FIRST LANGUAGE

ARTICLE

www.sagepublications.com Vol 26(4): 421–438 (200611)
DOI: 10.1177/0142723706067438

Fast-mapping in young children with autism spectrum disorders

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ABSTRACT
A longitudinal correlational design was used to examine whether fast-mapping mediates the relationship between attention-following and vocabulary size in a group of 29 young children diagnosed with autism spectrum disorders. Attention-following was measured at the initial visit. Fast-mapping as well as comprehension and production of noun vocabulary were measured six months later. Attention-following had a significant predictive association with fast-mapping and with both vocabulary outcomes. Fast-mapping had a significant concurrent association with vocabulary and met all the criteria for mediating the association between attention-following and the number of nouns children understood and said at the follow-up. These findings support the value of targeting attention-following to increase word learning for children with ASD.

KEYWORDS
Attention-following; comprehension; language development; vocabulary acquisition; word learning

INTRODUCTION

Most children diagnosed with autism spectrum disorders (ASD) have delays in language development relative to their nonverbal mental ages (Stevens, Fein, Dunn, Allen, et al., 2000; Tager-Flusberg, 1986; Tager-Flusberg & Sullivan, 1998) and approximately half of young children with autism fail to acquire speech as their primary mode of communication (Prizant, 1996). Using speech to communicate successfully with others is dependent, in part, on developing a functional vocabulary, i.e., spoken word use that is frequent, flexible and nonimitative (DeMyer, Barton, DeMyer, Norton, et al., 1973; Kobayashi, Murata & Yoshinaga, 1992; Venter, Lord & Schopler, 1992).

In English, the majority of words that comprise the child's early lexicon are object nouns (Fenson, Dale, Reznick, Bates, et al., 1994). It is not yet known why some children with autism learn to use noun vocabulary to communicate and others do not. But research has shown that early referential word use is positively related to long-term outcomes for this group of children (Gillberg, 1991; Howlin, Mawhood & Rutter, 2000; Liss, Harel, Fein, Allen, et al., 2001) and is one of the strongest longitudinal predictors of social adaptive functioning (Venter et al., 1992). Thus, understanding the process of word learning for children with autism is a first step toward the goal of increasing the proportion of these children with useful speech.

Fast-mapping as a word learning process

Learning the conventional meanings of object labels requires that children make an arbitrary link between labels that are heard and object referents that are seen in the environment. The rapid, associative process by which label and object are paired to establish the earliest entry of a word in a child's lexicon was termed 'fast-mapping' in a classic study by Carey & Bartlett (1978). Theoretically, the initial fast-mapping process is followed by a more protracted period of 'slow-mapping' during which the partial representation of each new word is elaborated, both linguistically and conceptually, and fully incorporated into the child's expanding lexicon. Many studies, subsequent to Carey & Barlett (1978), have employed the theoretical construct of fast-mapping as an explanation for how typically developing children acquire new vocabulary words (Akhtar & Tomasello, 1996; Baldwin, 1991, 1993a, 1993b; Baldwin & Markman, 1996; Tomasello & Barton, 1994; Woodward, Markman & Fitzsimmons, 1994).

The general design for these types of word learning studies has been to provide exposure to a label-referent pairing followed by assessing whether a novel word has been learned. In the most highly scaffolded experimental paradigm, the adult labels an object at which a child is already looking (Baldwin, 1993b). With such adult follow-in labeling, a word-object pairing is formed by the child based on the close temporal association between hearing the label and seeing the object. Typically developing children can learn a novel word under this condition by about 13 months of age (Woodward et al., 1994).

In a naturalistic context, however, parents do not restrict their labeling behavior exclusively to objects in the child's current focus of attention. About 50% of the time, parents refer to objects and events at which the child is not looking at the time they hear the adult label (Harris, Jones & Grant, 1983). In these discrepant labeling situations

(Baldwin, 1995), children cannot rely on temporal contiguity between label and object to guide their word learning; they must actively follow adult behaviors, such as looking and pointing, to determine which referent the adult intends to label (Baldwin & Tomasello, 1998; Tomasello & Barton, 1998). Under conditions of discrepant labeling, children should be better word learners to the extent that they can respond to cues that indicate the adult's focus of attention (Baldwin, 1991, 1993a, 1993b, 1995).

Fast-mapping studies have demonstrated a steady age progression in children's ability to learn new words under conditions of adult discrepant labeling. That is, by 16 months of age, typically developing children do not learn a new word but do avoid learning an incorrect word when the adult's focus of attention differs from their own (Baldwin, 1991, 1993a). By 19 months of age, typically developing children are able to shift their attention and learn a new word by following into the adult's attentional focus (Baldwin, 1993a; Tomasello & Barton, 1998). Finally, by 24 months of age, typically developing children can shift attention to learn a new word even when sensory cues (i.e., noise or movement) from a salient, but unlabeled, object compete with the referential focus of the adult (Moore, Angelopoulous & Bennett, 1999).

The role of attention-following in the process of fast-mapping

Successful learning of a novel word in an experimental task employing discrepant labeling requires that the child actively respond to the speaker's focus of attention (Baldwin, 1995). That is, when the child hears a novel label, he/she must turn his/her head or change the direction of his/her gaze to find the object to which the adult intends to refer. Child behaviors that monitor and respond to the attentional focus of a conversational partner have been called by many different, but related, terms, such as gaze monitoring (Baron-Cohen, Cox, Baird, Swettenham, et al., 1996) or responding joint attention (Seibert, Hogan & Mundy, 1987). In the current study, we use the term 'attention-following' (Carpenter, Pennington & Rogers, 2002) to refer to child responses to verbal and nonverbal cues that indicate the focus of adult attention. Typically developing children, as a group, are likely to display high levels of responsiveness to these types of social-pragmatic cues when interacting with adults in a referential context (Carpenter, Nagell & Tomasello, 1998). Experimental studies of word learning with typically developing participants have been concerned with measuring the outcome of the fast-mapping process; that is, has the child learned a novel word? These studies typically have not focused on quantifying attention-following as a correlate or predictor of fast-mapping.

This is an important question for children with autism who frequently display lower levels of attention-following than do typically-developing children (Baron-Cohen, 1989; Leekam, Baron-Cohen, Perrett, Milders & Brown, 1997; Leekam, Hunnisett & Moore, 1998) and for whom attention-following is concurrently and predictively related to language development (Charman, Baron-Cohen, Swettenham, Baird, et al., 2003; Mundy, Sigman & Kasari, 1990, 1994; Sigman & Ruskin, 1999). Understanding the association between attention-following, fast-mapping and word learning in children with autism is theoretically and clinically important to those who seek to improve language learning outcomes for this group of children. If attention-following is positively related to fast-mapping and vocabulary size for children with autism, then targeting attention-following may represent an important strategy for improving vocabulary; that is, increased attention-following would enable more accurate and efficient fast-mapping.

Fast-mapping in children with autism

Only one study in the literature has examined fast-mapping in children with autism (Baron-Cohen, Baldwin & Crowson, 1997). This study is suggestive of the way that fast-mapping and attention-following may dissociate in this group of children. Baron-Cohen and colleagues used a modified version of the Baldwin (1993a) paradigm and demonstrated that school-aged children with autism (mean chronological age 9 years, 2 months; range 7–12 years) made mapping errors because they incorrectly used their own focus of attention as a strategy for making word-object associations rather than using the speaker's gaze direction to guide their word learning. In fact, only 29% of the participants with autism were able to correctly map verbal labels to object referents when the speaker's direction of gaze was discrepant from their own. Over 70% of chronological age-matched participants with developmental delay and almost 80% of language-matched typically developing toddlers (mean CA 24 months, range 20–30 months) were able to learn a novel word in the discrepant labeling condition.

When the speaker's direction of gaze coincided with their own, 89% of children with autism were able to make accurate word-object pairings. It is important to note that children with autism did not *fail* to learn the novel word in the discrepant labeling condition. They simply selected their own toy as the referent for the label they heard, rather mapping the label to the toy indicated by the experimenter's attentional focus. The findings of Baron-Cohen et al. (1997) provide evidence that the fast-mapping process is intact for school-aged children with autism but that the ability to make appropriate word-object mappings is impaired, presumably due to a deficit in attention-following.

Measuring attention-following and fast-mapping in young children with autism

Studies employing measures of attention-following for children with autism often use the frequency of correct responses or the percentage of trials administered to which the child accurately responds to a single adult cue indicating a target located at some distance from the child (Mundy et al., 1990, 1994; Mundy, Sigman, Ungerer & Sherman, 1986; Seibert et al., 1987). This was the case in the Baron-Cohen et al. (1997) study, in which cues to adult referential focus consisted entirely of adult changes in the direction of eye gaze, as the adult looked either at their own object or the participant's object.

In the current study, we were interested in examining the association between attention-following, fast-mapping and word learning in children with autism under four years of age. Children with autism, with mental ages under 48 months, are unlikely to orient spontaneously to an object in response to adult gaze shifts and head turns, but will demonstrate improved attention-following in response to adult labeling and pointing at an object that is located near to the child (Leekam et al., 1998). We reasoned it was likely our young participants with autism would score at floor levels in response to the kinds of subtle attention directing cues that were provided in the Baron-Cohen et al. (1997) study. In order to achieve sufficient variability in performance to test the associations of interest, we decided to measure attention-following in an experimental context in which the object was located close to the child and the adult increased the salience of the target object by using additional linguistic and object-related behavioral cues.

In addition to the challenges of measuring attention-following, we also reasoned that many of our participants would perform at chance levels in response to a forced-choice or dichotomous measure of fast-mapping, especially one that required the participant to comply with the examiner's request to indicate a particular object. The developmental status of the children in this study made compliance with such task demands unlikely. Thus, our goal was to develop a measure of fast-mapping that would not require an overt behavioral response from the child. In addition, we wanted to develop a continuous measure of fast-mapping that would be sensitive to individual differences in performance so that the associations of interest might be detected.

Research questions

Theoretically, fast-mapping enables children to make a rapid associative pairing between a novel label and an object referent when learning a new word. The ability to follow accurately into the attentional focus of an adult conversational partner should increase the efficiency with which a child can fast-map new labels for objects. Thus, both attention-following and fast-mapping should have a positive association with each other and with word learning outcomes. No previous study for any group of children has attempted to measure the association between attention-following and fast-mapping or the association between fast-mapping and the number of object nouns that children can understand and use. Employing a scaffolded measure of attention-following and a continuous measure of fast-mapping, we addressed the following research questions for a group of young children diagnosed with autism spectrum disorders:

1. Is there a positive predictive association between attention-following and fast-mapping?
2. Is there a positive predictive association between attention-following and object noun vocabulary?
3. Is there a positive concurrent association between fast-mapping and object noun vocabulary?
4. Does fast-mapping mediate the relationship between attention-following and later vocabulary size?

METHOD

Participants

Twenty-nine children participated in the current study. At Time 1, participants had a mean chronological age (CA) of 32.4 months (*SD* = 6.3, range 24–46) and a mean

Table 1 Descriptive characteristics of participants

Characteristic	*Mean*	*SD*	*Range*
CA (months), Time 1	32.4	6.3	24–46
Months between Time 1 and Time 2	6.3	0.6	5.3–7.9
Mullen Mental Age, Time 1 (months)	18.9	4.9	12–30
CARS severity of autism, Time 1*	33.5	4.3	23.5–44
CDI comprehension total, Time 1	126	97	6–372
CDI production total, Time 1	62	95	0–346
CDI comprehension total, Time 2	226	103	0–390
CDI production total, Time 2	138	122	0–390

* Mild-moderate range of severity for Childhood Autism Rating Scale (CARS) is 30–36.

mental age (MA) of 18.9 months (SD = 4.9, range 12–30). Children were seen approximately six months later for follow-up (Time 2). The average time interval between the initial and follow-up visits was 6.3 months (SD = 0.61, range 5.3–7.9). Descriptive characteristics of the participants are presented in Table 1.

All children received a clinical diagnosis of autism (N = 20) or PDD-NOS (N = 9) from a licensed psychologist with extensive experience in the assessment of young children. Clinical diagnoses were based on criteria provided in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV-TR*; APA, 2000). Diagnosis of autism spectrum disorder was confirmed for all participants using the *Autism Diagnostic Observation Schedule – Generic* (*ADOS-G;* Lord, Rutter, DiLavore & Risi, 1999). For these participants, severity of autism was moderate as measured by the *Childhood Autism Rating Scale* (*CARS*; Shopler, Reichler & Renner, 1999).

Participants were seen as part of a larger project and were recruited from several sources (e.g., a university-based diagnostic evaluation center, a state network providing early identification services, parents or other community agencies) and also met the following inclusion criteria: (a) absence of identified genetic, metabolic or progressive neurological disorders, and (b) absence of severe sensory or motor deficits.

Design

The study used a longitudinal correlational design. Attention-following was measured at Time 1. Comprehension and production of object noun vocabulary as well as fast-mapping were measured at Time 2.

Stimulus objects and words

The attention-following and fast-mapping trials used 8 stimulus objects that were constructed from a variety of small wooden shapes. The objects were approximately

12–18 cm tall and were attached to a 10-cm diameter circular wooden base, enabling each object to stand on a table without rolling. Each object, including the base, was painted a glossy, bright color. The objects were constructed so that they did not resemble any object that would be familiar to young children, as confirmed through pilot testing. The objects were sorted into pairs with the goal of maximizing color and shape differences between the objects. All children were tested with the same pairs of objects. Within pairs of objects, one object was designated as the target object. Order, side of presentation and target assignment were randomly assigned across children. The following novel words were used to label the target objects: modi, tooko, dawnoo, koba.

Procedures

Attention-following and fast-mapping procedure (AFF)

This procedure consisted of 8 attention-following trials during which one novel object was presented. For each pair of novel objects, one object was labeled with a CVCV nonsense word and the other object was not. Each pair of attention-following trials was followed by a fast-mapping comprehension trial designed to test whether a novel word had been learned. The entire procedure (i.e., 8 attention-following trials and 4 fast-mapping comprehension trials) was administered at both visits, but few children showed any evidence of acquiring the noun labels at Time 1. The same 8 stimuli and verbal labels were used a both time points, but each label was paired with a different novel object at Time 2. Therefore, the attention-following variable was coded from the 8 attention-following trials administered at Time 1, while the fast-mapping variable was coded from the four fast-mapping comprehension trials administered at Time 2.

Attention-following trials

The attention-following trials usually took less than 6 minutes to administer. During the procedure, the children were seated or stood behind a curved table that was positioned against a corner of the testing room. The examiner was seated across the table approximately 60 cm from the child. A parent or research assistant helped the child to stay in the general area behind the table, and parents were instructed to refrain from interacting with the child during the trials. Each object was presented to the child for approximately 30 seconds. Only one object at a time was visible to the child.

For each trial, the examiner attempted to get the child's attention and then introduced the object from the designated side by bringing the object up from below the table. This procedure was designed to increase the probability of attention-following by simultaneously using multiple attention-directing cues towards an object that was within easy reach of the child. The following strategies were used during each trial to direct the child's attention: (a) presenting a single object at a time; (b) placing the object close to the child and encouraging the child to handle the object; (c) using child-directed speech; (d) using proximal gestures (i.e., adult gestures that touched the object); (e) using adult eye gaze and head turns toward the object; and (f) moving the object. While using these strategies, the examiner moved the object diagonally across the table until it was centered in front of the child, close enough for the child to reach out and touch it. Although the intention of the adult was to encourage the child to look at and examine the novel object, the task was considered referential in that verbal and nonverbal cues to support attention-following were presented within a context of social interaction.

For each pair of attention-following trials, one trial was designated as the Label trial and the other trial as the Talking trial. During Label trials, the novel object was labeled with a two-syllable nonsense word presented in sentence final position (e.g. 'I've got a modi! Look at this modi! You can play with my modi!'). During Talking trials, the child was exposed to an equivalent amount of adult child-directed speech without labeling the novel object (e.g. 'Look at this! Wow! You can play with mine! It's my favorite!'). Both types of trials involved continuous attempts to direct the child's attention for approximately 30 s before the object was removed and the next one presented.

Fast-mapping trials

After each pair of objects had been presented during the attention-following phase, a fast-mapping comprehension trial was conducted to assess whether the child had learned the name for the labeled object. At the onset of each fast-mapping trial, the examiner attempted to gain the child's attention and told the child that they were going to play a game ('Guess what? We're going to find the modi! Ready?'). The examiner held one object in either hand, with the objects out of sight under the table edge and on the same side as the object had been presented in the preceding pair of attention-following trials. While looking straight ahead at the child, the examiner slowly raised both objects above the edge of the table and encouraged the child to look at the target object ('Here comes the modi! Get the modi!'). The examiner then slowly and simultaneously moved both objects diagonally toward the child while telling the child to look at the labeled object ('Look at the modi! Where's the modi?'). The examiner was careful not to allow the child to grasp either object until the child had clearly looked towards the target object, even if this object was not the first one towards which the child looked. If the child failed to look at the target object after 15 s had elapsed, the fast-mapping trial was ended. Children were allowed to obtain either one or both objects at the conclusion of each testing presentation in order to maintain motivation for task participation. They were also encouraged to place the objects into a Ziploc storage bag and zip the bag closed before the examiner proceeded to the next trial of the attention-following procedure. This procedure established a routine for task completion and usually allowed the object to be removed without protest.

MacArthur Communicative Development Inventory (CDI)

The CDI (Fenson et al., 1994), a widely used parent report instrument that has high utility in characterizing early lexical and grammatical skills, was used to assess vocabulary comprehension and production. The CDI Infant Scale contains a vocabulary checklist of 396 words typically acquired by children exposed to American English from 8 to16 months of age. Of these 396 words, 229 words are object nouns. Object noun vocabulary was used as the outcome variable in the current study as the process of fast-mapping presumably results in an associative link between a verbal label and an object referent. The CDI Infant Scale was used instead of the Toddler Scale because the latter does not have a comprehension checklist. None of the participants reached the ceiling level in number of words understood or number of words understood and said, indicating that the CDI Infant Scale was developmentally appropriate for this group of children at both time points. Parents were asked to complete the CDI at Time 2, and raw scores for object nouns only were used as the metric for the size of comprehension and production vocabulary.

Mullen Scales of Early Learning (MSEL)

The MSEL (Mullen, 1995), a standardized developmental test for children aged 3–60 months, consists of five subscales: gross motor, fine motor, visual reception, and language comprehension and production. The gross motor subscale was not administered for the current study. The age equivalent score for each participant was used to provide an index of overall developmental level.

Childhood Autism Rating Scale (CARS)

The CARS (Schopler, Reichler & Renner, 1999), a 15-item behavior rating scale, is used to provide a rating of severity for children with autism. After observing the child and examining other relevant information, the examiner rates the child on each item using a 7-point scale that reflects the degree to which the child's behavior deviates from that of a typically developing child of the same age. A total score is computed by summing across the individual item scores. Scores falling in the autism range can be divided into two categories: mild-to-moderate autism and severe autism.

Coding and reliability

Administration of the attention-following procedure at Time 1 and the fast-mapping procedure at Time 2 were videotaped, captured into digital format and coded using ProcoderDV (Tapp, 2003), a software system designed for PC computers. ProcoderDV allows accurate frame-by-frame collection of observational data from digital media. After coding, data files were exported into MOOSES software (Tapp, Wehby & Ellis, 1995) for calculation of cumulative durations and frequencies for subsequent analysis.

Attention-following

Attention-following was coded for each object presented. Due to the proximal nature of the task and the provision of continuous attentional directives by the examiner, most children did look at the target objects at some point during each trial. To differentiate children within the sample, duration of looking at the target objects was selected as the metric for attention-following. However, the duration of object presentation during each attention-following trial sometimes varied from a consistent length due to variable child compliance. A proportion metric was used for the attention-following variable because preliminary analysis confirmed that trial duration was positively correlated with duration of object attention, $r(29) = 0.39$, $p < 0.04$, two-tailed. The proportion was computed for each child using total duration that the child looked at the object as the numerator and total duration of the trial as the denominator.

The timing for each trial began when the examiner raised the object above the edge of the table and into the child's potential field of vision. The onset of attention-following was coded when the child first looked at the presented object and was coded if the child was visually attending to the object, with or without touching. The offset of attention-following occurred whenever the child looked away from the object. Frame by frame coding of attention-following was continued until the frame of the videotape in which the object was removed by the examiner and was no longer located within the visual field of the child.

Average proportion of attention-following was coded from presentation of all 8 stimulus objects for 20 children. Due to human error in videotaping (i.e., the child and/or object were off-screen), presentation of seven stimulus objects was coded for 1 child, and presentation of 6 stimulus objects was coded for 8 children. Data from all 29 children were included in the data analyses.

Fast-mapping

The variable used to quantify fast-mapping was average latency until first look to the target object. The timing for the fast-mapping trials began when the examiner moved both objects above the edge of the table and into the child's potential field of vision. The offset of coding was the first frame in which the child looked at the object designated as the target for that pair of objects (i.e., the labeled object). Average latency of first look to the target objects was coded from presentation of 4 trials for 25 children, 3 trials for 3 children, and 1 trial for 1 child. Human error in videotaping was the cause of the uncodable trials for these 4 children.

Reliability

Interobserver reliability was calculated using intra-class correlation coefficients (Suen & Ary, 1989) for the attention-following and fast-mapping variables. Independent reliability coding was conducted on a random sample of 20% of the attention-following and fast-mapping sessions. The intra-class correlation coefficients were 0.96 and 0.80 for attention-following and fast-mapping, respectively. *G* coefficients greater than 0.60 are considered acceptable (Mitchell, 1979).

RESULTS

Mean values of the proposed correlates

Despite the continual redirection of the participant to the stimulus objects and the presence of only a single object during each trial, considerable variability in the distribution of attention-following performance was obtained. The average proportion of attention-following during the 30-s trials was 0.46 ($SD = 0.19$, range 0.11–0.78). For the fast-mapping measure, the average latency of first look to the target object was 2.35 s ($SD = 1.73$ s, range 0.6–8.33 s). As measured by the CDI at Time 2, the average number of object labels comprehended and produced was 117 words ($SD = 51$, range 0–183 words) and 73 words ($SD = 62$, range 0–182), respectively. Chronological age was not significantly related to measures of attention-following ($p < 0.84$, two-tailed), fast-mapping ($p < 0.60$, two-tailed), vocabulary comprehension ($p < 0.63$, two-tailed) or production ($p < 0.194$, two-tailed).

Demonstrating a mediating relationship

Demonstrating that fast-mapping mediates the relationship between attention-following and vocabulary requires that four conditions be met (Baron & Kenny, 1986): (a) the predictor variable must be significantly associated with the outcome (e.g., attention-following must be predictively related to comprehension or production); (b) the predictor variable must be significantly associated with the hypothesized mediator (e.g., attention-following must be predictively related to fast-mapping); (c) the hypothesized mediator must be significantly associated with the outcome (e.g., fast-mapping must be related to either comprehension or production); and (d) the strength of the association between the predictor and the outcome variable(s) must be reduced by removing the variance attributable to the mediator (e.g., the relationship between attention-following and either comprehension or production must be rendered non-significant when variance attributable to fast-mapping is included in the analysis).

Bivariate correlations between attention-following, fast-mapping and vocabulary

One-tailed significance levels were used in the following analyses as all associations were predicted to be positive. According to the first condition for demonstrating a mediating relationship, attention-following must be significantly related to vocabulary outcomes. There was a significant bivariate association between attention-following at the initial visit and the number of object nouns at the follow-up, both for comprehension, $r(29) = 0.31$, $p < 0.04$, one-tailed, and production, $r(29) = 0.32$, $p < 0.04$, one-tailed. According to the second condition for establishing a mediated relationship, attention-following must be significantly related to fast-mapping. There was a significant bivariate association between attention-following at Time 1 and fast-mapping at Time 2, $r(29) = 0.39$, $p < 0.02$, one-tailed. According to the third condition for demonstrating mediation, fast-mapping must be significantly related to vocabulary outcomes. There was a significant bivariate association between fast-mapping and the number of object nouns at the follow-up visit, both for comprehension, $r(29) = 0.58$, $p < 0.001$, one-tailed, and production, $r(29) = 0.55$, $p < 0.001$, one-tailed.

Regression analyses predicting comprehension and production

The final condition for demonstrating a mediated relationship requires that the strength of the association between attention-following and vocabulary be reduced when the variance attributable to fast-mapping is removed. To test this final condition, attention-following and fast-mapping were entered simultaneously into two hierarchical linear regression analyses predicting either comprehension or production of noun vocabulary. As presented in Tables 2 and 3, the two regression analyses revealed that the association of attention-following with either comprehension or production no longer reached significance, while fast-mapping remained a significant predictor of the number of object nouns children understood and produced at Time 2. Thus, fast-mapping met all the conditions necessary to be considered a mediator of the association between attention-following and both comprehension and production of object noun vocabulary.

Table 2 Hierarchical analysis predicting the unique variance in object noun comprehension at Time 2 attributable to attention-following, removing effects of fast-mapping ($N = 29$)

Variable	*B*	*SE B*	*ß*
Step 1			
Attention-following	80.81	47.93	0.309*
R^2 for Step 1 = 0.10			
Step 2			
Attention-following	25.15	45.01	0.096
Fast-mapping	0.54	0.17	0.546**
ΔR^2 for Step 2 = 0.25			

* $p < 0.05$, one-tailed; ** $p < 0.01$, one-tailed

Table 3 Hierarchical analysis predicting the unique variance in object noun production at Time 2 attributable to attention-following, removing effects of fast-mapping ($N = 29$)

Variable	*B*	*SE B*	*ß*
Step 1			
Attention-following	103.89	58.36	0.324*
R^2 for Step 1 = 0.11			
Step 2			
Attention-following	41.70	56.46	0.130
Fast-mapping	0.60	0.21	0.498**
ΔR^2 for Step 2 = 0.21			

* $p < 0.05$, one-tailed; ** $p < 0.01$, one-tailed

DISCUSSION

Fast-mapping provides a theoretical mechanism by which the ability to follow adult attentional cues can result in learning more vocabulary words, particularly object labels. That is, once the child follows into the attentional focus of the speaker, the ability to rapidly form an associative link between label and object provides the initial basis for learning a new word. This study tested whether the association between attention-following and later object noun vocabulary was mediated through fast-mapping for a group of 2-and 3-year-olds diagnosed with ASD. To examine the hypothesized associations, we developed a continuous measure of fast-mapping that would be sensitive to variations in performance of very young word learners. By meeting the criteria for detecting a mediated relationship, the current study provides empirical, albeit correlational, support for the theory that attention-following facilitates vocabulary development by enabling accurate fast-mapping.

In the current study, as suggested by Leekam et al. (1998), young children with autism were able to follow into the adult focus of attention when given continuous attention-directing cues to an object located close to the child. Children who followed attentional directives most proficiently mapped nonsense words most accurately six months later. Children who mapped most effectively had the largest concurrent comprehension and production vocabularies for object nouns. As expected, these data support two proposals: (a) when more scaffolded attentional directives are provided, children with autism can use attention-following to learn new words, and (b) the mechanism by which attention-following supports noun acquisition is through fast-mapping.

Previous studies using fast-mapping paradigms have not attempted to quantify child attention-following when examining the process of word learning. Rather, the relation between attention-following and word learning has been examined using a manipulation of experimental condition, such as the comparison of adult follow-in or discrepant labeling (for review, see Akhtar & Tomasello, 2000). Follow-in labeling refers to a word learning context in which the adult labels the referent that represents the child's current focus of attention. In contrast, discrepant labeling refers to a word learning context in which the adult labels their own focus of attention; such a context requires the child to shift his/her gaze in order to identify the adult's intended referent. Studies, such as that of Baron-Cohen et al. (1997), support the interpretation that attention-following is important for accurate fast-mapping but do not explicitly test the association between the two constructs. In the current study, attention-following was measured during the experimental procedure and the probability of children making a mapping was maximized by using repeated and proximal adult directives to scaffold attention-following. This was an important manipulation in that young children with autism, who were impaired in following attentional cues, were able to participate in the fast-mapping task. Despite this scaffolding, there was sufficient variance in the extent to which children both followed attentional cues and mapped the object label to allow consideration of the associations between attention-following, fast-mapping and vocabulary outcomes.

The goal of the current study was to develop a continuous metric that allowed the possibility of quantifying individual differences in fast-mapping ability. Most published studies have used either a forced choice paradigm (Baldwin, 1991, 1993a; Woodward et al., 1996) or a duration measure of preferential looking (Hollich, Hirsh-Pasek & Golinkoff, 2000; Schafer & Plunkett, 1998) as the metric for fast-mapping. Duration measures may involve the proportion of time spent looking at the target or the duration of the first or longest look to the target. The current study differed from previous studies in that *latency to first look at the target object* was used as the measure of fast-mapping. One other study for children with developmental disabilities has used a latency measure in a fast-mapping paradigm. Chapman, Sindberg, Bridge, Gigstead & Hesketh (2006) used a response time metric to measure comprehension of fast-mapped words in a group of 19 adolescents with Down syndrome. However, these participants were required to respond to comprehension probes by selecting the target from a choice of five objects.

In general, procedures that involve the presentation of many items at one time are not well tolerated by children with autism. In addition, chance responding accounts for a large portion of the variance in individual scores when a forced choice procedure is used. By using a latency measure, the need to administer a large number of items during the fast-mapping task was eliminated, making task demands more manageable than a longer test would have been for young children with autism. Replication of the results of the current study would provide additional support for the utility of the latency measure of fast-mapping as a tool for examining the process of word learning in young children diagnosed with autism spectrum disorders.

The current study has important clinical implications as well. If attention-following enables accurate fast-mapping, as these results demonstrate, then targeting increased attention-following through interventions may increase word learning outcomes for children with ASD. Additionally, use of redundant sensory cues to increase the salience of target objects is important for scaffolding and maintaining child attention-following, particularly during developmental periods when the children are not responding to more distal attentional directives (e.g., gaze or points). Finally, providing a verbal label once the child is looking at a referential target can result in accurate-object mapping by the child.

Limitations

The limitations of the current study are shared by all correlational studies of children with autism. Unmeasured child characteristics such as self-regulation or compliance may be responsible for the hypothesized association, instead of the constructs of interest (i.e., attention-following, fast-mapping, and object label vocabulary). The only way to rule out the influence of such unmeasured variables completely would be to use an experimental design in which attention-following is successfully targeted with a treatment and subsequent effects on fast-mapping and object label vocabulary are examined. This concern could also be addressed in the context of short-term effects on fast-mapping if proximal attention-following cues (touching and moving an object located close to the child) were used to obtain the child's attention prior to providing the object label in one condition while distal attention-following cues (pointing, head turns and eye gaze) were used to obtain the child's attention prior to providing the object label in another condition. The dependent variable in such a study would be the extent to which children demonstrate fast-mapping of object labels assigned to either condition. Another approach would be to use a treatment that is designed to affect generalized attention-following ability (e.g., Whalen & Schreibman, 2003) and to examine whether successful acquisition of attention-following from such a treatment has an indirect effect on generalized object label acquisition.

Perhaps the most critical limitation of this study is the absence of a typically-developing group that would demonstrate whether the observed associations also obtain for a comparison population. Fernald and colleagues (Perfors, Magnani & Fernald, 2002) have used an eye-tracking procedure to measure reaction times in response to the presentation of spoken words in 64 typically developing children from 12 to 25 months of age. These investigators compared a latency measure of word recognition to vocabulary comprehension scores at 15, 18, 21 and 25 months and demonstrated significant correlations between latency of on-line word recognition and both comprehension and production vocabulary. Although Fernald's measure was used to assess comprehension of known words rather than newly fast-mapped labels, the results certainly support the construct validity of assessing word learning in typically developing children using a latency metric.

Conclusions and future directions

The current study is the first to demonstrate an empirical association between attention-following, fast-mapping and vocabulary acquisition for any group of children. By provided repeated and proximal attention-directing cues, very young children with autism were able to follow into an adult's focus of attention to learn a new word during a referential task. Results suggest the value of targeting increased attention-following as well as adult use of proximal attention directing cues, with verbal labeling of referents subsequent to child compliance with attentional directives, as ways to improve noun acquisition for young children with ASD. An extension of the current study could be conducted to examine the associations of interest in samples of children with other developmental disabilities (i.e., Down, Williams and fragile X syndromes) as well as children who are typically developing. This would clarify the extent to which this study's findings generalize to these populations. Also an additional study might compare the use of the latency measure of fast-mapping with a more traditional forced-choice paradigm for measuring novel word learning.

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