J Autism Dev Disord (2014) 44:2064–2071
DOI 10.1007/s10803-014-2074-1

BRIEF REPORT

Brief Report: Generalisation of Word–Picture Relations in Children with Autism and Typically Developing Children

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Published online: 21 February 2014

Abstract We investigated whether low-functioning children with autism generalise labels from colour photographs based on sameness of shape, colour, or both. Children with autism and language-matched controls were taught novel words paired with photographs of unfamiliar objects, and then sorted pictures and objects into two buckets according to whether or not they were also referents of the newly-learned labels. Stimuli matched depicted referents on shape and/or colour. Children with autism extended labels to items that matched depicted objects on shape *and* colour, but also frequently generalised to items that matched on only shape *or* colour. Controls only generalised labels to items that matched the depicted referent's shape. Thus, low-functioning children with autism may not understand that shape constrains symbolic word–picture–object relations.

Keywords Autism · Words · Understanding pictures · Generalisation · Shape bias · Colour

Introduction

Words and pictures are symbols that serve a general referencing function. A photograph of a red Corvette can be taken to represent a unique exemplar (e.g. my red Corvette) or an object category (e.g. cars in general). Similarly, the verbal label "car" can refer to cars in general or to a specific exemplar. Because pictures are representations of real objects, the same label can refer to both three- and two-dimensional versions of an entity. Children must learn that verbal labels paired with pictures (a) refer to symbolised referents rather than pictures themselves, and (b) can be generalised to objects that belong to the same category as the depicted referent. Over the first 2 years of life, typically developing (TD) children develop a robust understanding of word–picture–object relations that enables them to correctly generalise labels from pictures (e.g. Preissler and Carey 2004). By contrast, low-functioning children with Autism Spectrum Disorder (ASD) experience profound linguistic impairments (Anderson et al. 2007) and have difficulty generalising labels from pictures to objects (Preissler 2008; Hartley and Allen, in press).

TD children begin learning word–referent relations at approximately 12-months (Bloom 2002), and the majority of the earliest-acquired words refer to object categories that are well-organised by shape (Samuelson and Smith 1999). Smith et al. (2002) state that the process of learning object names selectively tunes children's attention to shape, which in turn accelerates their acquisition of novel object names. As children map a particular noun to additional category members, they quickly realise that "cars" share the same global structure (Samuelson and Smith 1999). By approximately 24-months, TD children infer the general rule that noun–referent relations are constrained by shape, and thus generalise newly-learned words to novel objects based on this feature, rather than other perceptual properties (e.g. colour, size, texture; Landau et al. 1988).

The emergence of this "shape bias" is underpinned by categorisation—the cognitive process that organises information into conceptual groups and enables the evaluation of new information based on existing concepts (Klinger and Dawson 2001). TD infants organise object categories through the abstraction of prototypes (e.g. Younger 1990),

The study was conducted as part of the first author's doctoral research.

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which can be considered the "central tendency" of a particular category (Posner and Keele 1970). It is believed that abstract mental representations of category-defining shapes direct children's generalisation of object names (Son et al. 2006). That is, if the global shape of a newly encountered object (e.g. a Persian cat) is sufficiently similar to a stored prototype (e.g. the cat basic level category), the child may generalise the label for that prototype (e.g. "cat") to the novel object. Categorisation is also involved in picture comprehension. When a child views a picture, they must compare the depicted referent against their existing prototypes in order to decide what object is represented. Alternatively, if a picture depicts an unfamiliar object, viewers can generate a prototype directly from the representation, enabling generalisation to other pictures and real world referents. By 18–24 months, TD children almost always extend newly-learned words from pictures to depicted objects, therefore demonstrating their knowledge of symbolic word–picture–object relations (Preissler and Carey 2004).

In contrast, approximately 30 % of children with ASD are nonverbal at 9-years due to severe linguistic impairments (Anderson et al. 2007). Many of these children are taught to communicate using pictures via intervention protocols such as the Picture Exchange Communication System (PECS; Frost and Bondy 2002). However, this population may have a fundamental difficulty understanding symbolic relations between words, pictures and objects. Impairments in word learning are common in autism, and studies have shown that children with ASD tend to learn object names via an associative mechanism (e.g. Baron-Cohen et al. 1997). Furthermore, children with ASD do not privilege sameness of shape as a basis for extending labels to novel objects (Tek et al. 2008). Tek and colleagues investigated whether children with ASD evidenced an attentional bias to shape in word learning across a 12-month period. Over the year, children with ASD developed sizeable vocabularies (exceeding 100 count nouns), but at no stage evidenced the shape bias heuristic, suggesting a dissociation between vocabulary size and the maxims governing word learning in autism.

Differences in word-object mapping and generalisation evidenced by children with ASD may be related to inherent deficits in visual processing, categorisation and prototype formation. For example, Klinger and Dawson (2001) examined the ability of high-functioning children with ASD to abstract prototypes of unfamiliar animal-like categories. In this task, children with ASD had no difficulty performing rule-based categorisations, but they failed to learn categories via prototype formation. One possibility is that children with ASD are unable to form prototypes because they do not selectively attend to shape when processing visual stimuli. Prototype formation demands the ability to selectively abstract global shape information, but children with ASD evidence a preference for processing local details at the expense of holistic meaning (e.g. Frith and Happé 1994). It may be that children with ASD process novel objects in a predominantly feature-based fashion (similar to how they process faces; e.g. Joseph and Tanaka 2003), and fail to develop a shape bias because they do not identify shape as the most pertinent determinant of category membership.

Word learning difficulties in children with ASD also manifest in the pictorial domain. In Preissler's study (2008), low-functioning children with ASD were taught an unfamiliar word (e.g. "Whisk") repeatedly paired with a black-and-white line drawing of an unfamiliar object (e.g. a whisk). At test, children were asked to identify the referent of the newly-learned word when presented with the drawing and the previously unseen depicted object. Unlike TD children, children with ASD displayed a strong tendency to select the picture alone, indicating their failure to understand that the label referred to the object category represented by the picture. One explanation of Preissler's (2008) findings is that picture comprehension in low-functioning children with ASD is contingent on a high degree of iconicity (the extent that a symbol resembles its referent). In their recent study, Hartley and Allen (in press) taught low-functioning children with ASD a series of novel words paired with pictures of unfamiliar objects that varied in iconicity (e.g. colour and non-colour pictures). At test, children were asked to select the referent of the newly-learned label from arrays consisting of the target picture paired with the depicted object and then a differently-coloured version of the depicted object. Overall, children with ASD extended verbal labels to referent objects approximately twice as often in colour picture trials relative to non-colour picture trials (48.6 vs. 25.7 %). Furthermore, most children with ASD who extended labels to depicted objects also generalised to novel category members that differed in colour (as ability-matched TD children did). These findings implicate colour as an important influence on whether children with ASD comprehend symbolic picture–referent relations and extend labels to depicted objects.

However, given their impairments in prototype and category formation, it cannot be assumed that children with ASD map relations between words, colour pictures and objects in the same manner as TD children. While it is clear that children with ASD benefit from greater iconicity when generalising words from pictures, they may not abstract minimalist shape-based representations of depicted referents as TD children do. Due to their localised processing bias and weak central coherence (e.g. Frith and Happé 1994), category defining details (e.g. global shape) and category irrelevant details (e.g. size, colour, texture) may not be psychologically separable for children with ASD. As a result, they may be unable to weight these perceptual details when deciding whether to extend a known label to a novel item (picture or object) on the basis of category membership. Hence, it is possible that children with ASD may generalise newly-learned word–picture relations based on multiple and independent perceptual details (e.g. shape and/or colour).

The present study investigates whether low-functioning children with ASD generalise labels from colour pictures to objects based on similarity of shape, colour, or both shape and colour. Children with ASD and ability-matched TD children were taught novel words paired with colour photographs of unfamiliar target objects, and were required to sort items into two buckets according to whether or not they were also referents of the newly-learned labels. Sorted items included real target objects, differently-coloured variants of target objects, other unfamiliar objects that were colour-matched to target objects, familiar objects, and pictures of each object. Based on Hartley and Allen (in press), we anticipated that some children with ASD would map associative word–picture relations and fail to generalise, while others would generalise labels to target objects and differently-coloured variants. We also predicted that the absence of a shape bias (Tek et al. 2008) may cause some children with ASD to over-extend labels to unfamiliar objects that match pictures on colour, but not shape. By contrast, we expected TD children to only generalise labels to items that matched pictures on shape.

Method

Participants

Participants were 17 low-functioning children with ASD (all male; M age = 9.7 years, range 4.1–16.1) and 17 TD children (6 males, 11 females; M age = 3.5 years, range 2.2–6.4) with normal, or corrected-to-normal, colour vision. Children were recruited from local specialist schools, mainstream schools, nurseries and preschools. All children with ASD received a diagnosis of autism from a qualified educational or clinical psychologist, using standardised instruments (i.e. ADOS and ADI-Revised; Lord et al. 1994, 2002) and expert judgment. Diagnosis was confirmed using the Childhood Autism Rating Scale (CARS; Schopler et al. 1980), as completed by a class teacher (M score: 41, range 31.5–51.5). Groups were matched on receptive vocabulary (ASD: 3.5 years, range 2–6.2; TD: 3.5 years, range 2–5.4) as measured by the British Picture Vocabulary Scale (BPVS; Dunn et al. 1997).[1] In addition, the nonverbal intellectual abilities of each group, as measured by the Leiter-R (Roid and Miller 1997), were not significantly different, $t(32) = -.81$, $p = .43$.

All children with ASD were current PECS-users, and the sample was linguistically representative of children who receive and benefit from picture-based communication interventions.[2] The study was approved by the Lancaster University Ethics Committee and informed consent was obtained from parents.

Materials

Stimuli included familiar objects, unfamiliar objects, laminated colour photographs of each, and two opaque white 6-litre Tupperware boxes. Photographs were taken with a 9.2 megapixel camera and edited using Adobe Photoshop. All photographs were standardised to 2 × 2 inches, conforming to the PECS training literature guidelines (Frost and Bondy 2002).

Sixteen familiar objects were used in two Training Trials. Each of the 4 Test Trials involved a unique set of 4 objects and colour photographs of those objects (see Fig. 1).

Procedure

Participants were tested individually in their own schools and accompanied by a familiar adult. Children were reinforced throughout the session for attention and good behaviour. Correct performance was only reinforced during Training Trials.

Children sat at a table opposite the experimenter, with two Tupperware boxes positioned between them (one left and one right of centre). The experimenter told the child that they would be playing a game that involved sorting things. Two Training Trials were then administered, counterbalanced for order. First, the experimenter showed

[1] The BPVS scores of 4 children with ASD and 1 typically developing child were marginally below the lowest raw score with a standardised age equivalent (of 2.3 years). Consequently, we conservatively assigned these children a receptive language ability of exactly 2 years. This research is particularly relevant to individuals with language impairments who have difficulty with standardised assessments, display challenging behaviours and receive picture-based communication training.

[2] Seven children with ASD were functionally non-verbal (no spoken words), 7 had some words and produced utterances of 1–3 words in length (including echolalic utterances) and 3 could speak some short phrases over 4 words long. Participants' experience using PECS varied between 5 months and 10 years. Their progress ranged from Stage 1 to fully-trained user (see Frost and Bondy 2002). The pictures used by participants to communicate varied individually, with coloured drawings/symbols and black-and-white drawings/symbols the most common. Several children used a mixture of picture types that varied in iconicity and only four children in the sample used "some" colour photographs.

(a) Target Object (b) Novel Object (c) Distracter Object (d) Familiar Object

(e) Target Object (f) Novel Object (g) Distracter Object (h) Familiar Object

(i) Target Object (j) Novel Object (k) Distracter Object (l) Familiar Object

(m) Target Object (n) Novel Object (o) Distracter Object (p) Familiar Object

Fig. 1 Object stimuli used in the sorting task; set 1 (**a–d**), set 2 (**e–h**), set 3 (**i–l**) and set 4 (**m–p**)

the child a familiar practice object (car/dog) and named the object several times [e.g. "This is a car (dog). See, it's a car (dog). Have a look at the car (dog)"]. He then pointed to one of the containers and demonstrated that the named object should be placed inside, before allowing the child to copy this action [e.g. "Cars go in here. See, the car goes in here (experimenter places object in appropriate container). Can you put the car in here?"]. The experimenter informed the child that they should place further examples of the named object in the same container (e.g. "I want you to put cars in here"), and then pointed to the other container and stated that non-named items should be placed in there (e.g. "Other things go in here."). A series of items were presented one-by-one and in a random order for the child to sort (e.g. "So where does this go? And where does this go?"). To reinforce task understanding, the first item presented was always identical to the practice object. The remaining items were either cars/dogs or other familiar objects from different categories. If a child made an error, the experimenter demonstrated the correct response and re-started the trial from the initial step. Training Trials were repeated until the child correctly sorted all items without help. The distribution of sorted items was 5 cars (vs. 3 non-cars) and 4 dogs (vs. 4 non-dogs). This discrepancy was intended to prevent children from inferring that a certain number of items should be sorted into each container in the Test Trials. Four Test Trials followed (see Fig. 2). For each trial, the experimenter showed the child a colour photograph of an unfamiliar object (target picture) and assigned it a novel label (e.g. "This is a blicket. See it's a blicket. Have a look at the blicket"). Four novel labels (blicket, parloo, gariff, nellby) were counterbalanced for order. The experimenter then pointed to one of the containers and demonstrated that the named item should be placed inside, before allowing the child to copy this action [e.g. "Blickets go in here. See, the blicket goes in here (experimenter places target picture in the appropriate container). Can you put the blicket in here?"]. The experimenter informed the child that they should place further examples of the named object in the same container (e.g. "I want you to put blickets in here"), and then pointed to the other container and stated that non-named items should be placed in there (e.g. "Other things go in here."). Additionally, the experimenter retrieved the target picture and placed it in front of its container to prevent children from forgetting where named items should go.

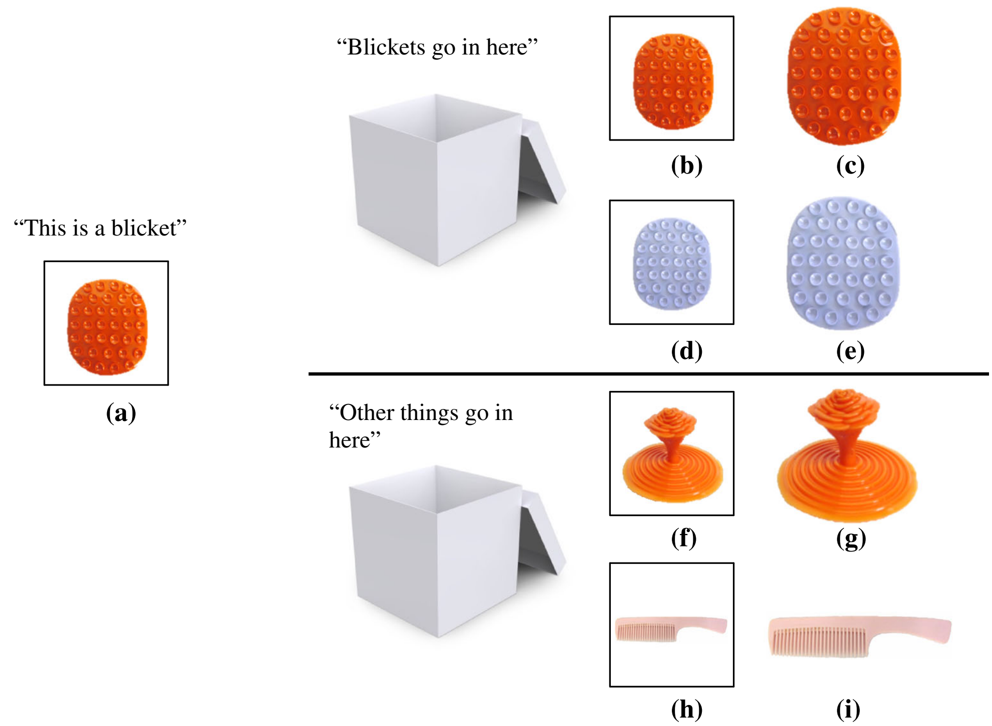

Fig. 2 Illustration of Test Trial procedure and stimuli: target picture (**a**), copy of target picture (**b**), target object (**c**), novel picture (**d**), novel object (**e**), distracter picture (**f**), distracter object (**g**), familiar picture (**h**) and familiar object (**i**)

The experimenter then presented a series of 8 items, one-by-one and in a random order, for the child to sort into the two containers (e.g. "So where does this go? And where does this go?"). Those items consisted of the target object (the unfamiliar object depicted in the target picture), a novel object (a differently coloured version of the target object), a distracter object (a different unfamiliar object that was exactly the same colour as the target object), a familiar object, a copy of the target picture, a novel picture (a photograph of the novel object), a distracter picture (a photograph of the distracter object) and a familiar picture (a photograph of the familiar object). After sorting 4 items, the experimenter reminded the child which container the named items were meant to be placed inside (e.g. "Remember, blickets go in here. Other things go in here"). A different set of stimuli was used on each Test Trial, and order of sets was counterbalanced.

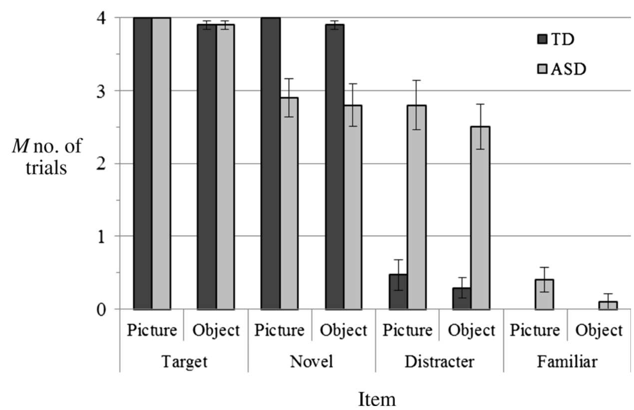

Fig. 3 Mean number of trials (out of 4) that children with autism (ASD) and typically developing children (TD) generalised labels from target pictures to each item type

Results

Training Trials

All children passed both Training Trials by placing the named items in one box and the non-named items in the other box. All TD children passed both Training Trials at their first attempt. Thirteen children with ASD passed both Training Trials at their first attempt, two required two attempts to pass Training Trial 1, one required two attempts to pass Training Trial 2, and one required two attempts to pass both Training Trials.

Test Trials

Every child completed all 4 Test Trials. In each trial, children learned the name of an unfamiliar target picture and then sorted 8 items according to whether or not they were also referents of the label. The number of times that children generalised labels to each type of item was calculated, yielding 8 scores (each out of 4) per participant.

The mean rates that children generalised labels from colour photographs to each type of item are displayed in Fig. 3.

These data were entered into a 2(Group) × 8(Item) mixed ANOVA. Main effects of Group, $F(1, 32) = 13.86$, $MSE = .59$, $p = .001$, $\eta p^2 = .3$, and Item, $F(1.89, 60.31) = 180.62$, $MSE = 1.87$, $p < .001$, $\eta p^2 = .85$, were qualified by a significant Group × Item interaction, $F(1.89, 60.31) = 28.24$, $MSE = 1.87$, $p < .001$, $\eta p^2 = .47$. Between-group comparisons for each item showed that TD children and children with ASD generalised labels to target pictures and target objects at equal rates, TD children generalised labels to novel pictures, $F(1, 32) = 16.1$, $p < .001$, and novel objects, $F(1, 32) = 15.69$, $p < .001$, significantly more often than children with ASD, children with ASD generalised labels to distracter pictures, $F(1, 32) = 33.07$, $p < .001$, and distracter objects, $F(1, 32) = 40.56$, $p < .001$, significantly more often than TD children, children with ASD generalised labels to familiar pictures significantly more often than TD children, $F(1, 32) = 5.68$, $p = .023$, and the two groups generalised labels to familiar objects at equal rates. The rates at which TD children generalised labels to target pictures, target objects, novel pictures, and novel objects were equivalent and all significantly higher than rates of generalisation to distracter pictures (all $ps < .001$), distracter objects (all $ps < .001$), familiar pictures (all $ps < .001$) and familiar objects (all $ps < .001$), which were all equally low. Thus, TD children almost always generalised labels from colour photographs to similarly-shaped items, and almost never generalised to items that differed in shape. For children with ASD, rates of generalisation to target pictures and target objects were equivalent and significantly higher than rates for almost every other item ($ps = .001$–$.08$; the difference between rates for target objects and novel pictures bordered on significance). Children with ASD generalised labels to novel pictures, novel objects, distracter pictures and distracter objects at statistically equivalent rates, that were all significantly above-chance ($ts = 2.06$–3.57, $ps = .003$–$.056$; rate of generalisation to the distracter object was borderline), and significantly greater than rates of generalisation to familiar pictures and familiar objects (all $ps < .001$), which were both equally low. Overall, children with ASD almost always generalised labels from pictures to items that matched depicted objects on shape *and* colour, but they also extended labels at above-chance rates to shape-matched items (novel pictures/objects) *and* colour-matched items (distracter pictures/objects), suggesting that both perceptual cues direct their extension of words from photographs. Additional analyses confirmed that between-group differences were not related to Gender.[3]

For TD children, generalisation rates did not correlate with chronological age, receptive language ability or nonverbal intellectual ability. This is unsurprising given that the whole group demonstrated the same general response pattern. For children with ASD, generalisation rates did not correlate with chronological age, nonverbal intellectual ability or years of PECS training. Generalisation to novel objects positively correlated with receptive language ($r = .57$, $p = .02$), and generalisation to distracter pictures negatively correlated with receptive language ($r = -.53$, $p = .03$). Also, there were significant negative correlations between CARS score and generalisation to novel pictures ($r = -.62$, $p = .008$) and novel objects ($r = -.77$, $p < .001$). These correlations suggest that children with more severe autism were less likely to generalise labels from photographs based on sameness of shape, without sameness of colour.

Discussion

This study investigated the cues that direct the generalisation of words from colour photographs by low-functioning children with ASD and language-matched TD children. Participants were taught novel words paired with photographs of unfamiliar target objects, and were required to sort a series of items according to whether or not they were also referents of the newly-learned labels. Children with ASD almost always extended labels to items that matched depicted objects on both shape and colour, but also frequently generalised to items that matched on only shape *or* only colour. By contrast, TD children only generalised labels to pictures and objects that matched the depicted referent's shape. Our study suggests that low-functioning children with ASD understand that words paired with colour photographs relate to independently existing referents, however, they often generalise based on incorrect dimensions (i.e. colour). This atypical pattern of responding indicates a fundamental misunderstanding of the rules that govern symbolic word–picture–object relations.

The finding that children with ASD frequently generalised labels from colour photographs was somewhat surprising, given that Preissler (2008) and Hartley and Allen (Experiment 1; in press) reported that children with ASD often form associative word–picture relations. It is likely that the higher rate of generalisation in the present study was elicited by differences in our word learning procedure.

[3] As our ASD sample only consisted of males, we conducted two follow-up analyses to rule-out a possible effect of Gender. Firstly, the data from the TD children were entered into a 2(Gender) × 8 (Item) mixed ANOVA, which showed that Gender had no influence on their generalisation of word–picture relations. Secondly, we reran the between-groups analyses including only the male TD children. Exclusion of the female TD children yielded exactly the same Group × Item interaction and simple main effects as the primary analyses.

In both previous studies, children were required to actively pair words and target pictures over a minimum of 5 consecutive training trials, and were directly reinforced for doing so. This repeated and reinforced pairing may have narrowed the referential relation to the extent that the picture itself (rather than the depicted object) was considered the referent of the word. Indeed, in a second experiment, Hartley and Allen showed that children with ASD tend to categorise pictures with their referents when word–referent relations are not reinforced. We argue that the procedure in the present study was sufficient to foster learning of non-associative word–picture relations; children heard labels paired with target pictures multiple times, however, the relation was not narrowed through repeated reinforcement, enabling children with ASD to generalise.

Although children with ASD in this study extended labels from photographs to objects, they generalised based on both shape and colour at above-chance rates. Therefore, this low-functioning population did not display a shape bias; they utilised colour (a category-irrelevant cue) as a basis for naming just as frequently as shape (a category-defining cue). This atypical response pattern indicates that children with ASD have significant difficulty organising new word-referent concepts around shape. It may be that their failure to selectively attend to global shape when learning object names subsequently impacts on their ability to categorise via the abstraction of shape-based prototypes. Weak central coherence (Frith and Happé 1994) may prevent children with ASD from identifying similarity of global shape as the perceptual constraint that organises word-referent categories, thus inhibiting the development of the shape bias word learning heuristic. Consequently, in our sorting task, low-functioning children with ASD categorised pictures based on two separate parts—shape and colour. This informs our understanding of *how* new concept formation in autism and typical development might differ. When TD children learn a novel word–picture relation, they generate a minimalist representation of the depicted referent's shape, which provides a basis for comparison when deciding if additional objects belong to the same category and should receive the same label. By contrast, children with ASD do not selectively abstract global shape and may instead generate mental representations that are characterised by multiple, equally-weighted, perceptual details (e.g. shape and colour) that serve as independent bases for label extension.

Generalisation to novel category members (shape-matched items) was negatively correlated with CARS score, suggesting that children with more severe autism were less likely to generalise labels from photographs based on similarity of shape. As nonverbal intellectual ability did not correlate with generalisation rates for any items, this effect was not an artefact of higher cognitive ability in children with lower CARS scores. It is possible that children with the most severe autism experience the greatest difficulty recognising sameness of shape when categorising novel objects that differ in colour and, for these children, colour may be the most pertinent cue when establishing new word-referent concepts (see Hartley and Allen, in press). Receptive language also positively correlated with generalisation to novel objects, and negatively correlated with generalisation to distracter pictures. Although previous research suggests that the shape bias is directly related to language development in young TD children (e.g. Tek et al. 2008), it is difficult to draw that conclusion here given that receptive language did not correlate with generalisation to novel pictures or distracter objects.

At an applied level, this study provides further evidence that iconic colour pictures facilitate the generalisation of words to objects in children with ASD (also see Hartley and Allen, in press). Consequently, we recommend that picture-based interventions such as PECS should be delivered using iconic colour, rather than black-and-white, representations of vocabulary to maximise the probability that recipients map referential word–picture–object relations. However, given that low-functioning children with ASD have difficulty abstracting shape as the key constraint underlying word–referent relations, it is possible that their categorisation is rule-based. Due to impairments in prototype formation (Klinger and Dawson 2001), it may be that children with ASD require multiple experiences with a variety of category members in order to generate hypotheses that correctly define category membership. As such, it may be beneficial to deliver picture-based interventions using differently-coloured depictions of object category members in order to increase the likelihood that children with ASD recognise that shape, rather than colour, defines category membership. The benefits of such training would be an interesting topic for future research.

The failure of children with ASD to demonstrate a shape bias when generalising labels from photographs cannot be attributed to insufficient language development, as all children had a receptive language age of at least 2-years—the age at which the shape bias typically emerges. Furthermore, Tek et al. (2008) showed that the absence of a shape bias in autism is not related to general word learning deficits, inadequate vocabulary size, or the inability to notice similarity of shape among visual stimuli. Indeed, Hartley and Allen (in press) showed that low-functioning children with ASD are good at matching even black-and-white line drawings with similarly-shaped objects regardless of labelling. Thus, it appears that low-functioning children with ASD have specific difficulty identifying shape as the primary cue that directs the mapping of categorical word–picture–object relations. Naturally, we must caution against generalising the results of this experiment to high-functioning children or adults with autism. However, it is important to state that the children who participated in this study were representative of the population that this research is most relevant to: low-functioning individuals with impaired language development who receive and benefit from picture-based communication interventions.

In summary, we have shown that low-functioning children with ASD form referential relations between words and colour photographs, however, they do not evidence a shape bias when generalising labels to real objects. We propose that deficits in categorisation and prototype formation (e.g. Klinger and Dawson 2001) may prevent children with ASD from privileging shape as a basis for generalising word–picture relations. Consequently, they are just as likely to incorrectly extend labels to objects that match depicted referents on colour (but not shape). Conversely, language-matched TD children only generalise labels to objects that belong to the same category as depicted objects, as indicated by sameness of shape, rather than sameness of colour. Therefore, this study is the first to demonstrate that different cues constrain the mapping of novel word–picture–object relations for TD children and children with ASD.

Acknowledgments We would like to thank the children and staff at Hillside Specialist School, Preston (UK), Sunny Brow Day Nursery, Kendal (UK), Castle Park School, Kendal (UK), and Burton Preschool, Burton-in-Kendal (UK).

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