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The use of computer-generated fading materials to teach visual-visual non-identity matching tasks

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Many everyday matching tasks taught to persons with developmental disabilities are visual-visual non-identity matching (VVNM) tasks, such as matching the printed word DOG to a picture of a dog, or matching a sock to a shoe. Research has shown that, for participants who have failed a VVNM prototype task, it is very difficult to teach them various VVNM training tasks using standard prompting and reinforcement. A potential rapid training procedure for teaching VVNM tasks would include within-stimulus prompt fading. Such a training procedure, however, requires suitable teaching materials. In this paper we describe a strategy for creating computer generated fading steps, and illustrate their application for rapid teaching of VVNM discriminations.

We set out to apply within-stimulus prompt fading to teach a visual-visual non-identity matching (VVNM) discrimination to individuals who had failed a VVNM prototype task. Early in the process, we encountered considerable difficulty in generating suitable teaching materials. In the process of overcoming this difficulty, we encountered a computer software program that facilitated the creation of fading materials. The purpose of this paper is to describe that computer software program and to illustrate its application in a case-study that investigated the rapid teaching of a VVNM discrimination using within-stimulus prompt fading.

A common problem in caring for individuals with developmental disabilities is matching the difficulty of training tasks to the learning abilities of the client. Consequently, when a direct-care worker attempts to teach tasks to a client, both the client and the direct-care worker are likely to experience confusion and frustration. In order to combat this problem, Kerr, Meyerson, and Flora (1977) created the Assessment of Basic Learning Abilities (ABLA) Test, an empirically validated assessment tool for individuals with developmental disabilities. The test assesses the ease or difficulty with which an individual can learn to perform six discriminations, called levels, that are thought to underlie many everyday training tasks. The discriminations include: Level 1, a simple imitation; Level 2, a two-choice position discrimination; Level 3, a two-choice visual discrimination; Level 4, a two-choice match-to-sample discrimination; Level 5 a two-choice auditory discrimination; and Level 6, a two-choice auditory-visual discrimination (See Table 1).

Table 1
A Description of the ABLA Levels and the Types of Discriminations Required.

ABLA Level	Types of Discriminations
1) Imitation:	
A tester puts an object into a container and asks the client to do likewise	A simple imitation
2) Position Discrimination:	
When a red box and a yellow can are presented in a fixed position, a client is required to consistently place a piece of foam in the container on the left when the tester says, “Where does it go?”	A simultaneous visual discrimination with position, colour, shape, and size as relevant cues
3) Visual Discrimination:	
When a red box and a yellow can are randomly presented in left-right positions, a client is required to consistently place a piece of foam in the yellow can when the tester says, “Where does it go?”	A simultaneous visual discrimination with colour, shape, and size as relevant cues

Table 1 Cont'd

ABLA Level	Types of Discriminations
4) Match-to-Sample Discrimination:	
A client demonstrates Level 4 if, when allowed to view a yellow can and a red box in randomly alternating left-right positions, and is presented randomly with a yellow cylinder and a red cube, he/she consistently places a yellow cylinder in the yellow can and a red cube in the red box.	A conditional visual-visual identity discrimination with colour, shape, and size as relevant cues
5) Auditory Discrimination:	
When presented with a yellow can and a red box (in fixed positions), a client is required to consistently place a piece of foam in the appropriate container when the tester randomly says, "red box" (in a high-pitched rapid fashion) or "yellow can" (in a low-pitched drawn out fashion).	A conditional auditory-visual non-identity discrimination with pitch, pronunciation, and duration as relevant auditory cues and with position, colour, shape, and size as relevant visual cues
6) Auditory-Visual Discrimination:	
The same as Level 5, except that the right-left position of the containers is randomly alternated.	A conditional auditory-visual non-identity discrimination, with the same auditory cues as Level 5, and with only colour, shape, and size as relevant visual cues

During ABLA testing, a participant sits across from the tester at a table. The testing procedures utilize a standard prompting and reinforcement method which includes three components. First, before formal testing of an ABLA level begins, a participant is given a demonstration of the correct response on that level, followed by a guided trial in which the tester physically guides the participant to make the correct response. Second, the participant is then given the chance to perform the task independently. Once the participant demonstrates a correct independent response on a level, formal testing of that level begins. Third, during testing, a correct response is followed by a reinforcer (e.g., preferred edible, praise), while an incorrect response is followed by an error correction procedure, consisting of a demonstration, a guided trial, and an opportunity for an independent response. For each ABLA level, a "pass" is defined as eight consecutive correct responses, while a "fail" is defined as eight cumulative incorrect responses.

There are many established generalizations concerning the ABLA test (Vause, Yu, & Martin, 2007). First, the levels are hierarchally ordered in difficulty (Kerr et al., 1977; Martin, Yu, Quinn, & Patterson, 1983; Wacker, 1981). Second, the ABLA test has high test-retest reliability (Martin et al., 1983). Third, failed levels are difficult to teach using standard prompting and reinforcement procedures (Meyerson, 1977; Stubbings & Martin, 1995, 1998; Witt & Wacker, 1981, Yu & Martin, 1986). Fourth, performance on the ABLA tasks is highly predictive of the client's ability to learn similar everyday activities (Martin, Thorsteinsson, Yu, Martin, & Vause, 2008).

ABLA Level 4 is a visual-visual quasi-identity matching task in which a client is required to place a small red cube into a red box and a small yellow cylinder into a yellow can (see Table 1). ABLA Level 5 is a two-choice auditory discrimination and Level 6 is a two-choice auditory-visual discrimination (see Table 1). Considering that research has shown that the great majority of participants who pass ABLA Level 5 also pass Level 6 (Martin & Yu, 2000), Sakko, Martin, Vause, Martin, & Yu (2004) suggested that a VVNM prototype task might be a worthwhile replacement for ABLA Level 5. The VVNM prototype task uses two manipulanda and two containers, similar to ABLA Level 4 (see Table 1). Specifically, the task requires participants to learn to match a silver-coloured piece of wood shaped into the word "BOX" to a large red box, and a purple-coloured piece of wood shaped into the word "Can" to a large yellow can. The testing procedure for the VVNM prototype task is identical to the ABLA testing procedure that was summarized previously.

Many everyday matching tasks are VVNM tasks, such as matching the printed word CAT to a picture of a cat and the word DOG to a dog, or matching a shoe to a sock, or a cup to a saucer. Sakko et al. (2004) found that the VVNM prototype task (a) falls in a predictable place in the

ABLA hierarchy in terms of level of difficulty (between levels 4 and 6), (b) has high test-retest reliability, and (c) is highly predictive of performance on everyday VVNM tasks. However, for individuals who pass ABLA Level 4 and fail ABLA Level 6, teaching VVNM training tasks is extremely difficult, requiring hundreds of training trials (Vause, Martin, Yu, Marion, & Sakko, 2005). Considering that several studies have indicated that within-stimulus prompt fading is more effective than extra-stimulus prompt fading for teaching certain types of visual discriminations to persons with developmental disabilities and children with autism (Schreibman, 1975; Witt & Wacker, 1981; Wolfe & Cuvo, 1978), we wanted to investigate within-stimulus prompt fading to teach a VVNM discrimination to participants who passed ABLA Level 4 and failed ABLA Level 6. That led us to the problem that we identified earlier, namely, how could we structure fading materials for such an endeavour?

The present research used a single-subject, alternating treatments design to compare standard prompting and reinforcement (SPR) to standard prompting and reinforcement plus within-stimulus prompt fading (SPRF) for teaching VVNM training tasks to a person with severe developmental disability. At the start of the SPRF training, the participant responded correctly to a previously-mastered ABLA level 4 identity match-to-sample task. Using a computer software program to create the fading materials, we then slowly faded the manipulanda in colour, size, and shape over an additional nine steps. By the end of training, the participant was responding correctly to a non-identity VVNM task. We believe that the computer software program can be used to generate fading materials that will be very helpful in teaching a variety of tasks to persons with developmental disabilities, and potentially children with autism.

Method

Participant and Setting

The participant was a middle-aged male diagnosed with a severe developmental disability. He resided in a community and residential facility for persons with developmental disabilities. Prior to training, the participant passed up to and including ABLA level 4, but failed ALBA level 6, the VVNM prototype task, a VVNM generalization task, and two VVNM training tasks. Sessions were conducted in research rooms at the facility. During the sessions, the participant was seated at a table across from the experimenter.

Materials

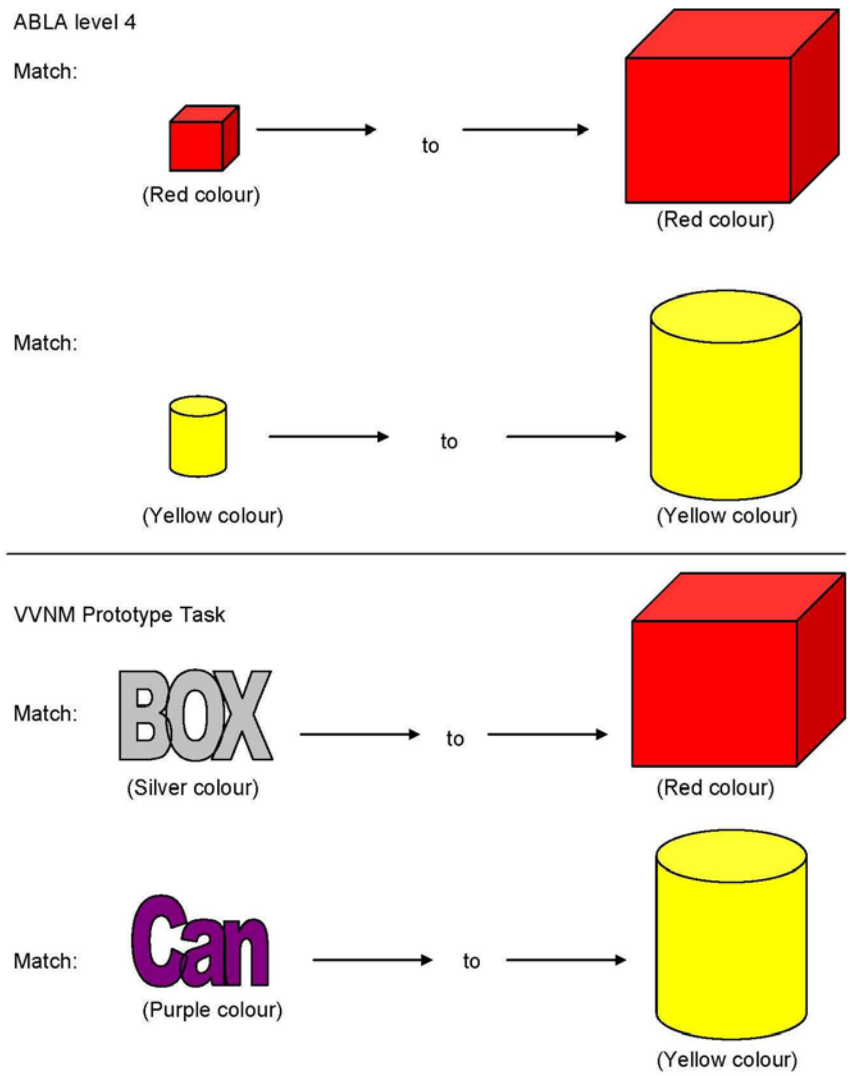
Materials for the ABLA test included a red box (14 cm x 14 cm x 10 cm) with black diagonal stripes, and a yellow can (15 cm in diameter and 17 cm in height). For ABLA levels 1, 2, 3, and 6, we used an irregularly shaped piece of white foam (5 cm in diameter). For ABLA level 4, we used a small red striped cube (5 cm x 5 cm x 5 cm) and a small yellow cylinder (9 cm x 4 cm) (see Figure 1).

For the VVNM prototype task, two pieces of wood shaped into the words "BOX" and "Can" and coloured silver and purple, respectively, were used in addition to the red box and yellow can that were used for the ABLA test (see Figure 1).

For the VVNM generalization task, three dimensional objects were used. The participant was required to match paperclips to a stapler, and a pencil sharpener to a pencil.

The VVNM training tasks involved teaching a participant to place an object on top of a container that was of a different colour, shape, and size than the object (Component A), and to place a different object on a second (and different) container (Component B). The fading steps were created using the computer program Adobe® Photoshop® CS3 10.0, a graphics editor that is used for image manipulation. Each fading image and its reverse image were printed on photo paper and then laminated. A piece of foam board was placed between the two images to create a three-dimensional object. Because of the complexity of the tasks, a more detailed description will be given in conjunction with the description of the training procedures.

Figure 1. **ABLA Level 4 and VVNM prototype task materials.**



Procedures

Preference assessment

Prior to the start of the testing sessions, we consulted with the resident staff about the participant's reinforcers and interest (e.g., wrestling video, coffee). At the start of each session, the participant was provided a choice of several of those reinforcers and the first two that were chosen were then randomly alternated throughout the session to reinforce correct independent responses.

ABLA testing. The ABLA assessment was conducted following standard testing procedures to determine the participant's current ABLA level (Kerr et al., 1977; Martin & Yu, 2000). The assessment began with a demonstration of the task being assessed, followed by a guided trial and an opportunity for an independent response. During the demonstration, the tester (the first author) provided the verbal cue "where does it go?", and placed the manipulandum (a piece of foam for levels 1, 2, 3, and 6, and either a cube or a cylinder for level 4) into the correct container. For the guided trial, the tester again provided the verbal cue, handed the participant the manipulandum, and physically guided the participant to place the manipulandum into the correct container. Finally, the opportunity for an independent response was provided; the tester provided the verbal cue, handed the manipulandum to the participant, and waited for an independent response. After a successful independent response, test trials began on that level.

Correct responses were followed by verbal praise and a preferred reinforcer (e.g., wrestling video, coffee). If the response was incorrect, another demonstration, guided trial and an opportunity for an independent response occurred until there was a successful independent response. During the error correction procedure, a correct independent response was followed by praise only. An incorrect independent response is followed by a repeat of the error correction procedure. Errors on the independent portion of the error procedure did count towards the failure criterion, while correct responses did not count towards the pass criterion. For each level, a pass was defined as eight consecutive correct responses, while a fail was defined as eight cumulative errors.

VVNM prototype task and training tasks. The VVNM assessments were conducted in the same way as the ABLA assessment, but used the VVNM prototype materials and other three-dimensional objects described previously.

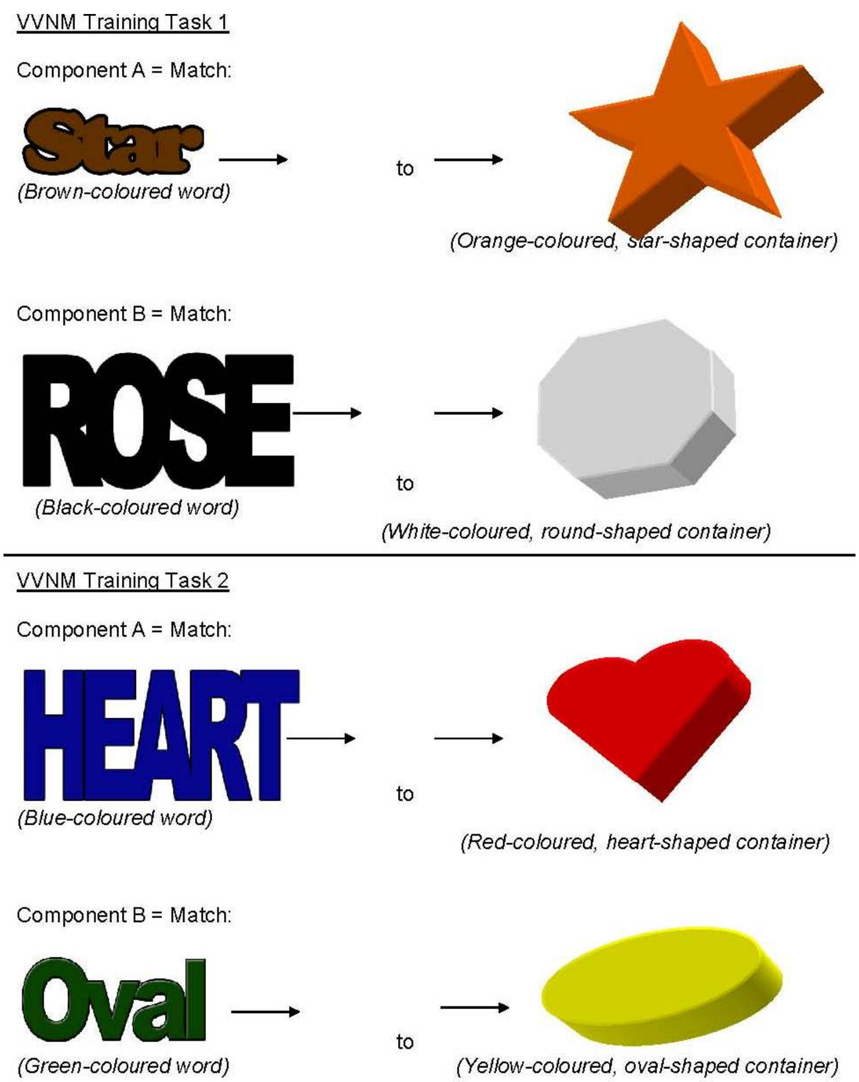
Research Design

A single-subject alternating-treatments design was used to compare the effects of two different training procedures, a standard prompting and reinforcement (SPR) procedure (identical to the ABLA procedure described above) and SPR plus a within-stimulus fading component (SPRF, to be described later). The two training procedures were then alternated over each successive training session. Each training session was 20 minutes in length, which is approximately the length of a typical ABLA assessment. Training on a task continued until that task was mastered, defined as eight consecutive correct responses, or until 200 trials was reached, whichever occurred first.

In order to maximize the participant's ability to discriminate between the SPR procedure and the SPRF procedure, physical alterations were used for each type of session. For the SPR training sessions, a yellow tablecloth was draped over the table, and the participant was seated at the south end of the table. The trainer (the first author) wore a pale yellow t-shirt and had her hair pulled back. For the SPRF training sessions, a green tablecloth was used, and the participant was seated at the north end of the table. The trainer wore an orange sweater and wore her hair down.

SPR Procedure. The SPR procedure was identical to that described previously for the ABLA and VVNM assessments. One of two VVNM training tasks (Task 2 in Figure 2) was randomly assigned to SPR.

Figure 2. Examples of two sets of VVNM training task materials.



SPRF Procedure. The SPRF procedure was similar to the SPR procedure, except for the inclusion of within-stimulus fading, first for Component A, and then for Component B, of a VVNM training task (Task 1 in Figure 2). During the fading procedure, the participant began training with an

ABLA level 4 match-to-sample discrimination (e.g., matching a small, orange-coloured, star-shaped item to an orange-coloured, star-shaped container and matching a small, white-coloured, round-shaped rose to a white-coloured, round-shaped container (see Figure 3). After the participant had successfully performed the match-to-sample task once (i.e., demonstrated a correct independent response on both items), the fading procedure was introduced for Component A. On the next independent trial, the participant proceeded to the first of nine additional fading steps that slowly faded the original manipulandum (e.g., small, orange-coloured, star-shaped item) into a word (e.g., large, brown-coloured word "STAR"; see Figure 4). Thus, for the final fading step (Step 10), the participant was performing Component A of a VVNM training task (e.g., matching the large, brown-coloured word "STAR" to an orange-coloured, star-shaped container). There were also nine intermediate steps that could be used during the error correction procedure, as described below (e.g., Step 1B fell between Steps 1 and 2; Step 2B fell between Steps 2 and 3, etc.)

Figure 3. **An illustration of the first fading step and the last fading step for the two components of VVNM training task 1 (shown in Figure 2).**

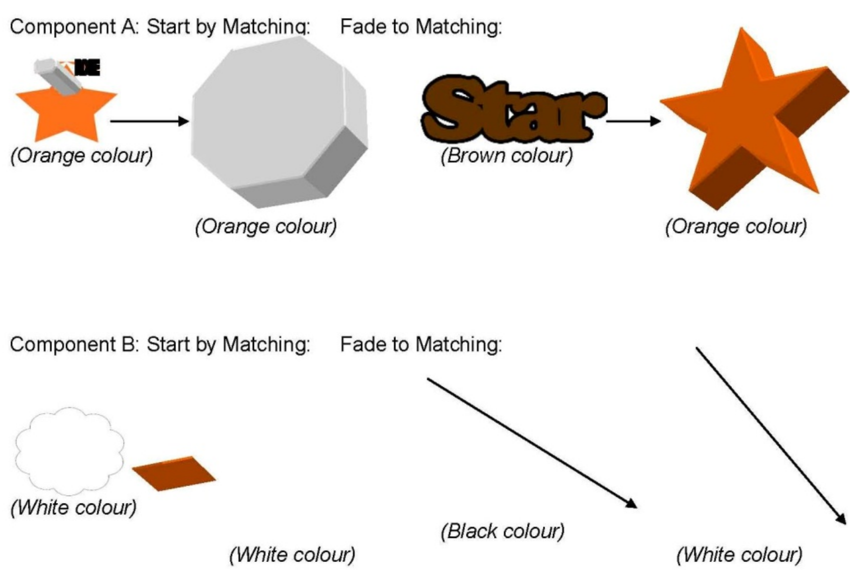
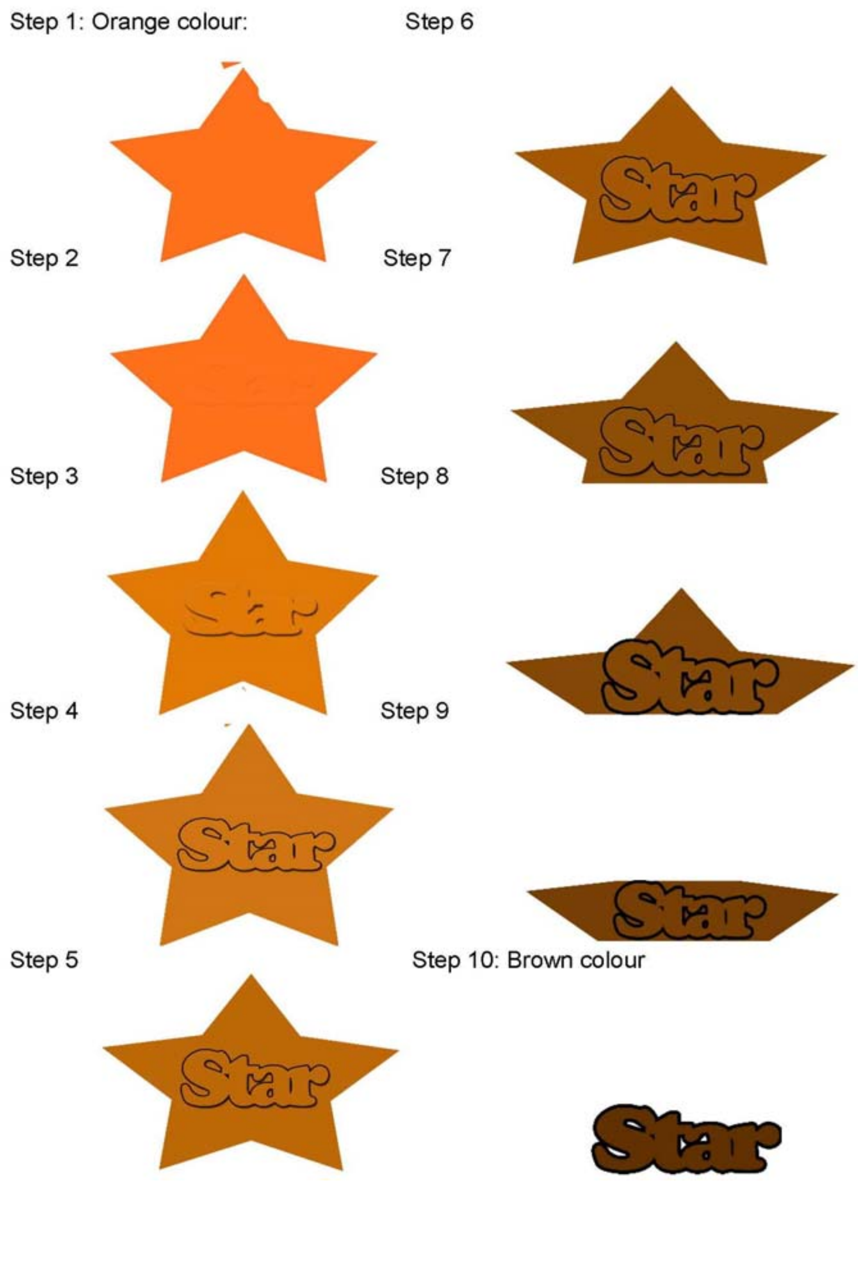


***Figure 4.* The ten "STAR" fading steps for Component A of the VVNM training task 1.**

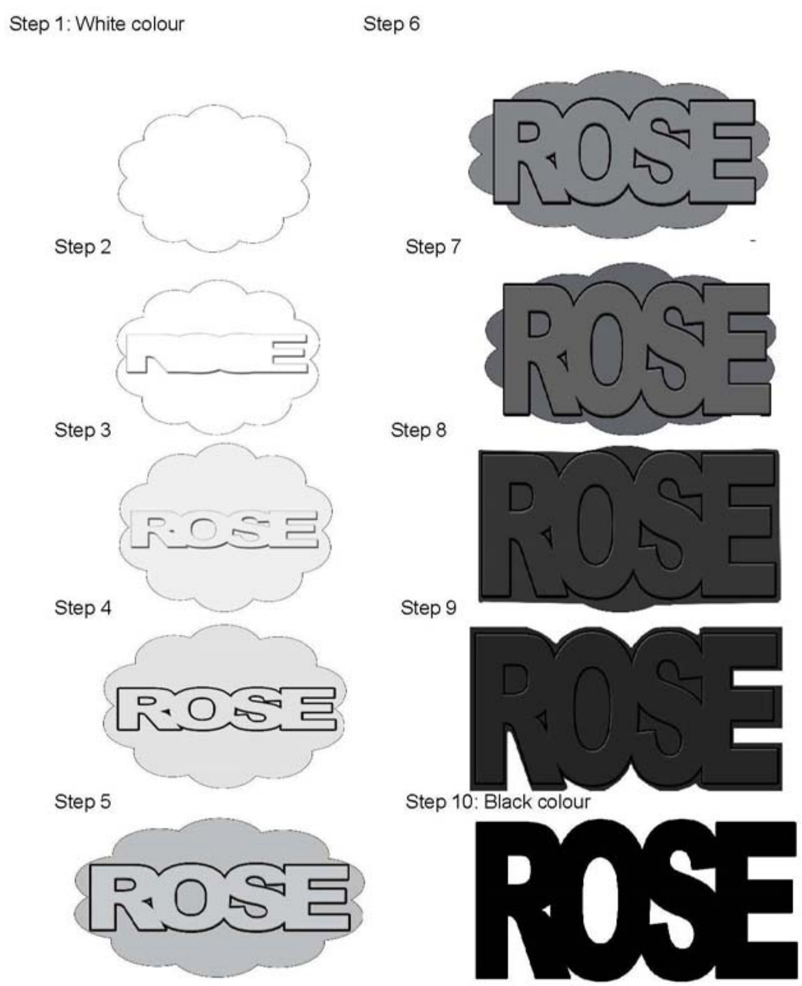


During each fading trial, if the participant correctly matched the manipulandum to the correct container on his first attempt, the subsequent fading step was used in the next trial until the final fading step was reached. However, if the participant matched a manipulandum to the incorrect container, the trainer introduced an error correction procedure. Following an error, the trainer a) provided a demonstration of the previous, presumably-easier, fading step; b) presented an opportunity for an independent response on that step; then c) immediately provided an opportunity for an independent response on the current fading step. If the participant responded correctly, training would continue and the failed step would be presented again in the next test trial. However, if the participant responded incorrectly to the current fading step a second time, a demonstration, guided trial, and opportunity for an independent response would once again be provided on the previous fading step. This was followed by an opportunity for an independent response on a new intermediate fading step, and then an opportunity for an independent response on the failed fading step. A correct response would be followed by a new test trial with the failed step. A third incorrect response on the current fading step was followed by a demonstration, guided trial, and opportunity for an independent response on the failed fading step. Again, a correct response was followed by a new test trial with the previously failed step. A fourth incorrect response would terminate the session.

Once the participant reached Step 10 (Component A of the VVNM discrimination), the above error correction procedure was replaced with the standard ABLA error correction procedure (i.e., demonstration, guided trial, and independent response on Step 10). If the participant made eight cumulative errors at Step 10, we moved back to Step 9. In order to pass Step 10 of Component A of the VVNM task, the participant was required to make eight consecutive correct responses at Step 10.

After Component A had been successfully faded, Component B was faded in an identical manner (i.e., begin by matching a small, white-coloured, rose-shaped item to a white coloured, round-shaped container; and then complete the fading steps until the participant matched the large black-coloured word "ROSE" to a white-coloured, round-shaped container; see Figure 5). If the participant performed errorlessly, the minimum number of trials to learn both components of a VVNM training task was 52 trials.

Figure 5. **The ten "ROSE" fading steps for Component B of the VVNM training task 1.**



If the participant met the mastery criteria on both components of a VVNM training task using either the SPR procedure or the sequential

SPRF procedure, the second VVNM training task (see Figure 2) was then taught using the more effective procedure.

Once the participant had completed training, we tested for generalization on the original VVNM prototype task, matching the silver-coloured word “Can” to a yellow can and matching the purple-coloured word “BOX” to a red box, as well the VVNM generalization task using three-dimensional objects (described previously).

Reliability Assessments

Inter-observer reliability (IOR)

IOR checks were conducted for 65% of the sessions. An observer independently recorded both the correct and incorrect responses by a participant for each trial. A trial was defined as an agreement if the observer and the trainer recorded the same response; otherwise, it was defined as a disagreement. An IOR score was calculated for a session by dividing the number of agreements by the number of agreements plus the number of disagreements, and then multiplying by 100% (Martin & Pear, 2007). Agreements ranged from 91% to 100% across observed sessions, with a mean of 99%.

Procedural Integrity (PI)

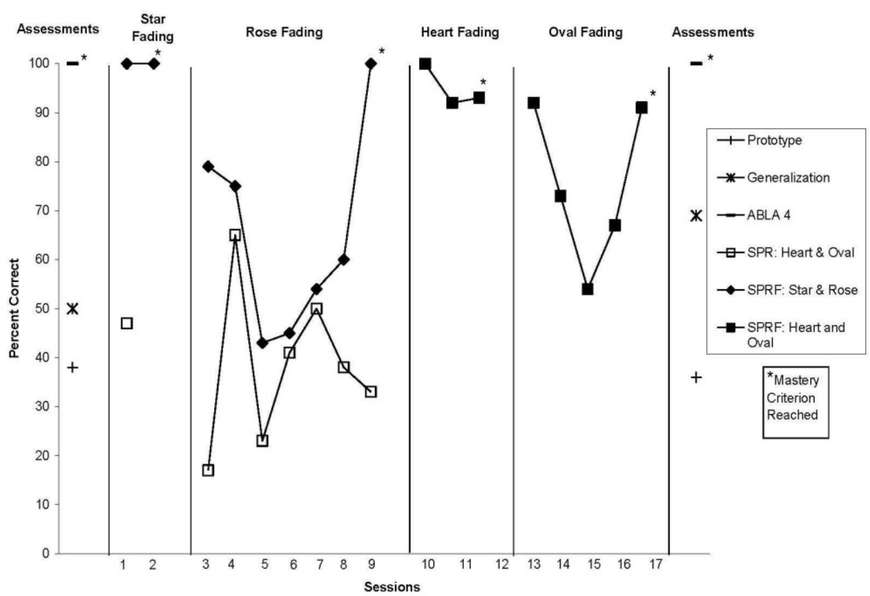
PI checks were conducted for 65% of the sessions using a checklist that listed the steps to be followed by the trainer. During a PI check, the observer recorded whether or not the trainer had carried out each item on the checklist correctly. A PI score for a session was calculated by dividing the total number of instances in which a step was conducted correctly, by the total number of steps on all trials in that session. PI scores ranged from 98% to 100% across observed sessions, with a mean of 99%.

Results

The participant initially received SPRF with the Star/Rose task, and SPR with the Heart/Oval task. He rapidly met the mastery criterion for the

Star fading task in 24 trials over two sessions, and for the Rose fading task in 87 trials over seven sessions (see Figure 6; refer to Sessions 1 to 9). At this point, the participant had received 120 trials over eight sessions on the Heart/Oval task using the SPR training procedure, but failed to meet the mastery criterion. Thus, SPR training on the Heart/Oval task was discontinued, and training on this task using the SPRF procedure began (the fading steps are available from the first author). The participant rapidly met mastery criterion for the Heart fading task in 36 trials over three sessions, and the Oval fading task in 55 trials over five sessions (refer to Sessions 10 to 17 in Figure 6). Following training, the participant was retested on the VVNM prototype task and on the VVNM generalization task, and failed both tasks.

Figure 6. **Percent correct responses per session.**



Discussion

According to these results, it appears that, like other ABLA levels, a VVNM task can be rapidly taught using a multiple-component training package. Furthermore, the results replicated past research findings, demonstrating that failed VVNM tasks are resistant to training using standard prompting and reinforcement training. Although these results will need to be replicated with additional participants, they are very encouraging. Previous attempts to teach VVNM training tasks to participants who had failed the VVNM prototype task required 100s of training trials (Vause et al., 2005). Using the computer-generated materials for within-stimulus fading enabled us to teach a VVNM task to a participant in 111 trials, and a second task in 91 trials. These results are very promising.

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