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Emergent Language Responses Following Match-to-Sample Training among Children with Autism Spectrum Disorder

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Abstract

The present study explored the effects of match-to-sample training on emergent responses in the domains of receptive and expressive language among children with autism spectrum disorder (ASD) in an applied setting. A concurrent multiple probe design across six participants was applied, with a follow-up after 10 days. All six children participated in a match-to-sample training procedure. The participants were trained to match a picture card of an item with a word card corresponding to the name of the item, and a word card of an item with a picture card corresponding to the name of the item. After training, three participants developed the emergent responses of receptively identifying and expressively naming both picture cards and word cards. There was a correspondence between acquired matching skills and the development of emergent language responses. Follow-up measures showed that the acquired emergent responses remained somewhat stable over time. The results are discussed in relation to prior research and in terms of implications for teaching children with ASD language skills in applied settings such as preschools. The results are also discussed in relation to the participant's prior verbal skills and to the retention of emergent language responses.

Key words: Emergent language responses, match-to-sample, matching training, language acquisition, autism spectrum disorder.

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Novelty and Significance

What is already known about the topic?

- Two of the defining features of autism spectrum disorder (ASD), are delays in language development and difficulties in attaining basic communication skills.
- Several specialized methods of teaching children with ASD language skills have been developed from the principles of applied behavior analysis (ABA).
- Match-to-sample procedures have in previous research shown to be effective and useful for teaching many children with ASD language skills by relating different stimuli to each other.

What this paper adds?

- Match-to-sample training can be used in applied settings not only to teach matching skills but also to increase receptive and expressive verbal skills for children with ASD.
- Successful match-to-sample training and formation of emergent language responses may be related to higher language skills prior to training, but not for all children with ASD.
- Participants who displayed stable emergent language responses during match-to-sample training in the current study did not show full retention in the follow-up which indicates that maintenance training of newly acquired language skills might be a necessary part of teaching language skills in applied settings.

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Two of the early defining features indicative of autism spectrum disorder (ASD), are delays in language development and difficulties in attaining basic communication skills (American Psychiatric Association, 2013; Zwaigenbaum *et alii*, 2009). Verbal behavior constitute a central part of both a person's life and society in general and lack of these capabilities will constrain the individual from expressing desires and needs and from engaging in socially significant behaviors (Higbee & Sellers, 2011; Sundberg, 2007; Vismara & Rogers, 2010).

Extensive behavioral research supports the notion of verbal behavior as a function of specific environmental experiences that has to be learned by all individuals. Naming theorists (Horne & Lowe, 1996) suggest that in early language development, listener and speaker responses are independent from each other. Therefore, individuals need to experience certain reinforcing consequences in order to learn how to integrate these stimulus functions so that intra-individual behaviors are transformed into meaningful utterances such as naming objects (Crystal, 2006). Research shows that when children learn to transform listener and speaker functions, and thus learn how to form stimulus equivalent relations, this propels more complex verbal behavior (Greer & Longano, 2010). The defining characteristics of stimulus equivalent relations are reflexivity, symmetry and transitivity (Sidman & Tailby, 1982; Sidman 1971). In practice this means that by directly teaching two stimulus relations, four other stimulus relations can emerge without additional teaching. In an applied setting, this could be exemplified as following: if teaching that the spoken word "dog" is the same as a picture of a dog, and the same as the written word dog, then a picture of a dog is the same as the spoken word "dog", the written word is the same as the spoken word "dog" (symmetry), the picture of the dog is the same as the written word, and vice versa (transitivity). Thus, learning how to form stimulus equivalent relations opens up for indirect emergent learning that is of tremendous importance in rapid and advanced language acquisition (McLay, Sutherland, Church, & Tyler-Merrick, 2013; Mudford *et alii*, 2009; Sidman & Tailby, 1982). The formation of stimulus equivalent relations is however a function of certain experiences that often may be missing in children with ASD and children with language delays (Greer & Speckman, 2009). It is thus of great importance to understand which environmental contingencies to apply to help children with ASD form emergent language responses which are fundamental in complex verbal behavior.

In order to promote the development of language skills among children with ASD specialized methods for preschools, kindergartens and grade schools have been developed utilizing the principles of applied behavior analysis (ABA). A well-established method applied for children with ASD is the Lovaas model of Applied Behavior Analysis (1987; 2003), which is a structural model where language skills are broken down into basic components and trained in a sequential manner. The training involves reinforcement procedures of target behaviors, such as match-to-sample training. In a match-to-sample training procedure, children with ASD are explicitly given an environmental experience that reinforces putting different stimuli in relation to each other, such as matching a written word with a picture of an item (Sidman & Tailby, 1982). Previous research shows that children with ASD who undergo match-to sample training in an experimental setting often are successful in learning to form stimuli relations. By applying match-to-sample procedures, receptive (identifying stimulus) and expressive (naming stimulus) language responses emerge for some of the participants (Carr, Wilkinson, Blackman & McIlvane, 2000; McLay, Sutherland, Church, & Tyler-Merrick, 2013; Mudford *et alii*, 2009). However, there are variations in the research findings and different accounts

on which variables control for the emergence of stimulus equivalent relations, that bring questions of the applicability of these results to other children with ASD (Greer & Speckman, 2009). Research has shown that children with ASD who have higher verbal competence prior to match-to-sample training have a faster rate of acquisition of emergent untrained responses compared to children who have lower verbal competence (O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009). Some children with ASD seem to need modified teaching conditions to develop emergent relations and the amount of training is also highly individual (Cuvo & Riva, 1980; Murphy & Barnes-Holmes, 2010). Howarth and Greer (2015) suggest that stimulus equivalent relations only emerge among participants who previously have learned symmetry relations and verbal tacts. Other researchers, such as Horne and Lowe (1996), suggest that naming (integration of listener and speaker responses) is a prerequisite that is needed for the development of further emergence of stimulus equivalent relations.

Although several studies have shown the benefits of teaching stimulus equivalence to children with ASD via a match-to-sample procedure in applied school settings, there are still many aspects to further inquire regarding both training procedure and the formation of emergent language responses. As outlined by McLay, Sutherland, Church, and Tyler-Merrick (2013), there is a lack of studies conducted in applied settings that include standardized descriptions of participant's developmental characteristics including prior verbal skills, as well as a lack of studies controlling for retention of emergent language responses. Further, as stated by O'Donnell and Saunders (2003), in order to gain a better understanding of whom may benefit from match-to-sample training, it is also of importance to include participants with limited verbal skills in this type of research. If emergent stimulus relations are established and retained for most children (with varied verbal skills) with ASD by standard language training this could have potential implications for preschools and other schools working with children with ASD, because this means matching training could be applied not only to train matching skills but also to accelerate the rate of acquisition of language by indirectly establishing additional expressive and receptive responses.

The present study aimed at exploring the effects of match-to-sample training on emergent verbal responses across six children diagnosed with ASD with varying verbal skills in their everyday school environment during a total period of seven weeks. The purpose was to explore if such training could facilitate the emergence of untrained responses in the skill domains of expressive and receptive language among children with ASD, and to explore whether prior verbal skills had implications on both learning and retention.

Method

Participants

Participants for the study were recruited from a special education preschool located in the State of New York, USA. They were chosen based on recommendations from preschool staff, inclusion and exclusion criteria, learning records and observations by the study's authors (H.B., S.J., & R.C.). The participating children were not able to assess the significance of participating in this study. Therefore, their parents signed an informed consent prior to the study. Participants received no financial remuneration. The current project had been ethically approved locally at the preschool's research committee

review board and at the Department of Psychology, Stockholm University, as a part of the first (H.B.) and second (S.J.) author's Master degree Thesis.

Four boys and two girls between the ages of three to eight years participated. A psychologist prior to the study diagnosed them with ASD. Inclusion criteria were the child's ability to respond to contingencies of reinforcement, to have basic matching skills, to exhibit a minimum of problem behavior and/or stereotypy, and to have the ability to intelligibly imitate at least one three-syllable word. The first three inclusion criteria were assessed by a combination of the children's learning records and information from the children's teachers, while an expert trainer (R.C.) tested if the children could imitate a three-syllable word during screening. Exclusion criteria were the ability to sight and phonetically read, intermediate to advanced receptive and/or expressive language skills, echolalia, no prior basic vocal responses, and the use of communication device or PECS as the primary form of communication. Approximately 10 other children were screened for the study but failed to meet inclusion criteria, mostly due to displaying intermediate to advanced receptive and/or expressive language skills while performing match-to-sample baseline test trials. All subjects were given pseudonyms for the following exposition.

Learning records and psychologist evaluations were obtained for all participants. The record followed the procedure outlined in The Assessment of Basic Language and Learning Skills Revised (ABLLS-R; Partington, 2006), and all assessments were done within six months from the onset of the study for each participant. Data from the subscales of visual performance (matching skills), receptive language, and labeling (expressive language) were obtained and evaluated for the participants. Five different levels of acquired skills were coded from "very low" to "very high." Less than 20% acquired abilities in a subscale was considered "very low," less than 40% "low," less than 60% "moderate," less than 80% "high," and above 80% was considered "very high."

L a five-year-old boy, diagnosed with ASD, had severe social communication problems and language delays as well as significant difficulties with social emotional reciprocity and impulse control. His ABLLS-R record was very low for matching and for receptive and expressive abilities. L was easily distracted and engaged in some self-stimulatory behavior during the training procedure.

J an almost five-year-old boy, diagnosed with ASD, had significant delays in cognitive functioning tested with Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III; Wechsler, 2002), and an extremely low range of adaptive functioning assessed by Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Sparrow, Cicchetti, & Balla, 2005). His ABLLS-R record was very low for matching and for receptive and expressive abilities. J displayed some spontaneous expressive language and also some echolalic behavior. He easily attended to his match-to-sample training and responded well to reinforcement during trials.

S a five-year-old girl, diagnosed with ASD, had a low communication level within the first percentile according to Vineland II. Her ABLLS-R record was low for both matching and receptive abilities and very low for expressive abilities. S did not display any spontaneous expressive language. However, she was engaged in the training procedure and tried to communicate by pointing and using her hands.

P a boy who was four years old and diagnosed with ASD, showed a low adaptive level assessed with Vineland II. His ABLLS-R record was very high for matching as well as for receptive abilities and high for expressive abilities. P attended to the training procedure and visually scanned his instructor after responding during trials. He would occasionally exhibit screams and elopement behaviors when physically prompted to the correct answer during the matching-to-sample training.

M a three-and-a-half-year old boy diagnosed with ASD, had a full scale IQ within the 0.2 percentile according to the Stanford Binet Intelligence Scale V (Roid, 2003). Vineland II showed communication skills within the eighth percentile. His ABLLS-R record was very low for matching, moderate for receptive abilities, and low for expressive abilities. M had difficulties attending to his match-to-sample training; he was easily distracted and appeared to be disturbed by loud noises.

A a girl who was eight years old, was diagnosed with ASD and had low cognitive functioning assessed with Bayley Scales of Infant and Toddler Development, Third Edition (Bayley, 2006) and low overall adaptive functioning in the first percentile assessed by Vineland II. Her ABLLS-R record was low for matching, high for receptive, and very low for expressive abilities. A displayed some self-stimulatory behavior while still engaging in the match-to-sample training, and used single-word mands to request reinforcers.

Settings and Materials

Sessions took place at a school desk in the office area of the preschool. The training stimuli sets were 3x5 inch picture cards and 3x5 inch word cards gathered from a box of picture and word cards that the preschool used in their everyday curriculum. The word cards displayed text in lowercase letters written in Cambria font size 65. The picture cards displayed images of different items; some showed the item on a white background while others displayed images that filled up the whole card. Examples of items (e.g. words- and pictures) used in the study were "rhinoceros", "corn-dog", "saw", and "hammer." Previously untaught picture and word cards were gathered to be used as neutral distractors during the teaching procedure. During screening and baseline test trials cards already known to the participants were identified and excluded, resulting in the majority of the participants not sharing stimulus sets with each other but rather training with different word and picture pairs. Teachers provided information about the participants highly preferred reinforcers. Edibles, tangible items, and social praise were used as continuous contingent reinforcement. Before each session, an instructor (i.e., teacher taking part in the study) identified a reinforcer that the participant wanted to work for from the participant's list of preferred reinforcers. The instructor upon the participant's request repeated the procedure as needed to facilitate a change of reinforcer during the intervention in order to reduce the likelihood of occurrence of behaviors maintained by escape and avoidance. Requests could be defined as both expressive verbal behaviors from the participant and the instructor noticing that the participant showed a declining interest in working for the specified reinforcer by continuously shifting focus from the task.

A standardized data sheet was used to manually record data throughout the match-to-sample training. Additional materials were used as interobserver assessment data sheets, baseline data sheets, emergent responding probe data sheets, and an implementation quality check questionnaire developed by the first and second authors (H.B. & S.J.) to be completed by the instructors providing the instruction to the participants.

Design

A concurrent multiple probe design across participants was used to demonstrate experimental control of the emergence of untaught responses (Cooper, Heron, & Heward, 2014). The design also followed the structure of an ABAB design with a follow-up phase. Although language development is not regarded as reversible, this combination

of designs was applied to both control for retention on emergent responses following match-to-sample training in an applied setting, and augment the ecological validity of the study (Belloso Diaz & Pérez González, 2015) by imitating an ordinary pre-school setting were periods of training are often interrupted by events such as national holidays, absence due to illness, etc. This was a minimally invasive procedure, differing very little from the normal training procedures these children were subjected to during an ordinary school day. Study procedures were performed in accordance with the Declaration of Helsinki of 1975, as revised in 2008.

The training procedure of match-to-sample constituted the independent variable, depicted in the graphs as mastered steps of matching words to pictures and pictures to words for each participant. The dependent variables were three different response classes: (1) matching, number of correct responses (matching words to pictures and pictures to words) in the domain of matching; (2) receptive language, number of correct responses (identifying words and pictures) in the domain of emergent receptive language; and (3) expressive language, number of correct responses (labeling words and pictures) in the domain of emergent expressive language.

The two A-phases included baseline measurements of three dependent variables: matching, receptive language, and expressive language. The two-B phases consisted of match-to-sample training and measurements of the dependent variables receptive language and expressive language. The follow-up phase included baseline measurements of three dependent variables: matching, receptive language, and expressive language.

The two A-phases and the follow-up phase were conducted during one day each, while each B-phase was conducted during two weeks. The first B-phase consisted of ten working days whereas the second consisted of eight working days due to national holidays. Two intervention pauses were applied after each B-phase; the first one was one week long, while the second was ten days long because of national holidays. A synoptic illustration of the ABAB with replication-set up and time plan can be seen in Figure 1.

Measurements

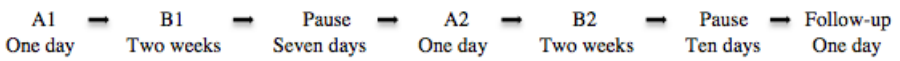

Figure 1. A synoptic illustration of the ABAB with replication-set up and time plan. A1 and A2 comprise baseline measures of the three dependent variables matching, receptive language and expressive language. B1 and B2 comprise match-to-sample training and measures of the independent variable matching training as well as of the two dependent variables receptive and expressive language. Follow-up comprises follow-up measures of the three dependent variables matching, receptive language and expressive language.

Baseline measures of the three dependent variables matching, receptive language, and expressive language were collected at three separate times during one day. A measure point consisted of one probe for each conditional stimulus aggregating to six trials (one trial for each picture and one for each word in the three stimulus pairs). Each stimulus was presented once in a random order. Three picture/word pairs previously unknown for each participant were identified as target stimuli in the training phases during baseline condition. A stimulus pair was considered to be unknown if the participant achieved 33% or less correct responding for each dependent variable throughout baseline measures.

During the two B phases, data collection of matching training was executed per trial during each session. Data collection of emergent receptive and expressive language

responses were made once every day at least 15 minutes after the match-to-sample training. Procedures for observing these responses were similar to baseline; however, to avoid overexposure to target stimulus and to avoid any accidental learning, probes were only conducted for the items that had already been introduced to the participant in the match-to-sample training. Data collection started with one stimulus set and expanded to two or three contingent on the progress in the participant's matching training. Receptive and expressive trials were held separately and no arrangements were made to reinforce target responses.

No reinforcers, contingent on the occurrence of correct responding, were administered during baseline. A field size of three items placed in a horizontal row on the desk in front of the learner was used in the receptive and matching conditions. The discriminative stimulus (SD) for matching was "Match (name of item)". The SD for receptive language was "Touch… (name of item)". A field size of one item was used in the expressive condition and the SD for expressive language was "What is it?" Correct responding for matching was defined as taking the stimulus card from the instructor and placing it on the target stimulus in the field, correct responding for receptive language was touching the target stimulus in the field, and correct responding for expressive language was vocally stating the name of the target stimulus. A response was considered correct if it was independently performed within five seconds from the delivery of the SD. The follow-up measurements of the three dependent variables -matching, receptive language and expressive language- were identical to the procedure applied in the two baseline conditions.

Procedure

The intervention was based on the nine-step procedure outlined by Lovaas (2003) for teaching children conditional discrimination via match-to-sample training (see Figure 2). This method consists of the progressive introduction of new stimuli where the instructor teaches new relations in a sequence. The sequence started with the first stimulus in different settings and required this to be mastered before adding another stimulus, and then one more following the same procedure. The mastery criteria for step 1 and 3 was correct responding across five consecutive times; for step 2, 4, 5 and 6, correct responding across three consecutive times; for step 7, 8 and 9, 90%-100% independent correct responding across two consecutive teaching sessions. Contingent on the occurrence of an incorrect response, the instructor said "No" and repeated the SD together with an immediate prompt and differential reinforcement for the response. The SD was then re-presented with faded prompts until the participant could provide correct responding independently. Each training session included two separate blocks of matching training: 10 to 15 trials of matching words to pictures and 10 to 15 trials of matching pictures to words. The trials varied because of practical reasons, such as when a participant had mastered a training step and there were too few trials remaining to be able to introduce the next step. The amount of stimuli in each training block depended on which training step the participant was currently practicing, varying from one to three stimuli.

In order to promote treatment integrity, the senior author of this study (R.C.) provided expert training and supervision to instructors during a preparation phase. Instructors were given the opportunity to practice the teaching procedure with children who had not participated in the study before the start of the intervention.

Observations by the first and second authors (H.B. & S.J.) and the expert trainer of the participants (R.C.) during baseline trials and match-to-sample training were used to

Steps 1 and 3	→	Discrimination training of S^D1 respectively S^D2 with no distractors
Steps 2 and 4	→	Discrimination training of S^D1 respectively S^D2 in the presence of two distractors.
Steps 5 and 6	→	Discrimination training of S^D1 and S^D2 in the presence of each other and one distractor.
Steps 7 and 8.	→	Random rotation of S^D1 and S^D2 in fixed respectively switched positions.
Step 9	→	Discrimination training of S^D3 following steps 1, 2, 5, 7, and 8.

Figure 2. An overview of the interventions different steps of training.

assess inter-observer agreement (IOA). IOA data were collected during the two baselines and the follow-up phase, as well as during 28% of the intervention phases. IOA was calculated as a percentage of total observations wherein the two observers had marked the same response. IOAs were in the range of 98%-100% across all participants in more than 580 baseline trials, 600 intervention trials, and 200 follow-up trials.

In order to assess treatment fidelity, a questionnaire consisting of five questions was developed by the first and second authors (H.B. & S.J.) and utilized to determine instructor adherence to the teaching procedures. The instructors completed the questionnaire at four different occasions during the two intervention phases. Each question has five response alternatives in the form of a Likert scale, ranging from 1 "Do not agree" to 5 "Completely agree." All instructors reported that they were able to implement the intervention and collect data according to the outlined procedure (M= 5). The sessions had mostly been conducted without any disturbances (M= 4.83) and without any problem behaviors (M= 4.30). Instructors generally reported that participants were motivated and alert during the sessions (M= 3.96).

Data Analysis

For the visual presentation, a percentage score for each dependent variable baseline procedure and follow-up phase was calculated from the number of correct responses divided by the maximum amount of responses for every daily set of trials. During the intervention phases, the dependent variables, receptive language and expressive language, were calculated following the same procedure, while the independent variable, matching training, was measured as the percentage of acquired matching steps divided by the maximum amount of possible matching steps.

RESULTS

As can be seen in Figure 3, all six participants increased their matching skills in various degrees over the course of the study. The participant (P) who had stronger expressive and receptive skills at the onset of the study was able to develop emergent responses faster than the other participants with the exception of J. P showed high levels of retention during the second baseline phase, he did however not fully retain his high levels of receptive emergent responding from the second intervention phase in the follow-up condition. J, P, and S mastered almost all of the match-to-sample training steps and developed emergent responding as depicted in their graphs in Figure 3. J and P mastered several match-to-sample training steps in a rapid pace during the first intervention phase, although their emergent responses differed. J developed stable emergent responding in the first intervention phase, while P's emergent responding fluctuated until the second intervention phase. J also showed almost full retention of his newly acquired verbal responses in both the second baseline and in the follow-up condition. S had a slower acquisition rate of matching training steps compared to J and P. Her receptive

emergent responding fluctuated between the sessions during the two intervention phases but became stable during the last three probes in the second intervention phase, while her expressive language skills remained close to zero throughout the study. S did not fully retain her levels of correct emergent responding in the follow-up condition as compared to the last three probes in the previous intervention phase.

Unlike P, J, and S, neither L, M nor A developed any stable emergent responding over time, as depicted in their graphs in Figure 3. L was absent for a total of eight days and slowly progressed in the match-to-sample training, where he only mastered a third of the total match-to-sample training steps. His emergent receptive responding was inconsistent and he did not exhibit any emergent expressive responding. M's results were similar to those of L. M acquired less than half of the matching training steps and displayed some receptive emergent responding whereas his correct expressive responding remained close to zero. Neither M's nor L's responding increased above the chance level of 33% in the follow-up condition, thus showing a lack of retention in M's emergent receptive responding. A mastered a few match-to-sample training steps in the first intervention phase; however, her acquisition rate slowed down in the second intervention phase and stayed on a mid-level of mastered matching steps. Her correct expressive emergent responding increased slightly during the intervention phases while her receptive emergent skills fluctuated throughout. She did not maintain her acquired level of correct expressive and receptive responding from the second baseline and intervention phase in the follow-up condition.

DISCUSSION

The purpose of the present study was to investigate if match-to-sample training could facilitate the acquisition and retention of emergent untrained expressive and receptive responses among preschool children with ASD in an applied setting. The results indicate that five of six participants were able to learn to relate different stimuli to each other by match-to-sample training, and three of the participants developed somewhat stable emergent responses following match-to-sample training during the second intervention phase. The participants who mastered high levels of match-to-sample training steps also developed high levels of emergent responding, which shows that match-to-sample training in itself may prove to be helpful in the acquisition of untrained language responses for children with ASD. However, only one of the six participants displayed full retention of both expressive and receptive emergent language responses in the follow-up condition.

These results fall in line with the overall findings of McLay, Sutherland, Church and Tyler-Merrick (2013) by showing that match-to-sample training is a functional way to teach children with ASD how to relate different stimuli to each other. The participants required different amounts of trials to achieve mastery, as was also evident in previous research (Murphy & Barnes-Holmes, 2010). The individual differences in forming emergent responses illustrate the complexity and individuality of language development and add questions about prerequisite skills that might have affected the results. Stronger expressive and receptive skills at the onset of the study were connected to faster development of emergent responses and higher levels of retention, which is similar to the findings of O'Connor, Rafferty, Barnes-Holmes and Barnes-Holmes (2009). Contrary to this finding, one participant (J) with very weak preceding language skills according to ABLLS-R acquired both receptive and expressive emergent responses faster than any other participant in the study, which strongly opposes the notion that

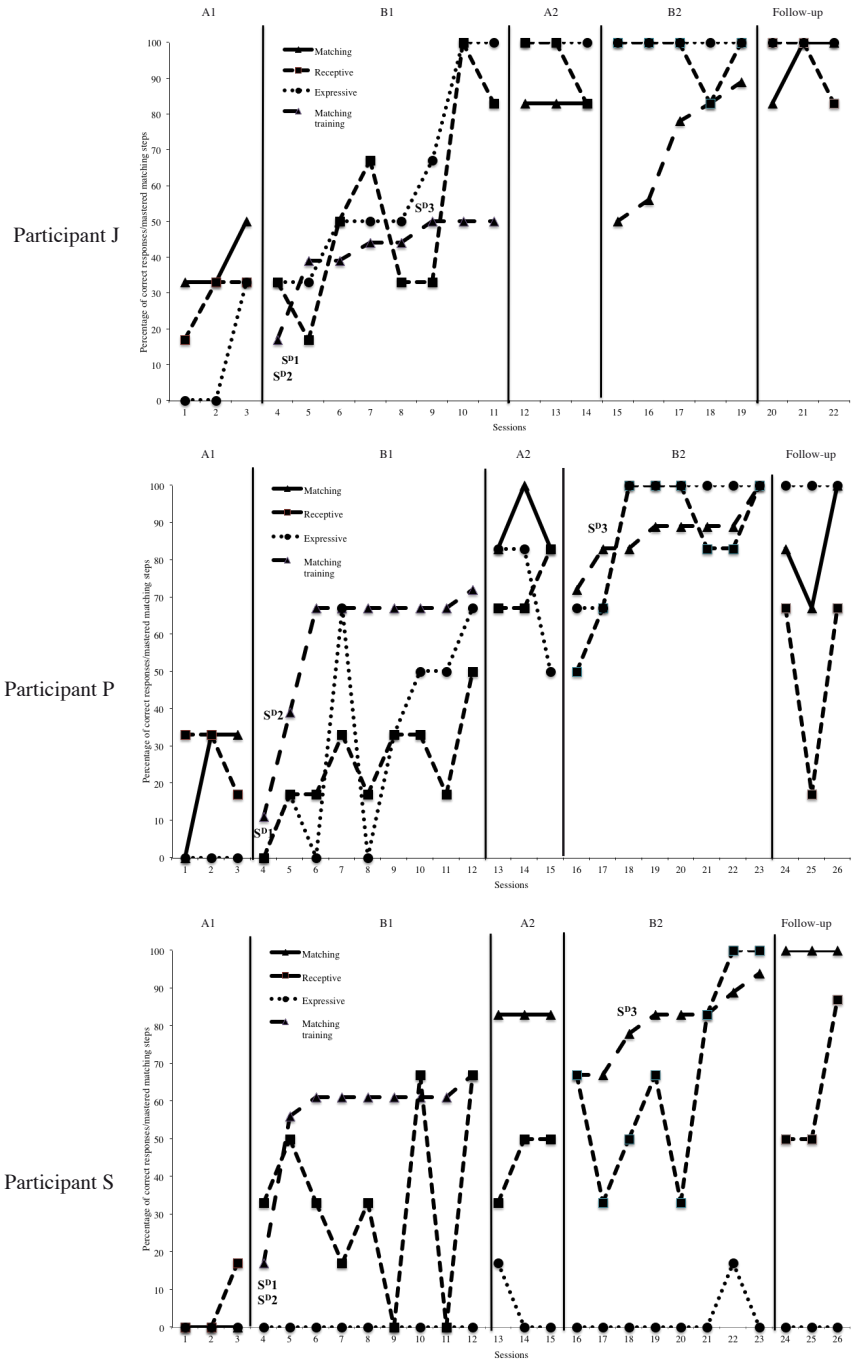

Figure 3. The percentage of correct responses/mastered matching steps over baselines, intervention phases and follow-up measures. The symbols "S^D1", "S^D2" and "S^D3" pinpoint the introduction of each stimulus pair in the matching training.

Participant L

Participant M

Participant A

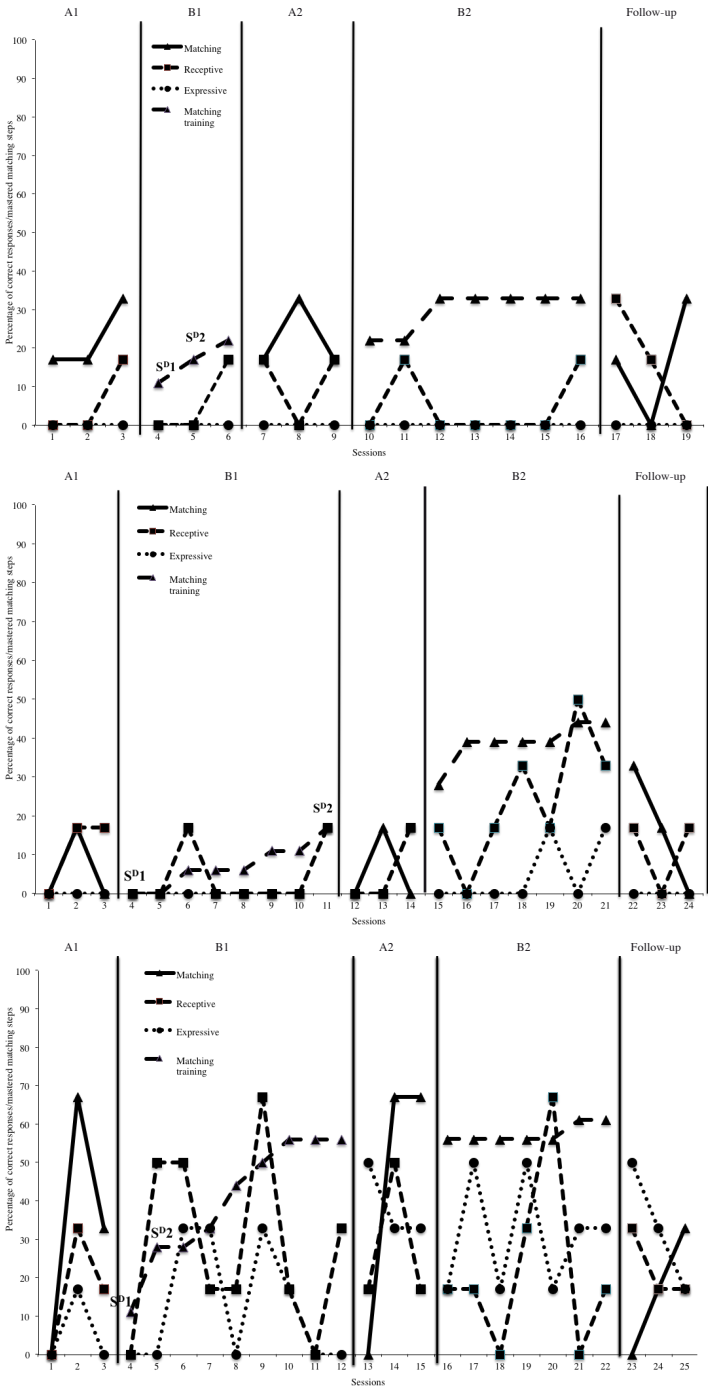

Figure 3 (cont.). Percentage of correct responses/mastered matching steps...

weak language skills prior to match-to-sample training rule out the possibility of fast development of emergent responses on an individual level. The instructors noted that J often echoed their vocal instructions outside of the study context and this also happened occasionally during the matching training. According to naming theory (Horne & Lowe, 1996) echoics could play an important role in the emergence of stimulus equivalent relations, which may have been the reason why J developed emergent responses at a relatively fast pace. The matching training procedure applied in this study includes a vocal tact (e.g "Match rhinoceros") allowing for incidental echoic verbal responses. With the exception of J, the participants did not show full retention of both expressive and receptive emergent responses in the follow-up condition. This could indicate that children with ASD who show stable emergent responding over three probe sessions or more following match-to-sample training still might need further maintenance training to retain their newly acquired verbal skills over the course of the preschool semester.

The sequenced matching procedure designed by Lovaas (2003) was clearly effective for three of the participants; however, the varied results of the three other participants imply that further research is needed to explore how the procedure could be adapted to individual needs.

The use of a convenience sample brings limitations to the ability to generalize the results from the present study. The participants attended the same preschool, shared some specific characteristics, and were familiar to the match-to-sample procedure. Other caveats are the risk of exposure effect to the independent variable, even though this risk was somewhat reduced by using single probes instead of massed probes during the intervention phases. The study does not control for accidental exposure effect prior or during the study, as the ecological validity and applicability (e.g., English words) was prioritized over the use of abstract symbols. It is thus possible that participants may have encountered target stimuli outside the preschool environment both before and during the study. A concurrent multiple probe design across participants was chosen due to the difficulties of applying experimental control of language learning while reducing the risk of an exposure effect by continuous baseline measures as outlined by Belloso Diaz and Pérez González (2015). The design also followed the structure of an ABAB design with a follow-up phase, commonly used for reversible behaviors (i.e., usually not verbal behaviors). The purpose of the ABAB set-up was to get a somewhat longitudinal perspective of language learning, and to simulate an applied setting as ABA training in preschool often is interrupted by events such as national holidays or absence due to illness. While giving an overview of what language training and learning might look like in an applied setting, this also brings limitation to the study. It is possible that a different design such as a non-concurrent multiple probe design across participants would have provided stronger experimental control of the participants' emergent language development, thus strengthening the overall reliability of the study. Because of practical reasons, a non-concurrent design was however not used. Each child participated in a total of approximately seven weeks from first baseline measure to follow-up, and it was not possible to conduct the study for a longer period of time.

The instructors participating in the study were chosen by the principal of the preschool based on their interest in participating and their assessed teaching skills. It is plausible that the skill level and the experience of the instructors may have altered the study's outcome. Instructors and children were randomly matched together before the onset of the study and worked together throughout the whole procedure. It is thus not possible to rule out that different pairs of instructors and children could have affected the

individual results of the match-to-sample training. Due to practical reasons, it was not possible to probe for the dependent variable matching skills during the two intervention phases, but only during baseline and follow-up conditions, because the participants needed time for their ordinary preschool curriculum in addition to the implementation of the study.

The results from the IOA and the implementation quality check questionnaire showed high agreement between observers and excellent adherence to the procedural manual, which strengthens the reliability of the implemented procedure.

The ecological validity of the current study can be considered strong, because the design somewhat imitates the natural setting of the participants' preschool environment where intensive periods of ABA training are combined with pauses due to weekends, holidays, and such. The design allows for following the emergent effects of training over time for each participant in conditions similar to his or her natural environment, showing not only the immediate effects of match-to-sample training but also the effects of temporarily withholding the training. Teachers were adopted as instructors and learned to apply the teaching procedure after a short period of training, implying that the training format easily could be implemented in similar applied settings. The detailed data of the participants' prior language skills and the inclusion of participants with somewhat different learning profiles mirror the broad spectrum of individual expressions evident among children with ASD and help provide an extended understanding of emergent responses in this population.

The results from this study warrant further studies that replicate these findings among larger populations of children with ASD; for example to further explore the applicability of the results to children with even more limited expressive and receptive language repertoires and who use sight and phonetic reading, or other communication devices. The study encourages an understanding of the longitudinal emergent effects of match-to-sample training and its role in language development. Future potential implications for preschools and schools working with children with ASD can be the application of match-to-sample training not only to teach matching skills but also to accelerate the rate of acquisition of language development by indirectly reinforcing additional expressive and receptive responses.

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