An operant analysis of joint attention and the establishment of conditioned social reinforcers

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An operant analysis of joint attention skills suggests that conditioned social reinforcers play a crucial role in shaping and maintaining joint attention skills in typically developing humans. Although joint attention response topographies can be established successfully in children with autism through contrived reinforcers, natural consequences may not maintain the behavior. Hence, treatment of joint attention problems in children with autism may require the establishment of natural social consequences as conditioned reinforcers. The standard procedure for conditioning new reinforcers is the “pairing procedure.” However, clinical observations suggest that a pairing procedure may not be particularly effective. The current study compared the “pairing procedure” with an explicit operant discrimination procedure. First, a previously neutral stimulus was established as discriminative stimulus for a response that produced a reinforcer, and then tested for conditioned reinforcer effects when being presented contingent upon an arbitrary response with no additional contingent reinforcers. Second, another previously neutral stimulus was repeatedly paired with a reinforcer, and then tested for conditioned reinforcer effects as in the first procedure. Seven of the eight children completed both sequences, and five of these seven children emitted a markedly higher number of responses when stimuli established as $S^D$s were contingent upon them than when stimuli used in the pairing procedure were response contingent. For the sixth child, the difference in favor of the $S^D$ procedure was minor, whereas for the last child, the difference was in the opposite direction. In sum, the results suggest that conditioned reinforcers can be more effectively established through the discriminative stimulus procedure than through simple pairing with an unconditioned reinforcer. Possible implications for joint attention teaching procedures are discussed.

Keywords: Joint attention, conditioned reinforcers, pairing, operant discrimination, operant analysis.

Even if joint attention skills must consist, in part, of some specific response forms, (e.g., head turning, gaze shifting, pointing), joint attention is more than just a formal unit. The intricacy of specifying that “more” is obvious from the diversity of attempts to define the term. Although Butterworth (1991) defined joint attention simply as “looking where someone else is looking”, such simultaneous looking can occur without “jointness”, “coordination”, or “synchronization” of attention. As an illustration, Tomasello (1995) described two common types of interaction between child and adult which would lack the “true jointness” criterion even if satisfying the above definition: In one scenario, called “onlooking,” something may catch the attention of two people simultaneously, but without either persons’ behavior being influenced by the other’s. In a second scenario, called “cued looking,” an infant may just respond to others’ head orientation as a cue because it “often results in interesting sights,” and such cued looking is not joint attention, because “the infant does not know that the...
adult is attending” (Tomasello, 1995, p. 106). In a similar vein, Bruner (1995) suggested that, “joint attention involves knowing that another is looking at and experiencing something in the visual world” (p. 7), and Baldwin (1995) wrote that joint attention depends on “the recognition that mental focus on some external thing is shared” (p. 132).

In behavior-analytic terms, such “knowing” and “recognition of mental focus” point crudely to controlling relations between environmental events and behavior. Thus, to qualify as “joint attention”, the direction of another person’s gaze or pointing must enter into the control of the child’s looking in a specific direction, as an antecedent (in responding to joint attention; RJA) or as a reinforcing consequence (in initiating joint attention; IJA). Further, the reinforcing consequence must consist of more than simply nonsocial stimuli localized in the direction of that other person’s line of regard. The relevance of social reinforcers is embedded in a common distinction between “protoimperative” and “protodeclarative” gestures. Whereas protoimperative gestures have sometimes been defined as “requests . . . intended to make another person do something for one’s benefit” (Sarría, Gómes, & Tamarit, 1996, p. 51), the term protoimperative is sometimes preserved for cases that involve “coordination of attention with other people” (Sarría et al., 1996). Protodeclarative gestures have been defined as a preverbal effort to direct other’s attention to an object or event (Bates, Camaioni, & Volterra, 1975) and have, according to Tomasello (1995) “the purely social motive of sharing attention to something” (p. 111). Such “social sharing” of “awareness”, “experience”, “affect” or “interest”, as contrasted with obtaining specific things for one’s own benefit, has been underscored as what defines “true joint attention” (Bruner, 1975; Collis & Schaffer, 1975; Mundy, Sigman, & Kasari, 1994). Some authors have insisted that such “sharing” mechanisms cannot be objectively observed and recorded, and that it is therefore difficult to assess and intervene in these skills in children with autism (e.g., Naoi, Tsuchiya, Yamamoto, & Nakamura, 2008). However, to the extent that we can meaningfully talk about such mechanisms and decide whether they are present or absent in the repertoire of a specific child, there must be some observational basis for talking about them. A detailed analysis of the consequences that typically follow IJA in joint attention interactions seems to be required.

More than 25 years passed after the first publications related to joint attention until the first behavior-analytic studies in the area appeared. The first published report of a systematic attempt to use behavior principles in order to establish joint attention skills in children with autism was written by Whalen and Schreibman (2003). Their “naturalistic behavior modification technique,” mixed discrete trial training (DTT) with pivotal response training (PRT) procedures. The results of the intervention showed that RJA skills were established in all five children during RJA training, improvements from pre-training assessments were evident on post tests, including unstructured generalization tests. Further, the targeted IJA skills, gaze shifting and pointing, were effectively established in four of the five children, and improvements were clearly shown in these skills during post-intervention assessments and were generalized to different settings, such as in the presence of the parents. At follow-up, three of the four children who completed training still demonstrated RJA skills well above baseline level during conditions similar to initial acquisition, and at least two of the children did so even during generalization conditions with their mothers. However, all four children showed a marked drop in IJA skills, i.e., both gaze alternating and “protodeclarative pointing”, compared to performances immediately post intervention. Apparently, in the absence of the contrived reinforcement during training, natural consequences were not sufficient to maintain the recently acquired IJA skills. Hence, although the Whalen and Schreibman (2003) study demonstrated that many basic skills in joint attention interactions can be effectively taught to children with autism, the “sharing” that is often incorporated in definitions may still be lacking. To the extent that the children’s performances were maintained by “characteristic” or “specific” reinforcers, these
performances would not qualify as examples of “true joint attention”. Rather, they are requests, or protoimperatives.

Like Whalen and Schreibman, Jones and Carr (2004) stressed the difference between a declarative or indicative function and an imperative or request function and pointed out that, because joint attention skills involve both forms and functions, the task for an effective intervention program is to teach both. Further, they outlined a number of intervention techniques that may effectively teach specific joint attention skills. However, none of them have been applied such as to convincingly establish the core social function of joint attention and, hence, “the core deficit has not fully been addressed” (Jones & Carr, 2004, p. 21).

Finally, based upon the literature on generalized reinforcement and on pivotal skills training, Jones and Carr presented a series of suggestions regarding how this core deficit of social motivation could be built. Yet, as Jones and Carr pointed out, the natural consequence for joint attention is exactly the type of social interaction that, “unfortunately, . . . is typically not reinforcing to children with autism” (p. 22). As an alternative, however, they suggested the use of idiosyncratic forms of social reinforcers that may be quite effective even if normal social events are not (Green et al., 1988). Yet, if such idiosyncratic or alternative social consequences are not naturally occurring consequences of behavior, it would seem doubtful that such reinforcers could be better suited than other contrived reinforcers for the maintenance of IJA skills when only natural contingencies prevail.

Another strategy suggested by Jones and Carr was what they called “Establish the presence of the adult as a generalized reinforcer.” The suggested procedure was “repeatedly pairing the presence of the adult with a wide variety of highly preferred reinforcers.” The details of this procedure remain to be spelled out and, as the authors made clear, to be tested. If, as Jones and Carr suggested, the core social function of JA is that particular social events function as reinforcers and these particular social events do not function as reinforcers for behavior in children with autism, it seems that a key to solving the problem lies in arranging contingencies that will most effectively establish new stimuli as reinforcers.

A considerable advantage resulting from a behavior-analytic perspective on JA is that a vast literature on well-established behavioral principles is almost automatically relevant (e.g., Catania, 2007; Cooper, Heron, & Heward, 2007; Skinner, 1969). For instance, Dube, MacDonald, Mansfield, Holcomb, and Ahern (2004) interpreted a mother looking at an interesting event as a likely conditioned reinforcer for a three-year-old girl’s gaze shift towards her, and that the adult’s smiling, giving signs of approval, affectionate gestures etc., may function as generalized social reinforcers. A next question, then, is how the mother’s looking at the interesting event, smiling, verbalizing, and so on, may have become established as reinforcers for the child’s behavior. Particularly, when the reinforcing effect of such social stimuli seems to be lacking for the behavior in children with autism, the question is whether, and how, we most effectively can establish a reinforcing effect of such social events. Technically speaking, how can we most effectively establish the relevant social stimuli as conditioned reinforcers for the behavior of children with autism? We do know that conditioned reinforcers are established in the natural environment as well as during application of behavior-analytic procedures. Moreover, behavior-analytic research has identified at least two different procedures that can establish new stimuli as conditioned reinforcers (e.g., Kelleher & Gollub, 1962), and Gollub (1970) wrote that “a fair assessment of the status quo acknowledges two different, although sometimes overlapping, procedures for establishing conditioned reinforcers” (s. 362). These were the classical conditioning (or “pairing”) procedure and an operant discrimination procedure. Unfortunately, behavior-analytic sources are not very clear on how conditioned reinforcers can be established most effectively. Typically, textbooks describe procedures in which new stimuli acquire a reinforcing function from being “paired”, “associated”, or “correlated” with other reinforcers (e.g., Grant & Evans, 1994; Martin & Pear, 1996). However, there are also
reports on an apparent non-effectiveness of these procedures (Lovaaes et al., 1966). Consider an operant discrimination (SD) procedure as an alternative: For instance in order to establish nodding as a conditioned reinforcer, we might, rather than simply nod and present a reinforcer (i.e., pairing), make the reinforcer contingent upon our nodding plus some behavior in the child, such as helping him- or herself get some snack or toy from a table. In the latter procedure, a stimulus (i.e., the nod) is first established as a discriminative stimulus (SD) for a response that produces a reinforcer.

Myers (1958) wrote that, “one may ask whether either situation [classical or operant conditioning] is generally more effective when other variables are held constant...” (p. 299), but still missing is research that directly compares the effectiveness of these different procedures. The main purpose of the present study, therefore, was to investigate whether new stimuli are most effectively established as reinforcers (1) by being correlated with an unconditioned reinforcer through pairing (classical conditioning), or (2) by being established as discriminative stimuli for responses that produce an unconditioned reinforcer (operant discrimination).

Method

Participants

Eight children of varying age and diagnoses (autism, developmental disability, typically developing) were recruited, through the special health care system as well as through acquaintances, for participation in the study. Parents of all the children consented to their children’s participation in the study, and fictitious names of the children are used throughout this report. Four of the children, Cato (4.11 years old), Dan (4.4), Geir (12.5), and Hans (10.10) were diagnosed with autism. Two were diagnosed with Down syndrome, Even (4.4) and Finn (7.0), while two, Alf (2.7) and Britt (4.5) were typically developing children (see Table 1).

The five youngest children were in Kindergartens, while the three oldest went to school. Cato and Dan received early and intensive behavioral intervention (20-25 hours per week) in their kindergartens. The two oldest children, Geir and Hans, had received such treatment before, and they continued to receive behavioral treatment in school. Alf, Britt, Even, and Finn were in ordinary programs in their kindergartens or schools. Even and Finn also received some special education.

Because the youngest participant, Alf, was rapidly fatigued during pre-testing, he was, in agreement with his parents, dismissed from further participation in the study. Thus, seven of the eight children completed the study.

Setting

The child and the teacher were seated on opposite sides of a suitable table, facing each other. An assistant teacher stood behind the child and prompted the child’s responses in accord with the specified procedure. A parent or another familiar person, as well as three assistants were present throughout the sessions. The assistants conducted manual recordings and video recordings, and kept track of the time. Experimental sessions with each child were run during 1-2 hours each of three days within one week. Individual adjustments were made regarding the duration of sessions and breaks. Pre- and posttests lasted between 45s and 3.5min.

Design

A single subject design was used, with pre- and posttests for all of the seven participants who completed the study. The object of the pretest was (1) to identify responses contingent upon which stimuli could be delivered in order to measure a reinforcing effect of those stimuli, (2) to identify stimuli that did function as reinforcers, and (3) to identify neutral stimuli (i.e., stimuli that did not already function as reinforcers). The latter stimuli would then be included in either of two procedures (SD or classical conditioning) in order to investigate which of the two procedures will most effectively establish those previously neutral stimuli as conditioned reinforcers.

Apparatus and stimulus materials

All sessions were video recorded, and cumulative records of responding were later produced
from these recordings, using the "Cumulative Recorder" program (Norton, 1988). Scorings from the video were conducted by manually pressing the space bar on the computer each time a target response occurred on the video.

A laptop was used to administer auditory or visual stimuli, such as applause or smileys. These were turned on through a mouse click, and the durations of the stimuli were preset in accord with procedural descriptions. Materials included edibles, moving toys, a door bell, a toy cell phone, wooden blocks, paper drinking cups, an ice cube board, a Pez figure plastic sticks, and cloth balls. In addition, laminated color cards, a

<table>
<thead>
<tr>
<th>Participant</th>
<th>Alf</th>
<th>Britt</th>
<th>Cato</th>
<th>Dan</th>
<th>Even</th>
<th>Finn</th>
<th>Geir</th>
<th>Hans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs.months)</td>
<td>2.7</td>
<td>4.5</td>
<td>4.11</td>
<td>4.4</td>
<td>4.4</td>
<td>7.0</td>
<td>12.5</td>
<td>10.10</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Typically developing</td>
<td>Typically developing</td>
<td>Autism</td>
<td>Autism</td>
<td>Down Syndrome</td>
<td>Down Syndrome</td>
<td>Autism</td>
<td>Autism</td>
</tr>
<tr>
<td>No. of tested responses</td>
<td>3</td>
<td>5</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Chosen response $S^0$ (R1)</td>
<td>Touch square on table</td>
<td>Move wooden block across line on table</td>
<td>Put cloth ball into vertical pipe</td>
<td>Point to circle on table</td>
<td>Clap hands</td>
<td>Put cloth ball into vertical pipe</td>
<td>Point to circle-shaped paper sheet on wall</td>
<td>Move wooden block from one case to another</td>
</tr>
<tr>
<td>Chosen response classical cond. (R2)</td>
<td>Move wooden block across line on table</td>
<td>Put one cup on top of another</td>
<td>Move cloth ball from one hole to another on a board</td>
<td>Move cloth ball from one hole to another on a board</td>
<td>Touch own should</td>
<td>Turn a card mounted on a stick</td>
<td>Move cup from one table to another</td>
<td>Move cloth ball from one hole to another on a board</td>
</tr>
<tr>
<td>No. of tested stimuli</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Chosen stimulus $S^0$ (NS1)</td>
<td>&quot;Yay&quot; sound from PC</td>
<td>Red smiley on PC monitor</td>
<td>Frog sound from toy</td>
<td>Yellow ball on a stick</td>
<td>Blue card on a stick</td>
<td>&quot;Yay&quot; sound from PC</td>
<td>Yellow ball on a stick</td>
<td>Sound from a toy cell phone</td>
</tr>
<tr>
<td>Chosen stimulus classical cond. (NS2)</td>
<td>Door bell sound</td>
<td>Thumb on the edge of the table</td>
<td>Sound from a toy cell phone</td>
<td>Yellow square in window</td>
<td>Yellow ball on a stick</td>
<td>Scratch sound (plastic against wood)</td>
<td>Thumb on the edge of the table</td>
<td>Sound from a Pez figure</td>
</tr>
<tr>
<td>Extra stimulus materials (No.)</td>
<td>None</td>
<td>5</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
paper pipe, and a tennis stick with a tennis ball mounted at one end were constructed prior to the experiment (see Table 1). All response alternatives were designed to allow for free-operant responding and had a distinct beginning and end to facilitate recording. All specifically arranged visual stimuli were presented on the table in front of the child, whereas auditory stimuli were always presented out of sight. All manipulations of these stimuli were conducted by the trainer but hidden from the child’s view. Time was automatically recorded by the video camera.

Pilot study
A pilot study was carried out with two participants (a typically developing 3-year-old girl and a 16-year old boy with Down syndrome) in order to identify any obstacles that might occur when carrying out the prescribed training- and test procedures. Two important adjustments were made on the basis of the findings from the pilot study. First, a lack of adult responsiveness to the child’s behavior easily led to the child’s disinterest (i.e., walking away, initiating conversations with others, etc.), so the experimenter would be instructed to respond as naturally as possible to any inquiries from the child and give moderate attention throughout training and testing, though not contingent upon the child’s task-related performances. Second, session durations, types of responses and stimulus materials needed to be individualized to a large extent for each child (Table 1).

Procedure
The procedure is summarized in Table 2. Preference assessments were based on the multiple-stimulus without replacement (MSWO) method (DeLeon & Iwata, 1996) in order to identify potential positive (SR) to be applied in the succeeding procedures. For each child, eight to ten potential reinforcers were identified for alternating use during later training sessions.

Pretests of neutral responses, neutral stimuli, and reinforcing stimuli, were also completed on the first day. Neutral responses were identified using a free operant reinfirmer test during three different conditions: (i) automatic reinforcement, (ii) response-contingent presentation of a presumed neutral stimulus, and (iii) positive reinforcement. The tests were based on a standard definition of reinforcement (e.g., Catania, 2007), and the objective was to identify at least four “neutral” responses that were not automatically reinforced, and two neutral stimuli, i.e., stimuli with no prior reinforcing effect, to be used during succeeding procedures.

Discrete, arbitrary responses were tested for automatic reinforcement (i). First, the assistant trainer physically prompted the response twice. The second prompt was given within two seconds following reinforcement of the first response. Next, the trainer gave the instruction: “Do whatever you like, but please stay in your chair.” The response was considered eligible for use in a later phase of the study if no unprompted responses occurred or if responses extinguished rapidly (i.e., 30s without a response, or the child left the chair). If a high rate of responding developed, or if the 30s-without-a-response criterion was not reached within three minutes, the response was characterized as automatically reinforced and, hence, discarded from further use in the study.

Two different auditory or visual neutral stimuli were needed for the experiment, one for the pairing (classical conditioning) procedure, and one for the SD (operant discrimination) procedure. One of the four identified responses that were not automatically reinforced was randomly selected for each test of a presumed neutral stimulus. As in the previous test for automatic reinforcement, the response was physically prompted twice and the presumed neutral stimulus was presented contingent upon each occurrence of the response. If no unprompted responses followed, or if a period of 30s without a response occurred within three minutes, the
stimulus was defined as neutral. If a high rate of responding developed, or if the 30s-without-a-response criterion was not reached within three minutes, the stimulus was characterized as (already) functioning as a positive reinforcer and, hence, discarded from further use in the study. The first stimulus to be identified as neutral according to the criteria with respect to the behavior of each child was designated NS1, and the second stimulus identified according to those criteria was designated NS2. For six of the seven children, NS1 was assigned to be used in the $S^D$ procedure and NS2 to the pairing procedure, whereas for one child (Hans), NS2 was used in the $S^D$ procedure and NS1 in the pairing procedure.

Table 2. Summary of Procedure.

<table>
<thead>
<tr>
<th>Day</th>
<th>Phase</th>
<th>Description</th>
<th>Objective</th>
<th>Duration in min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pretest</td>
<td>Multiple-stimulus without replacement</td>
<td>Identifying 8-10 potential positive reinforcers</td>
<td>20 – 30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) Automatic reinforcement</td>
<td>Define four response alternatives that exclude automatic reinforcement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Response-contingent presentation of neutral stimulus</td>
<td>Identify two neutral stimuli (no reinforcing effect)</td>
<td>30 – 60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Positive reinforcement</td>
<td>Identify positive reinforcers</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$S^D$-procedure</td>
<td>Prompt the response (grabbing things from the table)</td>
<td>Establish the response</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent the response (grabbing things from the table) in the absence of the (to become) $S^D$ &amp; reinforce in its presence</td>
<td>Establish the response under $S^D$ control</td>
<td>90 – 150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Three 3-trial sessions after $S^D$ criterion is reached</td>
<td>Strengthen $S^D$ control</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Posttest after $S^D$ establishment</td>
<td>New response method: Stimulus 1 established as $S^D$, delivered contingent upon neutral response from Pretest 1</td>
<td>Test if $S^D$ is established as a conditioned reinforcer</td>
<td>10 – 15</td>
</tr>
<tr>
<td></td>
<td>Pairing (classical conditioning procedure)</td>
<td>Pairing neutral stimulus with unconditioned reinforcer</td>
<td>Establish neutral stimulus 2 as a conditioned reinforcer (same number of pairings as trials to establish $S^D$)</td>
<td>20 – 40</td>
</tr>
<tr>
<td></td>
<td>Posttest after pairing</td>
<td>New response method: Stimulus 2 used for pairing with unconditioned reinforcer is delivered contingent upon neutral response 2 from pretest</td>
<td>Test if stimulus from the pairing is established as a conditioned reinforcer</td>
<td>10 – 15</td>
</tr>
<tr>
<td>4</td>
<td>Second posttest</td>
<td>Post tests in reverse order 2–3 weeks later</td>
<td>Test maintenance and/or possible sequence effects</td>
<td>20 – 40</td>
</tr>
</tbody>
</table>
In order to exclude generalization effects from the S\textsuperscript{D} procedure, the neutral stimulus to be used during the pairing procedure was retested for reinforcing effects prior to the pairing procedure. If the stimulus was no longer neutral as defined above, a pretest of another presumed neutral stimulus was completed.

Following the pretests of neutral responses and stimuli, the preferred stimuli identified during the initial preference test were tested directly for positive reinforcer effects upon one of the identified neutral response forms. Again, two responses were physically prompted, the preferred stimuli were presented contingent upon each response, and the trainer gave the instruction: “Do whatever you like, but please stay in your chair.” If response rate increased or responding endured, the stimulus was identified as a positive reinforcer and selected for use in the succeeding S\textsuperscript{D} and pairing procedures. Because of the recent reinforcement procedure, the response was discarded from further use in the study, and the two remaining neutral responses were used during posttests for conditioned reinforcer effects.

Operant discrimination training (S\textsuperscript{D}) procedure. The S\textsuperscript{D} procedure was conducted on the second day of the study. One of the identified neutral stimuli was established as a discriminative stimulus (S\textsuperscript{D}) for a specific arbitrary response. Eight to ten different potential reinforcing stimuli were placed on the table in front of the child. The S\textsuperscript{D} training progressed through three steps. During Step 1, the response, pointing to an item or taking an item from the table, was established. The trainer said: “Please take (or point to) what you want.” If the child did not respond, the response was physically prompted, and the prompt was faded over the next few trials. After five trials, the child was instructed to take a break away from the table for 1-2 min. During Step 2, the response (i.e., pointing or taking) was differentially reinforced in the presence of one of the neutral visual or auditory stimuli identified during the pretests. The stimulus to be established as an S\textsuperscript{D} (from now on referred to as the S\textsuperscript{D}) was presented for 2-4 sec., and if the response occurred within this interval, it was reinforced and recorded as correct. If a response occurred in the absence of the stimulus, the child’s hand was physically blocked, and the response was recorded as incorrect. The S\textsuperscript{D} was presented in accord with a variable time schedule in which the time between a reinforcer delivery and the next stimulus presentation was gradually increased from approximately VT\textsuperscript{3}s through VT\textsuperscript{5}s to VT\textsuperscript{9}s. Advancement from one VT schedule to the next was contingent upon three consecutive correct responses. After the child met the discrimination criterion of nine out of ten consecutive correct responses when the S\textsuperscript{D} was presented according to the VT\textsuperscript{9}s schedule, the final mastery criterion was the errorless completion of a sequence of three additional consecutive three-trial sessions. Duration of breaks between sessions varied from child to child.

S\textsuperscript{D} Posttest. The posttest of conditioned reinforcement following the S\textsuperscript{D} procedure was carried out on the next day. A quick rehearsal consisting of five consecutive correctly completed trials was conducted before the participant was given a 10-min break, and the posttest administered.

The purpose of the test was to investigate whether the stimulus that was established as an S\textsuperscript{D} for a specific response during the S\textsuperscript{D} procedure would also function as a conditioned reinforcer for an arbitrary response. Hence, a response that was shown during pre-testing not to be automatically reinforced was prompted twice, and the stimulus that had been established as an S\textsuperscript{D} was presented contingent upon each occurrence of the response. Immediately following the delivery of a consequence contingent upon the second prompted response, the child was given the following instruction: “Do what you like, but please stay in your chair.” The session lasted for maximum 3.5 min, or until other termination criteria were met, such as extinction (i.e., 30 sec. without a target response) or until the child demonstrated any type of resistance or frustration, such as leaving the chair, lying down, asking to quit, and so on.

Classical conditioning (pairing) procedure. Following the S\textsuperscript{D} posttest, the second training procedure was conducted by pairing a second neutral (visual or auditory) stimulus with the
delivery of identified positive reinforcers. The procedure was a delayed conditioning procedure in which the previously neutral stimulus was presented 1s before the presentation of the positive reinforcer. The neutral stimulus remained on for 2-4s to ensure an overlap between the neutral stimulus and the reinforcer. During the pairing procedure, the child was seated at the table, and the teacher presented the neutral stimulus and the reinforcer the same number of times that were necessary in order to reach the final criterion for the establishment of $S^D$ control during the $S^D$ procedure. The same assortment of positive reinforcers as those used during the $S^D$ procedure were used, but were kept out of site of the child. After a 1s-duration of the neutral stimulus, the teacher either delivered an edible reinforcer directly into the child’s mouth, or displayed a toy directly in front of the child for 1-3s. For each child, the number of reinforcer deliveries and the duration of the sessions were the same as during the $S^D$ training procedure.

Pairing posttest. The test of conditioned reinforcement following the pairing procedure was also completed on the third day. The stimulus that was paired with a positive reinforcer during the pairing procedure was presented contingent upon another arbitrary response that had been shown during the pretest not to be automatically reinforced. As in the posttest following the $S^D$ procedure, the objective was to investigate whether the previously neutral stimulus had acquired the effect of a conditioned reinforcer as a result of the pairing procedure.

Individual procedural adaptations

Alf and Even were able to work for only short periods of time, so sessions were kept very short. When the criterion was not met after an extra day of $S^D$ training for Alf, he was dismissed from further participation in the study. Even took frequent breaks away from the table but often returned within 15 s and was allowed to continue responding.

Initial response prompting was often sufficient for Britt, Geir, and Hans to emit a large number of responses and to continue responding for a long time in the absence of specific programmed consequences. In order to reduce the probability of such continued responding in the absence of programmed reinforcement, extra stimulus materials were present throughout the experiment so that several response alternatives were made more likely, and in one case (Geir) by increasing effort so that he had to rise from the chair as part of the response.

Cato showed a relatively high rate of verbal responses, such as “finished” or “nope” during the pretest as well as during both posttest, so that the criterion for terminating sessions with Cato was increased to two such responses within a session. Dan’s breaks during the pairing procedure were shortened to 3-4s and were spent at the table because he protested intensively when asked to leave the table as well as when asked to come back. For practical reasons, Dan was also the only one to receive the posttest following the $S^D$ procedure on the same day. Finn occasionally protested by lying down on the floor close to or under the table. Further training was then simply delayed until he returned to his seat. Response alternatives and stimulus materials were tested individually and adapted to each child.

Reliability and treatment integrity

All training and recording was conducted by four master students in behavior analysis as part of their master thesis projects, all of these had minimum 10 years of clinical experience after completing their bachelor degrees, and all had participated in the planning of the experiment as well as in the pilot study with two children.

Interobserver agreement was calculated as agreements/(agreements + disagreements) x 100. (Cooper et al., 2007). Two independent observers recorded from video, and interobserver agreement was assessed for 93 % of all sessions (56 of 60). Overall agreement was 89.3 %. Treatment integrity during the $S^D$ and pairing procedures was assessed as correct/(correct + incorrect) x 100. Sessions were scored as correct if (a) the teacher presented the visual or auditory stimulus in accord with the criteria specified in the procedure. (timing and duration), (b) the teacher increased the criterion successively during the establishment of the $S^D$ according to the criteria (VT2-VT10s), (c)
teacher delivered reinforcer contingent upon the correct response (in the S\text{D} procedure) or timely upon the presentation of the neutral stimulus (in the pairing procedure), and (d) no technical problems occurred. The total number of sessions scored was 121, and mean integrity was 91.7\%, ranging from 86\% - 100\% across children.

Results

The number of responses tested for each participant in order to identify minimum four responses that would not occur at a high rate in the absence of programmed consequences ranged from 5 to 12, the number of stimuli tested in order to identify two neutral stimuli ranged from 4 to 7. Further, as can be seen in Table 3, six of the seven children emitted a higher number of responses during the test that identified the first neutral stimulus (NS1) than during the test in which the second neutral stimulus was identified. The last child emitted no unprompted responses during either of the two tests in which NS1 and NS2 were identified. The number of trials necessary to reach the criterion for the establishment of one of the neutral stimuli as an S\text{D} for the selected arbitrary response ranged from 24 to 87.

Figure 1 shows individual cumulative records of responding during the test for automatic reinforcement (in the absence of programmed consequences; left) and when stimuli identified as potential reinforcers during the prior preference test were delivered contingently upon these responses (right). All children emitted a substantially higher number of responses when previously identified potential reinforcers were presented response-contingently than in the absence of programmed consequences. Hence, the results of the direct reinforcer test demonstrated positive reinforcement for all seven children.

The total number of responses emitted by each child who completed the study during the first posttests following the S\text{D} procedure and following the pairing procedure are shown in Figure 2 (upper panel). As can be seen from the figure, five of the seven children showed markedly higher rates of responding during the test following the S\text{D} procedure than during the test following the pairing procedure. The numbers of unprompted responses emitted during the posttest following the S\text{D} procedure and following the pairing procedure, respectively, were for Dan 25 versus 0, for Cato 40 versus 3, for Britt 175 versus 17, for Even 12 versus 0, and for Finn 23 versus 11. For the sixth child, Geir, there was only a minor difference in the number of unprompted responses in favor of the test following the S\text{D} procedure, 28 versus 22, whereas the last child, Hans, showed the opposite result, with a lower number of responses following the S\text{D} procedure than following pairing, 12 versus 70. Two of the five children who showed markedly higher rates of responding following the S\text{D} procedure also emitted several responses (that might indicate conditioned reinforcement) following the pairing procedure. Thus, during the test for conditioned reinforcement following the pairing procedure, Britt emitted 17 unprompted responses, and Finn 11. However, as can be seen from the individual cumulative records of responding during the posttests (Figure 3), the response patterns consist of a burst followed by no responding (Finn) or a very low rate (Britt). The remaining three children (Cato, Dan, and Even) showed little or no indication of conditioned reinforcement following the

| Table 3. For Each Participant, the Number of Tested Responses and Stimuli, the Number of Responses Emitted During the Tests of Stimuli Identified as Neutral, and the Number of Reinforcers Delivered During Each of the Procedures (S\text{D} and Pairing). |
|-----------------|--------|--------|--------|--------|--------|--------|--------|
| Participants    | Brit (ND) | Cato (Aut) | Dan (Aut) | Even (Downs) | Finn (Downs) | Geir (Aut) | Hans (Aut) |
| No of tested responses | 5      | 12     | 7      | 6      | 7      | 11     | 9      |
| No of tested stimuli | 5      | 7      | 4      | 4      | 6      | 6      | 6      |
| No of responses during NS tests | NS1 | 22 | 2 | 10 | 2 | 3 | 0 | 3 |
|                     | NS2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| No of S\text{D} presentations | 27 | 36 | 36 | 42 | 87 | 24 | 30 |
classical conditioning procedure. Relations between the duration of responding during the posttests following the $S^D$ procedure and following the pairing procedure

Figure 1. Cumulative records of participants’ responding during pretests of automatic reinforcement (left) and reinforcers (right). The values of the axes vary across participants, but are kept the same for each participant across tests. The number of responses for each participant during each condition is shown by the number on each cumulative record, and the duration of the test for each participant is indicated by the numbers on the right side of the x-axes.
Discussion

The background of the current study was an operant analysis of joint attention skills that suggests that a core problem related to deficient joint attention skills in children with autism is a lack of effectiveness of specific social stimuli as reinforcers for their behavior. An important target for applied behavior analysis, then, would be to develop the most effective procedure possible with respect to establishing such social stimuli as effective reinforcers for appropriate behavior in children with deficient joint attention skills. Unfortunately, the literature on conditioned reinforcement thus far is not very helpful. Hence, the main purpose of the study was to investigate the relative effectiveness of two main procedures identified early in the literature on conditioned reinforcement (Kelleher & Gollub, 1962). The effectiveness of establishing a previously neutral stimulus as an S<sup>D</sup> for a specific response that produces a positive reinforcer was compared with the effectiveness of simply pairing a previously neutral stimulus with a positive reinforcer in a 1s-delay classical conditioning procedure. The effectiveness of each procedure in establishing a previously neutral stimulus as a conditioned reinforcer was tested in a new-response procedure (e.g., Fantino & Logan, 1979) in which the stimulus, after being (1) established as an S<sup>D</sup> or (2) paired with a positive reinforcer, was presented contingent upon a response that was previously demonstrated not to be automatically reinforced.

We compared the number of responses emitted when the response-contingent stimuli were those previously established as S<sup>D</sup>’s with the number of responses emitted when response-contingent stimuli were those that had been paired with reinforcers. Overall, all seven children who completed the study emitted more than ten unprompted responses during tests for conditioned reinforcement following the S<sup>D</sup> procedure, whereas only four did so during the test following pairing. Further, five of the children clearly emitted more responses following the S<sup>D</sup> procedure than following the pairing procedure, indicating that the previously neutral stimuli were more effectively established as conditioned reinforcers through the S<sup>D</sup> procedure than through pairing. However, for one child, the difference in number of responses generated following the S<sup>D</sup> versus the pairing procedure was very small, and for the last child, the difference was in the opposite direction, with more responses emitted when an arbitrary response was followed by the stimulus that was just paired with a positive reinforcer then when a response was followed by the stimulus that had been established as an S<sup>D</sup>. A possible explanation for the low rate of responding in this child (Hans) during the test following the S<sup>D</sup> procedure was that an adhesive plaster on his index finger seemed to produce self-stimulatory behavior and completely override the experimenter-controlled contingencies. After a rapid sequence
Figure 3. Individual cumulative records of responding during tests for conditioned reinforcement following the SD procedure (left) and following the pairing procedure (right).

The values of the axes vary across participants, but are kept the same for each participant across tests. The number of responses for each participant during each condition is shown by the number on each cumulative record, and the duration of the test for each participant is indicated by the numbers on the right side of the x-axes. Beginnings and ends of short self-initiated breaks are indicated by horizontal marks on the cumulative graph for Even.
of 12 responses during the initial 15s of the test, he was observed picking on and “talking to” the adhesive plaster for the rest of the session. During the test following the pairing procedure, the plaster had fallen off his finger and no longer provided the opportunity for that specific self-stimulatory behavior. Except for the results from Hans, the effect of the $S^D$ procedure in establishing conditioned reinforcers was demonstrated with children of different age (4.4 to 12.5) and diagnoses (autism, developmental disability) or no diagnosis (typically developing), whereas the conditioned reinforcer effect following the pairing procedure seemed to me most pronounced in the older children, i.e., Geir (12.5) and Hans (10.10), who also had a longer history of intensive behavioral treatment.

Two serious shortcomings of the present study must be noted. Most important, stimuli identified as neutral were sequentially assigned to the $S^D$ and pairing procedures, and the “neutral stimuli” may not have been equally “neutral”. A retrospective check shows that all five children who emitted a higher number of responses following the $S^D$ procedure than following pairing had also emitted more unprompted responses during the test of neutral stimuli that were used in the $S^D$ procedure than during the test of those used during pairing. Moreover, the child with a higher number of responses following the pairing procedure had emitted more unprompted responses during the test of the neutral stimuli used for that procedure than during the test of those used in the $S^D$ procedure, and the child with only a slightly higher number of responses following the $S^D$ procedure emitted no unprompted responses during the tests of the two neutral stimuli that were used for the $S^D$ procedure and the pairing procedures. One possible interpretation of the relatively consistent finding of fewer responses during NS2 testing than during NS1 testing is that it might be a repeated extinction effect, because extinction with response-contingent presentation of NS1 always had to be demonstrated before NS2 could be tested. Hence, the higher number of responses during the NS1 test than during the NS2 test may reflect the order of testing rather than any differential effects of $S^D$ and pairing procedures. In any case, this shortcoming should be eliminated in a replication either by applying a stricter criterion for neutral stimuli or by assigning half of the NS1 stimuli and half of the NS2 stimuli across participants to each of the two training conditions.

Second, for every child, the $S^D$ procedure and the corresponding test of conditioned reinforcers were run before the pairing procedure and its corresponding test. Because the tests were run in extinction (i.e., with no programmed reinforcing consequence except the previously neutral stimulus), the effect of an extinction history during the test following the $S^D$ procedure may have generalized to the test following the pairing procedure. The rationale for running the $S^D$ procedure first was that this procedure allows us to specify a mastery criterion and to record the number of reinforcements delivered before the criterion is reached, whereas the pairing procedure itself does not involve any behavior change criteria that would allow us to determine a sufficient number of pairings before testing. However, the number of reinforcements necessary to reach the criterion of $S^D$ control with the participants in the present experiment varied from 24 to 87, with mean and mode values below 40. Hence, a systematic replication of the experiment could reverse the order of $S^D$ and pairing procedure, starting with 40 pairings of one neutral stimulus with unconditioned reinforcers before a conditioned reinforcer test and an $S^D$ procedure with the same number of reinforcements.

In spite of the shortcomings and the need for replications, a superiority of the $S^D$ procedure compared to the pairing procedure with respect to establishing new stimuli as conditioned reinforcers seems indicated by the results of the present study. The results are also in accord with previous studies that have shown that conditioned reinforcers may not be established very effectively through a pairing procedure (Lovaas et al., 1966; Schoenfeld, Antonitis, & Bersh, 1950). A direct background for the study was an operant interpretation of joint attention skills (Dube et al., 2004; Holth, 2005) which suggests that standard social stimuli, such as nods, smiles, and changes in gaze direction, seem to
function effectively as positive reinforcers for certain joint attention skills in typically developing children, whereas reinforcing effects of those stimuli in children with autism often seem to be lacking. Therefore, providing an empirically based answer to the question of how we can most effectively establish previously ineffective stimuli as reinforcers may lead to a substantial improvement in procedures for establishing joint attention skills in children with autism. In fact, a recent study (Isaksen & Holth, 2009) explicitly employed an $S^D$ procedure with children with low scores on joint attention skills and diagnosed with autism, in order to (1) establish adults’ nods and smiles as conditioned positive reinforcers, (2) generalize the function of nods and smiles to more natural training situations, and (3) maintain the reinforcing effect of nods and smiles in regularly occurring situations, such as turn-taking tasks. In addition to completing training successfully, all four children made significant progress in joint attention skills during posttests, and the skills were maintained at 1 month follow-up.

Knowledge of how conditioned reinforcers can be most effectively established would seem to be of crucial importance to a number of other “applied issues” as well, such as in clicker training, in the establishment of token economies, and in standard early intervention procedures for the establishment of praise as a conditioned reinforcer. In spite of this, the literature on conditioned reinforcement thus far does not contain very helpful instructions beyond the general “pairing,” “associating,” or “correlating” the clicker sound, the token, or the praise with primary reinforcers. Hence, systematic replications of the present study would be useful in order to supply clearer recommendations regarding procedures across different instructional programs that aim to establish conditioned reinforcers or rely on their establishment. It is conceivable that the maintenance of skills established through behavior-analytic interventions, such as joint attention skills, will depend less on our effectiveness in establishing those skills in contrived settings than on our effectiveness in establishing normal maintaining consequences of those skills as conditioned reinforcers.

References


