Development of audience design in children with and without ASD

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ABSTRACT

We examined two hypotheses concerning the development of *audience design* by contrasting children with and without Autistic Spectrum Disorder (ASD) in referential communication. The two-stage hypothesis predicts that the ability to use contrastive size adjectives for ambiguity avoidance develops separately from and faster than the ability to avoid perspective-inappropriate descriptions for their addressee. The single-stage hypothesis assumes that both abilities reflect speakers' perspective-taking, and they should develop in tandem with each other. Experiment 1 found that 6-to-10 year olds with and without ASD produced disambiguating size adjectives (" *small door"*) equally often when the size-contrasting competitor (large door) was in the visual context *shared* with their addressee. When the competitor was hidden from their addressee, that is, it was part of children's *privileged* context, children with ASD produced more perspective-inappropriate size adjectives than those without ASD, providing support for the two-stage model. Experiment 2 showed a similar pattern of results with 11-to-16-year-old adolescents. Compared to adults, 6-10-year-olds without ASD produced more perspective-inappropriate size adjectives in the privileged context, while producing fewer disambiguating size adjectives in the shared context, demonstrating more "egocentric" behaviours than adults. Importantly, whereas 11-16-year-olds without ASD produced disambiguating adjectives nearly as often as adults in the shared context, they produced perspective-inappropriate adjectives more than adults in the privileged context. This indicated that even in non-ASD, the ability to avoid perspective-inappropriate descriptions develops more slowly than the ability to avoid ambiguous descriptions, delaying the onset of adult-like audience design, consistent with the two-stage hypothesis.

Key words: audience design; referential communication; perspective-taking; ASD; language development; adjective

INTRODUCTION

When referring, speakers can choose different descriptions. A cup can be referred to by a bare noun such as *cup* or by a more specific description such as *big cup*. One of the long-standing issues in developmental research is how children learn to adapt referential descriptions to the addressee's informational needs via a process called *audience design* (Clark & Murphy, 2002). In a classic experiment, Horton and Keysar (1996) showed that adult speakers used contrastive modifiers (as in *small circle*) more when a *referential competitor* (e.g., large circle) was also visible to their addressee than when it was hidden from their addressee. Contrastive adjectives such as "small" help the addressee uniquely identify speakers' intended referent in a context with multiple category exemplars (e.g., two circles). But if the addressee cannot see the referential alternative, the use of contrastive adjectives would be misleading, as they imply the presence of another category exemplar (i.e., *small circle* suggests the presence of a large circle) (e.g., Olson, 1970; Osgood, 1971) when the addressee cannot see any. Thus, speakers in Horton and Keysar may have avoided contrastive modifiers when they were inconsistent to the addressee's perspective, in line with pragmatic theories such as the one proposed by Grice (1975), who argued that cooperative speakers avoid ambiguity as well as redundancy for their addressee. An important question is how children acquire such skills.

Although subsequent research has shown that children aged around 4 or 5 (Nilsen & Graham, 2009), 5 or 6 (Bahtiyar & Küntay, 2008; Nadig & Sedivy, 2002) show sensitivity to the addressee's perspective in the production of contrastive adjectives, research has also shown that unlike adults, children often fail to produce contrastive adjectives for ambiguity avoidance (e.g., Deutsch & Pechmann, 1982). Also, without any research on the development of speakers' perspective-taking in older children and adolescents, it has remained unclear how children acquire adult-like audience design. Moreover, whilst debates focus on how perspective-taking affects audience design in adults (e.g., Clark & Marschall, 1981; Horton & Keysar, 1996), no previous studies have examined whether the theories make the right developmental predictions. The primary aim of the current study was to address this. Specifically, we focus on the mechanism that drives the development of audience design in children as well as adolescents, by contrasting predictions that we present in relation to two competing models that explain audience design in adults.

Investigating adults, Horton and Keysar (1996) argued that what the addressee knows or does not know is relatively high-level knowledge. As a result, speakers initially plan their speech "egocentrically", using their own contextual knowledge: if they see a size-contrasting competitor (a large circle), they plan a contrastive adjective (as in *small circle*), regardless of whether the referential competitor (e.g., large circle) is also visible to their addressee. If the addressee cannot see the competitor, speakers adjust their plan and choose a bare noun (as in *circle*), which complies with the addressee's contextual knowledge. If the addressee can also see the competitor, no adjustment will be implemented. This *monitoring and adjustment* account assumes that audience design occurs serially; speakers initially aim to distinguish the referent from others for unique reference (*ambiguity avoidance*), irrespective of the addressee's access to the referential competitors, and perspective-taking typically happens *late* when speakers correct their initial choice of description by accommodating the addressee's perspective (*addressee accommodation*). We may therefore speculate that audience design in children develops in two separate stages: the ability to use contrastive adjectives for ambiguity avoidance is separable from and develop faster than the ability to avoid perspective-inappropriate contrastive adjectives for addressee accommodation. Hence, even if children learn to produce contrastive adjectives as frequently as adults for ambiguity avoidance when both children and their addressee can see the referential competitor, children are more likely to produce perspective-inappropriate adjectives than adults when the addressee cannot see the competitor that they see. We call this a *two-stage* hypothesis.

An alternative account, which we call the *single-stage* hypothesis, however, is that ambiguity avoidance and addressee adaptation develop together, because perspective-taking is also central to children' ability to avoid ambiguous descriptions: speakers know what their intended referent is, so the use of a contrastive modifier is led by their communicative concern about the addressee's comprehension. According to Clark and his colleagues' common ground principle (e.g., Clark, 1996;

Clark & Wilkes-Gibbs, 1986; Clark & Marschall, 1981), speakers base their descriptions on the information mutually shared with their addressee (or *common ground*, Clark, 1992); speakers produce a contrastive adjective when the competitor is also visible to their addressee, that is, when the competitor is in the visual context *shared* with their addressee, but they produce an unmodified bare noun when the competitor is invisible to their addressee, so the presence of the competitor is part of the speaker's *privileged* context. On this account, both inclusion and exclusion of contrastive modifiers is determined by speakers' perspective-taking. We may thus infer that the ability to produce contrastive adjectives for ambiguity avoidance and the ability to avoid perspective-inappropriate contrastive adjectives reflect the same phenomenon, so that they develop in tandem with each other. Consistent with this, researchers have attributed children's tendency to produce ambiguous descriptions (e.g., Deutsch & Pechmann, 1982) to poor perspective-taking skills (e.g. Piaget, 1926). More specifically, research has shown that children are unable to evaluate whether a message contains ambiguity (Robinson & Robinson, 1977; Singer & Flavel, 1981), even though they experience comprehension problems following ambiguous instructions (Patterson, Cosgrove, & O'Brien, 1980; Plumert, 1996; Revelle, Wellman, & Karabenick, 1985) or implicitly detect ambiguity (Nilsen, Graham, Smith, & Chambers, 2008; Nilsen & Graham, 2012), possibly because they tend to overestimate the addressee's ability to identify the referent (Robinson & Robinson, 1982) or fail to overcome their own knowledge about the correct referent (Beal & Belgrad, 1990; Beal & Flavell, 1984).

The current study thus examines the mechanism that underlies the development of audience design, by focusing on the relationship between the ability to use contrastive adjectives for ambiguity avoidance and the ability to avoid perspective-inappropriate adjectives for the addressee. To this end, we first compared children with and without Autistic Spectrum Disorder (ASD), a developmental disorder associated with impairments with perspective-taking abilities (e.g., Baron-Cohen, Leslie, & Frith, 1985; Perner, Frith, Leslie, & Leekam, 1989), because the two-stage hypothesis and the single-stage hypothesis make different predictions as to how the groups should differ, as we describe below.

ASD is primarily associated with impairments in reciprocal social interaction and communication, and repetitive or limited behavioural repertoire (APA, 2000). Children with ASD are unimpaired in simple *perceptual* perspective-taking; they can tell whether a particular object is visible to a person given the person's visuospatial relations with that object (Baron-Cohen, 1989; Hobson, 1984; Leslie & Frith, 1988). But children with ASD are known to have more difficulty with *conceptual* perspective-taking, computing another's mental state or a *theory of mind*, than those without ASD (e.g., Baron-Cohen et al., 1985; Perner et al., 1989). Most notably, children with ASD tend to show a delay in passing false-belief tasks relative to their chronological age (e.g., Baron-Cohen et al., 1985; Leslie & Frith, 1988) or verbal mental age (Happé, 1995; Leekam & Perner, 1991), as they often fail to distinguish their own belief (true) from another's different beliefs (false). The two-stage hypothesis assumes that the ability to use contrastive adjectives for ambiguity avoidance should develop "egocentrically", on the basis of speakers' own sensitivity to referential ambiguity, whereas the ability to avoid perspective-inappropriate adjectives for the addressee is led by speakers' sensitivity to the addressee's perspective. Hence, children with ASD should produce disambiguating contrastive adjectives as often as children without ASD, but they should show a delay in avoiding perspective-inappropriate adjectives when the referential competitor is hidden from their addressee. In contrast, the single-stage hypothesis assumes that ambiguity avoidance also requires perspective-taking. Thus, compared to their peers, children with ASD should produce fewer contrastive adjectives when the addressee could see the referential competitor, and when they produce contrastive adjectives, they should be less likely to adapt their use to the addressee's perspective.

Despite initial language delays (e.g., Howlin, 2003; Luyster, Kadlec, Carter & Tager-Flusberg, 2008; Wetherby, Watt, Morgan, & Shumway, 2007) and varying degrees of linguistic abnormalities (Eigsti, Ashley, de Marchena, Schuh, & Kelley, 2011; Tager-Flusberg, Paul, & Lord, 2005; Walenski, Tager-Flusberg, & Ullman, 2006), the majority of children with ASD, and particularly higher-functioning individuals with ASD, acquire functional language (Tager-Flusberg et al., 2005). During vocabulary learning, high-functioning children with ASD have been shown to map novel words to novel referents like children without ASD (Tek, Jaffery, Fein, & Naigles, 2008) and use the same contextual information as their controls when doing so (De Marchena, Eigsti, Worek, Ono, & Snedeker, 2011; Preissler & Carey, 2005). When producing sentences, high-functioning children with ASD can also align sentence structures with their partner, demonstrating unimpaired syntactic representations (Allen, Haywood, Rajendran, & Branigan, 2010). Furthermore, high-functioning adolescents with ASD take account of discourse factors similarly to their peers when using pronouns (Arnold, Bennetto, & Diehl, 2009; see also, Lee, Hobson, & Chiat, 1994). One possibility is that these aspects of language use are unaffected by ASD, because they do not require theory-of-mind abilities (Baron-Cohen, 1988; Tager-Flusberg, 1989). Indeed, language impairments in children with ASD have been found primarily in pragmatic aspects of language use (Baltaxe, 1977). For instance, research suggests that children with ASD are less likely to use the speaker's eye gaze to infer their intended referent during word learning (Baron-Cohen, Baldwin, & Crowson, 1997; Preissler & Carey, 2005), though more recent research has shown that relatively high-functioning children with ASD can use the partner's eye-gaze during vocabulary learning (Bani Hani, Gonzalez-Barrero, Nadig, 2013; Luyster & Lord, 2009; Norbury, Griffiths, & Nation, 2010). Moreover, individuals with ASD have more difficulty with spontaneous conversations (e.g., Capps, Kehres, & Sigman, 1998; Nadig, Lee, Singh, Bosshart, & Ozonoff, 2010, Tager-Flusberg & Anderson, 1991; Volden & Load, 1991). For instance, speakers with ASD are more likely to fail to adequately respond to queries (Capps et al., 1998; Paul & Cohen, 1984; Perner et al., 1989) or indirect requests (Ozonoff & Miller, 1996) and they have difficulty with maintaining the topic of conversation (Nadig et al., 2010).

Most relevant to the current study, Nadig, Vivanti, and Ozonoff (2009) examined if the individuals with ASD differed from those without ASD in ambiguity avoidance as well as in addressee adaptation. Using the same set-up as in Nadig and Sedivy (2002), they compared 9-14-year-olds with ASD (Mean: 11 years; N = 17) with those without ASD. There were three conditions in total: a same-category competitor (e.g., a small cup when the target was a tall cup) was either visible to their addressee (shared visual context) or hidden from the addressee (privileged context), and there was a control condition with no same-category competitor in any context. Speakers with ASD were 19% less likely to produce disambiguating contrastive adjectives than those without ASD when the referent and the competitor in the shared context had a same semantic category rather than different categories, but this difference was only marginally significant, indicating that ASD only marginally influences ambiguity avoidance. Importantly, the tendency to produce more contrastive adjectives when the same-category competitor was in the shared context rather than when it was in the privileged context was 39% weaker in the ASD group than in the control group, demonstrating an effect of ASD on addressee adaptation. Additional analyses showed that 3 out of 17 participants with ASD did not produce disambiguating contrastive adjectives when the shared visual context contained a same-category competitor for ambiguity avoidance, 5 out of 17 participants with ASD used contrastive adjectives for avoiding referential ambiguity in the shared context, but they were unable to adapt their use to their addressee's perspective, and 9 participants were successful in both. These results indicated that ambiguity avoidance in the shared context is acquired more easily than adapting descriptions to the addressee's perspective in 9-14-year-olds with ASD, consistent with the two-stage hypothesis.

Other evidence, however, suggests that speakers with ASD are impaired with ambiguity avoidance, as predicted by the single-stage hypothesis. Dahlgren and Dahlgren Sandberg (2008) reported that 7-to-14 year old children and adolescents (Mean: 10 years) with ASD produced ambiguous descriptions more often than those without ASD. Their study involved a relatively large sample (N = 30) of individuals with ASD, who were asked to verbally describe 16 faces with different characteristics (e.g., boy or girl, happy or sad, big or small, with or without a nose) for the addressee. Whereas control participants without ASD were able to verbally describe each picture unambiguously, participants with ASD rarely did so. Volden, Mulcahy, and Holdgrafer (1997) examined referential communication in 13-to-24 year-old adolescents and adults (Mean: 18 years) with and without ASD (N = 10 in each group). Their visual display contained two possible referents that varied on one of four possible attributes; colour, shape, texture or pattern and the position of a dot attached to each object. Overall, individuals with ASD tended to “overspecify” more than those without ASD, by referring to redundant features rather than focusing on distinguishing features. Although the study failed to find a significant group difference on average performance, possibly due to the small sample size or/and small number of trials (N = 8), the results can be taken to indicate that speakers with ASD are less effective in identifying the referent’s distinguishing features compared to those without ASD.

The question also remains as to how audience design in children without ASD develops, that is, whether speakers without ASD demonstrate a delay in avoiding egocentric contrastive adjectives relative to avoiding ambiguous bare nouns. So far, there is no evidence that suggests this. Nadig et al. (2009) reported that all 17 9-14 year olds without ASD were successful in both ambiguity avoidance and adaptation of descriptions to the addressee’s perspective. In Nadig and Sedivy (2002), the pattern of means indicated that 5-6-year-olds produced fewer disambiguating contrastive adjectives than adults when the same-category competitor was in the shared context, and they were less likely to adapt the use of contrastive adjectives given the addressee’s visual perspective. While these findings do not demonstrate a delay in addressee adaptation relative to ambiguity avoidance, we do not know if they develop together. Bahtiyar and Küntay (2008) found an age-related improvement in ambiguity avoidance as well as in the degree of addressee adaptation, as predicted by the single-stage hypothesis, though in their study, all age groups rarely produced perspective-inappropriate adjectives.

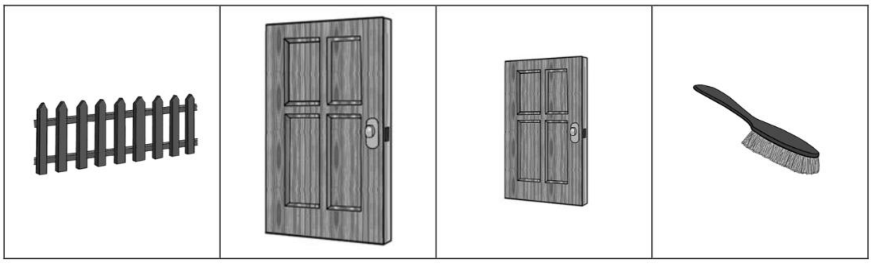
In sum, the current study we report below contrasted two hypotheses concerning the development of audience design. The two-stage hypothesis predicts that the ability to produce disambiguating contrastive adjectives is separable from and develops faster than the ability to avoid perspective-inappropriate adjectives. In contrast, the single-stage hypothesis assumes that perspective-taking is central to both abilities, which should develop in tandem with each other. Experiment 1 examined these hypotheses by comparing school-age children, aged 6-to-10 year-old, with and without ASD. Experiment 2 then compared 11-to-16-year-old adolescents with and without

ASD with children in Experiment 1. In both experiments, we examined how children or adolescents without ASD differed from young adults without ASD, aged 18-23 years.

EXPERIMENT 1

In a referential communication task adapted from Wardlow-Lane and Ferreira (2008), 6-10-year-olds (Mean: 8 years) with and without ASD and 18-23-year-olds adults without ASD (Mean: 21 years) took part. Each participant – hereafter, “the speaker” – was asked to instruct an experimental confederate – hereafter, the “addressee” – to identify a target picture. In the *same-category* condition, the speaker had to refer to a target object (the second object from the right in Fig. 1), when the display contained an object of the same category as the target (larger door as in Fig. 1A), whereas in the *different-category* condition, the competitor had a different category (large envelope as in Fig. 1B). Hence, the use of bare nouns (*door*) was ambiguous in the presence of a same-category competitor (Fig. 1A), but not in the context of a different-category competitor (Fig. 1B). Crucially, in the *privileged context* condition, an occluder was placed in front of the competitor, so that the competitor was visible to the speaker, but not to the addressee. In contrast, in the *shared context* condition, the occluder hid one of the unrelated objects from the addressee (e.g., the brush in Fig. 1), so that the competitor was visually present to the both speaker and addressee.

A: Same-category competitor (ambiguous) condition



B: Different-category competitor (unambiguous) condition

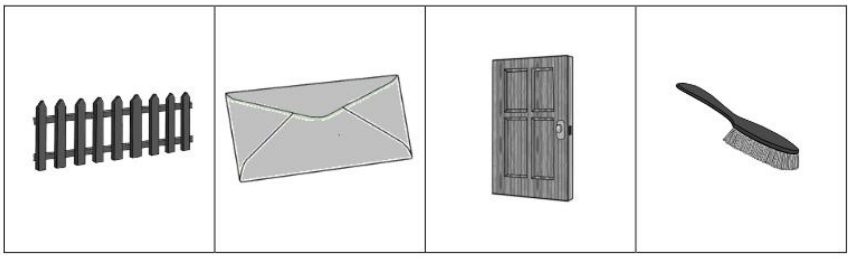


Fig. 1 Example stimuli

If children are sensitive to referential ambiguity, they should produce size-contrasted descriptions (e.g., *small door*) more when the competitor in the context makes the use of unmodified bare nouns (e.g., *door*) ambiguous (as in Fig. 1A) than when it does not (as in Fig. 1B). If they are sensitive to the addressee's perspective, then the effect of referential ambiguity should be larger when the competitor is in the shared context than when it is in the privileged context, as shown in previous studies. Importantly, the two-stage hypothesis predicts that the ability to produce contrastive adjectives in the shared context develops independently from perspective-taking, whereas the ability to avoid perspective-inappropriate adjectives for their addressee reflects speakers' perspective-taking. Hence, children with ASD should be able to produce contrastive adjectives (rather than bare nouns) equally often as children without ASD when the same-category competitor is in the shared context, whereas they are less likely to avoid perspective-inappropriate contrastive adjectives in the privileged context (relative to the shared context) than children without ASD. This should result in a weaker tendency to use fewer contrastive adjectives in the privileged context than in the shared context in ASD than in non-ASD. The single-stage hypothesis assumes that perspective-taking is central not only for avoiding contrastive adjectives in the privileged context but also for producing contrastive adjectives in the shared context. Thus, the single-stage hypothesis predicts fewer disambiguating size adjectives in the shared context in ASD than non-ASD, as well as a weaker tendency to avoid contrastive adjectives in the privileged context compared to the shared context in ASD than non-ASD.

Additionally, Experiment 1 examined whether and how 6-10-year-olds without ASD differed from adults. Although research has shown that the tendency to vary the use of contrastive adjectives given the addressee's perspective is weaker in children than adults, no research has demonstrated that children produce perspective-inappropriate contrastive adjectives more frequently than adults in the privileged context (Bahtiyar & Küntay, 2008; Nadig & Sedivy, 2002). In Nadig and Sedivy (2002), 5-6-year-olds without ASD did not appear to produce more perspective-inappropriate contrasting adjectives than adults in the privileged context, which might have been because 5-6-year-olds were generally less inclined to produce contrastive adjectives than adults. In Bahtiyar and Küntay (2008), 5-6-year-olds, 9-10-year olds and adults all rarely produced contrastive adjectives in the privileged context, though this might have been because the physical arrangement of the display made the object in the privileged context generally less salient to speakers. If children indeed have more difficulty with overcoming self-knowledge than adults (e.g., Birch & Bloom, 2004; Epley, Morewedge, & Keysar, 2004; Nickerson, 1999), however, 6-10-year-olds without ASD may produce perspective-inappropriate contrastive size adjectives more than adults in the privileged context.

Method

Participants. Twenty pairs of children, with and without ASD, aged between 6 and 10 years, were recruited from six mainstream primary schools in North Lanarkshire and South Lanarkshire Councils in Scotland. By disseminating information packs via the participating schools, we first recruited children's parents, who would be willing to allow their child to participate in our study and fill in the Social Communication Questionnaire (SCQ; Rutter, Bailey, Lord, & Pickles, 2003), a commonly used measure of autistic symptoms**.** Autistic children had been formally diagnosed with Autistic Disorder (n = 19) or Asperger's Disorder (n = 1) by a team of multidisciplinary professionals including a paediatrician and a speech and language therapist, and they were recruited from special units within the schools. Parents of both groups of children completed SCQ. Three children with ASD, who had a lower SCQ score (≤ 10) than the ASD threshold score of 15 (Berument, Rutter, Lord, Pickles, & Bailey, 1999), and three children without ASD, who had a higher SCQ score than 15, were excluded. Children without ASD were reported to be developing normally without any known disabilities. To ensure that children with and without ASD were similar in age or other cognitive abilities, children without ASD were individually matched with those without ASD on the basis of their chronological as well as verbal mental age (or receptive vocabulary) measured with the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton & Burley, 1997). Additionally, we administered two subtests of the Wechsler Abbreviated Scale of Intelligence (WAIS; Wechsler, 1999), productive vocabulary and matrix reasoning, to ensure that the matched individuals were also similar with respect to productive vocabulary and estimated IQ (all *F*s < 2, see Table 1), in case that BPVS overestimated language abilities (Kjelgaard & Tager-Flusberg, 2001; but see also Jarrod, Boucher, & Russell, 1997) or intelligence (Mottron, 2004) of our ASD sample. More extensive language measures and other IQ subtests - block design and similarities - were not possible because of time constraints during our school visits. An additional 8 children with ASD were recruited but excluded from further analyses because they did not complete the screening tests (n = 5) or had BPVS and IQ scores that were too low to match (n = 3). An additional 19 children without ASD were recruited but excluded, because their age or BPVS score could not be matched to children with ASD and/or they had a very high WAIS vocabulary score. Twenty young adults with a typical developmental history, aged between 18 and 23, were recruited from the University of Strathclyde student community in exchange for cash. At the end of participation, children and their parents received coloured pens and a shopping voucher, respectively.

Table 1. Children with and without ASD in Experiment 1

	Children			
	with ASD (n = 20) *M* (*SD*) [range]	without ASD (n = 20) *M* (*SD*) [range]	$F(1, 38)$	*p*
Gender (M:F)	20:00	20:00		
Chronological Age (years)	8.8 (1.1) [6.8-10.9]	8.3 (1.2) [6.3-10.5]	1.97	.17
Mental age (BPVS) (years)	7.3 (1.1) [5.5-10.1]	7.5 (1.5) [5.1-11.3]	< 1	.56
WASI Vocabulary *T* score (productive vocabulary)	47.8 (8.8) [34-61]	50.0 (8.0) [39-70]	< 1	.41
WASI Matrix Reasoning *T* score	43.5 (9.4) [28-65]	45.6 (8.6) [32-70]	< 1	.47
WASI Estimated Full IQ	93.1 (10.2) [76-107]	96.4 (9.7) [79-110]	1.07	.31
SCQ	27.7 (4.5) [21-35]	4.3 (3.0) [0-9]	370.80	< .001

Procedure and materials. The speaker and the addressee sat face-to-face, on opposite sides of the picture display, and an experimenter sat between the two (see Fig. 2). At the beginning of each trial, the addressee was asked to turn around from the table. The speaker then saw a visual display of common objects printed in four grid boxes on an A4 paper (see Fig. 1). Most pictures were taken from shaded images in Rossion and Pourtois (2004), and some were simple geometric shapes such as a circle and a triangle. Each display contained a *target* picture that participants had to describe, which was combined with a size-contrasting *competitor* picture. The target and competitor pictures had either the same semantic category (e.g., both were doors, Fig. 1A) or different categories (e.g., the target was a door, and the competitor an envelope, Fig. 1B). In total, there were 24 target pictures. All target pictures were medium-sized, and half of the competitor pictures were larger than the target pictures and half were smaller. The remaining two pictures in the display were always medium-sized, occupying about the half of the grid box, and they were from a different category from the target (e.g. fence, brush in Fig. 1). The positions of the target and competitor pictures were counterbalanced across conditions.

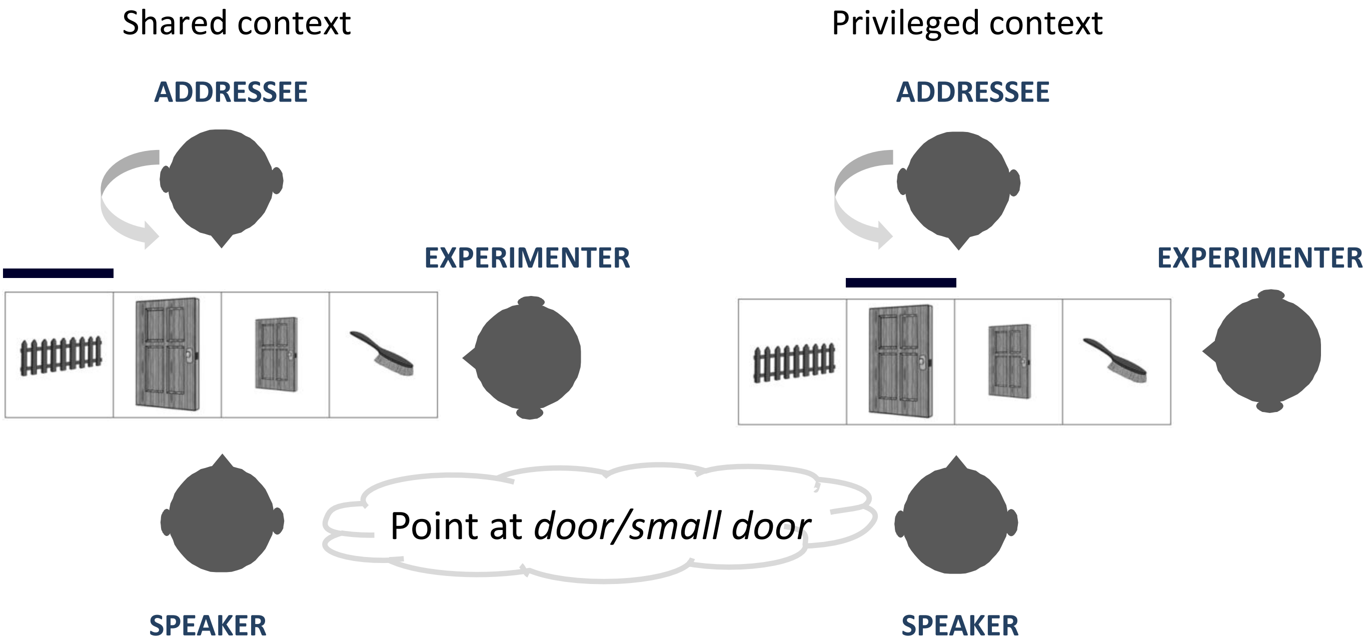


Fig. 2. Example set-up. The speaker referred to the small door when the large door (the same-category competitor) was visible (shared context) or invisible (privileged context) to the addressee. In the different-category competitor condition, the large envelope in Fig. 1 replaced the large door.

While the addressee was looking away from the display, the experimenter placed an occluder in front of one of the four pictures, so that the picture was blocked from the addressee's view (this visual occlusion was demonstrated to speakers by blocking one of the pictures from their view during instruction). In the *privileged context* condition, the occluder hid the size-contrasting competitor from the addressee, whereas in the *shared context* condition, one of the remaining two pictures was blocked from the addressee's view, and the competitor was visible to both the speaker and the addressee (see Fig. 2). The position of the occluder was counterbalanced across conditions. To ensure speakers were clearly aware which object was occluded from the addressee, the experimenter drew attention to the occluded object, saying: *This time we hide this from [the addressee's name]*. The experimenter then pointed at the target picture and asked the speaker to identify it to the addressee, *Tell [addressee's name] to point to this picture*. Once the speaker described the target picture (e.g., *Point to the large door / the door*), the addressee turned around and pointed at the picture described by the participant. This ensured that children could not use their eye-gaze to indicate their intended referent. When the speaker produced ambiguous bare nouns in the shared context condition, the addressee provided a standardized feedback, *Which one?*, prompting speakers to provide a clarification. The experiment took about 10 minutes including 8 practice trials, where the use of a bare noun was always unambiguous, and there was a short break halfway through. The instructions and procedure were the same in all groups, except that, to keep child participants engaged with the experiment, child participants received a small sticker each time the addressee identified the target picture.

Design. The size-contrasted competitor's similarity to the referent and its shared status were orthogonally manipulated, resulting in four conditions: (1) a same-category competitor in the shared context; (2) a same-category competitor in the privileged context; (3) a different-category competitor in the shared context; (4) a different-category competitor in the privileged context. The 24 items were distributed across four lists, with each list containing 6 items from each condition, with one version of each item. The conditions were distributed at a fixed random order and rotated over the items using a Latin square design. There were three groups of participants; children with ASD, children without ASD and adults without ASD. Five speakers from each group were assigned to each list. This resulted in a 3 (Group: Children with ASD vs. Children without ASD vs. Adults without

ASD) × 2 (Competitor: Same vs. Different category) × 2 (Sharedness: Shared vs. Privileged context) mixed design, where Group was a between-participants/within-items variable and Competitor and Sharedness were within-participants/within-items variables. There were no filler trials; half of the 24 trials had no category competitor in our study and we anticipated that participants would use very few size adjectives in those trials.

Results and discussion

We scored whether participants chose size-contrasted descriptions (e.g., *large door*) or descriptions without any size contrast (e.g., *door*). Participants occasionally corrected their initial descriptions before the addressee provided feedback. When participants produced these *self-repairs*, the analyses included their final description: e.g., we coded responses such as *the door, sorry the large door* as a size-contrasted description. We will return to this point in the General Discussion. No participants attempted to disambiguate their reference by other means (e.g., *the door on my right*).

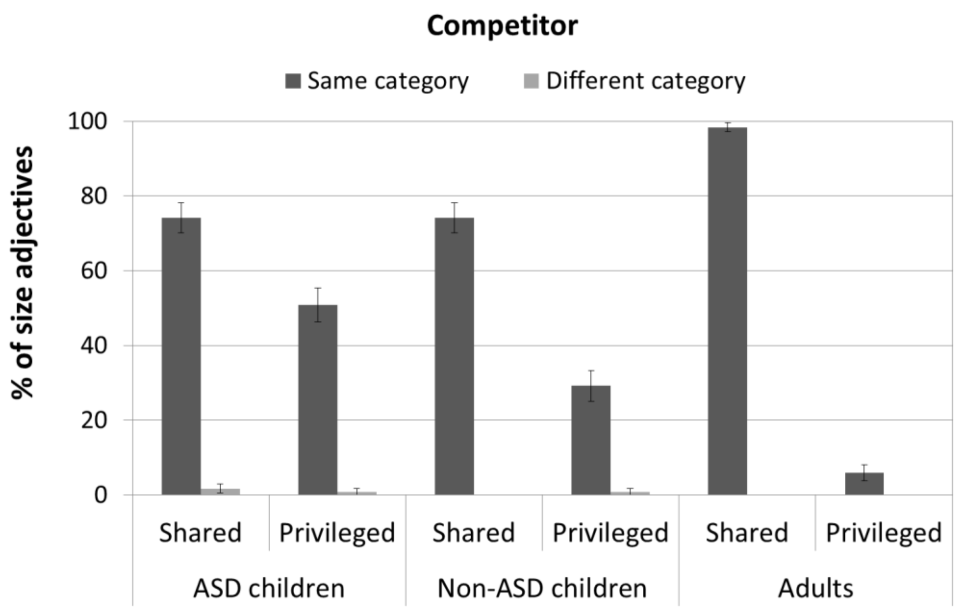


Fig. 3. Percentages of size adjectives relative to all descriptions in children with and without ASD and adults without ASD by condition. Error bars represent standard errors.

Fig. 3 shows the mean percentages of size adjectives (relative to descriptions without any size adjective) produced by children with ASD, children without ASD, and adults without ASD. All three groups hardly ever produced size adjectives in the different category competitor condition (ASD: n = 3, TD: n = 1, Adults: n = 0), suggesting that size adjectives were used contrastively rather than attributively. The analyses thus focus on the number of size adjectives (relative to descriptions without size adjectives) produced in the same-category competitor condition.

Children with vs. without ASD. First, we examined whether and how children with ASD differed from children without ASD in adjective use. Because the dependent measure was categorical (i.e., whether the description was size-contrasted or not), we used logit mixed effects modelling (Baayen, Davidson, & Bates, 2008; Barr, Levy, Scheepers, & Tily, 2013). We carried out log-likelihood ratio χ^2 tests to compute p-values, by using model comparison with maximal random effects, as described by Barr et al. (2008), unless stated otherwise. In the analyses on children with and without ASD, *Sharedness* (shared context vs. privileged context) was treated as a within-participants/items variable, and *ASD* (ASD vs. non-ASD) as a between-participants and within-items variable. These predictors were centred so that the results could be interpreted in terms of main effects and interactions as in traditional Analyses of Variance. The maximal random effects included by-participants and by-items random intercepts as well as by-participants and by-items random slope for Sharedness and by-items random slopes for ASD and the Sharedness × ASD interaction. As a measure of effect size, we report the coefficient estimate (β) for each variable by standardizing each contrast to be size 1, together with its associated standard error.

There was no significant main effect of ASD, $\chi^2(1) = 1.01$, $p = .32$ (β = 0.76, SE = 0.68), indicating that across conditions, children with and without ASD produced a similar number of size adjectives. There was a significant main effect of Sharedness, $\chi^2(1) = 24.20$, $p < .001$ (β = -2.77, SE = 0.45), indicating that across groups, children produced more size adjectives in the shared context (74%) than in the privileged context (40%). Importantly, there was a significant Sharedness × ASD interaction, $\chi^2(1) = 3.92$, $p = .05$ (β = 1.79, SE = 0.81), with a larger effect of Sharedness in children without ASD (45%) than in children with ASD (23%). We followed up this interaction by examining the effect of ASD in the shared context and privileged context separately. The maximal random effects included by-participants and by-items intercepts and a by-items random slope for ASD. In the shared context, children with ASD produced size adjectives as often as children without ASD, $\chi^2(1) = 0.01$, $p = .93$ ($\beta = -0.07$, $SE = 0.74$), whereas in the privileged context, children with ASD produced significantly more size adjectives than children without ASD, $\chi^2(1) = 3.77$, $p = .05$ ($\beta = 1.52$, $SE = 0.75$). Thus, whilst the ASD and non-ASD group did not differ in their ability to produce size adjectives for ambiguity avoidance, children with ASD produced significantly more perspective-inappropriate size adjectives compared to children without ASD.

Children without ASD vs. Adults. Next, we examined how children without ASD differed from adults without ASD. There was a main effect of Sharedness, $\chi^2(1) = 55.23$, $p < .001$ ($\beta = -11.54$, $SE = 1.91$), with more size adjectives in the shared context (87%) than in the privileged context (18%). There was no main effect of Age Group, $\chi^2(1) = 1.84$, $p = .18$ ($\beta = 0.11$, $SE = 1.98$), suggesting that across conditions, children produced size adjectives as often as adults. However, there was a significant Sharedness × Age Group interaction, $\chi^2(1) = 22.49$, $p < .001$ ($\beta = 14.37$, $SE = 3.79$), with a significantly larger effect of Sharedness in adults (93%) than children (45%). In the shared context, the children produced fewer size adjectives than adults, χ^2 (1) = 10.64, $p = .001$ ($\beta = -6.59$, $SE = 2.98$), whereas in the privileged context, children produced significantly more size adjectives than adults, χ^2 (1) = 13.00, $p < .001$ ($\beta = 6.58$, $SE = 1.92$).

Individual differences. Although children with ASD were more affected by privileged-knowledge than children without ASD, most children with ASD nevertheless produced contrastive adjectives in the shared context more often than in the privileged context, as shown in Fig. 4, albeit in varying degrees. In Nadig et al. (2009), about half of the participants with ASD were unsuccessful in addressee adaptation, and they were found to have lower language scores on Clinical Evaluation of Language Fundamentals (CELF -IV) (Semel, Wiig, & Secord, 2003) than other participants with ASD, who demonstrated successful addressee adaptation. Non-parametric correlation analyses revealed that in ASD, neither receptive (BPVS) nor productive (WASI) vocabularies were correlated with the increased tendency to use more adjectives in the shared rather than privileged context, $r_s(18)$

= .38, p = .10, $r_s(18)$ = .34, p = .14, or with the number of egocentric adjectives in the privileged context, $r_s(18)$ = .03, p = .89, $r_s(18)$ = -.05, p = .83. But BPVS and WASI vocabularies were related with the number of adjectives in the shared context; the higher receptive (BPVS) or productive (WASI) vocabularies, the more disambiguating size adjectives were produced in the shared context, $r_s(18)$ = .59, p < .01, $r_s(18)$ = .44, p = .05, respectively.

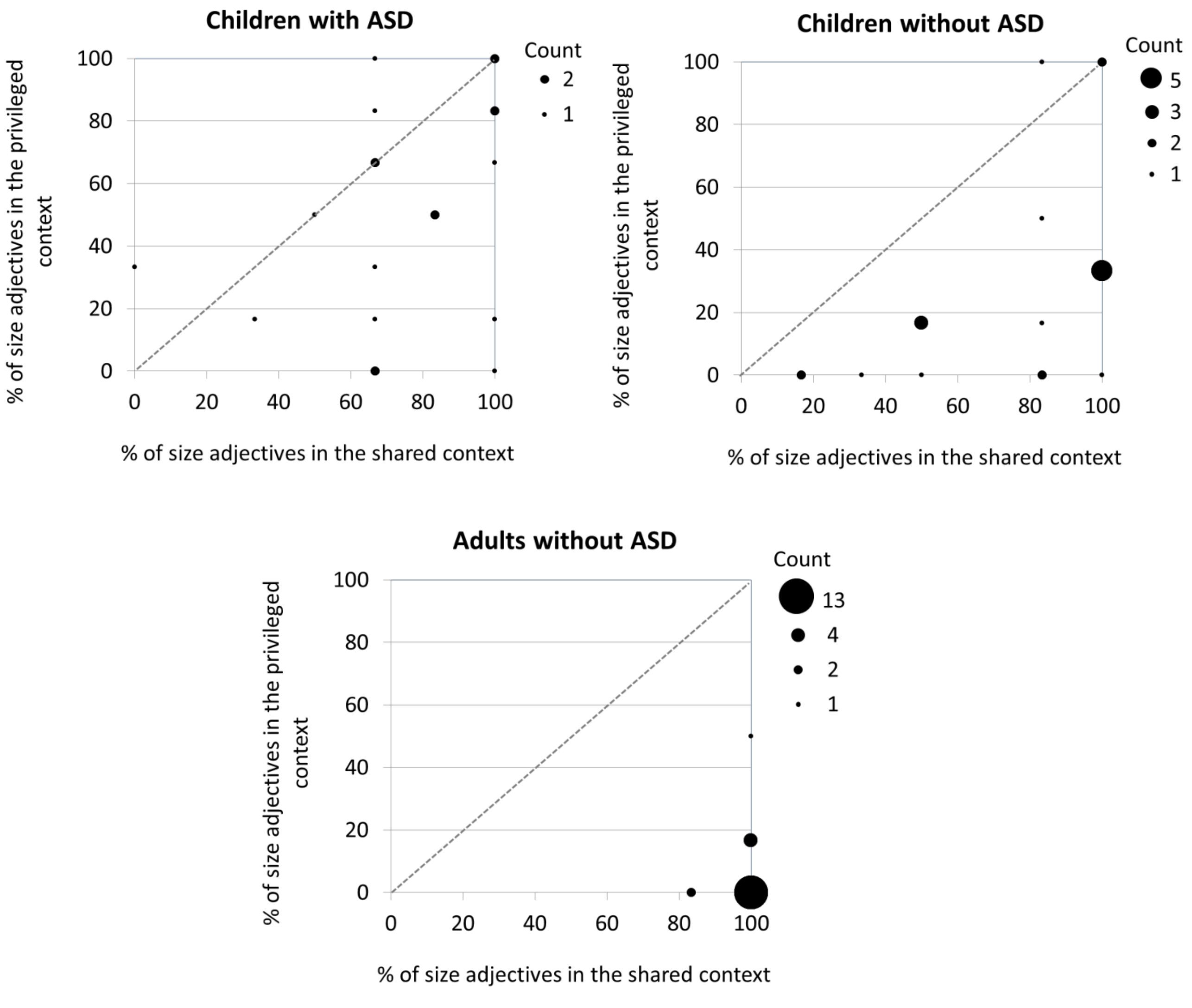


Fig. 4. Percentages of contrastive adjectives produced in the shared and privileged context by children with and without ASD and adults without ASD. Data points below the dashed line represent participants who produced more contrastive size adjectives in the shared context than in the privileged context.

Fig. 4 also shows some individual variations within non-ASD children, in contrast with adult participants, most of whom produced contrastive adjectives 100% of the time in the shared context but very few contrastive adjectives in the privileged context. One of our reviewers pointed out that some children without ASD had relatively low scores on the BPVS (verbal mental age) or lower-than-average IQs. Our analyses showed that in non-ASD, neither BPVS nor WASI vocabularies were correlated with the number of adjectives in the shared context, $r_s(18) = .17$, $p = .47$, $r_s(18) = .02$, $p = .93$, the number of adjectives in the privileged context, $r_s(18) = .17$, $p = .47$, $r_s(18) = -.36$, $p = .12$, or the difference between them, $r_s(18) = -.15$, $p = .52$, $r_s(18) = .28$, $p = .24$, respectively. Similarly, in non-ASD, IQ was unrelated to the number of adjectives in the shared context, $r_s(18) = .15$, $p = .53$, the number of adjectives in the privileged context, $r_s(18) = -.15$, $p = .53$, and the difference between the two, $r_s(18) = .35$, $p = .13$. IQ in children with ASD was also unrelated to the number of contrastive adjectives in the shared context, $r_s(18) = .29$, $p = .22$, in the privileged context, $r_s(18) = -.07$, $p = .77$, or the difference between the two, $r_s(18) = .24$, $p = .30$. Hence, there was no evidence to suggest that IQ or vocabulary measures influenced the adjective use in our non-ASD sample.

Instead, we found that age significantly correlated with the number of size adjectives in the shared context in non-ASD, $r_s(18) = .52$, $p = .02$, which indicated that younger children tended to produce fewer disambiguating size adjectives in the shared context. Moreover, although the use of contrastive adjectives in the privileged context was not significantly related to age, $r_s(18) = .31$, $p =.18$, children who produced more contrastive adjectives in the shared context were also more likely to produce contrastive adjectives in the privileged context, $r_s(18) = .62$, $p < .01$, as can be seen in Fig. 4. This suggests that some children, perhaps younger ones, were still learning to produce contrastive modifiers and their use of adjectives in the privileged context was at least in part determined by their ability to produce contrastive adjectives in the shared context. In ASD, the number of contrastive adjectives in the privileged context was not systematically related to the number of contrastive adjectives in the shared context, $r_s(18) = .33$, $p = .16$, possibly because of larger variability in perspective-taking within this sample.

On average, children with ASD produced contrastive adjectives equally often as children without ASD in the shared condition, but one might wonder if fewer perspective-inappropriate adjectives in non-ASD than in ASD were in part due to some children without ASD being generally less able to produce contrastive adjectives. To explore this possibility, we divided participants into two groups, those who were able to produce contrastive adjectives at 83% (5 out of 6) or above in the shared context (highly proficient adjective users) and those who produced contrastive adjectives less than 83% of the time in the shared context (less proficient adjective users). We then examined if ASD status affected adjective use in these two groups differently. There were 9 ASD children and 13 non-ASD children in the first group and 11 ASD children and 7 non-ASD children in the second group. In both highly proficient adjective users and less proficient adjective users, the tendency to use fewer contrastive adjectives in the privileged condition than in the shared condition was 17% weaker in the ASD than non-ASD groups (see Appendix), and there was no significant Sharedness × ASD × Group (high proficient vs. low proficient adjective users) interaction, $\chi^2(1) = 0.85$, $p = .34$ ($\beta = 1.53$, $SE = 1.71$), indicating that the impact of ASD was not dependent on speakers' general ability to produce contrastive modifiers.

In sum, Experiment 1 showed that 6-to-10-year-olds with ASD produced perspective-inappropriate contrastive adjectives more often than those without ASD when the addressee could not see the referential contrast (privileged context), but both groups produced disambiguating size adjectives equally often when the referential contrast was also visible to their addressee (shared context). The findings thus supported the two-stage hypothesis, demonstrating that the ability to avoid ambiguous descriptions develops independently from perspective-taking that affects the production of egocentric descriptions. Additionally, in ASD, vocabulary scores were correlated with ambiguity avoidance in the shared context, but not with addressee accommodation. In non-ASD, age was correlated with ambiguity avoidance in the shared context, not with addressee accommodation. These findings also indicate that ambiguity avoidance and addressee accommodation are affected by different factors, consistent with the two-stage hypothesis. Finally, 6-10-year-olds without ASD produced perspective-inappropriate contrastive adjectives more often than adults, even though they produced fewer disambiguating size adjectives than adults when the addressee needed such information, indicating that 6-10-year-olds without ASD were also more egocentric than adults.

EXPERIMENT 2

The two-stage hypothesis predicts that the ability to avoid ambiguous descriptions results from speakers' own sensitivity to referential ambiguity, whereas the ability to avoid perspective-inappropriate adjectives reflects speakers' perspective-taking. In Experiment 1, the comparison between 6-10-year-olds with and without ASD provided support for this hypothesis, demonstrating that children with ASD are able to avoid referential ambiguity as well as those without ASD in the shared context, despite delayed perspective-taking in the privileged context. A critical question is whether the two-stage hypothesis accounts for development of audience design *within each group*. The two-stage hypothesis predicts that ambiguity avoidance in the shared context develops faster than addressee accommodation in the privileged context. In contrast, the single-stage hypothesis assumes that ambiguity avoidance in the shared context and addressee accommodation in the privileged context reflect the same phenomenon; to the extent speakers improve ambiguity avoidance in the shared context, they should use fewer perspective-inappropriate contrastive adjectives in the privileged context. Experiment 2 contrasted these two predictions by investigating how adolescents, aged 11-16 (Mean: 13), with and without ASD, differed from children and adults in Experiment 1.

Method

Participants. Twenty pairs of 11-to-16-year-old adolescents with ASD and adolescents without ASD were individually matched on age and verbal mental age as before, and we ensured that the pairs were also similar in terms of IQ measures (all Fs < 1, Table 2). All participants were reported to be native speakers of British English, whose parents only spoke English at home, and they were recruited from eight secondary schools within North Lanarkshire Council, South Lanarkshire Council and Renfrewshire Council in Scotland. Adolescents with ASD were recruited from the special units within school. Two participants with ASD, who had a low SCQ score (< 10), and two participants without ASD, who had a relatively high SCQ score (≥ 15), were excluded. We included one participant with ASD, who had a SCQ score of 13, lower than the recommended cut-off of ≥ 15 but higher than the less stringent cut-off of ≥12 (Corsello et al., 2007). An additional three ASD participants were recruited but were excluded following the screening, because they did not complete the tasks (*n* = 1) or had low BPVS scores that could not be matched (*n* = 2). An additional 29 volunteers without ASD were excluded, due to recording failures (*n* = 3) or because they could not be matched with those with ASD due to their age, BPVS, or high WASI vocabulary (*n* = 26). Participants received a shopping voucher after participation.

Table 2. Adolescents with and without ASD in Experiment 2.

	Adolescents			
	with ASD (n = 20) *M* (*SD*) [range]	without ASD (n = 20) *M* (*SD*) [range]	*F*(1, 38)	*p*
Gender (M:F)	17:03	16:04		
Chronological Age (years)	3.7 (1.4) [11.8-16.3]	3.7 (1.2) [12.1-16.4]	< 1	.90
Mental age (BPVS) (years)	3.6 (2.3) [10.2-17.0]	3.4 (2.2) [10.7-17]	< 1	.75
WASI Vocabulary *T* score (productive vocabulary)	9.7 (10.5) [31-71]	2.4 (8.7) [39-70]	< 1	.39
WASI Matrix Reasoning *T* score	3.7 (11.3) [26-60]	1.5 (9.1) [21-55]	< 1	.50
WASI Estimated Full IQ	5.2 (14.1) [72-116]	5.3 (9.8) [79-117]	< 1	.98
SCQ	3.5 (6.3) [13-37]	3.8 (3.2) [0-10]	155.2	<.001

Materials, method and procedure. These were the same as in Experiment 1, except that participants did not receive stickers because they were older.

Results and discussion

Participants' descriptions were scored as before. No adolescents produced size adjectives in the context with a different-category competitor. Thus, our analyses focus on the number of contrastive size adjectives in the same-category condition. Fig. 5 reports the percentages of contrastive size adjectives (out of all descriptions) in each condition, together with the data from children and adults in Experiment 1. As before, we first compared adolescents with and without ASD in the effect of Sharedness (shared vs. privileged context).

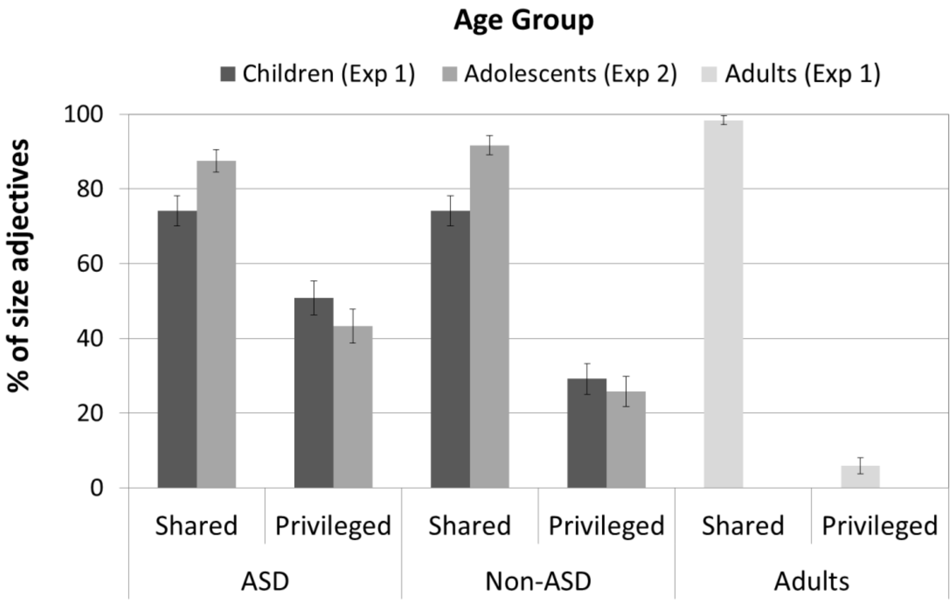


Fig. 5. Percentages of size adjectives relative to all descriptions for children and adolescents with and without ASD and adults without ASD when the same-category competitor was in the shared context and when it was in privileged context. Error bars represent standard errors.

ASD vs. Non-ASD adolescents. There was a significant main effect of Sharedness, $\chi^2(1) = 26.72$, $p < .001$ ($\beta = -5.19$, $SE = 0.83$), indicating that across groups, there were more size adjectives in the shared (90%) than in the privileged context (35%). There was no significant main effect of ASD, $\chi^2(1) = 0.11$, $p = .74$ ($\beta = 1.08$, $SE = 0.83$), suggesting that overall, adolescents with ASD and those without ASD produced size adjectives similarly often. Importantly, there was a significant Sharedness × ASD interaction, $\chi^2(1) = 4.13$, $p = .04$ ($\beta = 3.45$, $SE = 1.54$), indicating a larger effect of Sharedness in adolescents without ASD (66%) than in adolescents with ASD (44%). In the shared context, there was no reliable difference between the two groups, $\chi^2(1) = 0.51$, $p = .48$ ($\beta = -0.54$, $SE = 0.58$), but in the privileged context, adolescents with ASD produced more (18%) size adjectives than adolescents without ASD, though the difference was marginal, $\chi^2(1) = 3.38$, $p = .07$ ($\beta = 2.67$, $SE = 1.38$).

Adolescents vs. adults without ASD. The model with the maximal random effect structure did not converge, so we adopted the best-path approach as described by Barr et al. (2013): we first determined which random effect showed strongest improvement against the intercepts-only model, and then tested for inclusion of other random slopes against the model with the strongest random effect by adopting a liberal alpha level (p = .20). This resulted in the inclusion of by-participants and by-items random intercepts as well as a by-participants random slope for Sharedness. There was a main effect of Sharedness, $\chi^2(1) = 44.67$, $p < .001$ ($\beta = -9.29$, $SE = 2.02$), with more size adjectives in the shared context (95%) than in the privileged context (16%). The main effect of Age Group (adolescents vs. adults) was approaching significance, $\chi^2(1) = 2.83$, $p = .09$ ($\beta = 0.29$, $SE = 0.90$), which was qualified by a marginally significant Sharedness × Age Group (adolescents vs. adults) interaction, $\chi^2(1) = 3.51$, $p = .06$ ($\beta = 3.97$, $SE = 1.99$), with a larger effect of Sharedness in adults (93%) than in adolescents (66%). In the shared context, adolescents produced marginally fewer disambiguating size adjectives than adults, $\chi^2(1) = 3.29$, $p = .07$ ($\beta = -5.06$, $SE = 2.16$), whereas in the privileged context, they produced significantly more redundant size adjectives than adults, $\chi^2(1) = 6.68$, $p = .01$ ($\beta = 18.99$, $SE = 9.05$).

Adolescents vs children. We also examined if the effects of Sharedness and ASD were modulated by Age Group (children vs. adolescents) by running combined analyses of Experiment 1 (children) and Experiment 2 (adolescents). The random effects included by-participants and by-items random intercepts, by-participants random slope for Sharedness and by-items random slopes for Sharedness, ASD, Age Group (children vs. adolescents) and the three-way interaction. There was a significant main effect of Sharedness, $\chi^2(1) = 40.09$, $p < .001$ ($\beta = -3.78$, $SE = 0.45$), with more size adjectives in the shared context (82%) than in the privileged context (37%). There was no significant main effect of ASD, $\chi^2(1) = 0.76$, $p = .38$ ($\beta = 0.92$, $SE = 0.50$), and there was a marginally significant main effect of Age Group (children vs. adolescents), $\chi^2(1) = 3.10$, $p = .08$ ($\beta = -0.46$, $SE = 0.5$), with slightly more size adjectives in adolescents (62%) than in children (57%). The effect of Age Group was not modulated by ASD, $\chi^2(1) = 0.01$, $p = .93$ ($\beta = 0.13$, $SE = 1.00$). There was a significant Age Group (children vs. adolescents) × Sharedness interaction, $\chi^2(1) = 7.61$, $p = .01$ (β = 2.20, *SE* = 0.76), however, with a significantly larger effect of Sharedness in adolescents (55%) than in children (34%). In the shared context, adolescents produced significantly more size adjectives (90%) than children (74%), $\chi^2(1) = 8.41$, $p = .003$ (β = -1.63, *SE* = 0.50). In the privileged context, there was no significant effect of Age Group, $\chi^2(1) = 1.03$, $p = .31$ (β = 0.75, *SE* = 0.71), suggesting that adolescents produced as many perspective-inappropriate as children. Also, there was a significant Sharedness × ASD interaction, $\chi^2(1) = 5.78$, $p = .02$ (β = 2.02, *SE* = 0.77). In the privileged context, the ASD group (47%) produced size adjectives more than the non-ASD group (28%), $\chi^2(1) = 6.43$, $p = .01$ (β = 1.89, *SE* = 0.71), whereas both groups produced size adjectives equally often in the shared context, $\chi^2(1) = 0.02$, $p = .90$ (β = -0.07, *SE* = 0.49). There was no significant Sharedness × ASD × Age Group (children vs. adolescents) interaction, $\chi^2(1) < .01$, $p = .99$ (β = -0.02, *SE* = 1.52). This indicated that the impact of ASD on the degree of addressee adaptation was similar in children and adolescents, and the impact of Age on addressee adaptation was not modulated by ASD status.

Individual differences. As illustrated in Fig. 6, almost all adolescents produced more contrastive adjectives in the shared context than in the privileged context. As in Experiment 1, in ASD, the rate of disambiguating contrastive adjectives in the shared context was correlated with higher receptive vocabulary (BPVS, verbal mental age), $r_s(18) = .46$, $p = .04$. In non-ASD, the rates of contrastive adjectives in all contexts were not related to age or other cognitive abilities. Unlike in Experiment 1, however, the rate of contrastive adjectives in the privileged context was negatively correlated with the rate of contrastive adjectives in the shared context in non-ASD, $r_s(18) = -.58$, $p < .01$, indicating that the more disambiguating size adjectives in the shared context, the fewer perspective-inappropriate adjectives in the privileged context. Fig. 6 showed that about half of adolescents without ASD almost always produced disambiguating size adjectives in the shared context and they never produced perspective-inappropriate contrastive adjectives in the privileged context, demonstrating adult-like audience design. In ASD, there was no systematic relationship between adjective use in the shared context and that in the privileged context, $r_s(18) = .31$, $p = .18$; many adolescents with ASD ($n = 12$) produced disambiguating size adjectives 100% of the time in the shared context, but they nevertheless produced perspective-inappropriate adjectives frequently in the privileged context.

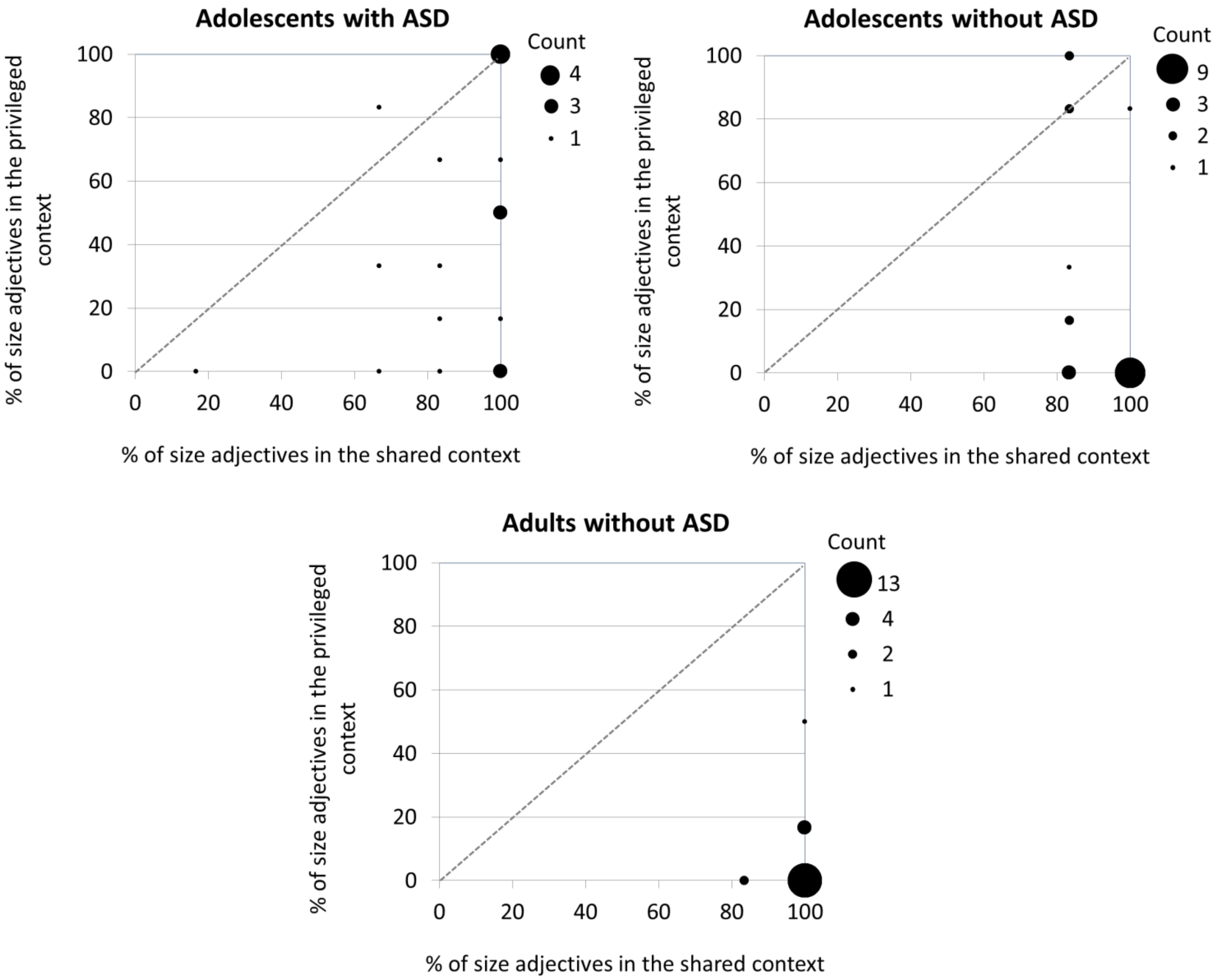


Fig.6. Percentages of contrastive size adjectives produced in the shared and privileged context by adolescents with and without ASD and adults without ASD. Data points below the dashed line represent participants who produced more contrastive size adjectives in the shared context than in the privileged context.

In sum, ASD affected the use of contrastive adjectives in adolescents; although speakers with ASD produced disambiguating contrastive adjectives similarly often as their peers in the shared context, they tended to produce more perspective-inappropriate contrastive adjectives in the privileged context. Regardless of ASD status, adolescents produced more disambiguating size adjectives in the shared context than children, but both groups produced perspective-inappropriate adjectives similarly often. Although the degree of addressee adaptation, that is, the difference in the number of contrastive adjectives produced in the shared and privileged context, was larger in adolescents and children, these results are not inconsistent with the two-stage hypothesis, which predicts that the ability to produce disambiguating adjectives in the shared context develops faster than the ability to avoid perspective-inappropriate adjectives in the privileged context. Furthermore, adolescents without ASD differed only marginally from adults in the shared context, but they were more likely to produce perspective-inappropriate adjectives than adults in the privileged context. This indicated that even after having mastered adult-like ambiguity avoidance, adolescents are more likely to produce perspective-inappropriate contrastive adjectives than adults, demonstrating a delay in addressee accommodation, again in accord with the two-stage hypothesis.

GENERAL DISCUSSION

The first experiment showed that 6-10 years with ASD were as good as those without ASD in using disambiguating size adjectives when their addressee could also see the referential competitor (shared context). But children with ASD were less able to take the addressee's perspective when the referential competitor was hidden from their addressee's view (privileged context) than their peers. The second experiment showed a similar pattern of results with adolescents. Importantly, the development of perspective-taking was also delayed (relative to ambiguity avoidance) in speakers without ASD; adolescents without ASD were nearly as good as adults in producing disambiguating size adjectives in the shared context, but they produced egocentric contrastive adjectives significantly more often than adults in the privileged context.

The current study thus provided evidence against the single-stage hypothesis, which assumes that perspective-taking determines not only speakers' ability to avoid perspective-inappropriate adjectives in the privileged context but also their ability to produce disambiguating adjectives in the shared context. The results instead supported the two-stage hypothesis, demonstrating that speakers' ability to produce disambiguating size adjectives develops separately from their ability to avoid perspective-inappropriate adjectives for their addressee. Young children often fail to refer unambiguously during referential communication. In contrast to what is often assumed, this does not necessarily demonstrate their impaired perspective-taking: children learn to avoid referential ambiguity in the shared context, regardless of whether they have special difficulties with perspective-taking. Before we discuss the mechanism that drives the development of addressee- adapted reference in detail, let us consider methodological issues.

First, Wardlow-Lane and Ferreira (2010) have shown that adult speakers tend to increase adjective use when their attention has been drawn to an object hidden from their addressee. In the current study, the experimenter drew the speaker's attention to a hidden object (*This time we hide this*). This was done to ensure that participants were aware which object was hidden from the addressee. Otherwise, we could not be sure if participants were unaffected by those objects; they may have cooperatively taken into account the addressee's perspective or they may have paid no attention to the identity of the hidden object. One may, however, ask how such a procedure affected the adjective use in different groups. In our study, the procedure did not seem to increase the use of contrastive adjectives in the privileged condition in adults, because hardly any adult speakers ever produced perspective-inappropriate contrastive adjectives. Even if the procedure did influence children's use of adjectives in the privileged context, it is not clear why adult speakers were able to ignore such information, and why children, particularly those with ASD, were more likely to be affected by the objects hidden from the addressee. These findings can be parsimoniously accounted for by assuming that children, particularly those with ASD, had more difficulty with perspective-taking, failing to overcome the privileged knowledge made salient by the experimenter. Second, Wardlow-Lane and Liersch (2012) showed with adults that incentives act to increase the use of contrastive adjectives in the privileged context. We may wonder if children produced more perspective-inappropriate adjectives than adults in the privileged condition because they received incentives, whereas adults did not. If the incentives were the main driving force behind the use of contrastive adjectives, it does not explain why children produced fewer size adjective than adults in the shared condition. Also, this account does not explain why adolescents produced significantly more contrastive adjective than adults in the privileged context, even though neither group received incentives, and children did not produce adjectives in the privileged context significantly more than adolescents, who did not receive incentives.

Third, in our study, the addressee provided verbal feedback when participants produced ambiguous descriptions. Evidence suggests that the addressee's feedback plays a role in the development of ambiguity avoidance in children (e.g., Matthews, Lieven, & Tomasello, 2007; Robinson & Robinson, 1985; amongst many), which raises the question of how the addressee's feedback might have differentially influenced ambiguity avoidance in different groups. We thus examined if the use of adjectives might have changed in the first and second half of the experiment and if so, how the pattern of change varied across different groups. Fig. 6 shows the number of contrastive adjectives produced in the first and second half of the experiment in each condition. In Experiment 1, the effect of Sharedness, the tendency to produce more size adjectives in the shared than in the privileged context, was stronger in the second half (48%) than in the first half (22%), $\chi^2(1) = 4.74$, $p = .03$ ($\beta = 1.96$, $SE = 0.70$), and this Sharedness × trial order interaction was not modulated by ASD status, $\chi^2(1) = 0.04$, $p = .83$ ($\beta = 0.36$, $SE = 1.36$). Interestingly, the improvement in the second half occurred primarily because children produced more disambiguating adjectives in the shared context (83%) in the second half than in the first half (66%), $\chi^2(1) = 6.40$, $p = .01$ ($\beta = -1.26$, $SE = 0.65$), and this change was not modulated by ASD status, $\chi^2(1) = 0.17$, $p = .68$ ($\beta = 0.39$, $SE = 0.84$). In the privileged context, children produced numerically fewer perspective-inappropriate adjectives in the second half (36%) than in the first half (44%), but this neither approached significance, $\chi^2(1) = 2.44$, $p = .11$ ($\beta = 0.62$, $SE = 0.51$), nor significantly interacted with ASD, $\chi^2(1) = 0.34$, $p = .56$ ($\beta = 0.62$, $SE = 0.90$). In Experiment 2, trial order did not modulate the effect of Sharedness, $\chi^2(1) = 0.03$, $p = .85$ ($\beta = 0.66$, $SE = 1.17$), perhaps because the rate of contrastive adjectives in the shared context was approaching ceiling in adolescents, and there was no trial order

× Sharedness × ASD interaction, $\chi^2(1) = 0.39$, $p = .53$ (β = -1.29, *SE* = 1.95). Thus, in Experiment 1, the degree of addressee adaptation improved in the second half than in the first half, because children, regardless of their ASD status, produced more disambiguating size adjectives in the shared context in the second half, whilst the rate of perspective-inappropriate descriptions did not significantly change over the course of experiment, providing further evidence for the two-stage hypothesis.

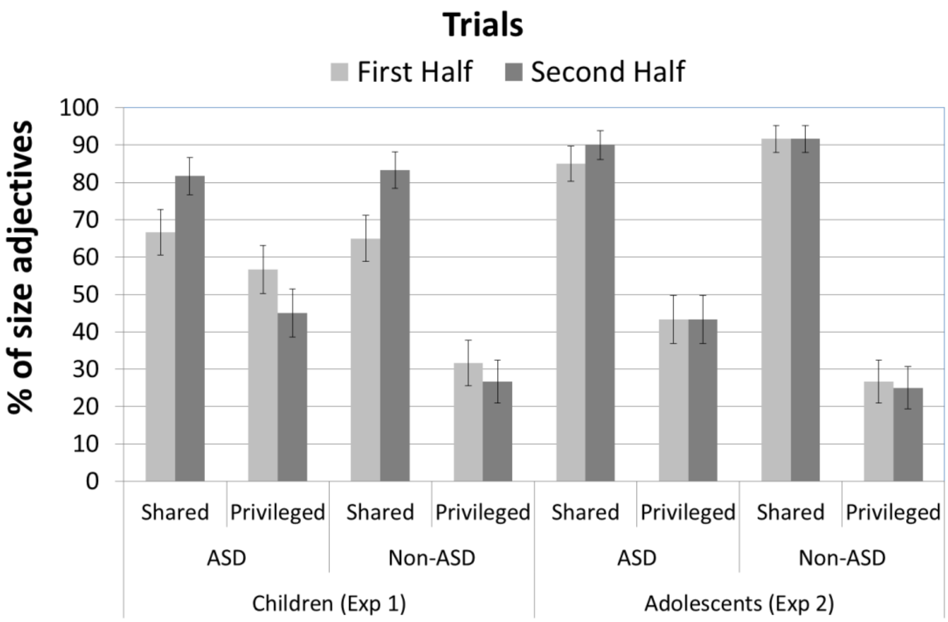


Fig. 6. Percentages of contrastive size adjectives produced in the shared and privileged context in the first and second half of the experiment in children and adolescents. Error bars represent standard errors.

As we noted earlier, participants occasionally corrected their initial responses immediately after producing them. As reported in Table 3, these *self-repairs* were generally very rare, and they occurred only when the competitor had the same category as the referent (i.e., bare nouns were ambiguous) and mostly because participants replaced ambiguous bare nouns with size-contrasted descriptions (*the door, the small door*). Interestingly, when children and adolescents corrected ambiguous descriptions, they did so mostly when the same-category competitor was visible to their addressee (shared context) (6.5%) rather than when it was not (the privileged context) (0.8%), $\chi^2(1) = 8.19$, $p < .01$ (β = -15.06, *SE* = 6.68), which was not modulated by ASD, $\chi^2(1) = 0.25$, $p = .61$ (β = -

2.30, *SE* = 13.36), or Age Group, $\chi^2(1) = 0.04$, $p = .85$ ($\beta = -0.51$, *SE* = 11.90), or the interaction between the two, $\chi^2(1) = 0.04$, $p = .84$ ($\beta = 1.72$, *SE* = 23.82). That is, children and adolescents were more likely to correct ambiguous descriptions when the competitor was in the shared context than when it was in the privileged context. In contrast, participants almost never corrected perspective-inappropriate contrastive size adjectives (e.g., *the small door, the door*) produced in the privileged context, despite the fact that hardly any participants ever chose contrastive adjectives when they themselves saw no same-category competitor. There was no significant main effect of ASD, $\chi^2(1) = 0.36$, $p = .55$ ($\beta = -1.59$, *SE* = 6.71) or Age Group, $\chi^2(1) = 0.70$, $p = .40$ ($\beta = 0.15$, *SE* = 5.95) on self-repairs.

Table 3. Percentages of self-repairs (relative to non-corrected descriptions) in the same-category competitor condition.

		the door, the small door		*the small door, the door*	
		Shared	Privileged	Shared	Privileged
Experiment 1	ASD	3.3%	0.8%	0.0%	0.0%
(Children)	Non-ASD	12.5%	0.8%	0.0%	0.0%
Experiment 2	ASD	5.0%	0.8%	0.0%	0.8%
(Adolescents)	Non-ASD	5.8%	0.8%	0.0%	0.8%
Adults	Non-ASD	0.8%	0.0%	0.0%	0.0%

As discussed earlier, the two-stage hypothesis we have proposed was originally inspired by the monitoring and adjustment account (Horton & Keysar, 1996). This account assumes that the initial language production processes proceed egocentrically and perspective-taking comes into play only during the late production processes. Hence, audience design critically depends upon speakers' self-corrections when their addressee's perspective diverges from their own: speakers use fewer contrastive adjectives in the privileged context than in the shared context, because they filter out contrastive modifiers that rely on their privileged knowledge during monitoring. Although these corrections are assumed to take place before articulation, if speakers indeed monitor their speech for violations of common ground, they would try to repair their speech when it violates the common ground principle by referring to the privileged information (cf. Levelt, 1983). In our study, participants corrected ambiguous descriptions, but they almost never corrected perspective-inappropriate adjectives (at least overtly), suggesting that during monitoring, children were more concerned with ambiguous descriptions rather than perspective-inappropriate descriptions. Ambiguous bare nouns could lead to communicative breakdown, whereas perspective-inappropriate contrastive adjectives never did. Therefore, children may have been monitoring their own speech primarily for avoiding communicative breakdown rather than for violations of common ground per se.

It is, however, important to note that children self-corrected ambiguous descriptions mostly when the competitor was in the shared context than when it was in the privileged context. This indicates that children took account of the addressee's perspective when correcting ambiguous descriptions. Moreover, children, both with and without ASD, increased the use of contrastive adjectives only in the shared context in the second half of the experiment, rather than producing contrastive adjectives more across all contexts. These observations suggest that children were able to learn when disambiguating was necessary, perhaps in part owing to the addressee's feedback being given only when ambiguous descriptions led to communicative breakdown. We therefore propose that audience design develops in children, both with and without ASD, not so much because they strive to avoid perspective-inappropriate modifiers when the addressee's perspective diverges from their own. Rather, it occurs because children learn to avoid communicative breakdown by producing disambiguated descriptions more frequently in the shared context, possibly in anticipation of the addressee's feedback. The more reliably or accurately children learn to use the addressee's perspective when deciding to use a contrastive adjective, the less likely they should produce such adjectives when the addressee cannot see the competitor.

In the current study, whereas children produced more disambiguating adjectives in the shared context in the second half of the experiment, they did not reliably use fewer perspective-inappropriate adjectives in the privileged context in the second half. One possibility is that children, particularly those with ASD, suffered from egocentric interference (e.g., Birch & Bloom, 2004;

Nickerson, 1999), erroneously assuming that the referential competitor that they saw was also visible to their addressee. The strong egocentric interference may have also meant that children were more likely to fail to intercept the infelicity of contrastive descriptions that disambiguated ambiguity in their own context, whilst they were more successful in detecting ambiguity, perhaps because they could rely upon their own contextual knowledge. Moreover, avoiding contrastive adjectives given the privileged status of the referential competitor requires speakers to overcome self-knowledge, and completely overcoming one's own knowledge may have also been cognitively too demanding. Horton and Keysar (1996) showed that when adults speakers were under time pressure, their use of contrastive adjective was unaffected by the shared status of the referential competitor, demonstrating that audience design is subject to available cognitive resources. In children, Nilsen and Graham (2009) found that during comprehension, 4-5-year-olds' tendency to grab or look at the referential competitor that was hidden from the speaker and hence could not be the speaker's intended referent was related to lower inhibition (see also Brown-Schmidt, 2009, who also showed that the lower inhibitory control, the higher likelihood of egocentric eye-gaze in adults), though they showed no evidence that inhibition affects the production of size adjectives. Wardlow (2013) found that young adults with higher executive functions and working memory were less likely to use perspective-inappropriate adjectives in the privileged context.

We should, however, probably note that adult addressee adaptation may not always hinge upon late adjustment, either. Although the two-stage hypothesis correctly predicts that addressee adaptation develops more slowly than ambiguity avoidance, both abilities could influence speakers' choice of descriptions at the same production stage. In the current study, nearly all adults demonstrated perfect addressee adaptation. Most adult speakers never produced contrastive adjectives when the addressee could not see the referential contrast, whilst they almost always produced adjectives when the addressee could see the contrast. They did this without producing any overt self-repairs. According to the monitoring and adjustment account, these adults also planned perspective-inappropriate adjectives initially, but they were adept at correcting them later before articulation. But it is also possible that adults were able to plan perspective-inappropriate adjectives from the onset of the production processes, alleviating the need of self-corrections. The addressee's perspective was made very clear to speakers, so such information might have influenced speakers' initial choice of descriptions at a relatively early stage of production processes, guiding them to identify which objects the referent needed to be discriminated against.

Our findings corroborated and expanded the finding by Nadig et al. (2009), who reported that compared to their peers, 9-14-year-olds with ASD demonstrated a weaker tendency to use fewer contrastive size adjectives when the size-contrasting competitor was hidden from their addressee than otherwise. In their study, individuals with ASD produced marginally fewer disambiguating size adjectives than the comparison group, so the results were not entirely inconsistent with the single-stage hypothesis. Our findings appear to contrast with Dahlgren and Dahlgren Sandberg (2008), who showed that speakers with ASD fail to refer unambiguously. In Dahlgren and Dahlgren Sandberg, the referential context consisted of 16 facial expressions. Research suggests that individuals with ASD often demonstrate special difficulty with processing facial expressions (see Schultz, 2005, for a review) and they also tend to perceive visual stimuli differently from those without ASD (Frith & Baron-Cohen, 1987). Therefore, participants with ASD may have performed poorly in referential communication in Dahlgren and Dahlgren Sandberg, because they were unable to identify the distinguishing visual features of different facial expressions as effectively as their peers. In our study, the visual displays contained no facial expressions, and they consisted of only four common objects. The category sets were contrasted only in size. In such circumstances, participants with ASD were not at a disadvantage over their peers in identifying the distinguishing feature visually: Even with a larger sample (*N* = 40 in the combined analyses) than those in previous studies, we found no evidence that children with ASD are impaired with ambiguity avoidance. Children with ASD also described the referent using common labels, so there was no indication that they conceptualized objects in the displays differently from their peers.

Research suggests that mentalizing abilities in children with ASD develop with age (e.g., Pellicano, 2007), as shown in studies that found that older individuals with ASD often pass theory-of-mind tasks (Bowler, 1992; Dahlgren & Trillingsgaard, 1996; Leslie & Frith, 1988). More specifically, in comprehension, Begeer, Malle, Nieuwland, and Keysar (2010) found no significant difference between adolescents/adults with ASD (Mean: 16 years) and their peers in the use of privileged information; when listening to size adjectives (as in *the big spoon*), participants with and without ASD were equally likely to grab a size-contrasting competitor s (largest spoon), which was hidden from the speaker and hence could not be the speaker's intended referent. Both groups also took equally long before identifying the correct referent (second largest spoon) visible to the speaker in the shared context. Although the effect of ASD on the production of perspective-inappropriate contrastive adjectives in the privileged context was marginal in adolescents in our study, the ASD status similarly influenced referential descriptions in children and adolescents.

We may therefore wonder if ASD affects perspective-taking differently in production and comprehension. In comprehension, the addressee needs to identify the speaker's intended referent on the basis of descriptions given by the speaker, and the search for the referent may be strongly determined by the semantic information conveyed by the speaker's description (Keysar, Barr, Balin, & Brauner, 2000), particularly if an object in the privileged context offers a better semantic fit to the speaker's description as in Begeer et al. (cf. Heller, Grodner, & Tanenhaus, 2008). In production, speakers can choose different descriptions on the basis of their conceptual representation about the referent (e.g., Brennan & Clark, 1996; Clark & Wilkes-Gibbs, 1986; Fukumura, 2015), and such a choice may be more susceptible to higher-order representation. We should, however, note that the production-comprehension asymmetry does not straightforwardly explain why privileged information has been shown to influence children and adults differently during both comprehension (Epsley et al., 2004) and production, as shown in our study. Future research should thus determine how ASD affects the development of perspective-taking in comprehension.

In sum, the current study makes two important contributions to the literature. First, we showed that relatively high-functioning children with ASD avoid referential ambiguity as well as children without ASD, even though they more often fail to adapt descriptions to the addressee’s perspective, indicating that ambiguity avoidance develops irrespective of a delay in perspective-taking. Second, the development of addressee accommodation tends to be delayed even in speakers without ASD; although adolescents without ASD avoid referential ambiguity nearly as well as adults, they nevertheless tend to produce perspective-inappropriate modifiers more than adults, delaying the onset of adult-like audience design. We propose that the development of audience design is driven by children’s endeavour to avoid ambiguous descriptions that would lead to communicative breakdown, which takes place independently from fully-fledged perspective-taking that circumvents the production of egocentric descriptions.

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APPENDIX: Percentages of contrastive adjectives produced in the shared and privileged context as a function of proficiency of adjective use in children with and without ASD.

Children	*n*	Shared	Privileged
Proficient users			
with ASD	9	96.3 (2.6)	61.1 (6.7)
without ASD	13	93.6 (2.8)	41.0 (5.6)
Low proficient users			
with ASD	11	56.1 (6.2)	42.4 (6.1)
without ASD	7	38.1 (7.6)	7.1 (4.0)

Note: Proficient users produced contrastive adjectives in the shared context above 83% of the time and less proficient users less than 83% of the time. Brackets represent standard errors.