PREDICTORS OF METAPHORICAL UNDERSTANDING IN HIGH FUNCTIONING AUTISM

SOBH CHAHBOUN VALENTIN VULCHANOV
DAVID SALDAÑA HENDRIK ESHUIS MILA VULCHANOVA

ABSTRACT: The main aim of this study was to test what language skills and competences predict the processing of metaphorical expressions in a priming lexical decision task in two groups of high functioning autistic participants (ASD) compared to age- and verbal comprehension matched controls, and whether Theory of Mind contributed to performance in the task. Our results suggest that different language predictors, but not Theory of Mind, exert an influence on the processing of metaphors at different stages of development in the autistic groups. Furthermore, we found that both control groups appear to have more developed understanding of figurative expressions and are at a stage beyond which structural language skills, vocabulary size and verbal comprehension no longer impact on figurative language competences. These results are consistent with other research demonstrating that figurative language development starts flattening out after age 10-12 (Vulchanova et al. 2011; Kempler et al. 1999). In contrast, figurative language comprehension appears to be still developing in the autistic groups of participants, where core language skills still exert an influence on performance.

KEYWORDS: fogurative langiage processing, metaphor, autism, language development.

1. INTRODUCTION

Autism is a neurodevelopmental disorder characterized by impaired social interaction and communication, and repetitive patterns of behavior (Diagnostic and Statistical Manual of Mental Disorders 5; American Psychiatric Association, 2013). Often the social and communication problems are accompanied by language impairment. However, the presence of language problems varies across the autistic spectrum, from complete failure to acquire verbal skills (at the lower end of the spectrum, Rapin 1991) to virtually intact structural language (at the higher end of the spectrum). Still difficulties with pragmatic aspects of language persist even in high-functioning individuals with autism and adequate verbal skills (Vulchanova et al. 2015; Eigsti et al. 2007). An open question is what is the source of this well-attested difficulty.

In typical development, the mastering of figurative language is a gradual process with fast acceleration observed in the first years of formal instruction at school (Nippold 1998; Vulchanova et al. 2015). It has been shown that the ability to process figurative and extended meanings in language depends on other language and cognitive competences and skills, such as metalinguistic awareness, and, in particular, the ability to provide word definitions (Levorato & Cacciari 2002). However, some of these competences appear to be delayed in individuals with ASD due to various factors, such as comorbidity with language impairment (LI) or lack of social stimulation. It has been shown that the development of idiom and metaphor comprehension in individuals with autism lags behind what is typical of their chronological age (Melogno et a. 2012a; Melogno et al. 2012b; Rundblad & Annaz 2010; Vulchanova et al. 2012a; Vulchanova et al. 2012b; Vulchanova et al. 2015). While this gap seems to get smaller as the individual grows older, adolescents and young adults on the spectrum still fail to reach an adequate level of comprehension in that domain, in comparison with typically developing peers (Vulchanova, et al 2012b; Vulchanova et al., 2015; Melogno et al 2012a).

Vulchanova and colleagues (2012a,b) report figurative language problems against clear strengths in the domain of structural language (core grammar – syntax and morphology), and highly developed vocabulary skills in a 10-year old child with Asperger's syndrome. These data attest a dissociation between structural language competence and figurative language in high functioning autism. A highly debated question is what causes the figurative language difficulties in autism. Two main approaches have been put forth. The first approach attributes the well-attested difficulty in the domain of non-literal language to another well-known problem in autism, namely the ability to attribute mental states to others (theory of mind, (ToM)) (Happé 1993; Baron-Cohen et al. 2000), on the assumption that both rely on awareness of intentionality of the speaker. Along similar lines, the deficit in processing figurative language has been explained through the more generic problem in communication and social interaction or a combination of interaction and socio-cognitive factors (Boucher 2012; Hobson 2012; Oi et al. 2013).

The second approach attributes the figurative language difficulties to weak verbal competences and highlights the importance of how verbal abilities are assessed (Norbury 2005). Zheng et al. (2015) found that semantic knowledge correlates with metaphor comprehension in high-functioning children with ASD, and that their understanding of metaphors differs from that of typically developing children. On this approach, the ability to process extended uses of language is directly proportionate to structural language and other verbal skills.

Vulchanova and colleagues (2012a,b) suggest that understanding figurative language demands competences going beyond structural language. Figurative language processing is in general more demanding, and quite likely, involves a broader set of skills, such as inferencing, information integration from multi-modal sources, the construction of adequate situation models and adequate use of knowledge base, and the ability to suppress irrelevant information (Vulchanova et al. 2012b; Happé 1997; Jolliffe & Baron-Cohen 1999, 2000; Myleset al. 2002; Nation et al. 2006; Norbury & Bishop 2002; Saldaña & Frith 2007; Rubio Fernandez 2007). And quite often it is a challenge to "achieve an appropriate level of focus as we move between a perspective on the development of specifically linguistic functioning among children with autism, and broader atypicalities in these individuals' social-relational and communicative engagement" (Hobson 2012).

Our aim in the current study was to investigate the extent to which different aspects of language status, such as structural language, receptive vocabulary size, conceptual reasoning and semantic skills can predict the performance of high functioning individuals with autism on a task involving different types of metaphors contra literal expressions. We also wanted to check the extent to which Theory of Mind (ToM) exerts and influence on figurative language comprehension. In this study we exploit metaphors as a central instance of figurative language where an association can be formed between two concepts on the basis of analogy, and where these two concepts typically do not bear an inherent relationship to one another. Thus, metaphor can be viewed as a bridge-builder between conceptual domains (Fauconnier 1985; Coulson & Van Petten 2002; Lakoff 2014), and as such, offers an excellent opportunity to test figurative language comprehension. Two types of metaphors were identified as stimuli, conventional metaphors and novel metaphors. These two types have been shown in previous research to dissociate from the point of view of processing. While conventional metaphors are similar to idioms and other lexicalized expressions, and can be retrieved from long-term memory (the lexicon), novel metaphors are transparent and call for on-line processing and dynamic comprehension (Gold & Faust 2010; Bowdle & Gentner 1999, 2005; Blank 1988; Blasko & Conine 1993; Giora 1997; Turner & Katz 1997). We therefore expected to find a difference in the language measures, which predict performance on the two types of metaphors.

Our hypothesis was that some of the background language measures would predict performance on the experimental task in the participants with autism in particular, modulated by experimental condition. In addition, we expected that different language skills and competences would differentially predict performance on speed and accuracy in the task. Furthermore, we expected to find a difference between the language competences and skills which predict performance by the participants with autism compared to their matched controls. We also expected to find a difference concerning what language measures predict performance in the two age groups selected for the study. Concerning Theory of Mind, we expected a lesser contribution to performance on the metaphorical task given recent results from research.

2. METHODS

2.1 Participants

Two age groups of high-functioning participants with ASD (N = 42) and typically developing (TD) controls ($N = 40$) were recruited, all native speakers of Spanish. The first age group included children in the age range ten to twelve years (TD n = 22 (males = 20; females = 2), $\bar{x} = 11.93$; and ASD n = 22 (males = 19; females = 3), $\bar{x} = 11.7$). The second age group included young adults from sixteen to twenty-two years old (TD n = 18, (males = 13; females = 5), $\bar{x} = 18.13$; and ASD n = 20 (males = 17; females = 3), $\bar{x} = 18.7$).
Participants and their legal guardians (usually the parents) provided written consent for entry into the study. The diagnosis of ASD was confirmed according to the Autism Diagnostic Observation Schedule (ADOS).

Participants were tested on a number of vocabulary and other verbal measures to ensure that they did not have any structural language deficit (see materials). Both the individuals with ASD and their typically developing peers were matched on age, gender and verbal comprehension based on the Wechsler scale (WISC-IV or WAIS-IV were used depending on the chronological age of the participant). The overall Composite Scores were as follows: for TD children, $\bar{x}$ IQ=109.166; for ASD children $\bar{x}$ IQ=104.22; for ASD young adults $\bar{x}$ IQ=104.8 and for TD young adults $\bar{x}$ IQ=108.266. The Verbal Comprehension Index (VCI) was as follows: for TD children, $\bar{x}$ VCI=108.94; for ASD children $\bar{x}$ VCI=114.22; for ASD young adults $\bar{x}$ VCI=118.5 and for TD young adults $\bar{x}$ VCI=118.73. The matching of the groups was based on the Wilcoxon Test and the smallest p-value was $p=.341$ suggesting that there were no significant differences observed between the groups.

2.2 Materials and stimuli

The main aim of our study was to establish the processing of three types of expressions, novel and conventional metaphors compared to free expressions. Each expression comprised a modifier and a noun and was based on the design used in Gold & Faust (2010). The study was designed as a cross-modal lexical decision task where the expression of interest (novel metaphor: conventional metaphor: free expression) served as a prime and participants gave lexical-decision responses to a target (word or non-word). The participants were asked to determine whether or not the target was a real Spanish word.

In a pilot study with 150 adult native speakers of Spanish, we determined the degree of familiarity and frequency of the target metaphor expressions used in the main study. We selected 68 metaphors, and the participants in the pilot were asked to rate the familiarity and frequency of the expressions using a Likert scale from one to five. On the basis of these ratings, the expressions that received a rating below 20% on the familiarity and frequency scale were selected as novel metaphors, while expressions that received 80% and above on the same scales were selected as conventional metaphors. This allowed us to verify the respective status of the target expressions used in the study.

The stimuli for the current study included 36 prime expressions classified into three different types: 12 novel metaphors (e.g: *ruido alegre* 'joyful noise'), 12 conventional metaphors (e.g: *ángel guardian* 'guardian angel') and 12 free combinations (non- metaphorical literal expressions) (e.g: *tulipán rojo* 'red tulip'), all comprising a noun and a modifier. The literal expressions included common nouns and modifying adjectives.

The same number of fillers as primes were added (N = 36). The fillers were literal expressions, which served as primes for the non-words in the experiment. Thus, each participant responded in total to 72 trials, 36 in each modality: visual modality (stimuli presented orthographically) and auditory modality (stimuli presented auditorily).

The target words were semantically related to the prime expressions. Spanish native speaker raters were consulted on the appropriateness of the prime in relation to the target. On half of the instances for each group of expressions, targets were related to the figurative interpretation of the prime, the remaining half were related to the literal meaning (Figure 1). For the selection of the target words the data base of the Basque Center on Cognition, Brain and Language (http://www.bcbl.eu/databases/) was used to ensure that the target words were frequent words in Spanish matched on length (average frequency range 3.72; min = 0.3, max = 7.34; with mean length of 2.8 syllables).

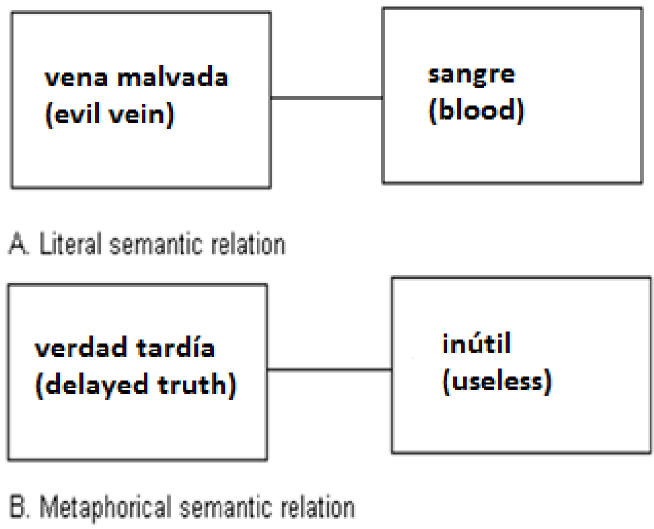

FIGURE 1. EXAMPLES OF THE TARGETS USED FOR OUR EXPERIMENT, BASED ON LITERAL (PANEL A) OR METAPHORICAL (PANEL B) RELATIONS

In order to obtain measures of the language status of participants, we conducted three language tests. The results from these tests were used in the analyses as independent variables and as predictors of performance on the experimental task which involved the processing of metaphorical language.

The following tests provided the background (predictor) variables. The Verbal Comprehension Index of the Wechsler Scales (WISC-IV for children up to 16 years old and WAIS for participants older than 16) was used as a measure of overall oral language comprehension. To obtain a measure of receptive vocabulary status, we used the Peabody Picture Vocabulary Test (3rd edition, PPVT-III, Dunn et al. 2006). The Grammatical Structures Comprehension Test (CEG; Mendoza et al. 2005) was used to test structural and semantic aspects of language status. The CEG is a Spanish adaptation of TROG (Bishop 1993). Theory of Mind (ToM) was measured using a False-Belief Task (Baron-Cohen et al. 1985) (e.g., *Sally-Anne/Ice-cream Van*).

2.3 Procedure

Each participant was tested individually in three different sessions. During the first session, participants were tested with PPVT-III and CEG. PPVT-III uses a multiple-choice paradigm and participants were asked to choose from four black and white drawings the one that best matched the meaning of a word presented orally. PPVT-III provides scaled scores of receptive vocabulary size based on typical development.

CEG uses a multiple-choice paradigm to evaluate receptive grammar, with an increasing level of difficulty in both typical language development in children and adults and can identify potential language problems. This test includes different types of sentences with increasing degree of complexity and difficulty. CEG explores receptive grammar competences of children from four to eleven years of age, but showed a Crombach's α = .91 also for older individuals (Mendoza et al. 2005). Thus, the reliability of the measurement scale allows for application on adults as well. CEG consists of 80 items, grouped in 20 blocks, and every block has 4 trials.

No reading is required by the individual for either of the tests.

In a second testing session, measures on the Comprehension sub-scale of the Wechsler Scale were collected. The Verbal Comprehension Index reflects the individual's ability to express concepts, to verbalize the relationships between them, and to reflect on their richness. It also indicates precision in the definition of concepts, as well as social understanding, practical judgment, acquired knowledge, verbal agility and intuition.

During the last session, participants performed in the priming task. They were presented with the prime expression, either on a computer screen, or via loud-speakers. The timing of the specific stimulus events on each trial was as follows: (1) The prime is presented as visual text on the screen or auditorily via the loud-speakers (depending on the experimental block); (2) a fixation point is presented followed by a 400 ms latency; (3) a target (word or non-word) is presented; finally, (4) participants are asked to determine whether or not the target is a real word in Spanish.

Stimuli were displayed on a color monitor controlled by E-prime software implemented on a compatible laptop (1280x1024 pixels). Responses were collected with a response box; response accuracy (ACC) and reaction times (RTs) were measured by the E-Prime 2.0 software (Psychology Software Tools 2012).

3. RESULTS

The data from the priming study of both the control and experimental group (N = 82) were analyzed with SPSS (Statistical Package for Social Science 22.0).

Reaction to responses was measured using 1000/RT (ms) as a speed measure rather than reaction times to correct for right skewedness of the reaction time data. We also excluded extremely high or slow responses.[1]

[1] In order to normalize our data, we calculated the Z value for each participant (Z_p) and for each item per age and group (Z_i). If the sum of the squares of the Z values was smaller or equal than 8 ($Z_p^2+Z_i^2 \leq 8$), the trial was included, and values bigger than 8 were excluded.

The language measures data were obtained from standardized tests; consequently, the scoring was based on the established scales of the manuals. Standardized scores were used in the analyses. Raw scores were used for the ToM measures.

3.1 Data analysis

A Pearson's correlation analysis on participants' scores from the language tests and the ToM task and accuracy and speed from the priming task was run to test for relationships between the variables. Both the scores on the background language tests and the ToM task and the performance on each variable (reaction speed and accuracy) of the priming task were analyzed. In addition, stepwise linear regression analyses were run to test for the contribution of receptive vocabulary size, receptive grammar competences and verbal comprehension on accuracy and speed in different conditions of the priming task.

3.2 Correlations and regressions

The first step was checking whether the scores of verbal comprehension, receptive vocabulary size (from PPVT-III) and receptive grammar correlated with each other and with ToM measures for each age group.

For the ASD young adults, the scores of verbal comprehension and receptive vocabulary size were significantly correlated (r=.662; n=18; p-value=.003). Also ToM was significantly correlated with verbal comprehension (r=.632; n=17; p-value=.006) and with receptive vocabulary size (r=.558; n=18; p-value=.016). For the ASD children group, verbal comprehension was correlated with receptive vocabulary size (r=.535; n=22; p-value=.010) and with receptive grammar r=.642; n=21; p-value=.05). ToM correlated with verbal comprehension (r=.535; n=20; p-value=.015), with receptive vocabulary size (r=.574; n=20; p-value=.008) and with receptive grammar (r=.533; n=19; p-value=.019).

No significant correlations were found between the language scores for both control groups.

Secondly, we checked which language measure correlated with ToM measures and with overall accuracy in performance on the priming task. Significant correlations were observed only for the ASD children group between accuracy and verbal comprehension (r=.474; n=22; p-value=.026), and receptive grammar (r =.429; n=22; p-value<.001).

A linear regression analysis showed that accuracy in the lexical decision priming tasks was significantly predicted by verbal comprehension scores (R^2=.186, F(1, 20)=5.783, p-value=.026), but the model was not significantly improved by the inclusion receptive grammar (Figure 2).

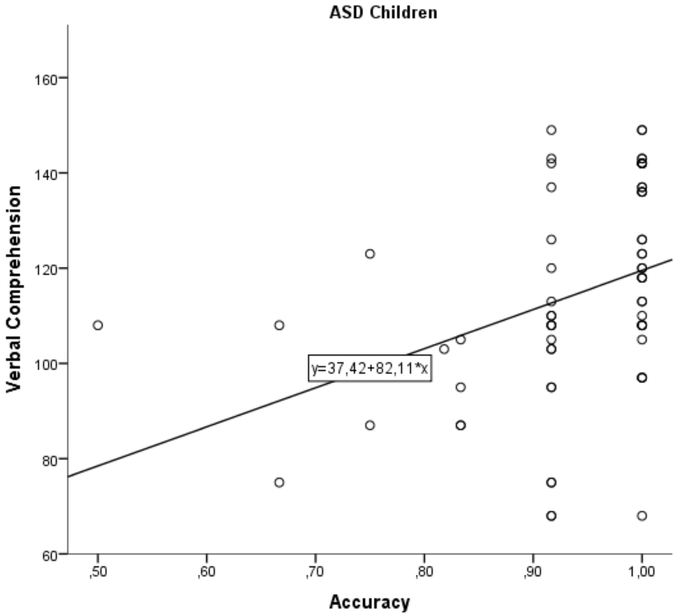

FIGURE 2. LINEAR REGRESSION MODEL FOR ASD CHILDREN'S ACCURACY AND VERBAL COMPREHENSION SCORES.

No significant correlations between the language measures, ToM and overall accuracy were found in the ASD young adult group and the two control groups.

To ascertain the level to which the language measures correlated with and predicted performance speed for correct responses in the priming task we ran a second Pearson's correlation analysis. For ASD young adults, speed correlated only with receptive vocabulary size (r=.515; n=19; p-value=.02). A linear regression analysis confirmed that performance speed was predicted by receptive vocabulary size (R^2=.265, $F(1, 17)$=6.144, p-value=.02) (Figure 3). The correlation between ToM and speed was marginally significant (r =.443; n=19; p-value=.057).

For control young adults, no correlations were found between speed and any verbal measure or ToM.

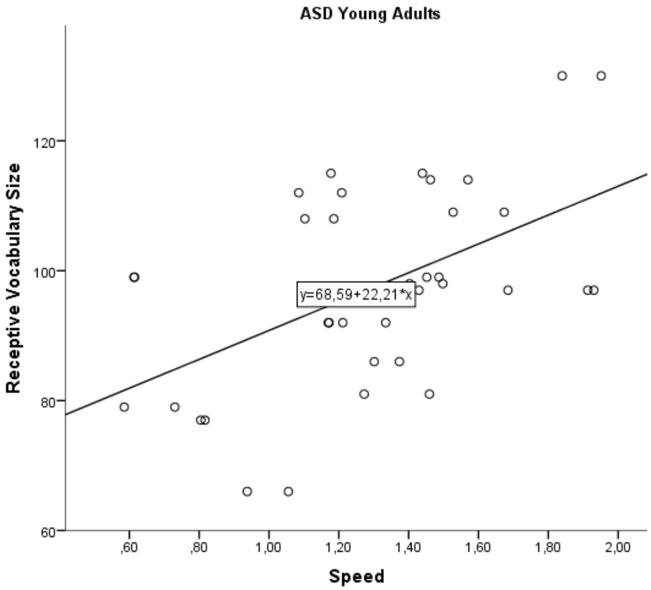

FIGURE 3. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS' SPEED AND RECEPTIVE VOCABULARY SIZE.

No correlation was found for the ASD children group between speed and language measures. For control children, only receptive grammar correlated with speed (r=-.103; n=18; p-value=.005), but the regression analysis did not confirm the role of speed as a predictor.

3.3 Results by experimental conditions

3.3.1 Visual vs. auditory modality condition

The next step in our analysis was checking how the different conditions in the experimental study correlate with the language measures and influence the accuracy and speed of the participants.

First, we checked the extent to which language measures predict speed and accuracy in the two experimental modalities, the visual and the auditory modality. For ASD young adults, receptive vocabulary size correlated with speed in both the visual modality (r=.514; n=19; p-value=.024) and the auditory modality (r=.472; n=19; p-value=.041). A linear regression analysis showed that speed was significantly predicted by receptive vocabulary size both in the auditory modality (R^2=.223, $F(1, 17)$=4.884, p-value=.036) (Figure 4) and in the visual modality (R^2=.469, $F(1,17)$=4.806, p-value=.021) (Figure 5). No correlation was found for ASD young adults between language measures and accuracy.

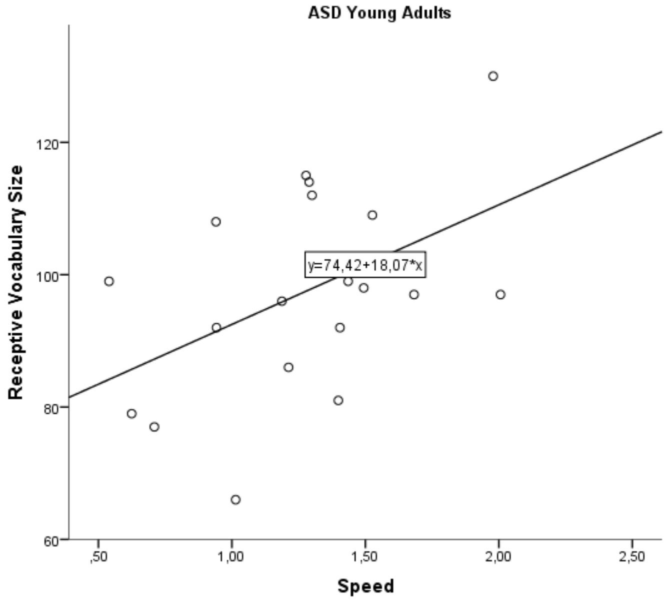

FIGURE 4. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS' SPEED AND RECEPTIVE VOCABULARY SIZE IN THE AUDITORY MODALITY CONDITION

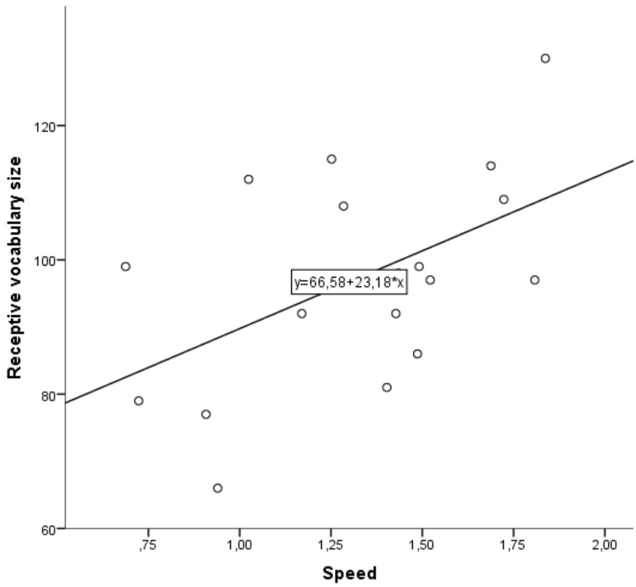

FIGURE 5. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS' SPEED AND RECEPTIVE VOCABULARY SIZE IN THE VISUAL MODALITY CONDITION.

For ASD children, a correlation was found in the auditory modality between accuracy and verbal comprehension (r=.518; n=22; p-value=.014), and receptive grammar scores (r=.475; n=21: p-value=.029). A linear regression analysis showed that accuracy was predicted by verbal comprehension only (R^2=.268, F(1,20)=7.328, p-value=.01) (Figure 6).

No correlations were found in the two modality conditions for the control groups.

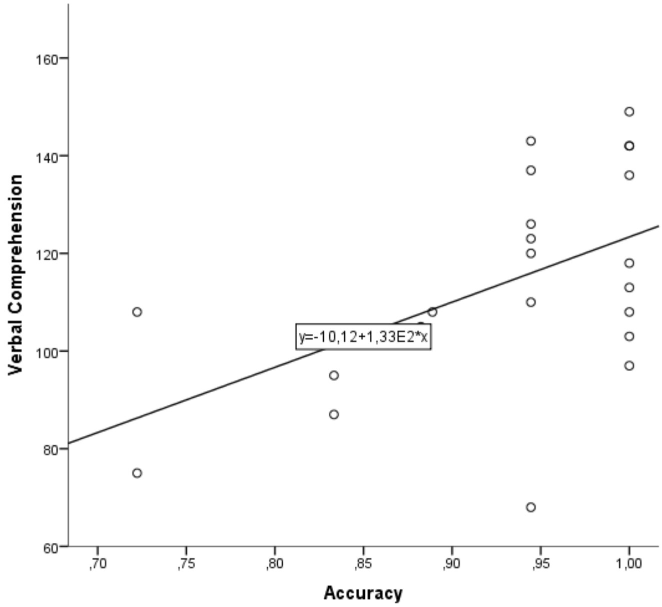

FIGURE 6. LINEAR REGRESSION MODEL FOR ASD CHILDREN' ACCURACY AND VERBAL COMPREHENSION IN THE AUDITORY MODALITY CONDITION.

3.3.2 Conventional Metaphor vs. Novel Metaphor vs. Free Expression condition

We also wanted to check whether the background language measures predict participants' performance depending on the type of expression of the prime in the study. For conventional metaphors, a significant correlation was found only for ASD young adults between speed and receptive vocabulary size (r=.606; n=19; p-value=.006). In order to be able to compare with the other analyses in this study, we ran a linear regression which showed that speed for conventional metaphors was significantly predicted by receptive vocabulary size (R^2=.367, F(1, 17)=9.848, p-value=.005) (Figure 7).

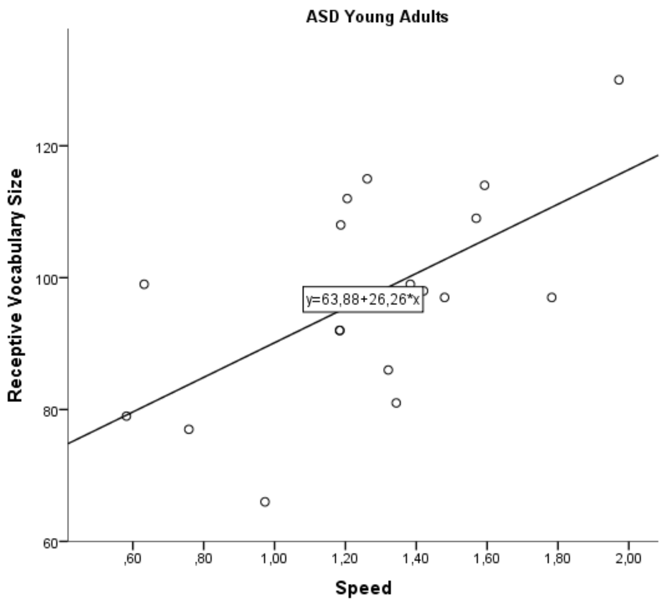

FIGURE 7. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS' SPEED AND RECEPTIVE VOCABULARY SIZE IN CONVENTIONAL METAPHORS CONDITION.

For novel metaphors, no significant correlations were found for any age group.

This was not the case for free combination (literal) expressions. For ASD young adults only speed, but not accuracy correlated with receptive vocabulary size (r=.527; n=19; p-value=.021). A linear regression analysis showed that receptive vocabulary size predicted speed (R^2=.277, F(1,17)=6.527, p-value=.024) (Figure 8). For ASD children, accuracy correlated with verbal comprehension (r =.552; n=22; p-value=.008) and receptive grammar scores (r =.617; n=21; p-value=.003). A linear regression analysis showed that only receptive grammar predicted accuracy (R^2=.380; F(1, 19)=11.667, p-value=.003) (Figure 9).

No correlations were observed for either of the control groups.

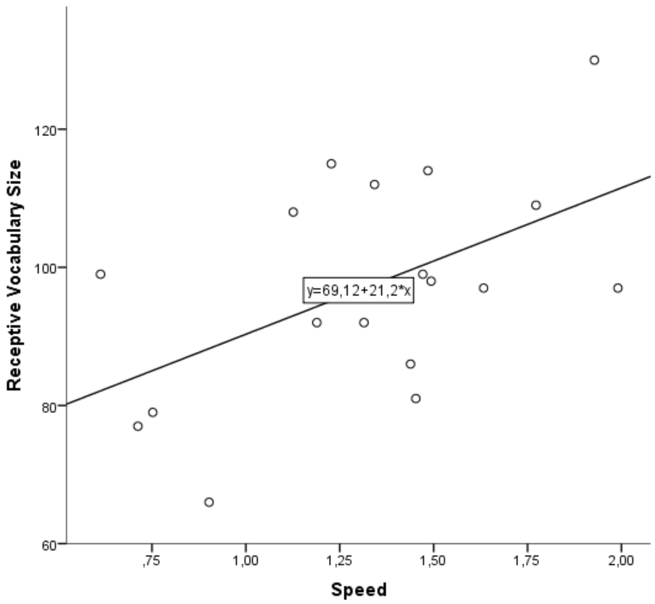

FIGURE 8. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS' SPEED AND RECEPTIVE VOCABULARY SIZE IN THE FREE COMBINATION TYPE OF EXPRESSION.

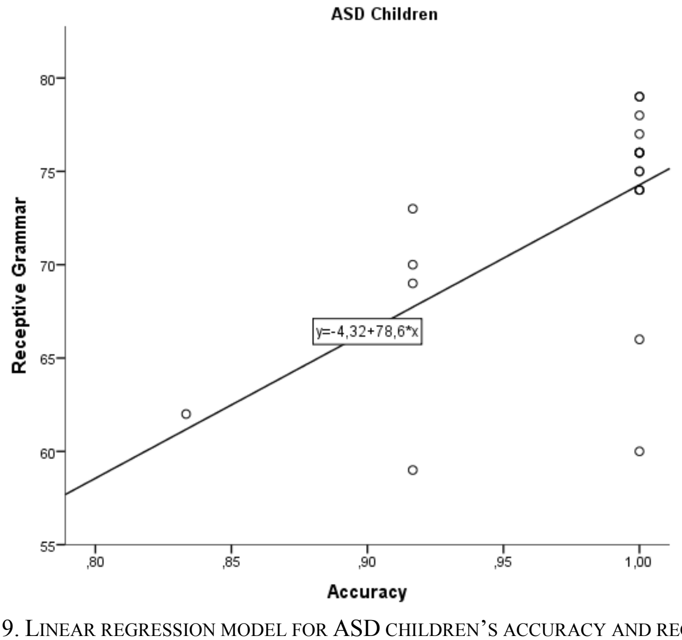

FIGURE 9. LINEAR REGRESSION MODEL FOR ASD CHILDREN'S ACCURACY AND RECEPTIVE GRAMMAR IN THE FREE COMBINATION TYPE OF EXPRESSION.

3.3.3 Metaphorical vs. Literal Prime condition

A crucial test in the experiment was whether performance in the condition where the relationship between the prime and target was literal, in comparison to the condition where the relation was metaphorical, was differentially predicted by the background language measures.

In the literal condition, the older groups showed no significant correlations. For ASD children, accuracy correlated with verbal comprehension (r=.437; n=22; p-value=.042) and a linear regression analysis showed that accuracy was significantly predicted by the verbal comprehension scores (R^2=.191, $F(1, 20)$=4.416, p-value=.004) (Figure 10). Interestingly, for control children, accuracy in that condition correlated negatively with receptive vocabulary size (r=-.485; n=22; p-value=.022). This was confirmed by a linear regression analysis which showed that receptive vocabulary size predicted accuracy with a negative slope (R^2=.235, $F(1, 20)$=4.416, p-value=.022) (Figure 11).

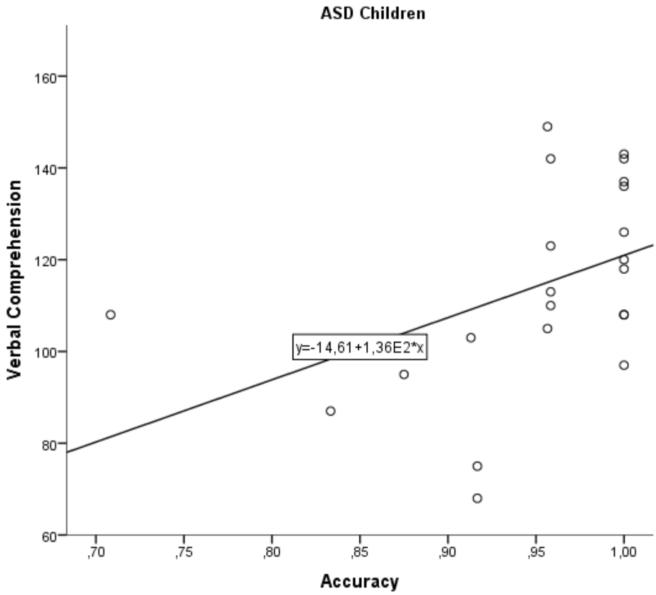

FIGURE 10. LINEAR REGRESSION MODEL FOR ASD CHILDREN'S ACCURACY AND VERBAL COMPREHENSION WHEN THE RELATION BETWEEN PRIME AND TARGET IS LITERAL.

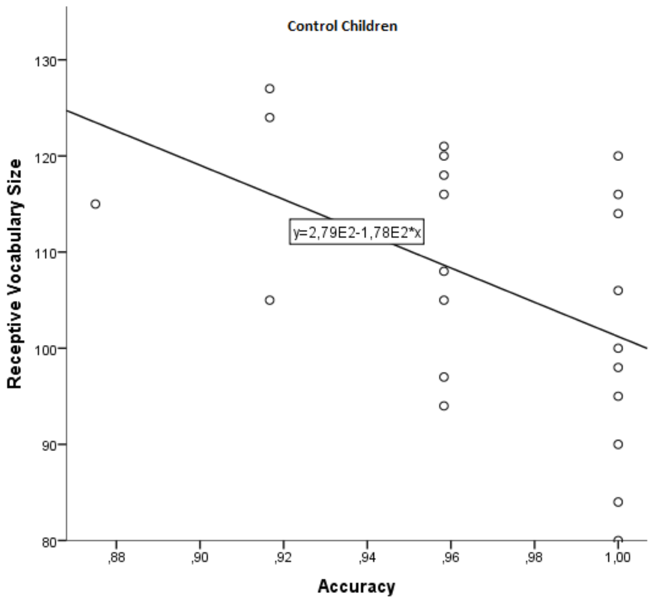

FIGURE 11. LINEAR REGRESSION MODEL FOR CONTROL CHILDREN'S ACCURACY AND RECEPTIVE VOCABULARY SIZE WHEN THE RELATION BETWEEN PRIME AND TARGET IS LITERAL.

In the metaphorical relation between prime and target condition, for ASD young adults, speed correlated with receptive vocabulary size (r=.550; n=19; p-value=.015), and a linear regression analysis confirmed that receptive vocabulary predicted speed in that group (R^2=.302; F(1,17)=7.359, p-value=.012) (Figure 12).

For ASD children, accuracy correlated with verbal comprehension (r=.426; n=22; p-value=.048) and a linear regression analysis confirmed that verbal comprehension predicts accuracy in that group (R^2=.181; F(1,20)=4.427, p-value=.048) (Figure 13). No correlations were found in the metaphorical relation condition for any of the control groups.

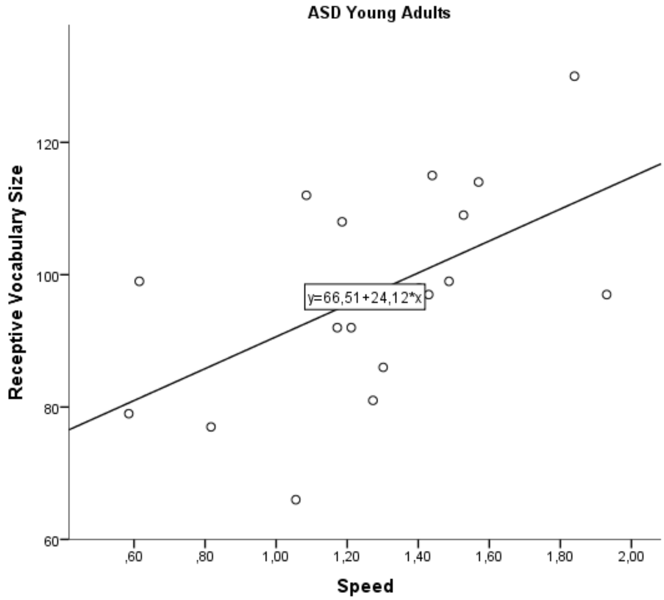

FIGURE 12. LINEAR REGRESSION MODEL FOR ASD YOUNG ADULTS AND RECEPTIVE VOCABULARY SIZE WHEN THE RELATION BETWEEN PRIME AND TARGET IS METAPHORICAL.

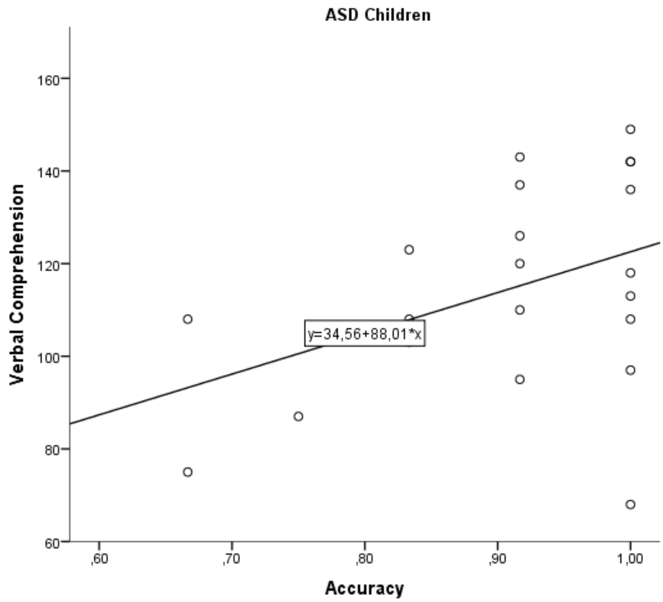

FIGURE 13. LINEAR REGRESSION MODEL FOR ASD CHILDREN AND VERBAL COMPREHENSION WHEN THE RELATION BETWEEN PRIME AND TARGET IS METAPHORICAL.

4. DISCUSSION

The study reported in this paper aimed to establish the relationship between language skills and competences and the processing of metaphors in two age groups of high functioning autistic participants compared to controls matched on age, IQ measures and verbal comprehension. We were also interested in the contribution of Theory of Mind (ToM) ability to metaphorical comprehension. The task exploited priming as a well-attested mechanism, which taps semantic or structural relations among lexical items in the mental lexicon. The expressions included in the experimental study were either metaphors requiring a figurative interpretation or free expressions, which required a literal interpretation. For the metaphorical expressions, the relationship between prime and target was either figurative, thus expecting faster and more accurate processing of the target word, or literal, expecting slower and possibly less accurate responses in the control participants, but less so for the autistic participants. We also expected that the background language measures would predict performance on the experimental task modulated by age and experimental condition. The results from Pearson's correlations and regression analyses showed an interesting and complex pattern of relationship between language skills and figurative language competence. No significant correlations were observed for any of the groups between ToM scores and any of the independent variables.

Interestingly, significant correlations were found overwhelmingly for the two ASD groups, but not to a similar extent for the two control groups. Overall, this is consistent with Norbury (2005), who found that semantic skills largely determine metaphorical understanding for participants in her study. However, the absence of a relationship between basic vocabulary, receptive grammar and semantic skills and metaphor comprehension in the control groups is surprising. A closer look at the results, however, may suggest that, while the participants with autism are still acquiring both some of the language competences and the ability to process metaphors, the controls are already past the stage where basic language skills continue to exert an influence on figurative language processing. This applies to both control age groups and is consistent with research in figurative language in typical development (Vulchanova et al. 2011; Kempler et al. 1999). Supportive evidence is the fact that no correlations were found in the two control groups in the condition where the relationship between the prime expression and the target word was metaphorical. Further evidence of this is the seemingly paradoxical negative correlation between vocabulary size and accuracy only in the condition where the relationship between metaphor prime and target word was literal, found only in the children control group. These results suggest that, for typical children with adequate vocabulary size, there is an interference between the metaphorical nature of the expression and the availability of a figurative interpretation in the presence of a word whose relationship to the prime is only literal. Also evidence from research in other language competences and skills shows a changing predictive force of predictors over development and the acquisition of the skill at hand. In the domain of reading acquisition predictors, such as letter knowledge and phonological awareness are reliable predictors at the initial stages, but not in later school years (Landerl & Wimmer 2008; Lervåg et al. 2009; Caravolas et al. 2013). Our findings are also consistent with the changing dimensionality of language skills over development, as attested in a recent longitudinal large-scale study (Caine et al. 2015).

The results from the two ASD groups indicate an interesting pattern of differential relationship between language competences and performance speed and accuracy depending on age. While for the older group of participants (ASD young adults) language skills exert an influence on speed, for the younger participants (ASD children), language competences influence accuracy, suggesting that the experimental design with alternating conditions (auditory vs. visual modality; figurative vs. literal relation between prime and target) is more demanding for the children, and requires the recruitment of core language skills. It should be noted that between the two performance measures used in the study, reaction speed taps the priming effect of the figurative expression, and as such measures figurative language comprehension. Accuracy essentially measures the ability to decide whether the target word is a real word or not. As such, it is not directly related to the main goal of the study. However, errors in accuracy can reveal potential interference effects in non-congruent trials (e.g. in trials where a metaphor prime precedes a target word related to it literally). This is demonstrated in the accuracy effects in the younger ASD group.

Another overall result is that, while for the ASD young adults there is a systematic relationship between vocabulary size and performance speed in the different conditions, for the younger group of participants with autism (ASD children), it is verbal comprehension that predicts performance on the task. The latter relationship indicates that figurative language comprehension, at least in initial stages of development, depends on a number of other skills: conceptual relations (mapping between concepts), similarities, reasoning and conceptualization, factual knowledge (e.g., the knowledge base). Apparently, the younger participants with autism in our study are still developing the strategies of how to recruit these types of competences in processing non-literal language. Receptive vocabulary is the most important predictor of speed on both conventional and novel metaphors, as well as in the auditory modality in the older ASD group. These findings contradict the findings in Norbury (2005) and the suggestion for a greater role of semantic skills, rather than sheer vocabulary size. The interpretation of the current results, however, is more open. These results may suggest that this age group is already at a more advanced stage and have automatized their processing strategies resulting in an influence of vocabulary size only on speed. Alternatively, since the task is a lexical decision on target items, a possible account may be that participants are not involved in processing the metaphorical aspects of the expressions, but are simply responding to the task.

Another result worth of notice is the predictive power found for receptive grammar for the children with ASD in the free (literal) expression condition and in the auditory modality condition, suggesting the role of structural language in the processing of non-figurative contexts, and more generally, for oral language. Interestingly, receptive grammar does not appear to predict figurative language comprehension in any other condition in either controls or participants with ASD, suggesting that figurative language requires more complex skills and quite possibly relies on their integration.

In this study we did not find any correlations between performance speed and accuracy and Theory of Mind measures in any of the groups. This result may be explained by the nature of the task which is based on metaphors. If the mechanism of processing metaphors operates on the basis of conceptual combination (Coulson & Van Petten 2002; Fauconnier 1985) and relies on analogy, it cannot be expected to be so strongly related to reading interlocutors' minds, but rather to conceptual operations and thought.

In the current study, we matched participants on verbal comprehension competences, which provided us with certainty that the individuals with ASD in the sample had intact language competence, and were similar to controls, despite individual differences. In addition, we controlled for the possibility of age being a predictor. It is quite common in studies of developmental deficits to use non-homogeneous age groups with big age variation. Moreover, figurative language is still developing also in adolescence (Nippold 1998). In this study, we used two different age-homogeneous groups, the first one, from ten to twelve years of age when figurative language understanding starts approximating adult knowledge, and young adults when this knowledge is already acquired. In this sense, the results may inform about figurative language development from a cross-sectional perspective. Our results suggest that different predictors exert an influence on the processing of figurative language at different stages of development in the autistic groups. Furthermore, we found that both control groups appear to have more developed understanding of figurative expressions and are at stage where structural language skills, vocabulary size and verbal comprehension no longer impact on figurative language competences. These results are consistent with other research demonstrating that figurative language development starts flattening out after age 10-12 (Vulchanova et al. 2011; Kempler et al. 1999). In contrast, figurative language comprehension appears to be still developing in the autistic groups of participants, where core language skills still exert an influence on performance. These results imply a different developmental trajectory in the ASD group compared to age- and language skills-matched controls.

ACKNOWLEDGEMENTS

This research has received funding from the European Union's Seventh Framework Program for research, technological development and demonstration under grant agreement n° 316748. We would like to thank the participants and the families for their effort and time in participating in this study. We are also grateful to ESR Martina Micai for helping in data collection, the Asociación Malagueña Síndrome de Asperger y TEA (AMSA), Spain for access to the ASD group, I.E.S. Martínez Montañés, and C.E.P. La Borbolla, Seville, Spain for access to the TD group.

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Sobh Chahboun
Language Acquisition and Language Processing Lab
Department of Language & Literature, NTNU
7491 Trondheim
Norway
email: sobh.chahboun@ntnu.no

Valentin Vulchanov
Language Acquisition and Language Processing Lab
Department of Language & Literature, NTNU
7491 Trondheim
Norway
email: valentin.vulchanov@ntnu.no

David Saldaña
Language, Cognition and Individual Differences Lab,
Faculty of Psychology, University of Seville
41018 Seville
Spain
email: dsaldana@us.es

Hendrik Eshuis
Language Acquisition and Language Processing Lab
Department of Language & Literature, NTNU
7491 Trondheim
Norway
email: hendrik.eshuis@ntnu.no

Mila Vulchanova
Language Acquisition and Language Processing Lab
Department of Language & Literature, NTNU
7491 Trondheim
Norway
email: mila.vulchanova@ntnu.no

APPENDIX 1

DESCRIPTIVE STATISTICS FOR LANGUAGE MEASURES, TOM AND SPEED

AGE GROUP		N	Minimum	Maximum	Sum	Mean		Std. deviation	Variance
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
ASD young adults	Verbal comprehension	18	68	147	2133	118,50	5,138	21,799	475,206
	Receptive vocabulary size	19	66	130	1847	97,21	3,551	15,480	239,620
	Receptive grammar	20	68	80	1489	74,45	,773	3,456	11,945
	ToM	19	2	7	98	5,16	,327	1,425	2,029
	Speed	20	,61	1,92	25,85	1,2925	,07835	,35037	,123
	Valid N (listwise)	17							
Control young adults	Verbal comprehension	15	92	150	1781	118,73	4,451	17,240	297,210
	Receptive vocabulary size	17	88	132	1856	109,18	2,659	10,961	120,154
	Receptive grammar	18	75	80	1420	78,89	,332	1,410	1,987
	ToM	13	6	7	88	6,77	,122	,439	,192
	Speed	18	1,08	2,20	29,72	1,6513	,07019	,29780	,089
	Valid N (listwise)	11							
ASD children	Verbal comprehension	22	68	149	2513	114,23	4,714	22,110	488,851
	Receptive vocabulary size	22	55	124	2305	104,77	4,078	19,128	365,898
	Receptive grammar	21	59	79	1514	72,10	1,338	6,131	37,590
	ToM	20	1	7	94	4,70	,371	1,658	2,747
	Speed	22	,42	1,39	22,29	1,0132	,04824	,22627	,051
	Valid N (listwise)	19							
Control children	Verbal comprehension	18	85	139	1961	108,94	3,845	16,315	266,173
	Receptive vocabulary size	22	80	127	2353	106,95	2,837	13,308	177,093
	Receptive grammar	22	62	79	1626	73,91	,811	3,804	14,468
	ToM	18	5	7	113	6,28	,195	,826	,683
	Speed	22	,85	1,62	27,87	1,2669	,04647	,21798	,048
	Valid N (listwise)	15							

APPENDIX 2

DESCRIPTIVE STATISTICS FOR LANGUAGE MEASURES, TOM AND ACCURACY

AGE GROUP		N	Minimum	Maximum	Sum	Mean		Std. deviation	Variance
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
ASD young adults	Verbal comprehension	18	68	147	2133	118,50	5,138	21,799	475,206
	Receptive vocabulary size	19	66	130	1847	97,21	3,551	15,480	239,620
	Receptive grammar	20	68	80	1489	74,45	,773	3,456	11,945
	ToM	19	2	7	98	5,16	,327	1,425	2,029
	Accuracy	20	,88	1,00	19,62	,9808	,00676	,03024	,001
	Valid N (listwise)	17							
Control young adults	Verbal comprehension	15	92	150	1781	118,73	4,451	17,240	297,210
	Receptive vocabulary size	17	88	132	1856	109,18	2,659	10,961	120,154
	Receptive grammar	18	75	80	1420	78,89	,332	1,410	1,987
	ToM	13	6	7	88	6,77	,122	,439	,192
	Accuracy	18	,82	1,00	17,53	,9741	,01037	,04399	,002
	Valid N (listwise)	11							
ASD children	Verbal comprehension	22	68	149	2513	114,23	4,714	22,110	488,851
	Receptive vocabulary size	22	55	124	2305	104,77	4,078	19,128	365,898
	Receptive grammar	21	59	79	1514	72,10	1,338	6,131	37,590
	ToM	20	1	7	94	4,70	,371	1,658	2,747
	Accuracy	22	,65	1,00	20,43	,9288	,01802	,08454	,007
	Valid N (listwise)	19							
Control children	Verbal comprehension	18	85	139	1961	108,94	3,845	16,315	266,173
	Receptive vocabulary size	22	80	127	2353	106,95	2,837	13,308	177,093
	Receptive grammar	22	62	79	1626	73,91	,811	3,804	14,468
	ToM	18	5	7	113	6,28	,195	,826	,683
	Accuracy	22	,90	1,00	21,32	,9689	,00705	,03305	,001
	Valid N (listwise)	15							

APPENDIX 3

PEARSON'S CORRELATIONS FOR LANGUAGE MEASURES, TOM AND ACCURACY

AGE GROUP		Correlation	Verbal comprehension	Receptive vocabulary size	Receptive grammar	ToM	Accuracy
ASD young adults	Verbal comprehension	Pearson	1	,662**	,409.	,632**	-,159
	Receptive vocabulary size	Pearson	,662**	1	,345	,558*	,071
	Receptive grammar	Pearson	,409.	,345	1	,385	,162
	ToM	Pearson	,632**	,558*	,385	1	,303
	Accuracy	Pearson	-,159	,071	,162	,303	1
Control young adults	Verbal comprehension	Pearson	1	,273	,455	,578	,264
	Receptive vocabulary size	Pearson	,273	1	,238	,204	-,045
	Receptive grammar	Pearson	,455	,238	1	-,056	-,239
	ToM	Pearson	,578	,204	-,056	1	,429
	Accuracy	Pearson	,264	-,045	-,239	,429	1
ASD children	Verbal comprehension	Pearson	1	,535*	,642**	,535*	,447*
	Receptive vocabulary size	Pearson	,535*	1	,624**	,574**	,223
	Receptive grammar	Pearson	,642**	,624**	1	,533*	,394.
	ToM	Pearson	,535*	,574**	,533*	1	,131
	Accuracy	Pearson	,447*	,223	,394	,131	1
Control children	Verbal comprehension	Pearson	1	,435	,115	,187	,069
	Receptive vocabulary size	Pearson	,435.	1	,134	,011	-,288
	Receptive grammar	Pearson	,115	,134	1	,180	,273
	ToM	Pearson	,187	,011	,180	1	-,146
	Accuracy	Pearson	,069	-,288	,273	-,146	1

** Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 4

PEARSON'S CORRELATIONS FOR LANGUAGE MEASURES, TOM AND SPEED

AGE GROUP		Correla-tion	Verbal compre-hension	Receptive vocabulary size	Receptive grammar	ToM	Accuracy
ASD young adults	Verbal comprehension	Pearson	1	,662**	,409	,632**	,317
	Receptive vocabulary size	Pearson	,662**	1	,345	,558*	,515*
	Receptive grammar	Pearson	,409	,345	1	,385	,325
	ToM	Pearson	,632**	,558*	,385	1	,443.
	Speed	Pearson	,317	,515*	,325	,443.	1
Con-trol young adults	Verbal comprehension	Pearson	1	,273	,455	,578	,370
	Receptive vocabulary size	Pearson	,273	1	,238	,204	,182
	Receptive grammar	Pearson	,455.	,238	1	-,056	,247
	ToM	Pearson	,578.	,204	-,056	1	,302
	Speed	Pearson	,370	,182	,247	,302	1
ASD chil-dren	Verbal comprehension	Pearson	1	,535*	,642**	,535*	-,018
	Receptive vocabulary size	Pearson	,535*	1	,624**	,574**	-,030
	Receptive grammar	Pearson	,642**	,624**	1	,533*	,060
	ToM	Pearson	,535*	,574**	,533*	1	-,156
	Speed	Pearson	-,018	-,030	,060	-,156	1
Con-trol chil-dren	Verbal comprehension	Pearson	1	,435.	,115	,187	-,073
	Receptive vocabulary size	Pearson	,435.	1	,134	,011	-,063
	Receptive grammar	Pearson	,115	,134	1	,180	-,172
	ToM	Pearson	,187	,011	,180	1	-,293
	Speed	Pearson	-,073	-,063	-,172	-,293	1

** Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 5

LINEAR REGRESSION MODEL FOR TOM AND SPEED

MODEL SUMMARY

AGE GROUP	Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics				
						R square change	F change	df1	df2	Sig. F change
ASD young adults	1	,443[a]	,196	,149	,30194	,196	4,155	1	17	,057 .
Control young adults	1	,302[a]	,091	,009	,30183	,091	1,106	1	11	,316
ASD children	1	,156[a]	,024	-,030	,22440	,024	,452	1	18	,510
Control children	1	,293[a]	,086	,029	,22017	,086	1,501	1	16	,238

ANOVA

AGE GROUP	Model		Sum of squares	df	Mean square	F	Sig.
ASD young adults	1	Regression	,379	1	,379	4,155 .	,057[b] .
		Residual	1,550	17	,091		
		Total	1,929	18			
Control young adults	1	Regression	,101	1	,101	1,106	,316[b]
		Residual	1,002	11	,091		
		Total	1,103	12			
ASD chil-dren	1	Regression	,023	1	,023	,452	,510[b]
		Residual	,906	18	,050		
		Total	,929	19			
Control chil-dren	1	Regression	,073	1	,073	1,501	,238[b]
		Residual	,776	16	,048		
		Total	,848	17			

APPENDIX 6

LINEAR REGRESSION MODEL FOR TOM AND ACCURACY

MODEL SUMMARY

AGE GROUP	Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics				
						R square change	F change	df1	df2	Sig. F change
ASD young adults	1	,303[a]	,092	,038	,03046	,092	1,717	1	17	,208
Control young adults	1	,429[a]	,184	,110	,04820	,184	2,483	1	11	,143
ASD children	1	,131[a]	,017	-,038	,08837	,017	,312	1	18	,583
Control children	1	,146[a]	,021	-,040	,03461	,021	,347	1	16	,564

ANOVA

AGE GROUP	Model		Sum of squares	df	Mean square	F	Sig.
ASD young adults	1	Regression	,002	1	,002	1,717	,208[b]
		Residual	,016	17	,001		
		Total	,017	18			
Control young adults	1	Regression	,006	1	,006	2,483	,143[b]
		Residual	,026	11	,002		
		Total	,031	12			
ASD chil-dren	1	Regression	,002	1	,002	,312	,583[b]
		Residual	,141	18	,008		
		Total	,143	19			
Control chil-dren	1	Regression	,000	1	,000	,347	,564[b]
		Residual	,019	16	,001		
		Total	,020	17			