Novel metaphor processing in young autistic children

Isabel Martín-González
University of the Basque Country (Vitoria-Gasteiz, Basque Country, Spain)

Kristen Schroeder
Ingrid Lossius Falkum
University of Oslo (Oslo, Norway)

Elena Castroviejo
University of the Basque Country (Vitoria-Gasteiz, Basque Country, Spain)

Agustín Vicente
University of the Basque Country (Vitoria-Gasteiz, Basque Country, Spain)
Ikerbasque Foundation for Science (Basque Country, Spain)

Abstract: The purpose of this study is to explore possible differences between autistic and neurotypical (NT) children in novel metaphor comprehension. Much of the recent literature has connected metaphor comprehension difficulties that autistic individuals exhibit to general linguistic abilities. In our design, we carefully pair-matched young autistic children (3.13 to 12.25 years of age) to NT controls (3.69 to 9.04 years of age) on verbal mental age and tested their metaphor interpretation abilities with a picture selection paradigm combined with eye tracking measures. We predicted differences in performance in both types of measures, although we foresaw autistic participants performing above chance in the picture selection task. However, results did not show a difference between groups in the picture selection task, which would favour accounts that relate metaphor interpretation to linguistic abilities in autistic population. Interestingly, the eye tracking observations revealed differences between groups concerning gaze movements in the region corresponding to the processing of the metaphoric vehicle. Such differences replicate those found in previous studies with similar designs, such as Vulchanova et al.'s (2019). On the other hand, the evidence presented and discussed in the paper does not suggest either impairment or delay with respect to metaphor processing. Rather, the evidence only suggests differences. While the source of such processing differences is still unknown, the results of the current study cast some doubts on the idea that the main factor in metaphor processing in the autistic population is their structural language level.

Keywords: metaphor; autism; children; development; eye-tracker.

Corresponding author: Isabel Martín-González, Department of Linguistics and Basque Studies, University of the Basque Country/Euskal Herriko Unibertsitatea, Vitoria-Gasteiz, Basque-Country, Spain. E-mail: isabel.martin@ehu.eus.

ORCID ID: https://orcid.org/0000-0003-4467-7120

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Introduction

Difficulties understanding non-literal uses of language are common across the autistic spectrum in everyday situations (Morra, 2016). In fact, many intervention programs targeting language or social skills include interventions on non-literal uses of language or non-explicit communication (McMahon et al., 2013; Melogno et al., 2017). However, results in the lab concerning non-literal uses of language are typically mixed, depending on what kind of non-literal use is being tested, method of assessment, and matching criteria for neurotypical (NT) controls. For instance, many studies on children, adolescents or young adults report special difficulties understanding irony and sarcasm (Deliens et al., 2017; Happé, 1993; MacKay & Shaw, 2004; Li et al., 2012; Panzeri et al., 2022; Saban-Bezalel & Mashal, 2019; Song et al., 2023), with performance on other aspects of non-literal language being more variable and frequently unaffected in tested samples. For example, many studies report NT-like comprehension of scalar implicatures (Chevallier et al., 2010; Hochstein et al., 2018; Pijnacker et al., 2009; Su & Su, 2015; Van Tiel & Kissine, 2018) (see Mazzaggio et al., 2021; Schaeken et al., 2018 for discrepant results), or on indirect speech acts (Kissine et al., 2015; Marocchini et al., 2022; but see Ozonoff & Miller, 1996; Paul & Cohen, 1985 for opposite results).

Current data on metaphor comprehension in autism is also mixed and the extent to which underlying processing may differ between autism and neurotypical (NT) development is underexplored, especially in younger children. In this study, we specifically evaluate the comprehension and processing of novel metaphoric utterances by autistic children, in comparison to verbal age matched controls, contributing to the wider debate on comprehension of non-literal uses of language in autism.

Theoretical Accounts for Non-literal Language Comprehension in Autism

Discrepant results between types of non-literal uses of language suggest that not all of them impose the same demands for autistic individuals. There have been attempts to theoretically disentangle non-literal uses of language in terms of what might be more costly specifically for autistic people. A distinction that has been proposed differentiates uses of language that require perspective-shifting, and those that arguably can be understood without adopting the perspective of the interlocutor (Andrés-Roqueta & Katsos, 2017, 2020; Kissine, 2016). Andrés-Roqueta & Katsos propose a distinction between *linguistic* and *social* pragmatics: linguistic pragmatics would mainly demand linguistic abilities and sensitivity to pragmatic norms such as pragmatic maxims of informativeness (which, according to them, would involve e.g., scalar implicature derivation). On the other hand, social pragmatics would require additional mind-reading abilities to track a speaker's belief and infer that the speaker's utterance should not contradict that belief (e.g., as in irony, sarcasm).

According to this view, metaphor comprehension would fall under linguistic pragmatics in that it would require sufficient structural language skills and sensitivity to pragmatic norms but arguably not the degree of mentalizing required in irony comprehension. A particularly influential study to this perspective is presented in Norbury (2005). Norbury evaluated the performance of autistic children with and without language impairment in a metaphor[1] comprehension task very similar to one used by Happé (1993), who claimed to have shown that autistic children's low performance in metaphor comprehension was related to their impairment in first-order Theory of Mind (ToM). In Norbury's study neither ToM nor autistic traits emerged as relevant predictors in the regression model, while core language skills did predict metaphor comprehension. Moreover, when matched on structural language abilities, autistic children performed just as well as their NT younger peers on metaphor comprehension. The author therefore concluded that structural language is a stronger predictor of performance in metaphor comprehension than ToM in autism.

Metaphor Comprehension in Autistic Individuals

Since the publication of Norbury (2005), many studies have offered support for the claim that metaphor *comprehension* is more or less spared in autistic individuals (children and adults) when paired on structural language skills, including verbal mental age (VMA) to NT controls (Giora et al., 2012, Kasirer & Mashal, 2014, 2016; Whyte et al., 2014, Chahbouhn et al., 2016; but see Morsanyi et al., 2020, for a meta-review suggesting opposite results). However, several other studies have suggested difficulties in metaphor *processing* in autistic adults, young teens or children whose linguistic and intellectual skills are within the typical range (Chahboun et al., 2017; Chouinard & Cummine, 2016; Gold & Faust, 2010; Vulchanova et al., 2019).

Reviews of metaphor processing in autistic population such as Kalandadze et al. (2019), or Lampri et al. (2023) suggest that discrepancies in results on metaphor between different studies might be due to variability in research methods (i.e., on-line vs. behavioural) and task designs (i.e., the type or form of the metaphor chosen). Concerning methods, on-line measures such as eye tracking (Vulchanova et al., 2019), reaction times (Chouinard & Cummine, 2016), semantic priming (Chahboun et al., 2017) or ERPs (Gold & Faust, 2010) uncover atypicalities in autistic individuals' processing of metaphors that do not emerge in studies using behavioural, multiple-choice paradigms (as in Norbury's own study). Although verbal skills have proven to be relevant to understanding different types of metaphors, the fact that differences persist between autistic and NT controls despite similar linguistic and intellectual skills, suggests that verbal ability may not account for the whole story.

Regarding the choice of materials, a particularly relevant factor of variability can be the *conventionality/novelty* of the metaphors tested. Conventional metaphors are

[1] The novelty/conventionality of metaphors in this particular study was not controlled for. Most of the metaphors appear quite conventional (i.e. something is an oven when it is quite hot). Most of the metaphors and similes are adapted from Happé, 1993. This is important because conventional metaphors may be processed differently from novel ones or, at least, require some specific skills, as commented in the following pages.

typically taken to be stored in the lexicon of proficient language users, suggesting a closer relation between structural language and metaphor comprehension. In contrast, understanding novel metaphors seems to require the recruitment of pragmatic (inferential) abilities (at least according to some prominent pragmatic theories; see e.g., Sperber & Wilson, 2015). Generally, evidence that compares directly between conventional and novel metaphors suggests that conventional metaphors are more difficult for autistic children and teens than novel ones (Zheng et al., 2015; Kasirer & Mashal, 2016; or see Melogno et al., 2012 for a review in autistic children; see Pastor-Cerezuela et al., 2020 for opposite results). Moreover, and specifically in children, vocabulary level has been found to relate to performance on conventional metaphors but not significantly for novel metaphors (Kasirer & Mashal, 2014; Olofson et al., 2014). The role of core language skills on novel metaphor comprehension is therefore less clear than in the conventional metaphor case.

Lastly, the results presented to this point include widely different profiles of autistic participants, especially with regard to chronological age. Most studies work with older children from 10 to 12 years old (e.g. Kasirer & Mashal, 2016, Chahboun et al. 2017, Vulchanova et al. 2019), a combination of older children and adults, or adult participants only (see Gold & Faust 2010 or Giora et al. 2012 as examples). A scarce number of studies has focused exclusively on children, and those that have, often include children of ages in which metaphor comprehension could already be more or less established, especially if including autistic profiles with typical IQ and linguistic skills.

Metaphor Comprehension in Autistic Children

Rundblad & Annaz (2010) ran a developmental study on conventional metaphor comprehension by autistic children ranging from 5 to 11 years old in a picture selection task. The results show little improvement with age, as well as a lack of relation between conventional metaphor comprehension and VMA at this point of development, though the sample was relatively small (11 children).

Van Herwegen & Rundblad (2018) compared autistic children and teens (mean age = 16 years) to chronological age matched NT controls on novel metaphor, using a picture selection task. They found that the autistic group performed significantly worse than controls throughout the entire age span included. As part of a second, longitudinal experiment, eight of the younger participants of the previous study were re-selected. Results showed that response accuracy significantly improved with age. This would suggest that novel metaphors may cause special difficulty for autistic children (more than conventional metaphors, which reinforces the finding by Kasirer & Mashal, 2016) but that this difficulty can be overcome— a finding that contrasts with Rundblad and Annaz (2010).

In contrast, Pastor-Cerezuela et al. (2020) found that novel metaphors were more difficult than conventional ones for autistic children, in a study comparing autistic (n=22) and NT (n=22) children aged 6 to 12. They also found that the autistic children

were less accurate than the NT children when matched either by chronological age or by verbal mental age.
These studies involved participants whose linguistic and intellectual abilities were, on average, within the typical range. However, neither study matched autistic participants to NT controls on these variables, relying instead on average measures. These findings suggest that average linguistic and intellectual skills alone may not ensure equivalent metaphor comprehension.

Conversely, Zheng et al. (2015) compared the performance of 15 autistic children to the performance of 15 NT children on metonymy and conventional and novel metaphor comprehension. They found that conventional metaphor was more difficult than novel metaphor for the autistic children, confirming again Kasirer & Mashal's (2016) findings. In addition, they found no inter-group differences in the *novel* metaphor condition. Accuracy on this condition was predicted by receptive vocabulary in the autistic group.

In a study combining eye-tracking, mouse-tracking, and picture selection, Vulchanova et al. (2019) investigated novel metaphor comprehension in autistic children aged 10 to 12 years. Participants, matched to NT controls on verbal comprehension using the Wechsler scales (Wechsler, 2005, 2012), achieved 80% accuracy in the picture selection task for novel metaphors and idioms combined—significantly lower than NT children. Eye tracking revealed that autistic participants fixated more and spent longer on literal images during the early stages of processing compared to NT controls. By the end of the trial, however, both groups paid little attention to literal representations. The authors interpreted these results as evidence that autistic participants required more time to consider the literal option and make a decision. Despite this, most autistic participants ultimately selected the correct answer.

Several conclusions can be drawn from these studies. First, obtaining a uniform sample of young autistic children is challenging; most studies involve mixed samples that include teenagers or adults. Second, conventional metaphors appear more difficult for autistic individuals than novel metaphors, as shown by Zheng et al. (2015) and Kasirer and Mashal (2016), regardless of task type (verbal explanation or multiple choice) or age range (5–16 years). Third, comparisons between Van Herwegen and Rundblad (2018) and Vulchanova et al. (2019), which both use a simple picture selection task with autistic children, suggest that matching participants on structural language skills is critical for success in novel metaphor comprehension. Vulchanova et al. (2019) matched participants on verbal and intellectual abilities using Wechsler scales, while Van Herwegen and Rundblad (2018) matched participants only on chronological age. The former group performed significantly better, suggesting that with equivalent verbal and intellectual skills, autistic participants' performance on novel metaphor tasks can approach that of NT individuals, albeit with some differences. In addition, Zheng et al. (2015) show that receptive vocabulary is an important candidate when predicting successful comprehension of novel metaphor in autistic children.

Finally, processing measures, such as those employed in Vulchanova et al. (2019), can reveal atypicalities not captured by accuracy measures alone. Gaze behaviour data indicate that processing may differ in autistic individuals, even when they ultimately achieve high accuracy. While autistic participants in Vulchanova et al. (2019) performed well (80% accuracy), their processing was slower and more focused on literal interpretations, which may have hindered their final performance in the selection task to a minor extent. Such findings highlight the value of integrating processing data with accuracy measures to better understand metaphor comprehension in autism.

The Present Study: Aims and Predictions

In our study we aimed to add to the scientific literature by exploring autistic children's metaphor comprehension in an understudied age range of 5 to 11 years of age. In particular, we wanted to investigate whether autistic children would exhibit more difficulties than NT children of their same VMA (pair-matched) with processing and understanding *novel metaphor*.

VMA-matching was made on the basis of receptive vocabulary scores, as one of the possible measures the Peabody Vocabulary test (PPTV, Dunn & Dunn, 1997) offers. The reasoning behind it is that children who are in a given developmental stage usually know the set of words that is used in the Peabody as a test for each age span. For instance, if typically, 5-year-olds know the meaning of "broom" or "bottle" that would mean that a child who knows those words but not the ones typical of 6 y.o., is more similar to 5 y.o., from a maturational point of view. We acknowledge, however, that receptive vocabulary is but a part of verbal abilities, and so that receptive vocabulary scores can only be considered a proxy for general verbal maturation. We used the Peabody test for receptive vocabulary both for practical reasons (especially in the case of autistic children, since it is easy for them to understand what they need to do, and it is also short) and because most of the studies that we cite also provide VMA measures based on the Peabody.

We obtained offline measures with a picture selection task including a literal competitor and simultaneous online measures by registering gaze movements with an eye tracker, using a Visual World Paradigm[2] (Cooper, 1974; Huettig et al., 2011; Tanenhaus et al., 1995). We had a particular interest in this type of design, since results of both types of measures appear to reveal different aspects of performance, and they can nuance each other. Blending both measures in the same task follows

[2] Visual World Paradigm (VWP) experiments involve visual input, usually pictures, and auditory stimuli (like a classical picture selection task). But they also include the registration of the participant's looks to the pictures while hearing the audio, which obviously contains information related to them, in one way or another. VWP results interpretations are based on what is known as a "linking hypothesis" which connects where participants look, their visual attention, to their unfolding comprehension or planification of an utterance (see Zhan, 2018, pp.1).

Vulchanova et al.'s (2019) task design. Our task is structurally very similar to it, although it differs in important aspects that will be detailed in the methods section, such as the type of metaphorical and literal context included, the type of literal competitor, etc.

Taking into account previous literature, we did not expect that autistic participants would fail to understand the novel metaphors included in this experiment across the board. However, we predicted that autistic participants would perform significantly worse than NTs in the picture selection task despite the VMA-matching, as happens in both Van Herwegen et al. (2018) and Vulchanova et al. (2019) with novel metaphors among autistic children with linguistic abilities close to the typical range. We also expected differences between both groups in how they process metaphors. On the other hand, we did not expect differences between groups in the baseline, literal condition, in either picture selection or in eye tracking.

The design of the task aimed at reducing uncertainty as to what the metaphor could mean by providing children with a piece of world knowledge that is relevant in order to figure out what the metaphor means. Utterances of metaphors in real life conversations are typically open ended (Pouscoulous, 2014), which may generate more uncertainty in autistic than in non-autistic individuals (see Vicente et al., 2023, on the role of uncertainty in non-literal language in autism). The paradigm has already been tested on NT children (ages 3 to 9), and results are published in Martin-Gonzalez et al. (2024). There it was found that until 6 years of age, NT children show below or at chance performance in picture selection. Regarding gaze performance, all age groups were above chance in looks to the correct metaphoric image, and such performance strengthened with age. The age span of 3 to 9 years of age proved to be critical to better understand the developmental trajectory of metaphorical abilities in NT children.

Method

Participants

Participants were 29 autistic children and 29 NT children, all native speakers of Spanish. Twenty-five of the autistic participants were recruited from Early Intervention Services and the Association of Autism in Vitoria-Gasteiz, Spain and four participants were recruited from the Association of Autism in Bilbao (APNABI) in Bilbao, Spain. Inclusion criteria were the following:

a) having a non-verbal IQ over 75 points per the Leiter-3 scale (Koch et al., 2019; Roid & Miller, 2013). We had no Leiter data for five participants, but they were reported by their clinicians in the Association to have average intellectual and linguistic skills.
b) being verbal or conversational children according to the Autism Diagnostic Observation Schedule (ADOS-2, Lord et al., 2012), or the report from the experts who either worked with them or performed the diagnosis.
c) having an official diagnosis of autism spectrum disorder (ASD) or of pervasive developmental disorder, in which case they were administered the ADOS-2

observation scale to confirm ASD.

The participants in the NT group were recruited from public schools in Vitoria-Gasteiz. A larger number of participants were part of a previous developmental study by Martín-González et al. (2024) and 29 were selected from the total sample for the purposes of the current study to be individually matched on verbal mental age, measured with the Peabody Picture Vocabulary Test III, (PPTV-III, Dunn & Dunn, 1997) with the participants in the autistic group. See the full details of group matching in Table 1.

Table 1. ***Group Matching.***

		Autistic group	NT group	T test
N		29	29	
Chronological Age (years)	Mean (SD)	7.66 (2.26)	5.97 (1.59)	t = 14.71, df = 1039.9, p < .001
	Age range	3.13 – 12.25	3.69 – 9.04	
Verbal Mental Age (years) - PPTV	Mean (SD)	6.073 (1.99)	6.09 (1.91)	t = -0.15, df= 1155.5, p = .88
	Age range	3.1 – 10.11	3.1 - 10.10	

As can be seen, groups were different with regard to chronological age. As detailed in the analysis section, part of our analyses is dedicated to disentangling whether this variable has an effect in the results, both for picture selection and eye tracking. This was due to the majority of autistic children in our sample, regardless of their intellectual ability, being below their chronological age in receptive vocabulary as measured by the PPTV-III.

Materials and Design

Building on Martín-González et al. (2024), the present experiment collected both behavioural and processing data on novel metaphor comprehension. To ensure all metaphors were novel in Spanish, we conducted a small survey which asked Spanish adults (N =21) to rate how familiar they were with some novel and conventional metaphors on a 1-7 Likert scale, where "one" was the lowest familiarity (see Martín-González et al., 2024 for the results, although novelty scores of the chosen items are included in the list of selected items in Appendix 1). Only metaphors with a mean score under 3 points were selected, or with a median of 2 points or less.

The design manipulated a within-subject and a between-subject independent variable. The former was Group (autistic vs. non-autistic) and the latter was Utterance type (literal vs. metaphorical). Specifically, in a picture-sentence matching task, children were presented with four pictures displayed on a computer screen (target, competitor and two distractor images), as exemplified in Figure 1, and heard a sequence such as (1), in Spanish (see Appendix 1 for a full list of the trial items).

There was a total of 20 items (i.e. 20 sets of four pictures). Participants heard 10 literal and 10 metaphoric utterances, presented in a randomized order. Participants were assigned to one of two lists which counterbalanced which items were presented with a metaphorical or literal statement. The position of the pictures (target, competitor, distractors) was randomized across items.

Figure 1. ***Example of Picture Assembly in a Trial.***

(1) Los saltamontes saltan mucho. {Este animal, Este niño} es un saltamontes. ¿Cuál es?
'Grasshoppers jump a lot. {That animal, That child} is a grasshopper. Which one is it?'

The task consisted in responding to the prompting question by pointing at one of the four pictures. Throughout the task, the child's eye gaze was recorded (see the details in the next subsection).

The structure of the trial was as follows: participants first heard a **context utterance** which described a generic property of the animal or object. The motivation for including this context utterance was twofold: first, it was intended to minimize the effects of differences in world knowledge by providing the piece of world knowledge information required to comprehend the metaphorical utterance; secondly, it was intended to minimize uncertainty, especially in the autistic population, by providing the specific feature to be used in the metaphorical mapping (on uncertainty and non-literal language in autism, see Vicente et al, 2023). The context utterance was followed by a **target utterance**, which presented the sentence containing either the literal or metaphorical condition to be tested (in (1), if the subject was "That animal", the sentence would be interpreted literally, and if it was "That child", it would be interpreted metaphorically). The final component of the trial was the prompting **question**, which forced the child to decide for one of the four alternatives.

For the purposes of eye gaze analysis, the relevant time windows were the following: the **target word**, that is the predicate noun of the target utterance (in (1), "grasshopper"), and the **question** ("which one is it?").
Table 2 schematizes a typical trial with the indication of the two conditions being

studied as well as the relevant windows for eye gaze analysis.

Table 2. ***Trial Structure.***

Condition	**Context sentence**	**Target utterance**		**Question (eye tracker window)**
			Target word (eye tracker window)	
Literal	Grasshoppers jump a lot	That animal	is a *grasshopper*.	Which one is it?
Metaphorical		That child		

Procedure

All participants were tested in a quiet room. Parents of autistic children were allowed to be in the testing room and some children who found it difficult to sit still, sat on their parents' lap, who were instructed to keep their eyes closed during the testing. Participants sat next to one of the experimenters, in front of a screen that was connected to the eye-tracker computer. Eye movements were recorded with a SMI RED250MOBILE portable eye tracker with a sampling rate of 250 hz. The experimenter set the eye tracker and then started the experiment with a 5-point calibration and validation phase. The experiment only continued if deviation of both eyes from the focus point was under 0.5 degrees. Afterwards, participants went through three practice trials to ensure their attention and understanding of the task. The practice trials were similar to critical ones but did not use any figurative language. Participants then continued with the 20 critical trials. The experimenter clicked to advance through the items so as not to rush the child's response. After the experimental session, they were given stickers as compensation. The calibration phase took approximately five minutes followed by an additional five to six minutes to complete the metaphor task.

Analysis

We conducted different analyses for picture selection and eye-gaze data, following a very similar strategy to the one in our previous work (Martín-González et al., 2024). On the one hand, we analysed which picture participants chose in each trial, from among the four options, and compared both groups (autistic vs. NT) in that regard. We focused on the choices for the literal picture compared to the metaphorical one in both conditions. On the other, we analysed where participants were looking at (which of the four pictures) during the unfolding of the auditory stimuli. In order to make statistical comparisons, we divided the auditory stimuli into regions (time-windows, see Table 2) and analysed the critical ones: the TARGET region, when they are hearing the metaphorical vehicle, i.e., the word that is being used with a metaphorical meaning, and the QUESTION region, in which participants were prompted to choose, to make a decision, while hearing 'which one is it?', at the end of the trial.

Our goal was to compare the gaze behaviour of both groups while processing these critical windows of the auditory stimuli, under both levels of the condition variable (literal and metaphorical) and both levels of the group variable (autistic and neurotypical). Since, as seen in Table 1, both groups differed with regard to chronological age (autistic children were older), we also tested the effect of this variable on both picture selection and eye tracking results. We sum-coded both independent variables (condition and group) in all analyses to better understand the main effects of these variables in the results overall (the effect of condition regardless of group and the effect of group regardless of condition; and lastly, whether there was an interaction effect between both variables).

To explore possible interaction effects, first we visualized data with different graphic formulas, all of which will be presented in this paper. In addition, we used the package *emmeans* (Lenth et al., 2023) to apply pairwise comparisons to delve into the differences between autistic and neurotypical participants in both conditions (only when significant interaction effects between the two categorical variables, condition and group, were present in the model output). The analysis script and datasets are available at the project's OSF page:
https://osf.io/ksuwv/?view_only=accde2b9d44b49eea164e75dce89796a

Gaze Behaviour

The analysis of gaze data was performed using the *afex* package in R (Singmann et al., 2022), to model results using a mixed-effects approach. Same strategy was used for both time windows, which were analysed separately. Thus, we built the same model but applied it separately to TARGET region data and QUESTION region data, in order to reduce noise in the analysis. In both models we included GROUP*CONDITION as fixed factors, due to our hypothesis that autistic children would experience more difficulties than NT children in the metaphorical condition, but not in the literal one. We included Item and Participant as random slopes, as well as CONDITION, as the intercept by Participant, and the interaction between CONDITION and GROUP as the intercept by Item. We followed the recommendations for a hypothesis-driven, maximal random factor structure, proposed by Barr et al. (2013).

Lastly, our response variable was *logGaze* (see (2)). We followed the approach taken by Ronderos et al. (2022), which we also followed in our previous study on this matter with neurotypical children (Martín-Gonzalez et al., 2024); that is based on creating a variable comparing the proportion of looks to the metaphorical picture with the proportion of looks to the literal picture, and transforming it to a logarithmic scale with log probability ratios (Arai et al. 2007, see (2) for the explicit formula). The advantage of using this variable is that it allows us to study the preference participants have for one of the critical pictures (the correct one) and compare it with the other one (the competitor), which also resembles the approach taken in picture selection analysis, as will be described below.

(2) *logGaze = log(proportion of looks to the metaphorical + 0.1/proportion of looks to the literal +0.1)*

The 0.1 correction stands in order to avoid divisions of 0/0 which would yield uninterpretable results. This variable will also be used to visualize results in some of the graphs. A summarized interpretation would be: if results are positive, in this case, it means that the preference is inclined towards the metaphorical picture, because it means that a greater proportion of looks are directed towards this area compared to the literal. Conversely, if results are negative, it means that more proportion of looks are directed towards the literal picture area than to the metaphorical. The closer the result is to zero, the less clear the preference is, as it means that both numbers in the division are similar to each other (a graphic example lies in Figure 3, in the results section).

Furthermore, we also wanted to explore the influence of chronological age in results, within both time windows. We coded the same mixed-effects model but adding AGE to the interaction between CONDITION*GROUP, as a numerical variable; thus, including a three-way interaction. Our hypothesis regarding the random variability did not change with the addition of AGE. Therefore, we used the same random factor structure for this model. This model was also sum-coded, since we wanted to explore whether age was a significant predictor overall (whether there was a main effect of chronological age, across groups and conditions), and also its interactions with group and condition.

Picture Selection

To analyse picture selection data, we fitted a mixed-effects model with exactly the same structure as the one for eye tracking data (and also using the same package, *afex*), also sum coded. The only difference being the response variable, which in this case was “response”, and contained 1 and 0 (1 for correct answers, 0 for incorrect). Our response variable was a dichotomic one, even though our picture selection task presented participants four different types of pictures: metaphorical, literal, object distractor and person distractor. All in all, as will be visualized in sections below, the preference for distractors was extremely low in both groups, and the real competition occurred between the literal and the metaphorical picture, in both conditions. Thus, we set the chance level at .50 and coded our response variable in the picture selection model as a dichotomic one, between the metaphorical and the literal picture. In order to run this model, trials in which distractors were chosen were deleted.

To study the influence of AGE in the picture selection results, we fitted the same model as for the eye tracking data (i.e. also with a three-way interaction, and the same random factor structure).

Results

Eye-Tracker

In Table 3 we declare the different patterns of eye tracking data for each group. Generally (and somewhat as expected) the quality of the eye tracking ratio was worse for the autistic participants, although not dramatically (around 15 percentual points, and standard deviation does not differ much from NT's). As said in the Methods section, calibration and validation of gaze for autistic participants was more difficult and interrupted.

Our sample for eye tracking data analysis has one less participant because the quality of eye tracking data was very low for one autistic participant in particular. There was no registration of this participant's saccades to almost any of the Areas of Interests. Therefore, their trials were not taken into account. This data exploration is also available in the data analysis scripts in the OSF repository.

Table 3. ***Characteristics of Eye-Tracking Data per Group and Condition.***

Group	Condition	N° observations (gaze movements in 16 ms)	Mean (SD) quality of eye tracking ratio	Sample size (N)
Autistic	Literal	23308	67.34 % (22.37)	28
Autistic	Metaphorical	24648	66.14% (23.93)	28
NT	Literal	31904	80.6% (18.26)	29
NT	Metaphorical	32748	80.51% (18.13)	29

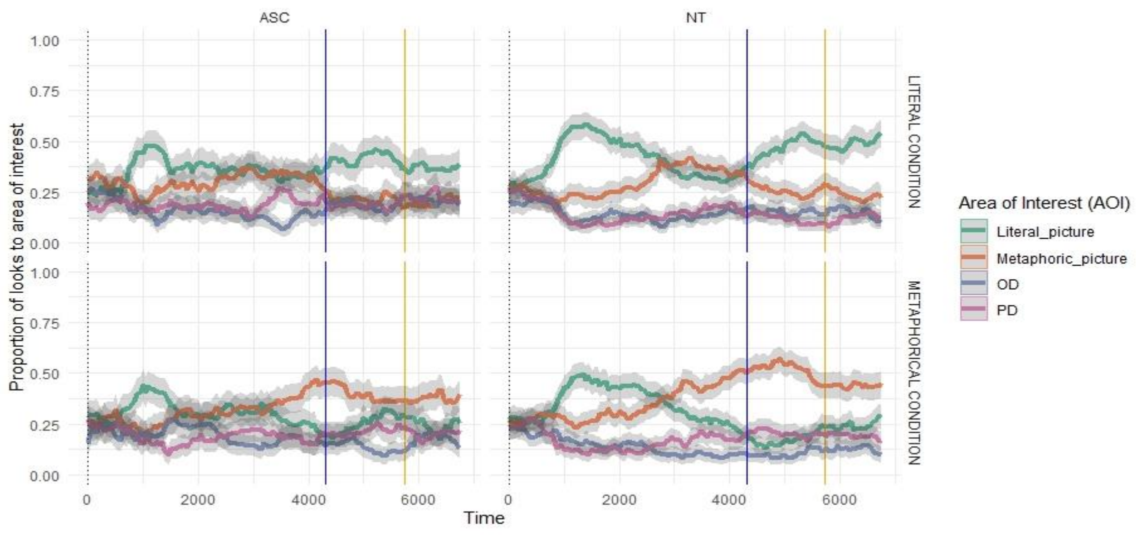

Figure 2. *Proportion of Looks to each Type of Picture during the Entire Trial.*
Legend: The blue line represents the mean start of the target utterance across trials (that kid/animal is a grasshopper). The yellow line represents the mean start of the metaphorical vehicle (grasshopper). The graph represents the average tendency of looks for all participants and trials. Error ribbons show 95 percent confidence intervals.

However, it seems that when participants start hearing the predicate information, in this case information about jumping (around 2000-3000 ms), they start to look at the metaphorical picture, since it is the only one which depicts jumping. This change happens with more clarity in the NT group than in the autistic group, in which there appears to be a period of mixed looks between the literal and the metaphorical picture around 2000-3000 ms, in both conditions (see orange and green line, in Figure 2). Also, in both groups, after the start of the target utterance, which disambiguates between which picture is going to be the correct one (by mentioning a child, who is a grasshopper, or an animal, which is a grasshopper), the amount of looks for either the literal or the metaphorical picture increases.

Nonetheless, in the autistic group and the metaphorical condition, there is again a period of mixed looks between the literal and the metaphorical picture, if we take a look into the area around the yellow line, which does not happen in the NT group. We will be looking into this effect more deeply in the next sections, when statistically analysing what children prefer in the target word region and the question region.

Lastly, there seems to be an interesting effect in the metaphorical condition (which was also observed in our previous study only with neurotypicals): both groups look to the metaphorical picture more frequently even before hearing the beginning of the target utterance. This does not happen in the literal condition. A possible explanation is that children are anticipating that the correct choice is going to be the jumping child; probably because they are hearing information about jumping, which leads them to look to the jumping child (following the example of the grasshopper trial) and then when they hear “that child” that reinforces the prediction. The real difficulty seems, though, to maintain that prediction when hearing again “grasshopper”, this time used metaphorically, to describe the jumping child. There seems to be a slight drop in the looks to the metaphorical picture especially in the autistic group, around the beginning of the target word (around the yellow line).

Target-word Region Analysis

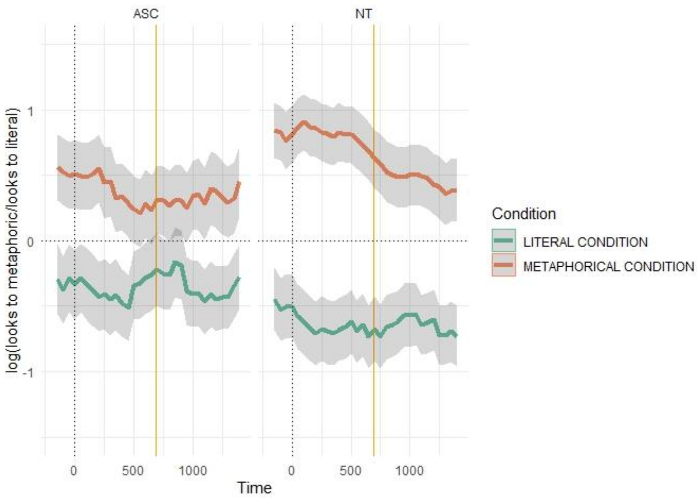

Figure 3. ***Depiction of Preference (logGaze) between Metaphorical and Literal picture at Target Word Region***.
Legend: Dotted line represents the beginning of the region. Yellow line represents the end of the target word (i.e. grasshopper), which begins at point 0. The graph represents the average tendency of looks for all participants and trials. Error ribbons show 95 percent confidence intervals.

As said, we wanted to explore the specific preference for either the metaphorical or the literal picture in each condition and time-window.
We built a mixed-effects model to test whether the interaction between group and condition was significantly influencing preference, i.e., the above-explained logGaze. Relevant output summary is displayed in Table 4.

Table 4. ***Eye-Tracking Results in the Target Word Region by Group and Condition.***

term	Estimate	Std. error	*df*	*t*	*p*
Intercept	-0.01	0.071	87.53	-0.08	.933
MET v. LIT	-0.95	0.15	86.07	-6.40	< .001***
AUT V. NT	-0.17	0.14	86.283	-1.21	.227
CONDITION X GROUP	0.68	0.29	86.753	2.34	.021 *

The model shows a main effect of condition (t value = 6.4, p<.001), but no main effect of group. The main effect of CONDITION would again speak in favour of both groups preferring the corresponding target image in each condition. The lack of a main effect of GROUP speaks in favour of groups performing similarly within each condition. However, there is an interaction effect between condition and group (t value = -2.33, p<.05). The interaction might be attributable to the fact that the difference between the literal and the metaphorical condition is not the same for both groups (as there is a differing distance between lines in Fig. 3, between both groups). Pairwise comparisons were performed to further explore the interaction. The difference between groups within the literal condition was not significant (p = .826), i.e., they performed similarly, but they did not in the metaphorical condition (p = .05), although the difference was marginal[3]. Thus, it seems that the metaphorical condition was more challenging at the processing level for the autistic group compared to their NT peers, at this time window.

Lastly, we ran a model to test the influence of chronological age in the eye tracker performance. We only found a significant interaction between AGE and CONDITION (t value = 2.53, p<.05), and CONDITION and GROUP (t value = - 3.22, p<.001) which replicates the results found in the general model for gaze movements in the target word region, and no main effect of AGE in results. Specifically, this means that age does not influence the preference for one picture or the other overall, in both conditions and groups; but that it influences preference differentially depending on the condition. The relevant output is depicted in Table 5, and depicted in Figure 5.

Table 5. ***Eye-tracking Results in Target Word Region by Condition, Group and Chronological Age.***

term	Estimate	Std. error	df	*t*	*p*
Intercept	0.01	0.075	85.27	0.19	.848
MET v. LIT	-0.89	0.15	83.39	-5.85	< .001***
AGE (years)	0.05	0.06	52.08	0.83	.413
AUT v. NT	-0.20	0.15	83.58	-1.37	.175
CONDITION X AGE	-0.31	0.12	52.38	-2.53	.014 *
CONDITION X GROUP	0.97	0.30	84.01	3.22	.002**
AGE X GROUP	-0.11	0.12	52.09	-0.91	0.366
CONDITION X AGE X GROUP	-0.19	0.24	52.38	-0.77	0.442

More specifically, it seems that in both groups, age influences the preference for the correct picture. As children in both groups grow older, their probability of looking at the metaphorical picture in the metaphorical condition and the literal picture in the literal condition increases (thus the interaction effect between AGE and CONDITION). However, and in line with the general results for the target word region (Figure 3, Table 4), explained above, the preference is less clear for the autistic group, in most of the age span included. NT children already start with much greater clarity of preference than autistic children (thus, the interaction effect between GROUP and CONDITION).

[3] From now on, we will take this difference as significant but marginal, which diminishes the strength in the conclusions of this study; thus, it can be considered as a limitation, that calls for further replication of the design. However, since the difference between groups in the literal condition was far from significant, the significant interaction effect found in the model (Table 4) can likely be attributed to the group differences observed in the metaphorical condition.

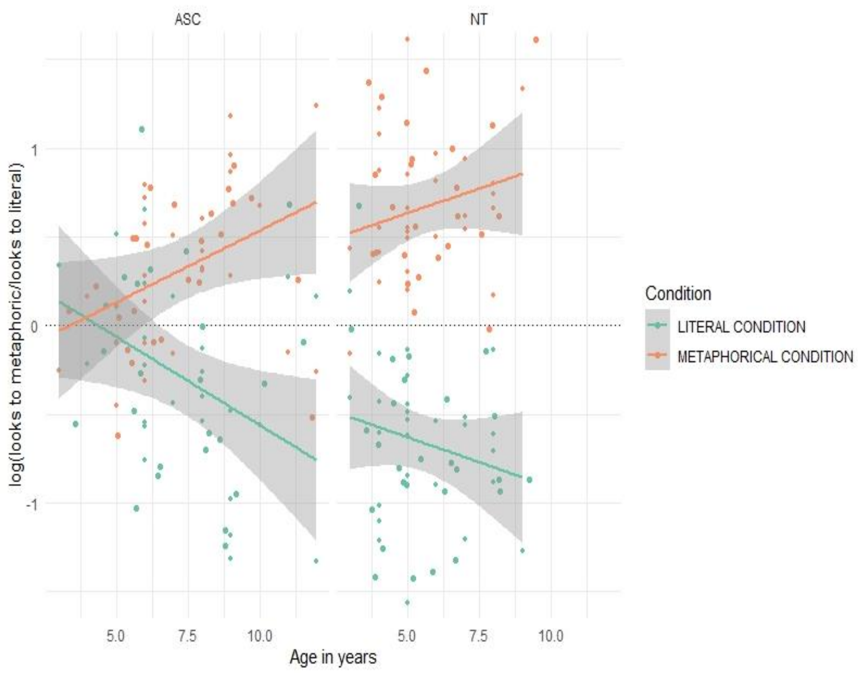

Figure 4. ***Development of Preference for Metaphorical vs Literal in the Target Word Region.***
Legend: Dots represent a single participant; the superimposed regression lines represent the mean tendency.

Question Region Analysis

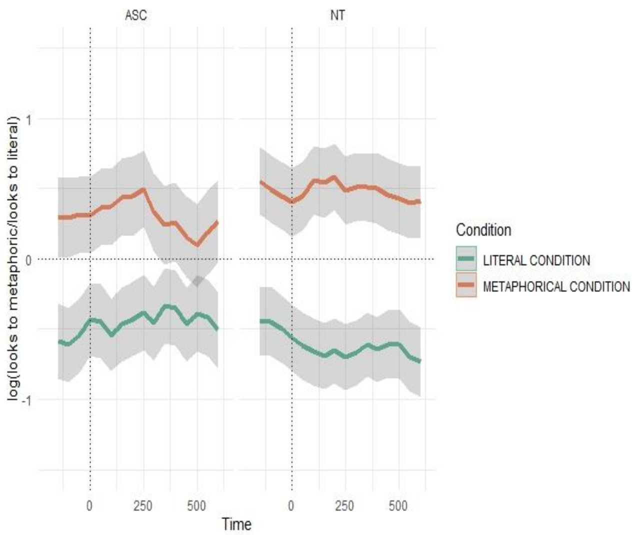

Figure 5. ***Depiction of Preference between Metaphorical and Literal picture at Question Region.***
Legend: Dotted line represents the beginning of the region. The graph represents the average tendency of looks for all participants and trials. Error ribbons show 95

percent confidence intervals.

As explained in the Analysis section, we ran another mixed-effects model with the same structure as the one used for the target time-window but applied to gaze movements during the question region (when children hear "which one is it?", see (1) and Table 2 above). Relevant output summary can be found in Table 6.

Table 6. ***Eye-Tracking Results in the Question Word Region by Group and Condition.***

term	Estimate	Std. error	df	*t*	*p*
Intercept	-0.04	0.09	74.76	-0.43	.670
MET v. LIT	0.89	0.14	81.36	-6.20	< .001***
AUT. V. NT	0.11	0.19	81.74	0.58	.559
CONDITION X GROUP	0.38	0.31	83.66	1.20	.233

Note: Singularity warning for this model.

In this region we only found a significant effect for CONDITION (t value = - 6.02, p <.001), no main effect of GROUP and the interaction between CONDITION and GROUP, which was significant in the target time window, did not remain within the significance threshold. This means both groups performed differently in each condition, i.e., preferring the metaphorical picture in the metaphorical condition, and the literal in the literal one (also according to the graph). When the moment of the decision is approaching, all children seem to have made up their minds with regard to which one is the correct picture, since there is no interaction effect between CONDITION and GROUP, as the one found in the target region analysis.
We also explored the influence of AGE as a linear predictor in the preference during the question region. Results from the model output are summarized in Table 7.

Table 7. ***Eye-tracking Results in Question Word Region by Condition, Group and Chronological Age.***

term	Estimate	Std. error	df	*t*	*p*
Intercept	-0.08	0.07	70.78	-0.82	.415
MET v. LIT	-0.89	0.15	77.97	-5.89	< .001***
AGE (years)	0.16	0.09	52.87	1.80	.077
AUT v. LIT	-0.03	0.20	77.71	-0.17	.865
CONDITION X AGE	-0.26	0.13	52.33	-2.11	.034 *
CONDITION X GROUP	0.69	0.33	82.43	1.84	.079
AGE X GROUP	0.12	0.17	52.83	0.69	.489
CONDITION X AGE X GROUP	0.09	0.25	52.31	0.38	.699

Results replicate the general question region model, as happened with the target region model. Moreover, no main effect of AGE is found, but a significant interaction with CONDITION (t value = -2.12, p<.05), same as happens in the target word region.

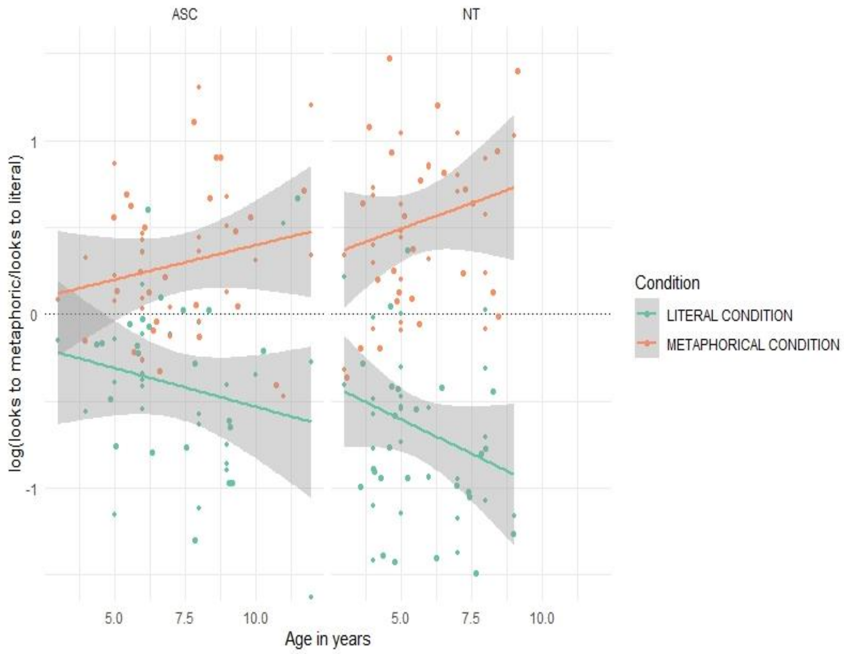

Figure 6. ***Development of Preference to Metaphorical vs. Literal picture in the Question Region.***
Legend: Dots represent a single participant; the superimposed regression lines represent the mean tendency.

Again, as tested in the target word region, the interaction effect found is due to the preference for the literal picture in the literal condition, and conversely, the metaphorical picture in the metaphorical condition, both of them increasing as children get older.

Picture Selection

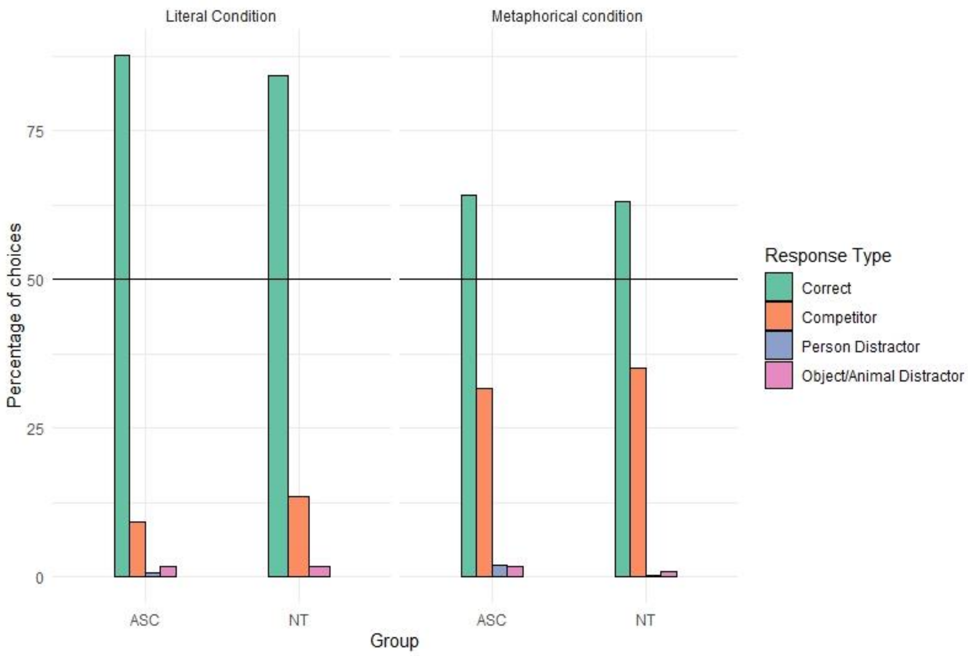

Figure 7. ***Percentage of Choices of each Category of Picture (Correct, Competitor, Person Distractor or Object/Animal distractor).***
Legend: Chance level was set at .50. Choices are depicted by all participants in all critical trials.

A mixed effects model was run to explore a possible interaction effect between CONDITION and GROUP. The relevant output summary can be found in Table 8.

Table 8. ***Picture selection Results by Group and Condition.***

term	Estimate	Std. error	*z*	*p*
Intercept	4.44	0.76	5.86	< .001***
MET v. LIT	3.79	1.05	3.60	< .001***
AUT v. NT	-0.03	0.97	-0.03	.973
CONDITION X GROUP	-0.09	2.07	-0.04	.965

There is a main effect of Condition only, not group (z value = 3.6, p<.001). Moreover, no significant interaction effect was found. The interpretation seems straightforward: both groups are choosing differently in each condition. In light of the graph (Figure 7), both groups exhibit a preference for the literal picture in the literal condition and the metaphorical picture in the metaphorical condition. Also, given that the intercept is significantly above zero, both groups are performing significantly above chance. These results dissociate from what is found in the target region analysis, in which the metaphor condition seemed to involve greater deliberation or doubt for the autistic participants (see Figure 3, Table 4). However, interestingly, they fit with the question region results, in which no specific difficulties with metaphor are found anymore (Table 6).

Regarding our analysis of chronological age effects, the relevant output summary can be found in Table 9.

Table 9. ***Picture selection results for Condition, Group and Chronological Age.***

term	Estimate	Std. error	*z*	*p*
Intercept	4.51	0.75	6.04	< .001***
MET v. LIT	3.09	1.09	2.83	.005 **
AGE (years)	1.52	0.52	2.88	.004**
AUT v. NT	-1.23	0.99	-1.60	.216
CONDITION X AGE	-1.84	1.15	-1.60	.109
CONDITION X GROUP	1.33	2.15	0.62	.537
AGE X GROUP	-0.74	1.01	-0.76	.445
CONDITION X AGE X GROUP	1.88	2.21	0.85	.395

Note: Singularity warning for this model.

A main effect of AGE as a continuous variable was found when testing the effect of the differential chronological age in both groups (z value = 2.88, p<0.001). This means age is a good linear predictor of picture selection results in both groups and since there are no interaction effects between age and condition or age and group, it does not seem that it influences differently in the literal or the metaphorical condition, or in the autistic group, compared to the NT. In our paper studying the development of NT comprehension of novel metaphors we did find an interaction effect between age and condition, that is visible in Figure 8.

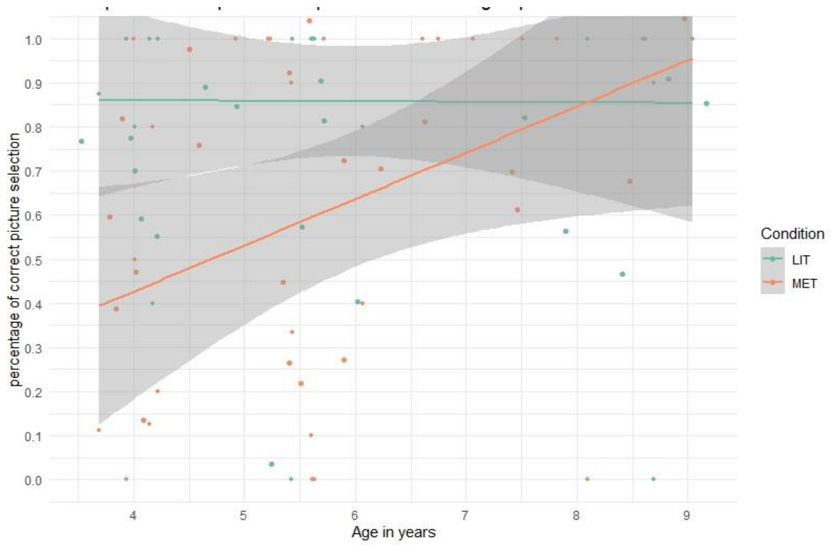

Figure 8. ***Development of Picture Selection Accuracy in the NT Group.***
Legend: Dots represent a single participant; the superimposed regression lines represent the mean tendency.

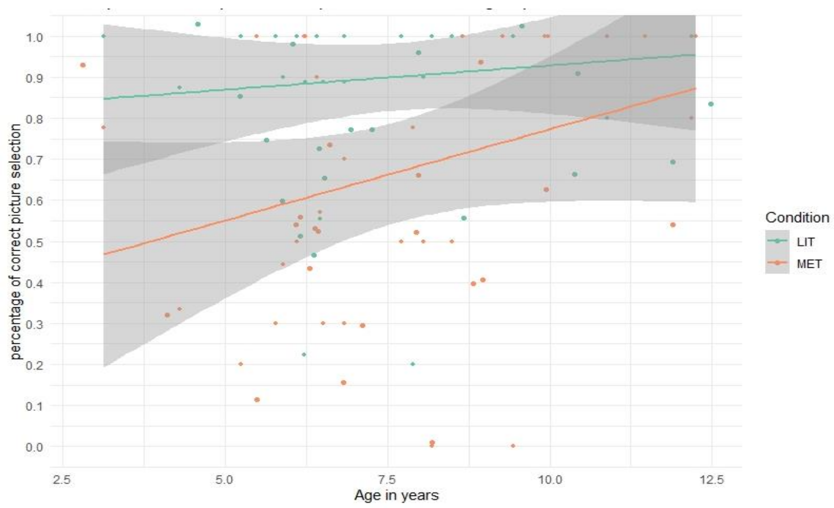

Figure 9. ***Development of Picture Selection Accuracy in the Autistic Group.***
Legend: Dots represent a single participant; the superimposed regression lines represent the mean tendency.

Discussion

In this study we sought to better understand how autistic children understand non-literal uses of language by exploring the case of novel metaphor comprehension. Previous literature suggests that when controlling for structural language maturation, group differences in the comprehension of certain non-literal language uses, such as metaphor, dissipate in off-line measures such as picture selection (Andrés-Roqueta & Katsos, 2017; Kalandadze et al., 2018; Norbury, 2005). However, whether autistic children are utilizing the same interpretive strategies or facing equal processing costs to achieve similar performance as language-matched peers is less clear, as the scarce literature that contains processing data points to (Vulchanova et al., 2019). Further complicating this issue, previous literature on metaphor comprehension in autism has (*i*) often mixed conventional and novel metaphors, which theoretically have differing processing costs, or (*ii*) not consistently controlled for language level – resulting in variability across study outcomes that is difficult to compare.

To this end, we have carefully matched our participants on verbal mental age and developed a task which tests novel metaphoric utterances specifically. By capturing on-line processing data via eye-tracking we hoped to better detect potential differences in autistic children's processing of metaphoric utterances – such as the degree to which a literal interpretation is considered. As we discuss our results, we will reflect on their significance to this wider debate.

Looking first to results from picture selection accuracy, we find that there was no difference between groups. Both groups chose the metaphoric referent above chance in the metaphoric condition and the literal referent above chance in the literal condition and rarely selected distractor pictures. Both groups also performed significantly higher in the literal condition than in the metaphoric condition. Even though our participants were matched only on receptive vocabulary, these results suggest an apparent alignment with accounts that stress the importance of general language skills for metaphor comprehension in autism (Andrés-Roqueta & Katsos, 2017; Kalandadze et al., 2018, 2019; Norbury, 2005) – so that when language level is controlled for, performance is on par with NT peers. Our results contrast with previous studies on novel metaphors such as Van Herwegen and Rundblad (2018), for whom performance of the autistic group was overall low and significantly below NT controls. However, this may relate to differences in matching procedure as their participants were matched on chronological rather than verbal mental age.

In contrast to picture selection results, we observed differences in the pattern of gaze behaviour during the unfolding of the target word in the metaphoric condition. Although both groups attend to the correct metaphoric referent during the target window, there is a significant difference in performance between groups in the metaphoric condition. Taking this result and the gaze trajectories depicted in Figures 2 and 3 into account, it seems that autistic children appear to display a less clear preference in the metaphoric condition as their looks fluctuate more between the competing literal and metaphoric referent pictures. However, as mentioned, the significance of the result is marginal, thus further research is warranted to replicate and strengthen these findings.

Nonetheless, these outcomes also fall in line with gaze performance data seen in Vulchanova et al. (2019), who also found signs of greater deliberation between the correct metaphorical image and the one depicting the literal interpretation in the autistic group. Moreover, as reported in Vulchanova et al. (2019), gaze fluctuations between literal and metaphoric pictures appear to pertain to early moments of processing, and as the decision moment comes closer, these fluctuations dissipate, and the autistic children end up choosing the correct option. This can be seen when analysing our question region results, in which there is no longer an interaction effect of condition and group and only a significant effect of condition remains. In this case, groups perform the same and prefer the literal option in the literal condition and the metaphorical option in the metaphorical condition.

Importantly, these results suggest a refinement to the narrative of the weight of language level in metaphor comprehension in autism: even though we may expect not to see group differences in accuracy, there are still differences only revealed in measures that tap into the processing of metaphoric sentences. Such differences in processing do not hinder comprehension of the metaphorical interpretations, at least in a task like the current one, suggesting processing differences that do not amount to impairment. The observed processing differences may also help us account for why comprehension of metaphor may be more challenging outside of the lab environment (Vicente et al., 2023) - as the experimental set up controls for world knowledge, discourse length, and offers visual support etc., all of which may optimize comprehension among autistic individuals with the required verbal abilities.

As commented in the Methods section, Martín-González et al. (2024) evaluated novel metaphor comprehension among a large sample of NT children. This allows us to descriptively compare the autistic sample not only to their peers, matched on verbal mental age but also to the age cohorts reported in the cross-sectional developmental study, and evaluate the hypothesis that metaphoric comprehension may be delayed in autistic children with respect to NTs. Regarding this hypothesis, we can say that none of the age groups studied in Martín-González et al. exhibited the profile of autistic children in the current study, when considering picture selection and gaze data together: overall, above chance accuracy in picture selection combined with a reduced difference between conditions in gaze behaviour. In fact, gaze behaviour for the autistic group may appear most similar to the younger NT children in the 3-4 age group who also showed a reduced difference between conditions, while still looking to the novel metaphoric image significantly more than the literal image in the target region. However, the 3- to 4-year-old NT children selected the literal option in the metaphoric condition more often than the metaphorical option. Regarding picture selection, the autistic group appears more akin to the older age ranges – 6 and older -- on par with the autistic groups' average VMA. This descriptive comparison to results from Martín-González et al. (2024) suggests that the overall profile of performance in the autistic group is not indicative of delay. The results contribute to the wider debate that we should not only consider the question of impairment or delay when conceiving of group differences. Metaphor processing could be different in the autistic population without necessarily implying an impairment or a delayed comprehension ability.

What could be the nature of this difference in processing between the autistic and the NT groups? Although we can infer that there may be differences in underlying processing, we cannot describe with any certainty the nature of how processing differs between groups, which is a limitation of the current study. It is possible that autistic participants have a reduced degree of certainty regarding non-literal interpretations of linguistic utterances (Vicente et al. 2023). According to some views, autistic individuals exhibit a higher degree of uncertainty than NT individuals across the board (Bervoets et al., 2021). Language processing should not be an exception to such a difference, especially when non-explicit linguistic communication is involved. Alternatively, these results are also compatible with an actual difference in processing. Theories of compensation effects in autism suggest that autistic individuals may resort to alternative or compensatory strategies to achieve the same means (Livingston & Happé, 2017). For example, we may find relations between language performance in autism and non-linguistic general cognitive skills, which would be unexpected for typical development. Standardized measures of non-verbal reasoning correlate with performance on standardized language assessments in autism (Faerman et al., 2023). Furthermore, non-verbal reasoning can have a predictive effect in autism performance in linguistic tasks, but not in NT teens, suggesting autistic participants may be relying on alternative cognitive resources to achieve performance similar to NT peers (Jensen de López et al., 2018). This points to the importance of considering implicit and explicit results in tandem and that conclusions on what is or what is not affected in autism may not necessarily align with what is or is not impaired in autism.

Conclusions

The purpose of this paper was to discuss empirical data concerning the comprehension of novel metaphor in verbal-age matched autistic and non-autistic children, collected through a paradigm that combined a picture-selection task and eye-tracking measures. In a nutshell, we encountered no differences in picture selection between the two developmental groups; nevertheless, we did encounter a marginal difference in processing profile, specifically in the target word region for the metaphorical condition. Our study brings to the table how possible differences in processing styles might be concealed by some methodologies. Differences can be found when analysing gaze movements that might reveal different processing profiles in autistic children when facing innovative metaphorical uses of language, even though in the end their accuracy does not differ from verbal age matched controls. While the results seem to rule out impairment for participants of the profile tested here, they suggest that autistic children might still be different from their NT peers in novel metaphor processing. However, the nature of such differences remains an open question, and this can be seen as a limitation of the current study.

Our design was focused on exploring potential differences in both processing and picture selection between autistic children and verbal age matched NT peers; rather than on unveiling the source of differences, if there were any. In spite of this, we may speculate two potential explanations of our findings, in line with relevant theoretical and experimental literature. We have suggested that autistic children may experience more uncertainty than NT children, which would make them waver between the literal and the metaphorical interpretation in a way that NT children do not. The compensation alternative, which we also consider, is that autistic children process metaphors differently. What seems to be "easy" in the case of NT children may require from autistic children more reasoning or effortful processing in any case. Such effortful processing may involve going back and forth between the literal and the metaphorical interpretation.

Be that as it may, the observed processing differences can help us achieve a more nuanced conception of how autistic traits impact everyday communication, and connect with testimonies from outside the lab, in which many autistic individuals report experiencing challenges with different kinds of figurative language. All this offers interesting paths for investigation on the subject to move forward.

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Data, code and materials availability statement

The relevant datasets with information (anonymized) about participants, the scripts used for the analysis, the materials for building the task and instructions on how to use all these files (ReadMe) are available on:
https://osf.io/ksuwv/?view_only=accde2b9d44b49eea164e75dce89796a
The experimental materials are also detailed in Appendix 1 in this manuscript.

Ethics statement

Ethical approval was issued by the University of the Basque Country's Ethics Committee for research with human beings. All parents/guardians gave signed consent prior to the participation in the investigation.

Authorship and Contributorship Statement

IMG conceived and designed the task. All authors contributed to designing the actual experiment and its implementation. KS, ILF and EC gave useful input about methodology and AV contributed the theoretical framework. AV helped in selecting participants and reached out for public schools to recruit NT children. IMG & KS collected the data. IMG & KS cleaned and reviewed the data. ILF provided tools and strategy to analyse the data. IMG analysed the data. All authors contributed to interpret the results. All authors drafted the paper. ILF, EC and AV contributed to fundraising. A special contribution is that of Dr. Camilo Rodríguez Ronderos who participated in the work with NT children and supervised and helped IMG in the data analysis for this particular study. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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License

Appendix 1

Experimental materials (with mean metaphor novelty scores in parenthesis)

1. Squirrels (2.27)

1 met. Squirrels climb up trees. That boy is a squirrel. Which one is it?
Las ardillas suben a los árboles. Ese niño es una ardilla. ¿Cuál es?
1 lit. Squirrels climb up trees. That animal is a squirrel. Which one is it?
Las ardillas suben árboles. Ese animal es una ardilla. ¿Cuál es?

Literal option: a squirrel climbing up a tree.	Distractor-literal: a cat jumping to the top of a wall.
Distractor-metaphorical: a boy climbing up a metal ladder	Metaphorical option: a boy climbing up a tree.

2. *Swordfish* (1.12)

2 met. Swordfish swim fast. That boy is a swordfish. Which one is it?
Los peces espada nadan rápido. Ese niño es un pez espada. ¿Cuál es?
2 lit. Swordfish swim fast. That animal is a swordfish. Which one?
Los peces espada nadan rápido. Ese animal es un pez espada. ¿Cuál es?

Literal option: a swordfish	Distractor-literal: a tiger
Distractor-metaphorical: a boy at the beach	Metaphorical option: a boy swimming

3. *Grasshoppers* (2.69)

3 met. Grasshoppers jump a lot. That boy is a grasshopper. Which one is it?
Los saltamontes saltan mucho. Ese niño es un saltamontes. ¿Cuál es?
3 lit. Grasshoppers jump a lot. That boy is a grasshopper. Which one is it?
Los saltamontes saltan mucho. Ese animal es un saltamontes. ¿Cuál es?

Literal option: a grasshopper jumping	Distractor - literal. a beatle jumping
Distractor-metaphorical: a boy running	Metaphorical option: a boy jumping

4. *Rhinos* (1.81)

4 met.Rhinos are strong. That boy is a rhino. Which one is it?

Los rinocerontes son fuertes. Ese niño es un rinoceronte. ¿Cuál es?
4 lit. Rhinos are strong. That animal is a rhino. Which one is it?
Los rinocerontes son fuertes. Ese animal es un rinoceronte. ¿Cuál es?

Literal option: a rhino	Distractor - literal. A giraffe
Distractor-metaphorical: a boy playing football with friends	Metaphorical option: a very big boy with wide shoulders and strong, flexed arms. He is standing between two slim children, ensuring a noticeable contrast

5. *Crocodiles* (1.42)
5 met. Crocodiles have big teeth. That boy is a crocodile. Which one is it?
Los cocodrilos tienen los dientes grandes. Ese niño es un cocodrilo. ¿Cuál es?
5 lit. Crocodiles have big teeth. That animal is a crocodile. Which one is it?
Los cocodrilos tienen los dientes grandes. Ese animal es un cocodrilo. ¿Cuál es?

Literal option: a crocodile with open mouth wide (showing big, sharp teeth) trying to bite a beach ball	Distractor-literal: a tiger with big teeth trying to bite a beach ball
Distractor-metaphorical: the face of a boy with long hair	Metaphorical option: the face of a boy with a wide smiling grin

6. *Sheep* (2.31)
6 met. Sheep have a lot of wool. That boy is a sheep. Which one is it?
Las ovejas tienen mucha lana. Ese niño es una oveja. ¿Cuál es?
6 lit. Sheep have a lot of wool. That animal is a sheep. Which one is it?
Las ovejas tienen mucha lana. Ese animal es una oveja. ¿Cuál es?

Literal option: a sheep with a thick wool fleece.	Distractor-literal: a cow
Distractor-metaphorical: a boy wearing lea jacket and cowboy boots.	Metaphorical option: A boy wearing thick white, fleece clothing (fuzzy white fleece sweater, hat and mittens).

7. *Leopards* (1.65)

7 met. Leopards have a lot of dots. That boy is a leopard! Which one is it?
Los leopardos tienen muchos puntos. Ese niño es un leopardo. ¿Cuál es?
7Lit. Leopards have a lot of dots. That boy is a leopard!
Los leopardos tienen muchos puntos. Ese animal es un leopardo. ¿Cuál es?

Literal option: a leopard	Distractor-literal: a zebra
Distractor-metaphorical: the face of a boy wearing sunglasses.	Metaphorical option: a boy with noticeable freckles on his face

8. *Hippos* (2.35)
8 met. Hippos have a very big mouth. That kid is a hippo! Which one is it?
Los hipopótamos tienen la boca muy grande. Ese niño es un hipopótamo! ¿Cuál es?
8 lit. Hippos have a very big mouth. That animal is a hippo! Which one is it?
Los hipopótamos tienen la boca muy grande. Ese animal es un hipopótamo! ¿Cuál es?

28. Literal option: a hippopotamus with mouth wide open	29. Distractor-literal: a pelican with mouth wide open.
30. Distractor-metaphorical: The face of a boy whistling	31. Metaphorical option: The face of boy with mouth wide open, looking like he's laughing really hard

9. *Chicks* (2.85)
9a. Chicks always follow their mum. That boy is a chick! Which one is it?
Los pollitos siempre van con su mamá. Ese niño es un pollito. ¿Cuál es?
9b. Chicks always follow their mum. That animal is a chick! Which one is it?
Los pollitos siempre van con su mamá. Ese animal es un pollito. ¿Cuál es?

Literal option: Chick walking next to her mother hen	Distractor-literal: two adult cats sleeping together
Distractor-metaphorical: a boy and a girl facing each other	Metaphorical option: A little boy walking next to his mother, following her by the hand, resembling the hen and chicken picture

10. *Flamingos* (2.38)
10 met. Flamingos are pink. That kid is a flamingo! Which one is it?
Los flamencos son rosa. Ese niño es un flamenco. ¿Cuál es?

10lit. Flamingos are pink. That animal is a flamingo! Which one is it?
Los flamencos son rosa. Ese animal es un flamenco. ¿Cuál es?

Literal option: a flamingo	Distractor-literal: a yellow duck
Distractor-metaphorical: a blond-haired boy who is very pale, lips bluish from the cold	Metaphorical option: a boy with very pink-tone skin.

11. *Caterpillars* (1.42)

11 met. Caterpillars inch on the ground. That kid is a caterpillar! Which one is it?
Las orugas van por el suelo. Ese niño es una oruga. ¿Cuál es?
11 lit. Caterpillars inch on the ground. That animal is a caterpillar! Which one is it?
Las orugas van por el suelo. Ese animal es una oruga. ¿Cuál es?

Literal option: a caterpillar inching on the ground	Distractor-literal: a frog jumping
Distractor-metaphorical: a boy stretching	Metaphorical option: a boy 'inching' like a caterpillar on the ground

12. *Vacuum cleaners* (2.35)

12 met.Vacuum cleaners absorb everything. That kid is a vacuum cleaner! Which one is it?
Las aspiradoras absorben todo. Ese niño es una aspiradora. ¿Cuál es?
12 lit. Vacuum cleaners absorb everything. That thing is a vacuum cleaner! Which one is it?
Las aspiradoras absorben todo. Esa cosa es una aspiradora. ¿Cuál es?

Literal option: a man vacuuming some dirt.	Distractor-literal: a man pushing a shopping cart.

Distractor-metaphorical: a boy eating a salad with a fork.	47. Metaphorical option: A boy eating a plate of spaghetti, slurping a plate of noodles into his mouth.

13. *Skyscrapers* (2.35)

13 met. Skyscrapers are tall. That kid is a skyscraper! Which one is it?
Los rascacielos son altos. Ese niño es un rascacielos. ¿Cuál es?
13 lit. Skyscrapers are tall. That thing is a skyscraper! Which one is it?
Los rascacielos son altos. Esa cosa es un rascacielos. ¿Cuál es?

Literal option: a skyscraper next to several small houses	Distractor-literal: a fence
Distractor-metaphorical: three kids sitting in chairs talking	Metaphorical option: A very tall boy standing between two shorter kids

14. *Balloons* (1.65)

14 met. Balloons are round. That kid is a balloon. Which one is it?
Los globos son redondos. Ese niño es un globo. ¿Cuál es?
14 lit. Balloons are round. That thing is a balloon. Which one is it?
Los globos son redondos. Esa cosa es un globo. ¿Cuál es?

Literal option: An orange balloon	Distractor-literal: a soap bubble
Distractor-metaphorical: An average size boy, wearing normal clothes.	Metaphorical option: a boy in a puffy snowsuit

15. *Computers* (2.15)

15 met. Computers do math very fast. That kid is a computer! Which one is it?
Los ordenadores hacen mates muy rápido. Ese niño es un ordenador. ¿Cuál es?
15 lit. Computers do math very fast. That thing is a computer! Which one is it?
Los ordenadores hacen mates muy rápido. Esa cosa es un ordenador. ¿Cuál es?

Literal option: a desktop computer with spreadsheet on the screen	Distractor-literal: a blender
Distractor-metaphorical: a boy sitting at a desk, painting	Metaphorical option: a boy sitting at a desk, working on an assignment. He is depicted having a thought bubble with an arithmetic equation.

16. *Strawberries* (1.35)

16 met. Strawberries are red. That kid is a strawberry. Which one is it?
las fresas son rojas. Ese niño es una fresa. ¿Cuál es?
16 lit. Strawberries are red. That thing is a strawberry. Which one is it?
Las fresas son rojas. Esa cosa es una fresa. ¿Cuál es?

Literal option: a strawberry	Distractor-literal: a green pepper
Distractor-metaphorical: The face of a boy with normal pale cheeks.	Metaphorical option: The face of a boy who has very red cheeks

17. *Rivers* (1.27)

17 met. Rivers have tons of water. That kid is a river. Which one is it?
Los ríos tienen mucha agua. Ese niño es un río. ¿Cuál es?
17 lit. Rivers have tons of water. That thing is a river. Which one is it?
Los ríos tienen mucha agua. Esa cosa es un río. ¿Cuál es?

Literal option: a river	Distractor-literal: a road
Distractor-metaphorical: a boy	Metaphorical option: a boy wearing soaking-wet clothes, standing in a puddle with drops of water falling to the floor

18. *Spinning tops* (2.46)

18 met. Spinning tops spin a lot. That kid is a spinning top. Which one is it?
Las peonzas dan muchas vueltas. Ese niño es una peonza. ¿Cuál es?
18 lit. Spinning tops spin a lot. That thing is a spinning top. Which one is it?
Las peonzas dan muchas vueltas. Esa cosa es una peonza. ¿Cuál es?

Literal option: a spinning top	Distractor-literal: a boy going down a slide

Distractor-metaphorical: a spinning sewing wheel	Metaphorical option: a boy doing a cartwheel.

19. *Scissors* (1.08)

19 met. Scissors cut stuff. That kid is a scissor! Which is it?
Las tijeras cortan cosas. Ese niño es una tijera. ¿Cuál es?
19 lit. Scissors cut stuff. That thing is a scissor! Which is it?
Las tijeras cortan cosas. Esa cosa es una tijera. ¿Cuál es?

Literal option: a pair of scissors cutting a big piece of paper	Distractor-literal: a hammer, hammering a nail
Distractor-metaphorical: a child carrying some boxes	Metaphorical option: a boy tearing a big piece of paper with his hands.

20. *Race cars* (1.92)

20 met. Race cars go very fast. That kid is a racing car! Which one is it?
Los coches de carreras van muy rápido. Ese niño es un coche de carreras. ¿Cuál es?
20 lit. Race cars go very fast. That thing is a racing car! Which one is it?
Los coches de carreras van muy rápido. Esa cosa es un coche de carreras. ¿Cuál es?

Literal option: a race car	Distractor-literal: a skate-board
Distractor-metaphorical: a boy doing a handstand	Metaphorical option: a boy running with a sprinting gait.