in that situation (e.g., "Say 'cookie'!") (Delprato 2001). However, pivotal response training can most likely neither achieve the same number of repetitions for any particular response as DTT, nor teach discriminations that are hard to master for a particular child (see discrimination training below).

Reviewing studies comparing DTT to other normalized and less structured interventions, Delprato (2001) reported larger gains for children who received more informal behavior analytic interventions. It is likely that different teaching techniques are differentially effective for different children (Schreibman et al. 2011). For example, DTT is likely to be more efficient for teaching basic learning skills (such as generalized motor and vocal imitation) and discriminations. Normalized interventions are likely to be more efficient for teaching generalized language use and to expand a basic behavioral repertoire that may have to be taught using DTT (Smith 2001). However, it is worth noting that, to date, no comprehensive outcomes studies have been published on EIBI programs that make exclusive use of naturalistic teaching strategies. Put another way, every single published controlled outcome study evaluating EIBI has contained a large proportion of DTT, usually combined with some amount of incidental teaching and/or natural environment training.

Discrimination Training

Discrimination training is an important element of DTT. Discrimination training is concerned with the way training stimuli and prompts are presented, and how prompts are subsequently removed. For example, if the child has learned to name a red block "Red," and a blue block "Blue," the child has learned to discriminate the colors red and blue, and the procedure used to establish this discrimination is called discrimination training.

What constitutes the optimal procedure for discrimination training may vary across children. Moreover, it may vary within the same child depending on which skills are being taught. Some skills are complex to learn and hence may require an elaborate discrimination training procedure involving many steps and a high number of training trials, whereas other skills are easier for the child to learn and might be effectively taught in considerably fewer trials. The teacher must always seek to use the discrimination training procedure which leads to mastery most quickly, and, typically, the more complicated and elaborate discrimination training procedure used, the more trials it takes to complete. We will start with a description of the most basic discrimination training procedure.

Basic Procedure: Teaching Language Comprehension

The following description of discrimination training is illustrated with a receptive language program, which is designed to teach the child to select particular objects (or pictures) upon hearing the name of the objects. This program is commonly known as receptive labels (Lovaas 2003), or manded stimulus selection (Michael 1985). Table 12.1 provides a summary of the teaching stages outlined below.

Mass Trials of the first Target without Distracters Mass trialing without distracters is the first step of this procedure. The aim is to teach

Table 12.1 Each teaching stage during discrimination training is shown, together with a summary of the process that is worked on in each stage

Teaching stage	Process during teaching stage
Mass trials S1	Mass prompting S1, 9 out of 10 correct
	Mass trials S1 + 1 ND, 9 out of 10 correct
	Mass trials S1 + 2 ND, 9 out of 10 correct
Mass trials S2	Mass prompting S2, 9 out of 10 correct
	Mass trials S2 + 1 ND, 9 out of 10 correct
	Mass trials S2 + 2 ND, 9 out of 10 correct
Block rotation S1 and S2	S2 + S1 as D, 9 out of 10 correct
	S1 + S2 as D, 9 out of 10 correct
	S2 + S1 as D, 3 out of 3 correct
	S1 + S2 as D, 3 out of 3 correct
	S2 + S1 as D, 2 out of 2 correct
	S1 + S2 as D, 2 out of 2 correct
	S2 + S1 as D, 1 out of 1 correct
	S1 + S2 as D, 1 out of 1 correct
Random rotation S1 and S2	Random presentation of S1 and S2

S1 stimulus one (e.g., car), *S2* stimulus two (e.g., dinosaur), *ND* neutral distracter, *D* distracter (e.g., dinosaur or car)

the child to select an object when given an instruction to do so. The selection response can be pointing, touching, or giving the object to the teacher. Often, giving the object to the teacher is a good selection response because the response requires the child to have more contact with the object as compared to when the response is only pointing to or touching, however no published research has definitively shown that one modality is superior to the others.

The child sits at the table (usually opposite the teacher) with no other training stimuli on the table except the object that is being taught (e.g., a car). If the child has no history of reinforcement for selecting the car at this stage, the likelihood that the child will correctly select the car contingent on hearing its name is low. Therefore, the teacher gives the child the name of the object vocally and then immediately following (or simultaneously) gives the child a prompt to perform the correct response. Following the completion of the correct response, reinforcement is delivered. Fading the prompts can be done very quickly for some children. Teachers can sometimes use a hand over hand prompt or simply point to the stimulus (i.e., the car) for the first few trials and then completely remove the prompts altogether. For other children, the process of fading the prompts may take longer and may need to be performed across many more trials, and very systematically across the members of the team teaching the child. In the latter case, it is still very important that prompts are faded as quickly as possible because it is sometimes the case that children with autism will become dependent on the prompts and will learn to wait for the prompt before making any attempt to perform the response independently.

Following the withdrawal of the prompts, the child is then able to perform the correct response independently. At this stage, the target object is still the only object on the table, and the child has most likely not learned to recognize the receptive noun car. For example, if the teacher said "San Francisco" to the child, instead of "Car," the child would most likely give the car to the teacher. Hence, more steps are needed to teach the child to correctly discriminate the car. The next step is to present other objects on the table (in addition to the target object) as distracters, while asking the child to give us the car.

Mass Trials of the first Target with Distracters This step teaches the child to select a particular object (i.e., the car) and not any other object upon the teacher's request. The teacher places the car and one other object on the table, equidistant from the child, in a line across the middle of the table. The distracter is a neutral stimulus (neutral distracter, ND) because it has not been used previously for teaching, and because it is not an

object of particular interest for the child. The teacher requests the target object, and because the child now has a history of reinforcement for touching the target object, many children will require only a small prompt (if at all) to select the correct object. The teacher continues to work on the child selecting the car in the presence of the ND, and works on randomly presenting the two objects on the table in different positions (left or right) until the child is able to select the correct object for 90% of trials.

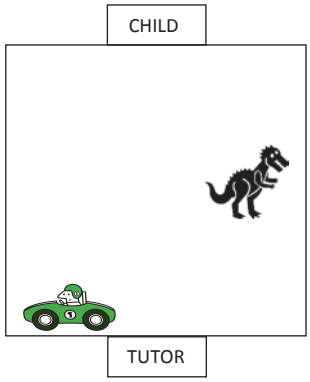
Next, a second ND can be added into the field of objects on the table. In a field of two objects (the car and the ND), the child has a 50% chance of selecting the correct object just by guessing, and therefore to be certain that the child is able to visually discriminate the target object from other objects, we introduce a third object into the array on the table. The second ND can be selected as the first one was, and introduced into the field of objects using the above prompting procedures, if required. The teacher continues to ask only for the car, but the position of the three objects on the table can be changed at random. The child must be able to select the target object correctly in 90% of trials before moving to the next stage of teaching. At this stage, the child has learned to select a particular object when given an instruction to do so, but the child has most likely not yet learned the receptive label car. That is, no matter if we say "Car" or "San Francisco" the child will most likely select the car.

Mass Trials of the second Target While maintenance trials are done for the car, teaching the second target noun label (e.g., dinosaur) begins and proceeds in the same way as described above (i.e., mass trials first alone, then with one and then two NDs). The reason we have selected the label dinosaur is that it contrasts well with the car. This is because the word "Dinosaur" sounds different to the word "Car" (in that it contains different sounds and the words are of different length), the objects look different from each other, and they have nothing in common.

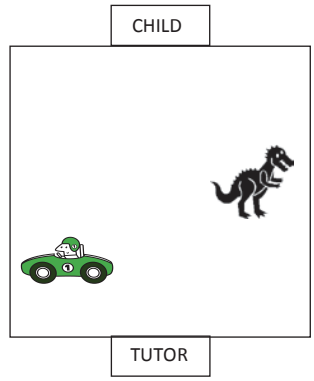
The teaching trials for the second object (dinosaur) should *not* be done immediately before or after the maintenance trials for the first object (car) in the same session for some children because of carry-over effects. At the end of the teaching for the object dinosaur, the child should be able to correctly select the object dinosaur when the teacher says "dinosaur" for 90% of consecutive trials, and with the dinosaur in the presence of two NDs, and when all three objects can be placed in random positions on the table. The same is true for the first object taught (car), but as yet the two objects have not been placed on the table at the same time, and the teacher has not presented the names "car" and "dinosaur" in consecutive or random trials.

Block rotation The aim of block rotation (also referred to as "expanded trials") is to have the two target objects that were previously worked on separately on the table at the same time, so that while hearing the name of target object one, the child selects that object, and when hearing the name of target object two, the child selects object two. This can be difficult for some children at first because the child has been reinforced for selecting both objects in the past, and up to now, there has been no focus on distinguishing between (discriminating) them. Now the child has to discriminate or listen to the object's name in order to produce a correct response. At this stage of discrimination training the child must learn to attend more closely to the verbal label given by the teacher because the choice of object is governed by the verbal label that is heard by the child. Figure 12.1 illustrates the following procedures.

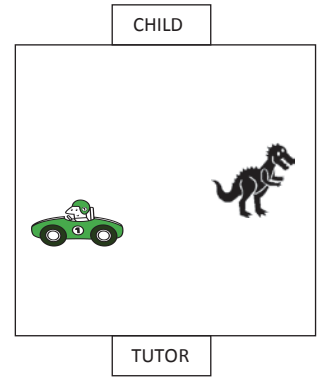
The teacher should continue to work on the second stimulus (in our example, dinosaur) because this is the one that has been worked on most recently and therefore the child is more likely to select this stimulus. The teacher places the stimulus (dinosaur) in the middle of the table but this time also places the first stimulus (car) on the table simultaneously. The car is placed at the back of the table, nearest the teacher, and the position of the stimuli makes it more likely that the child will select the stimulus in the middle of the table due to the lower response effort involved. Positioning the second stimulus at the back of the table and furthest away from the child is



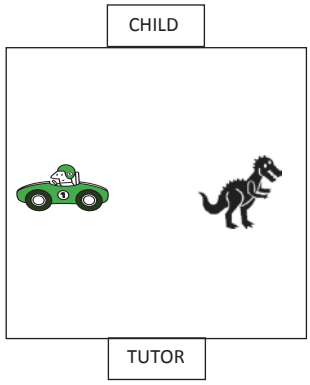
(1) Full position prompt



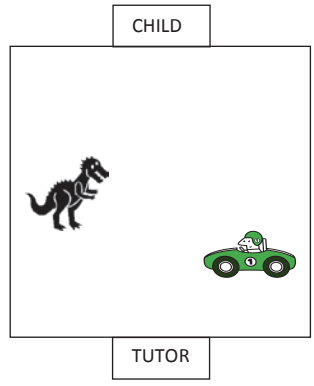
(2) Half position prompt



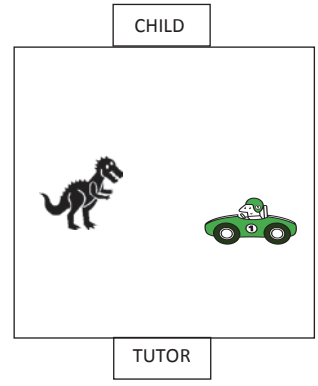
(3) Quarter position prompt



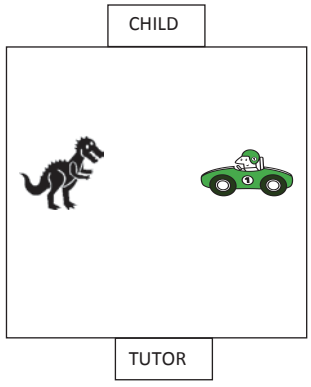
(4) No position prompt



(5) Switch position, half position prompt



(6) Quarter position prompt



(7) No position prompt

Fig. 12.1 To show the progression of the position prompts from full position prompt to no position prompt during block rotation

known as a *position prompt*. The teacher says the label ("Dinosaur") and the child selects the correct stimulus. Across repeated trials, the teacher moves the first stimulus (car) gradually forward on the table so that it is eventually in line with the dinosaur, and after mastery of this step, the left-right position of the two objects is randomized across trials. In other words, the position of the two objects is switched, and if needed position prompts can be used by moving the first stimulus (car) back on the table (nearer the teacher). This procedure is repeated until the child is able to select the second stimulus (dinosaur) in either the left or right position on the table with the first stimulus (car) level each time the positions are switched and with no position prompting used, on 90 % of consecutive trials.

When the child is able to do this, the teacher then works on the same procedure but this time when saying the verbal label for the first stimulus taught ("Car"). Because the child now has an extended reinforcement history for selecting the second stimulus (dinosaur), it is more likely that the child will touch that stimulus in the presence of any verbal noun given by the teacher. Therefore, when the teacher begins work on the first stimulus, the same procedure of using position prompts described above is used again, but this time with the first stimulus placed in the middle of the table and the second stimulus placed at the back of the table. The same procedures are used during this stage, and the child will get to the stage where they have learned to select the first stimulus (car) in either the left or right position on the table with the second stimulus (dinosaur) level each time the positions are switched and with no position prompting used.

Throughout this stage, the teacher has been presenting the child with blocks of trials for each stimulus being taught. The next step is to systematically reduce the number of trials in each block for each stimulus. For example, the teacher might present the verbal stimulus "Car" until the child responds correctly for three consecutive trials with the position of the car and the dinosaur randomized. Following the third correct trial of "Car" the teacher might switch to presenting the verbal stimulus "Dinosaur" while keeping the position of the car and the dinosaur on the table the same as in the previous trial. Upon a correct response, the position of the car and the dinosaur on the table is again randomized, and whenever the child responds correctly for three consecutive trials, the teacher might again switch to presenting the verbal stimulus "Car."

When the child is able to do three consecutive trials correct after making only two to three errors within the preceding ten trials, the teacher might change criterion to two consecutive correct trials of each label within a block. Following this, the teacher can then work on one correct trial for each label and then move into random rotation from there. Mastery criterion for changing the block from two correct consecutive correct responses to one correct response is that the child performs two consecutive trials correct after making only one to two errors within the preceding ten trials. Mastery criterion for this step and for moving to the next stage, random rotation, is a correct response with each of the two objects after making only one to two errors within the preceding five trials. It is important to remember that the positioning of the stimuli on the table is randomized.

Random rotation The goal of random rotation is to randomize the order in which the teacher requests the objects, while the position of the two objects on the table is randomized. When the child is able to correctly identify the objects requested in a random order by the teacher and when the position on the table is random for 90 % of trials, then the two stimuli are considered mastered and the child has learned to discriminate the two labels. If progress at this stage is slow, the teacher might consider using a different and more systematic approach (see Other Strategies to Facilitate Discrimination Learning, below).

Increasing the field of stimuli Following completion of random rotation for the first two stimuli, the teacher starts working on the third object. This involves repeating the above stages, and the above stages can be repeated for all stimuli to be taught. The new stimulus to be taught is worked on in mass trials. Neutral distracters can then be added, before moving into block rotation, first

with the first learned stimulus (in our example, car), and then with the next stimulus (dinosaur). The three stimuli can then be moved into random rotation so that the child has a field of three stimuli on the table. When the three stimuli can be placed on the table in random positions and one of the three stimuli can be asked for at random and the child is correct for 90% of trials then the third stimulus is considered mastered.

Subsequent objects can be taught in the same way, but the field of stimuli on the table is usually kept to three. Therefore, when working on the fourth object, only two of the three previously mastered objects are used as distracters on the table at the same time. However, for the fourth object to be mastered, it has to be mixed with all of the three previously mastered objects.

Other Strategies to Facilitate Discrimination Learning

For some children, the procedures described above may not be successful. For these children, an even more systematic and incremental procedure might be required, and recent applied research has designed and validated alternative methods of teaching discrimination when traditional approaches have not been successful. Below is a description of some of those procedures.

Revised blocked-trial procedure Smeets and Striefel (1994) built on research by Saunders and Spradlin (1989, 1990, 1993), and designed a revised blocked-trial procedure. The difference between block rotation in the discrimination training procedure described above and the revised blocked-trial procedure is that the latter involves keeping the position of the items on the table in constant position while the teacher requests the items in a random order. After mastery of this step, the position of the objects on the table is gradually and systematically varied.

More specifically, in Step 1 of the revised blocked-trial procedure, the two stimuli on the table (e.g., car and dinosaur) are kept in the same positions across trials, while the objects the teacher requests ("Car" or "Dinosaur") are presented in a random order. Following 90% or better mastery of Step 1, Step 2 involves reversing the position of the two objects on the table and maintaining those positions while the objects are once again requested randomly. Following 90% or better mastery of Step 2, Step 3 involves changing the position of the objects on the table after blocks of four consecutive correct trials, while continuing to request the objects randomly. Finally, Step 4 involves both random location of the objects on the table and the random requesting of the objects.

Combined blocking procedure A further development of the revised blocked-trial procedure was provided by Perez-Gonzalez and Williams (2002) and by Williams et al. (2005), and has been called the combined blocking procedure. Similar to the revised blocked-trial procedure, this procedure involves keeping the position of the items on the table in constant position, but in contrast to the revised blocked-trial procedure, the order of the requests are initially *not* presented in a random order.

More specifically, in Step 1 of the combined blocking procedure, the same object (Stimulus 1) is requested in blocks of ten trials, with the objects on the table in the same location each time. After 90% or better correct responding in a block of ten consecutive trials requesting Stimulus 1, the teacher begins requesting Stimulus 2 in blocks of ten trials (with the objects on the table in the same location each time) until 90% or better responding is achieved. Step 2 involves reducing the blocks of trials so that the same object is requested in blocks of five trials, and with the objects on the table in the same location each time. Mastery criterion is four out of five or five out of five consecutive correct responses. Step 3 involves reducing the blocks of trials once more, this time requesting the same object in blocks of two or three trials, again with the objects on the table in the same location each time. Mastery criterion is two out of three or three out of three consecutive correct responses. In Step 4, the objects are requested at random, with the objects on the table in fixed position. Step 5 involves the same random request of the objects, but this time the

position of the objects on the table is reversed and kept in the reversed location each time. Finally, in Step 6, the objects are requested at random, with the objects on the table in random position.

Random Rotation-only Procedures Recent research has examined the effectiveness of discrimination training without the initial phase of mass trialing. For some children, there may be a concern that the initial mass trialing may actually make acquisition during random rotation more difficult (Green 2001), and this was evaluated in a recent study by Grow et al. (2011). They found that starting teaching with random rotation was effective in teaching receptive labeling to three children with autism. Another recent study revealed mixed results and a 1-month follow up revealed no differences between the two discrimination teaching procedures (Gutierrez et al. 2009). In clinical practice, it is common to use the more involved discrimination training procedures early in treatment and then new programs can often be introduced with random rotation after students have acquired more highly developed discrimination repertoires. In other words, it appears that repeated discrimination training seems to establish a more generalized "ability to learn through discrimination training," often over the course of 2 or more years.

Sound Discrimination Prior research has shown that children who show deficits in the discrimination of *language* may learn to discriminate *nonverbal sounds*. For example, a child with autism may learn to point to a telephone after hearing its ring but not after hearing the word "Telephone." In a recent study, Eikeseth and Hayward (2009) assessed whether it is possible to use the sound of an object as a prompt (e.g., pointing to a telephone after hearing its ring) to teach receptive labels (e.g., pointing to a telephone after hearing the word "Telephone").

First, children who initially failed to learn receptive labels using the traditional discrimination procedure outlined above were taught to identify objects based on their sounds. Interestingly, the participants learned this discrimination quickly. Next, a fading procedure to transfer stimulus control from the sounds to the names of the objects was used. First, the teacher would state the name of one target object (e.g., "Telephone") immediately before sounding the object. Across successive trials, the teacher then faded out the sound prompt by decreasing the intensity and duration of the sound. The sound for the second object (e.g., drum) was then faded using the same procedure. Finally, the teacher presented the name of both objects in a random order (using the sound prompts when necessary) until mastery.

Discrimination Learning: Teaching Expressive Language

The procedure for discrimination training with expressive language is slightly different from that used to teach receptive language and matching. In this section, we will outline how to use discrimination training when teaching expressive language.

As an example of how we might use discrimination training to teach expressive language skills, we can consider how we might teach a social questions program. In this program, we are aiming to teach the child intraverbal skills, by asking the child a series of questions (e.g., "What is your name?", "How old are you?", and "Where do you live?"), and teaching them to provide the correct information as their response. We can begin this process in the same way that we do for receptive language programs, by first working on mass trials.

Mass trials The first question is taught in mass trials. For example, the teacher will work on repeated trials where the child is asked the question (e.g., "What is your name?") and is then prompted to give the correct response (e.g., "Tommy"). The teacher provides the child with a prompt in each trial to ensure that the child is successful and provides reinforcement for the correct response each time. As with receptive language programs, the teacher may need to start with a full prompt but in expressive language programs this may take the form of using vocal imitation so that the child repeats what the teacher tells him to say (echoic):

Teacher: "What's your name? Say Tommy"
Child: "Tommy"

As with the receptive language program, the teacher can use a prompt hierarchy (i.e., beginning with the most intrusive prompt and ending with the least intrusive prompt) to fade the prompts, so that eventually the child can produce the correct response without prompts. This may be done, in our example, by reducing the echoic prompt and by reducing the amount of the response that the teacher says when prompting. Over time, you might see the following prompt and prompt fading:

Teacher: "What is your name? Say Tommy"
Child: "Tommy"
↓
Teacher: "What is your name? Say Tom…"
Child: "Tommy"
↓
Teacher: "What is your name? Say To…"
Child: "Tommy"
↓
Teacher: "What is your name? Say T…"
Child: "Tommy"
↓
Teacher: "What is your name?"
Child: "Tommy"

When the child has mastered giving the correct response without prompts the teacher maintains the first mastered intraverbal ("What is your name?") and works on the second question (e.g., "How old are you?") in separate trials in a manner identical to the first one.

Switching and random rotation When the second intraverbal is mastered and is successfully being maintained then the goal is to be able to present both the first question ("What is your name?") and the second question ("How old are you?") to the child in a random order, and any number of times in a row, and for the child to be able to give the correct response each time. This is random rotation and therefore, as with the receptive language program, random rotation remains the goal of discrimination training.

As described above, with receptive language programs we can use block rotation to ensure that the child continues to give the correct response (Fig. 12.1). With expressive language programs, we can again use a system of prompting, but this time using the echoic prompt each time we switch from one question to the other (if required). Because the teacher last worked on the question: "How old are you?" this question can be asked first, more than once if required, and the correct response is reinforced. Following these trials, the teacher then immediately switches to the first question ("What is your name?") and prompts the response so that the child is correct when the question is switched:

Teacher: "How old are you?"
Child: "Four"
Teacher: "Yes, that's good! How old are you?"
Child: "Four"
Teacher: "Right! What is your name? Say Tommy"
Child: "Tommy"
Teacher: "Good! What is your name?"
Child: "Tommy"

The teacher can repeat this process for several trials in a row and over a series of trials or sessions the teacher can fade off the prompt that is required for the switch from one intraverbal to another:

Teacher: "How old are you?"
Child: "Four"
Teacher: "Right! What's your name? Say Tom…"
Child: "Tommy"
↓
Teacher: "How old are you?"
Child: "Four"
Teacher: "Great! What's your name? Say To…"
Child: "Tommy"
↓
Teacher: "How old are you?"
Child: "Four"
Teacher: "Good! What's your name? Say T…"
Child: "Tommy"
↓
Teacher: "How old are you?"
Child: "Four"
Teacher: "Fantastic! What's your name?"
Child: "Tommy"

When the child has consistently mastered switching from one response (for question two) to a different response (for question one) then the same process can be used in reverse. The teacher asks the child for question one, reinforces the response, and then switches to question two, prompting the response with a full prompt (e.g., echoic) at first, and then fading the prompt over subsequent switches. The aim is for the child to be asked either question one or question two in any order over subsequent trials and to give the correct response each time, irrespective of which question is asked and in what order.

Individualizing and Optimizing DTT and Discrimination Training

It is crucial that each child's program is individualized to provide an optimal learning environment. For example, if procedures such as mass trials, block rotation, and random rotation are not required during DTT, then they should be left out so that the program moves forward quickly and the child does not spend time working repeatedly on responses that are already mastered simply because the child has not completed all steps in the discrimination training procedure.

In this last section of this chapter, we will discuss different strategies that can be used to optimize and individualize DTT and discrimination learning. We will begin by describing a procedure called probing, which is used to systematically assess the extent to which a child masters specific skills or items.

Probing

Probing can be used to assess whether the child has already mastered an untaught item within a program. For example, does the child know a particular untaught receptive label so that this label can be added to the list of mastered items, and so that the program can move on to teaching other object labels? Another purpose of probing is for curriculum assessment. Curriculum assessment is used to examine which part of the child's curriculum has been mastered and which parts have not. For example, probing can be used to assess whether the child can recognize body parts, which is part of the curriculum that teaches the child to respond to simple instructions. If so, body parts can be omitted and the curriculum can be moved on to target other more advanced skills.

Instead of slowly introducing each new target stimulus in a careful and systematic manner, using step-by-step procedures such as mass trials, block rotation, and then random rotation, the level of mastery of new stimuli can be assessed first by running probe trials. To do so, the new stimulus is tested in *random rotation* with two previously mastered stimuli. For example, two mastered items are placed on the table in the presence of a third novel stimulus, and the teacher asks the child for all three stimuli in random order on consecutive trials and while changing the position of the stimuli on the table. If the child can perform the correct response for the new stimulus on these probe trials, then the stimulus can be considered mastered. There is no need to spend time using discrimination training procedures and the child's program can move forward to the next stimulus to be learned.

Exclusion

Exclusion is a procedure that can be used to teach new items by allowing the child to use a "process of elimination" to work out the correct response. It is very similar to probing in that new stimuli are taught in the presence of previously learned stimuli without first using mass trials and block rotation. Exclusion is typically used within a program where the child has already learned a number of items. For example, if the child has learned a number of receptive labels, the child might be ready to learn additional labels by exclusion. The teacher places two mastered items and the new item on the table in front of the child. First, the teacher requests one of the mastered items. Next, and without changing the position of the items on the table, the teacher requests the second mastered item. Given correct responses on these two mastered items, the teacher immediately requests the unknown item, still with the position of the items on the table unchanged. Given two

to three consecutive correct responses to the new item (still in the same position), the position of the items on the table is changed, and given three to five consecutive correct responses to the new item when presented on the table in random position, the teacher starts to request all three objects in a random order. Whenever mastered in random rotation, the new item is mixed with all (or most) of the previously mastered items. This is usually done by replacing one of the mastered items with another previously mastered item every time the child responds to it correctly.

Types of Antecedent Stimulus Control

During our discussion of DTT above, we have called the instructions and the task presented by the teacher an antecedent stimulus. Technically, antecedent stimuli include simple discriminations, conditional discriminations, simultaneous discriminations, and successive discriminations. Below, we will explain each type. A better understanding of stimulus control will enable the teacher to individualize the child's program even further, and will also give the teacher additional tools for designing effective discrimination training procedures when the child's learning is not progressing optimally.

Simple Discriminations (S^D) Simple discriminations occur when there is a three-term stimulus-response-consequence contingency (i.e., S^D-R-S^R contingency). For example, if a child emits the verbal response "Book" in the presence of the object book, the object book is the S^D and saying "Book" is the response. Other examples of S^D-R-S^R relations are simple intraverbals, such as fill-in-the-blank phrases like "Ready, set…" and "Peek-a-…" In this case, "Ready, set" (and "Peek-a") constitutes the S^D and the verbal response "Go" (and "Boo") constitutes the response. Also, instruction following such as waving in the response to the S^D "Wave bye-bye" is an example of a simple discrimination.

Conditional Discriminations In conditional discriminations, the three-term contingency (i.e., the stimulus-response-consequence contingency (S^D-R-S^R)) comes under the control of another antecedent stimulus, the conditional stimulus, and hence becomes a four-term contingency. The receptive labeling program outlined above is an example of a program which involves conditional discriminations. In this program, whether the correct response is to identify the car or identify the dinosaur depends on the teacher's instruction ("Car" or "Dinosaur"). Whenever the teacher says, "Car" touching the car is the correct response and touching the dinosaur is incorrect, and whenever the teacher says "Dinosaur" touching the dinosaur is correct and touching the car is not. Hence, what constitutes the correct response is conditional on another stimulus: the instruction given by the teacher. The teacher's instruction is known as the *sample* stimulus or the *conditional* stimulus and the "correct" stimulus on the table is called the S^D, and the "incorrect" stimulus (or stimuli) is called S delta (S^Δ) or S minus (S−). Thus, conditional discrimination involves the presence of a stimulus that alters the function of other stimuli.

Matching is another type of program involving conditional discriminations. In identity matching of colors, for example, the child is given a blue card to match to either a blue card or, say, a green card. The blue card that is given to the child is the conditional stimulus (or the sample stimulus), while the cards presented on the table (blue and green) are the S^D and the S^Δ. When the child is given the blue card, only the identical blue card is the correct match, and therefore that stimulus is a discriminative stimulus (S^D or S+). The other cards with other colors are not associated with reinforcement when given a blue card to match with the blue card and are therefore an S^Δ or S−. Hence, which of the stimuli on the table is a discriminative stimulus is conditional upon which sample stimulus is given to the child, and therefore this is a conditional discrimination.

Simultaneous Discriminations and Successive Discriminations Another factor that is relevant when teaching is whether the stimuli involved are present simultaneously in time, or if they occur one after the other. This is called simultaneous and successive discriminations, respectively.

The receptive labeling program involves a simultaneous discrimination of the S^D and the

S^{Δ} because the child selects one of several items presented on the table simultaneously in time. For example when hearing "Touch cup," the child selects the object cup amongst other items that are present simultaneously on the table, and choosing between the available items involves a simultaneous discrimination. However, receptive labeling also involves a successive discrimination. This is because the stimulus spoken by the teacher (e.g., "Touch cup" and "Touch ball") occurs across trails. Hence, responding to the conditional stimulus (sample stimulus) involves a successive discrimination and responding to the S^{D} and the S^{Δ} involves a simultaneous discrimination.

Curriculum and Types of Stimulus Control

As evident from the above, even relatively simple skills might involve complex stimulus control issues. To further illustrate this, we have examined a typical beginning language curriculum and described what types of stimulus control are involved in each of the programs. This is illustrated in Table 12.2. The curriculum skills listed in the left hand column are:

- Identity matching: Placing identical stimuli together in a match-to-sample procedure.
- Nonvocal imitation: The child watches and copies a range of actions performed by the teacher, including actions with objects, and gross, fine, and oral motor movements.
- Receptive instructions: The teacher gives instructions for the child to follow (e.g., "Wave" or "Clap hands")
- Receptive labels: The teacher gives the child an instruction to select a stimulus (e.g., "Give me car" or "Give me hat").
- Vocal imitation: The child listens to a vocal stimulus presented by the teacher (e.g., a sound, word, or sentence) and speaks it back to the teacher.
- Expressive labels: The child is shown an object and the child names it correctly.
- Simple intraverbals: Fill-in-the-blank phrases, such as "Ready, set…," "Peek-a-…," "A, B…," "1, 2…," "big…"

The remaining columns show the type of stimulus control involved in each program (simple, conditional, simultaneous, and successive), the type of stimuli involved, and the relation between stimuli and responses.

A *cross-modal relation* exists, for example, when a child sees something that he/she desires (e.g., an apple) and requests it (i.e., says "Apple"). In this case, the stimulus (apple) is visual, and the response (i.e., requesting the apple) is a verbal response that also is auditory because the child can hear him/herself speaking. In addition, saying "Apple" is a motor response because each word has a distinct oral motor topography. Hence, saying "Apple" when you see an apple is a cross-modal relation consisting of a visual stimulus and a verbal-auditory motor response.

Receptive instructions, where the teacher gives instructions for the child to follow (e.g., "Wave" or "Clap your hands"), also involves a cross-modal relation, where the S^{D} "Wave" is a verbal auditory stimulus and the response involves a gross motor action that is distinct for that particular S^{D}. Clapping, in contrast, involves a gross motor topography that is different from waving. In addition, clapping is visually distinct from waving.

Nonvocal imitation involves cross-modal relations where the stimulus is visual (e.g., the teacher demonstrates clapping) and the response involves a gross motor action that is distinct for that particular S^{D} (e.g., the child claps).

An arbitrary related stimulus is a stimulus that bears no relation to the form of other stimuli present, such as all verbal stimuli, written or spoken. The written word CAR bears no resemblance to the object car. Similarly, the spoken word "Car" bears no resemblance to the object car or the sounds it makes. Hence, they are arbitrarily related stimuli. As described above, research has shown that children with autism may readily learn object discriminations based on the objects' sound, but show difficulties establishing object discriminations when required to respond to the names of the objects (Eikeseth and Hayward 2009). The object name is an arbitrary related verbal auditory stimulus, whereas the object sound is a nonarbitrary and nonverbal auditory stimulus.

Table 12.2 For the skills that are typically taught to children with autism at the beginning of their programs (left hand column) the ticks indicate those types of discrimination that may be involved in learning the skill, together with other types of stimuli that may be present during acquisition of the skill

Skill	Antecedent stimuli and responses						
	Simple discrimination	Conditional discrimination	Simultaneous discrimination	Successive discrimination	Stimulus and response relation	Arbitrarily related	Vocal stimulus
Identity matching	No	Visual CS and visual $S^D$and the S^Δ	$S^D$and the S^Δ	CS	CS: VisualS^D: Visual R: Motor *without* a unique response topography	No	No
Nonvocal imitation	Yes	No	No	S^D	S^D: Visual R: Motor *with* a unique response topography	No	No
Receptive instructions	Yes	No	No	S^D	S^D: Verbal (auditory) R: Motor *with* a unique response topography	Yes	Yes
Receptive labels	No	Verbal CS and visual S^D and the S^Δ	S^D and the S^Δ	CS	CS: Verbal (auditory) S^D: Visual R: Motor *without* a unique response topography	Yes	Yes
Vocal imitation	Yes	No	No	S^D	S^D: Verbal (auditory) R: Verbal *with* a unique response topography	No	Yes
Expressive labels	Yes	No	No	S^D	S^D: Visual R: Verbal *with* a unique response topography	Yes	No
Simple intraverbals	Yes	No	No	S^D	S^D: Verbal (auditory) R: Verbal *with* a unique response topography	Yes	Yes

As can be seen in Table 12.2, if the child learns *identity matching*—which is one of the most basic programs of the beginning curriculum—the child is able to perform conditional discriminations.

Nonvocal imitation of gross motor actions—also a beginning curriculum program—involves successive discriminations. If the teacher continues to demonstrate the action until the child responds, it is a simultaneous discrimination. If, on the other hand, the teacher shows the action only briefly to the child and stops demonstrating it before the child responds, it is a delayed discrimination. Presenting the S^D so it occurs while the child emits the response may help the child acquire this skill.

Nonvocal imitation also involves cross-modal relations because the action is demonstrated visually to the child and the child's response is a motor response.

Receptive instructions are simple discriminations, and involve successive discriminations. Also, since the S^D "Clap" is not present while the child performs the response, it is also a delayed discrimination. It is also a cross-modal relation, where the instruction given by the teacher is verbal auditory and the child's response is motor.

Receptive labeling is often a more difficult skill to learn when compared to receptive instructions. This might be surprising since they both involve responding to verbal stimuli. However, the two programs differ in at least two important ways. Firstly, receptive labeling involves conditional discriminations whereas receptive instructions involve simple discriminations. Secondly, they differ in their response dimension in that receptive labels involve a selection response, while receptive instructions involve a motor response where the repose topography is unique to the S^D. Receptive labels involve selecting the target item placed in any position, and this selection is based merely on the form of the item. Receptive instructions, in contrast, involve distinct response topographies for each individual instruction given. The response topography for the instruction "Touch head" is touching the head, and the response topography for the instruction "Clap" is clapping, and clapping and touching the head are two different responses. Research suggests that discriminations involving visual-motor responses are easier to learn as compared to discriminations involving visual responses (Potter and Brown 1997). This knowledge can be used to design effective programing changes that may help a particular child acquire receptive labels, by altering the response topographies to become topography based. This can be done by requiring distinct response topographies for each object taught. For example, the child might be required to identify the car by driving it, to identify the cup by pretending to drink from it, and to identify the book by opening it.

In addition (or alternatively), using the sound discrimination procedure outlined above (teaching the child first to respond to an auditory nonverbal stimulus (object sounds) and subsequently fading in the object's name and fading out the object's sound) might facilitate learning of receptive labels.

Expressive labeling involves simple discriminations and successive discriminations. Expressive labels involve the presence of a visual stimulus and a vocal verbal response from the child. It is a cross-modal relation because the S^D is visual and the response is verbal.

Simple intraverbal behaviors involve simple discriminations and successive discrimination (e.g., answering "Go" in response to the S^D: "Ready, set…"). It is also a cross-modal relation where the S^D is auditory verbal and the response is a verbal vocal motor response.

As evident from the above, even the beginning curriculum involves complex discriminations and complex stimulus control issues. By using this knowledge, together with knowledge about which curriculum skills the child is acquiring and what part of the curriculum the child has difficulties with, the teacher may be equipped to problem solve and individually tailor teaching programs for each particular child. This in turn might help the child overcome these learning difficulties. Hence, the stimulus control technology available from behavior analysis is a helpful tool for facilitating learning in children with developmental delays of different degrees and for different reasons. By analyzing the type of stimulus

control involved in each type of curriculum skill, and by examining which skills the child is learning and which type of skills the child has difficulties learning, the teacher may be able to perform a type of *functional analysis of stimulus control,* which in turn can be used to individualize the child's program to maximum effect. Such an approach would constitute a careful analysis of each student's learning in terms of the behavioral processes at work, rather than a merely application of procedures and technology.

Summary and Future Research

DTT is an instructional procedure designed to improve the developmental and educational outcomes of children with autism and other developmental delays and is an important component of contemporary EIBI programs. DTT is a highly validated procedure and has been used to help children with autism acquire a wide range of skills including language, imitation, play skills, and social and emotional skills. In addition, DTT has been used to reduce aberrant behavior. DTT differs from other teaching methods in its focus on errorless learning, the large number and speed of repetition, the high degree of structure, and the arbitrary connection between task and reinforcement. This enables DTT to teach children who have not learned spontaneously in normal settings to acquire basic behaviors and discriminations necessary for continued development in normal settings.

Discrimination training is an important element of DTT. Discrimination training deals with the way in which training stimuli and prompts are presented and how prompts are subsequently removed, and a number of different discrimination training strategies exist to promote learning. It is clear from previous research, from an examination of the types of discrimination involved, and from an examination of the stimuli present in the relatively simple programs outlined in Table 12.2, that there are many elements that are present in all programs and that exert an effect on the ability of a child to master the skill being taught. Future research should be conducted to examine the role that different types of discriminations play in the learning of new skills by children with autism. Research could examine the effectiveness of working on skills using simultaneous discrimination procedures rather than successive discrimination procedures. Further, the type of stimulus that is present can be evaluated by examining the effects of changing arbitrary vocal stimuli into nonarbitrary auditory stimuli to teach children to discriminate different sounds as a prerequisite to discriminating vocal stimuli. The implications that this research has for treatment and teaching programs for individuals with different types of learning difficulties is potentially wide-ranging.

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