

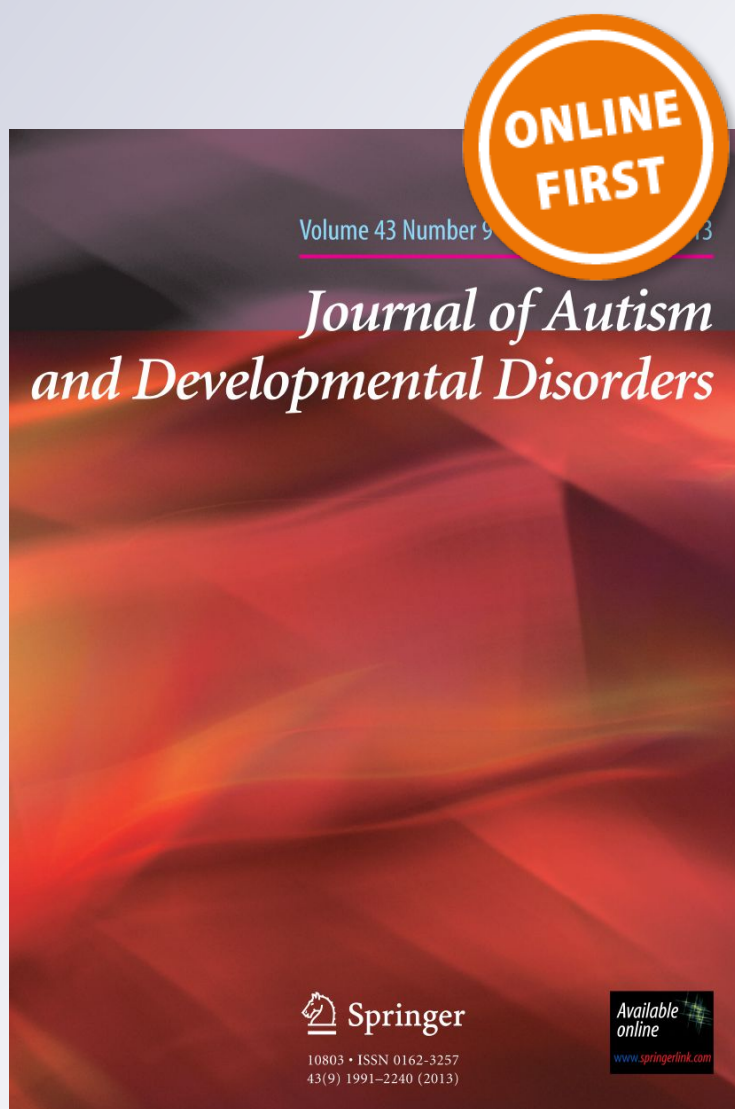
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# Different Factors Predict Idiom Comprehension in Children and Adolescents with ASD and Typical Development

Ronit Saban-Bezalel<sup>1,2</sup> · Nira Mashal<sup>2,3</sup>

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## Abstract

Autism spectrum disorder (ASD) is associated with deficient comprehension of figurative language and, specifically, idioms. Theories ascribe this to deficits in specific abilities (e.g., Theory of Mind [ToM]; executive functions [EF]; general language skills), but no comprehensive theory has resulted. This study investigated the differential contribution of various abilities to idiom comprehension among children and adolescents with ASD compared to matched controls with typical development (TD). The TD group outperformed the ASD group in idiom comprehension. However, whereas EF predicted idiom comprehension in the TD group, vocabulary predicted idiom comprehension in the ASD group. Our findings emphasize the link between general language competence and figurative language comprehension in ASD and point to different processing mechanisms in each group.

**Keywords** ASD · Idioms · Vocabulary abilities · ToM · Executive functions

Idioms are defined as strings of two or more words whose meaning is not directly derived from their direct verbal interpretation, but rather stores a unique figurative meaning (Roberts and Kruez 1994; Swinney and Cutler 1979). As such, idiomatic expressions possess a significant gap between what the speaker says (i.e., the literal meaning) and what the speaker means (Jakimova 2010). The ability to comprehend idioms is essential; they are common in daily life discourse, in routine classroom activity (Kerbel and Grunwell 1997), and in electronic and written media (Cooper 1999).

Three major psycholinguistic theories attempt to explain idiom processing. The Lexical Representation Hypothesis

(Swinney and Cutler 1979) posits that idioms are stored and retrieved from the lexicon as one unit, like any other word. On the other hand, the Configuration Hypothesis (Cacciari and Tabossi 1988) claims that each idiom has a “keyword,” a word that leads to its identification. Hence, an idiom will be retrieved from the mental lexicon only after accessing the “keyword.” A different approach, named the Idiom Decomposition Hypothesis (IDH; Gibbs et al. 1989), posits that idiom processing is determined by the degree of the idiom’s decomposability. Decomposability refers to the extent to which the words that construct the idioms contribute to the figurative interpretation (Libben and Titone 2008). Decomposable idioms (i.e., “pop the question”) are processed faster than non-decomposable idioms (i.e., “kick the bucket”) due to consistency between the linguistic and idiomatic meaning (Tabossi et al. 2009).

Idioms are considered a heterogeneous group of expressions that vary in semantic transparency, familiarity, and literality. Transparency refers to the degree of similarity between the literal meaning of the expression and its idiomatic interpretation. Transparent idioms, similar to decomposable idioms, are easier to comprehend, as the listener can rely upon the idiom’s literal meaning during processing. When the literal and idiomatic meanings are not related, the idiom is considered opaque (Nippold and Taylor 2002). Transparent and familiar idioms are easier to identify than

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opaque and less familiar idioms (Libben and Titone 2008; Vulchanova et al. 2015). Finally, literalness refers to idioms that hold a figurative meaning and plausible literal interpretation (i.e., kick the bucket).

Autism spectrum disorder (ASD) is reflected in a continuum of abilities and difficulties. According to the diagnostic and statistical manual of mental disorders (5th ed.; DSM-5; American Psychiatric Association 2013) a core disability of ASD lies in the social and communicative domain, of which comprehension of figurative language plays a significant role. Previous research examining figurative language processing in ASD indicates deficient comprehension and a tendency toward literal interpretation (Mackay and Shaw 2004). Indeed, the figurative comprehension abilities of children with ASD have been found to be comparable to children with typical development (TD) at younger ages (Abrahamsen and Smith 2000; Mackay and Shaw 2004; Rundblad and Annaz 2010). Several studies also examined idiom comprehension, an important subset of figurative language, among children, adolescents, and adults with ASD. Mashal and Kasirer (2011) examined idiom comprehension in adolescents with ASD using a multiple-choice questionnaire, and found adolescents with ASD (aged 12–15 years) identified fewer idiomatic meanings correctly compared to adolescents with TD (aged 12–13 years). In another study, children aged 5–12 years with ASD demonstrated comparable idiom performance to a syntax- and age-matched group with TD; additionally, ToM abilities were found related to idiom comprehension for the children with ASD, but not for the children with TD (Whyte et al. 2014). Norbury (2004) compared the ability to comprehend idioms in isolation and in context among children with ASD features, children with TD, and children with language impairment. The study showed that age, language abilities, and memory of the story's context were significant predictors of idiom comprehension in context. Among adults with ASD, a recent study of Saban-Bezelel and Mashal (2015) did not find difference in idiom comprehension compared to adults with TD when matched by expressive vocabulary abilities; however, a different pattern of hemispheric processing was observed. While processing the non-salient literal interpretations of idioms, adults with ASD demonstrated a bilateral pattern of hemisphere processing, whereas adults with TD showed a right hemisphere advantage; this suggests that adults with ASD use compensation mechanisms when interpreting figurative language (Saban-Bezelel and Mashal 2015).

Several approaches explaining the underlying difficulties observed in figurative language comprehension in ASD have been suggested. One of the major theories suggests that the root of social disability in ASD is deficiency in 'theory of mind' (ToM) ability (Baron-Cohen et al. 2001). According to this theory, individuals with ASD have difficulty grasping the mental state of the other, thereby making it particularly

difficult to understand social situations and communications used within them. For instance, when interpreting a figurative utterance, unlike literal language, the listener must understand the mental state of the speaker and deduce what the speaker means by his or her words. Hence, difficulty in mentalizing processes may contribute to difficulties in comprehension of figurative language. Indeed, Happé (1995) found that the ability to cope with ToM tasks predicted figurative language comprehension among children and adolescents with ASD. Only those who were able to successfully complete first order ToM tasks were able to comprehend metaphors; nevertheless, they still did not comprehend irony. In contrast, children and adolescents with ASD who were able to complete second-order ToM tasks succeeded in the comprehension of both metaphor and irony. Further support for the link between ToM ability and irony comprehension comes from a recent study that examined irony comprehension in children and adolescents with ASD and TD matched by age, language abilities, and executive function abilities (Saban-Bezelel et al. 2019). The TD group outperformed the ASD group on the irony comprehension task, but after the two groups were matched by second order ToM ability using the Hinting task (Corcoran et al. 1995), the difference in irony comprehension performance was eliminated. The link between ToM ability and idiom comprehension, on the other hand, has been established in children with ASD but not in children with TD (Whyte et al. 2014). Thus, understanding both irony and idioms in ASD requires mentalizing and language abilities (Pexman et al. 2019).

Gransbacher and Pripas-Kapit (2012) assert that individuals with ASD have no specific difficulty in figurative language comprehension, but rather a general difficulty in language comprehension. The authors note that gaps in figurative language comprehension previously found among individuals with ASD are, in fact, due to inadequate matching between study groups, such as matching solely based on receptive vocabulary comprehension (Gransbacher and Pripas-Kapit 2012). Indeed, findings from studies comparing figurative language comprehension in TD and ASD populations matched according to language proficiency support this contention (Norbury 2004; Saban-Bezelel and Mashal 2015; Whyte et al. 2014). Giora et al. (2012) also found that general language comprehension abilities, rather than autistic characteristics, are associated with the comprehension of ambiguous concepts. Further support for the role of general language abilities in figurative language comprehension was also discovered in a recent meta-analysis that examined figurative language comprehension in ASD (Kalandadze et al. 2016).

Other researchers attribute figurative language comprehension difficulties in ASD to a different cognitive source, namely, executive functioning. Executive functions (EF) refer to a variety of highly cognitive skills including

flexibility, inhibition, planning, working memory, initiation, and monitoring of operations. A recent meta-analysis of a wide range of EF tests established the presence of executive dysfunction in children and adolescents with high functioning ASD (Lai et al. 2017). In particular, a lack of mental flexibility (rigidity) can cause difficulty in switching between the different meanings (literal and non-literal) of a figurative expression (Landa and Goldberg 2005; Cummings 2009). Indeed, Mashal and Kasirer (2011) found that children with ASD were less successful in comprehension of idioms and conventional metaphors than their TD peers and performed more poorly on language-based executive functioning tasks. Consistent with these findings, Landa and Goldberg (2005) found that participants with ASD aged 7–17 performed less well on figurative language tasks and most tasks that involved executive functions, compared to a TD group; nevertheless, no significant relationship between figurative language comprehension and executive functions was found. A recent study by Kasirer and Mashal (2016) investigated which skills predicted performance in comprehension of familiar and unfamiliar metaphors in adolescents with ASD and TD. The potential predictors included scores on verbal tests (vocabulary, naming), non-verbal tests (Test of Non-Verbal Intelligence), and tests of executive functioning (fluency, Trail Making Test). The results revealed that only vocabulary, in addition to group membership, contributed to the prediction of comprehension of both types of metaphors; EF added nothing to the prediction beyond the background variables (Kasirer and Mashal 2016). However, it still remains unclear which abilities contribute to figurative language comprehension in each group (ASD, TD) independently.

Vulchanova et al. (2015) assert that the persistent difficulty in figurative language comprehension in ASD arises from an inability to judge the plausibility of events, and understand a co-locutor's intention in presenting a message. More specifically, Vulchanova et al. (2015) presented a different approach in which they attributed the difficulty of those with ASD to comprehend figurative language to a more general cognitive mechanism. According to this approach, during the language comprehension process, the listener is required to construct a mental representation of the meaning of the message (i.e., situation models). The authors contend that individuals with ASD find it difficult to build adequate representations while processing figurative language due to their difficulty in identifying the significant information that arises from the context and integrating the information. In summary, there is no consensus among researchers as to the origin of figurative language comprehension deficits found in ASD. Although this difficulty is mostly attributed to cognitive characteristics or language abilities of individuals with ASD, it is still unclear which abilities contribute to figurative language comprehension in ASD.

The present study intended to clarify the contribution of various abilities on figurative language comprehension in ASD by examining idiom comprehension among children and adolescents with ASD compared to age- and language-matched children and adolescents with TD. The study examined the differential contribution of three discrete abilities to idiom comprehension (e.g., ToM, executive functions, general language skills); to the best of our knowledge, no previous research has evaluated the contribution of these three explanatory models simultaneously. We hypothesized that there would be no difference between the TD and ASD groups in their ability to comprehend idioms (Saban-Bezael and Mashal 2015; Whyte et al. 2014). We also hypothesized that participants with TD would rely upon their underlying intact vocabulary or EF skills, but not on their ToM ability (Whyte et al. 2014), in order to comprehend idioms. In contrast, based on the theory of EF impairment (Lai et al. 2017) and ToM impairment (Baron-Cohen et al. 2001) observed in individuals with ASD, we hypothesized that they would rely instead on language abilities (i.e. vocabulary) to comprehend idioms.

## Method

### Participants

Forty-seven native Hebrew speakers, 23 with ASD (19 males) and 24 with TD (15 males) were recruited for the study. There was no statistical difference in gender distribution between the two study groups  $\chi^2(1) = 2.37$ ,  $p = .12$ . See Table 1 for the demographic characteristics of all participants. Participants in the ASD group had been previously diagnosed by an independent psychiatrist following DSM-IV-TR criteria (American Psychiatric Association 2000) or DSM-5 criteria (American Psychiatric Association 2013). The clinical diagnoses included pervasive development disorder—*not otherwise specified* ( $n = 13$ ), autism ( $n = 1$ ), high functioning autism spectrum disorder ( $n = 4$ ), and ASD ( $n = 5$ ). In light of the new classification that now appears in the DSM-5, we refer to the entire group as having ASD. To confirm ASD diagnosis, participants were also assessed with the Social Communication Questionnaire (Berument et al. 1999). This questionnaire covers three areas of functioning: reciprocal social interaction, language and communication, and repetitive and stereotyped behavior. All participants in the ASD group received a score above 15 on this questionnaire, further verifying the clinical diagnosis.

Participant recruitment adhered to [masked for blind review] university institutional research guidelines, and the study was approved by the [masked for blind review] Ministry of Education. Prior to their children's participation in the study, all parents received an explanation of the experiment's

**Table 1** Means (*and SDs*) of age, vocabulary, TMT-B, hinting, mental verbs-irony and mental verbs-literal scores by group

| Variables            | ASD<br>( <i>n</i> = 23) |           | TD<br>( <i>n</i> = 24) |           | <i>t</i> | <i>p</i> | Cohen's <i>d</i> |
|----------------------|-------------------------|-----------|------------------------|-----------|----------|----------|------------------|
|                      | <i>M</i>                | <i>SD</i> | <i>M</i>               | <i>SD</i> |          |          |                  |
| Age                  | 12.70                   | 1.71      | 12.19                  | 1.72      | 1.03     | .31      | 0.30             |
| Range (years)        | (9–15:6)                |           | (9–15)                 |           |          |          |                  |
| Vocabulary           | 38.61                   | 9.05      | 41.33                  | 8.64      | –1.06    | .30      | 0.31             |
| Range                | (26–57)                 |           | (18–55)                |           |          |          |                  |
| TMT-B                | 121.96                  | 53.95     | 107.50                 | 49.97     | .95      | .35      | 0.28             |
| Range                | (62–300)                |           | (51–290)               |           |          |          |                  |
| Hinting              | 13.13                   | 2.90      | 17.25                  | 1.51      | –6.15*** | < .001   | 1.78             |
| Range                | (7–18)                  |           | (13–19)                |           |          |          |                  |
| Mental verbs-irony   | 86.96                   | 11.05     | 93.33                  | 8.68      | –2.01*   | .03      | 0.64             |
| Range                | (60–100)                |           | (70–100)               |           |          |          |                  |
| Mental verbs-literal | 83.48                   | 15.55     | 93.33                  | 11.29     | –2.49*   | .02      | 0.72             |
| Range                | (40–100)                |           | (60–100)               |           |          |          |                  |

\**p* < .05, \*\*\**p* < .001

purpose and methods, and provided signed informed consent. The study was also explained to the children, whose assent to participation was solicited and received. The study was conducted in a quiet room at the participants' school. Instruments were distributed to each participant individually during one session in a random order. A short break between study tasks was provided if needed or requested by participants.

### Tests of Vocabulary, Executive Function, and ToM

Participants were tested for cognitive and language abilities previously linked to figurative language comprehension. The results are presented in Table 1.

#### Vocabulary

Vocabulary knowledge was tested with the vocabulary subtest of the Wechsler Intelligence Scale for Children—Hebrew (WISC-IVHEB; Wechsler 2003). In this task, participants are asked to provide definitions to words they hear.

#### Executive Function

The Trail Making Test (TMT; Reitan and Davison 1974) is a known neuropsychological test that is used to examine executive functioning and, in particular, mental flexibility (Tombaugh 2004). We used Trail B, in which participants are asked to connect a series of numbers and letters in ascending order; this task requires the subject to alternate between numbers and letters. The results, which are based on the time it takes the subject to complete the task, are converted to Z-scores. This test has previously been linked to figurative language comprehension (Mashal and Kasirer 2011).

### Theory of Mind (ToM)

#### Hinting Test

The Hinting test measures comprehension of intentions and ToM skills (Turner-Brown et al. 2008). The task was originally designed by Corcoran et al. (1995) and was translated by a professional translator into Hebrew for a previous study (Saban-Bezalel et al. 2019). The participants complete a questionnaire consisting of ten short stories describing different interactions between two speakers. Each story ends with one speaker dropping a hint. Following each story, the participant is asked about the speaker's intentions (i.e., what the speaker really meant to say). A correct answer describes the speaker's tacit intention. For each correct answer two points are given. If the participant doesn't answer the question correctly, he or she is given more information and then asked what the speaker wants the other character to do; a correct response to this earns a score of one point. If the subject fails to infer the intended meaning again, a score of zero is given for the item. The maximum score on this test is 20. Each item is read aloud to the participants with appropriate prosodic intonation (Corcoran et al. 1995). The Hinting test has been used in a variety of studies assessing ToM abilities and has good psychometric properties (e.g., Corcoran 2001; Marjoram et al. 2005; Saban-Bezalel et al. 2019). An example of an item is as follows:

Rebecca's birthday is approaching, so she says to her dad, "I love animals, especially dogs."

(Question) What does Rebecca really mean when she says this?

(If the participant fails to answer he or she is given additional information).

(Added Information) Rebecca goes on to ask, “Is the pet shop open on my birthday?”

(Question) What does Rebecca want her dad to do?

### Mental State Comprehension Task

In this task, participants are presented with 15 comic strips, ten with ironic interpretations (mental state irony comprehension) and five with literal interpretations (mental state literal comprehension). The comic strips were constructed using the Toondoo website (<http://www.toondoo.com>) (Saban-Bezalel et al. 2019) and are presented in a pseudorandom order. The participant is first presented with a comic strip comprised of three pictures (see Fig. 1). Following the child's reading of the comic strip the participant is asked a question that includes a “mental state” verb (e.g., know, expect, think, hope) about the scenario (e.g., “Does the child expect mom to make him a meal he likes?”). This question is presented simultaneously with the first picture (“I am so hungry”; see Fig. 1) and refers to the initial mental state of the protagonist. Mental state terms serve as a bridge between language, social cognition, and ToM (Hughes and Leekam 2004). A correct answer requires verbal comprehension (i.e., understanding the mental verb, the question asked, and the ironic situation depicted in the comic strips) along with mentalizing ability (inferring the mental/emotional state

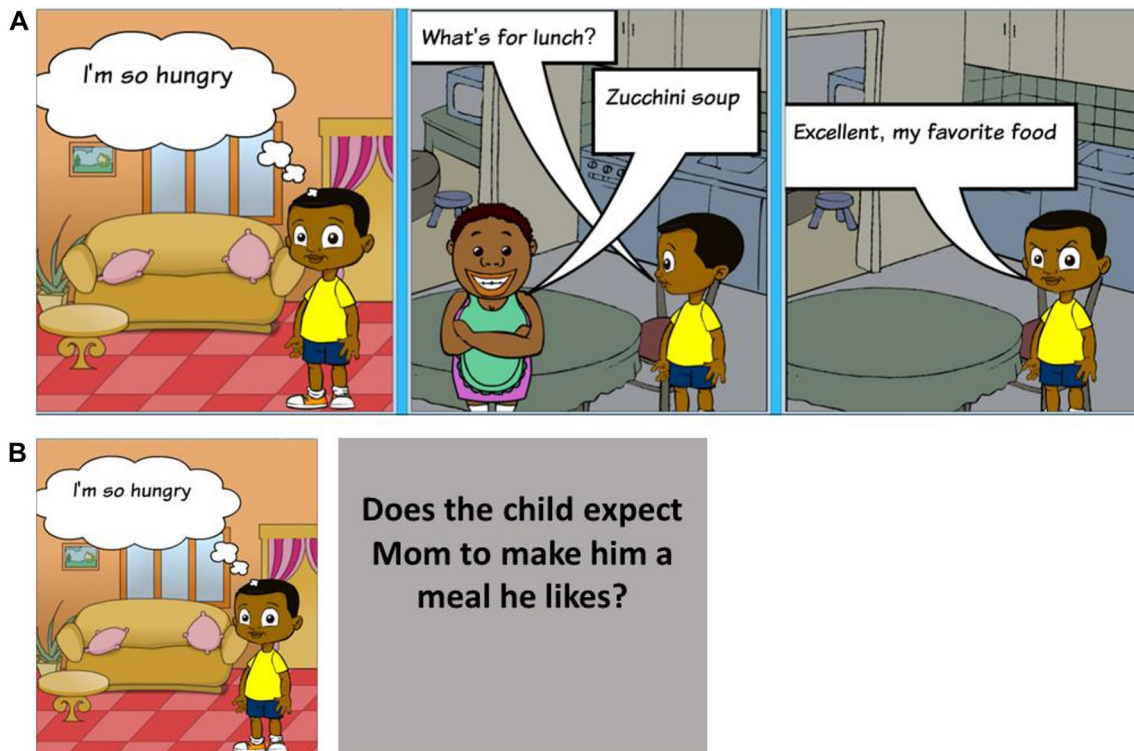
of the other; determining about what the character's facial expression hints). Indeed, studies have shown that language abilities, and especially mental state language, are significant to children's ToM development (Gola 2012; Ruffman et al. 2002). Scoring is done separately for ironic and literal comic strips to differentiate between ironic and literal interpretations. Each correct answer provides one point (with a maximum of 15 points); the task begins with two practice trials.

As can be seen in Table 1, whereas the groups were comparable on age, vocabulary, and EF (as assessed by the TMT-B) scores, the TD group outperformed the ASD group on ToM ability (as assessed by the Hinting test and the mental state comprehension task).

### Idiom Comprehension

#### Idiom Comprehension Task

The participants are given a multiple-choice idiom comprehension questionnaire that includes 20 idioms in Hebrew with plausible literal interpretations (e.g., “Shavar et harosh” which literally means “broke his head”). Each idiom is followed by four interpretations: a correct idiomatic interpretation (“struggled with a difficult problem”); a literal interpretation of the idiomatic expression (“wounded his head”); a literal distracter related to or repeating the verb of



**Fig. 1** Example of an ironic comic strip. The participants are presented with the three pictures describing an ironic or literal situation (a). Next, the first picture is presented simultaneously with a mental state question (b)

the idiom (“smashed to pieces”); and an unrelated interpretation (“opened the door”). Children are instructed to carefully read each idiom and choose the correct interpretation. For each idiom, the interpretations appear in a random order. The number of correct idiomatic interpretations is counted. This questionnaire is based on a pool of idioms assembled by (Mashal et al. 2008). All idioms were ambiguous, consisted of 3–4 words, and had high familiarity (See Appendix). This task has been previously used to examine idiom comprehension in ASD (Mashal and Kasirer 2011).

## Results

Due to the small sample size in each study group (ASD, TD), in order to examine whether the dependent variable (idioms test score) was normally distributed, we conducted Shapiro–Wilk tests for each study group. The results indicated that the dependent variable in each study group was not normally distributed ( $p = .04$ ). Furthermore, in order to examine the homoscedasticity of the variances, we conducted Levene’s tests on the dependent variable. The results indicated that the null hypothesis of equal variances was rejected on the idioms test score. Therefore, we conducted both a-parametric and parametric analyses. Since the findings of the a-parametric and parametric tests were identical, only the results of the parametric analyses were reported, as well as the median scores on the idioms test in each study group. The t-value reported indicates that equal variances were not assumed.

### Comparison Between ASD and TD on Idiom Comprehension

T-testing for two independent samples revealed significant differences between the two groups,  $t(45) = -4.18$ ,  $p < .001$ , indicating that scores on the idiom test were significantly higher among the TD group ( $M = 18.21$ ,  $SD = 2.04$ ,  $Mdn = 19.00$ ) compared to the ASD group ( $M = 13.43$ ,  $SD = 5.11$ ,  $Mdn = 14.00$ ).

### Correlations Between the Screening Scores and the Scores on the Idiom Comprehension Test

Next, we examined the correlations between the scores on vocabulary, TMT-B, Hinting, mental state comprehension task (irony and literal questions separately), and idiom comprehension. Partial correlation coefficient analyses (controlling for age) were conducted for each group separately (see Table 2).

As Table 2 shows, significant positive correlation was found between scores on idiom comprehension and vocabulary in the ASD group. Moreover, performance on the mental state irony comprehension and idiom comprehension tests were positively correlated in both groups. These results indicate that as the mental state irony comprehension scores increase, idiom comprehension increases, in both groups. However, while significant correlations were also found between TMT-B scores, Hinting test scores– and idiom comprehension– in the TD group, no significant correlations were found between these two test scores and idiom comprehension in the ASD group. Fisher  $r$ -to- $z$  transformations indicated no significant difference between the two groups in the correlation coefficients.

### Contribution of Background Characteristics and Screening Scores on Prediction of Idiom Comprehension

In order to examine the contribution of the background characteristics (age and gender), as well as vocabulary, EF (TMT-B), and ToM (Hinting, mental state irony comprehension, mental state literal comprehension) scores on the prediction of idiom comprehension, we conducted two mixed regression analyses, one analysis for each group. In the first step, the background characteristics were entered. In the second step, the scores on vocabulary, TMT-B, Hinting, mental state irony comprehension, and mental state literal comprehension scores were entered in a step-wise manner. Only variables that contributed significantly to the explained variance (EPV) beyond the background characteristics were entered into the regression model in the second step.

**Table 2** Partial correlation coefficients between idiom comprehension test and vocabulary, TMT-B, Hinting, Mental verbs-irony, and Mental verbs-literal scores, controlling for age in each group

|                      | ASD<br>Idioms (df=21) | TD<br>Idioms (df=22) | Fisher $r$ -to- $z$ transformation |
|----------------------|-----------------------|----------------------|------------------------------------|
| Vocabulary           | .51*                  | .34                  | $z = 0.67, p = .50$                |
| TMT-B                | -.20                  | -.58**               | $z = 1.47, p = .14$                |
| Hinting              | .11                   | .48*                 | $z = 1.32, p = .19$                |
| Mental verbs-irony   | .46*                  | .50**                | $z = 0.17, p = .86$                |
| Mental verbs-literal | .07                   | -.02                 | $z = 0.29, p = .77$                |

\* $p < .05$ , \*\* $p < .01$



Before conducting the regression analyses, Shapiro–Wilk tests were conducted for each study group in order to examine whether the residuals of the regression followed a normal distribution. The results indicated that the residuals of the regression were normally distributed among the ASD group ( $p = .57$ , skewness = .48, and kurtosis = .93) and among the TD group ( $p = .31$ , skewness = .47, and kurtosis = .92).

The regression analyses indicated that while the background characteristics contributed significantly (39.7%) to the EPV of idiom comprehension performance in the TD group [ $R^2 = 39.7\%$ ,  $F(2, 21) = 6.92$ ,  $p < .01$ ], no significant contribution was found for these background characteristics in the ASD group [ $R^2 = 3.5\%$ ,  $F(2, 20) = .36$ ,  $p = .70$ ]. The positive  $\beta$  coefficients of age indicated that as the age of the participants with TD increased, the performance on the idiom test increased, respectively. In the second step, vocabulary test scores contributed significantly (22.3%) to the EPV of idiom comprehension performance, beyond the background characteristics among the ASD group, whereas TMT-B scores contributed significantly (17.6%) to the EPV of idiom comprehension performance, beyond the background characteristics, among the TD group. The positive  $\beta$  coefficients indicated that as the vocabulary test scores in the

ASD group, and TMT-B scores in the TD group, increased, the idiom comprehension performance increased, respectively (see Table 3).

### Mediation Analysis

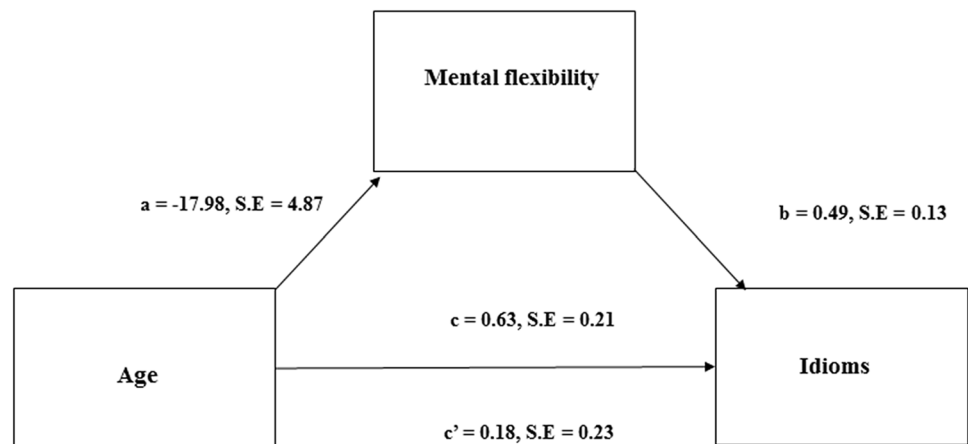
The regression results indicated a significant contribution of TMT-B scores to the EPV of idiom comprehension performance in the TD group. Moreover, the significant contribution of participants' age to the EPV in the first step ( $p = .004$ ) decreased when the TMT-B score was entered in the second step ( $p = .23$ ). In order to further examine whether the TMT-B scores serve as a mediating variable between the participants' age and idiom comprehension, we performed a mediation analysis using Process software (Hayes 2013). The results of the analysis revealed that the direct effect between age and idiom comprehension ( $b = 0.18$ ,  $p = .45$ ) was lower than the total effect ( $b = 0.63$ ,  $p < .003$ ) and the mediation analysis was significant among the TD group ( $z = 2.39$ ,  $p = .02$ ) but not the ASD group ( $z = .42$ ,  $p = .68$ ). The results thus indicate that the TMT-B scores served as a mediating variable between age and idiom comprehension in the TD group (see Fig. 2).

**Table 3** Results of the mix regressions for scores on the idioms test by the demographic characteristics and the scores on vocabulary, TMT-B, hinting, mental verbs-irony and mental verbs-literal tests in each study group

|               | Steps | Independent variables | B     | SE.B | $\beta$ | t       | R <sup>2</sup> | $\Delta R^2$ |
|---------------|-------|-----------------------|-------|------|---------|---------|----------------|--------------|
| ASD (df=3,19) | 1     | Age                   | .33   | .69  | .11     | .47     |                |              |
|               |       | Gender                | -2.52 | 3.06 | -.19    | -.82    | .035           | .035         |
|               | 2     | Age                   | -.37  | .69  | -.12    | -.54    |                |              |
|               |       | Gender                | -.01  | 2.95 | .00     | .00     |                |              |
| TD (df=3,20)  | 1     | Age                   | .72   | .21  | .61     | 3.51**  |                |              |
|               |       | Gender                | -1.42 | .72  | -.34    | -1.98   | .397**         | .397**       |
|               | 2     | Age                   | .29   | .23  | .24     | 1.25    |                |              |
|               |       | Gender                | -.97  | .64  | -.23    | -1.52   |                |              |
|               |       | TMT-B                 | -.02  | .01  | -.55    | -2.87** | .573***        | .176**       |

\* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

**Fig. 2** Mediation model in the TD group



## Discussion

The current study examined idiom comprehension among children and adolescents with ASD by assessing the contribution of various abilities that three main theories indicate explain figurative language comprehension difficulty in ASD. Two main findings emerged from the current study: first, participants with ASD, who were matched to TD participants by age, vocabulary, and executive function abilities, understood fewer idioms than their peers with TD. Second, idiom comprehension was predicted by vocabulary ability in the ASD group, whereas mental flexibility predicted idiom comprehension in the TD group.

Although we expected no group difference in idiom comprehension, the TD group in fact outperformed the ASD group. This finding is contrary to previous studies showing that when individuals with ASD are carefully matched on language abilities to their TD peers, no group differences in figurative language understanding are obtained (Gernsbacher and Pripas-Kapit 2012; Norbury 2004; Saban-Bezael and Mashal 2015; Whyte et al. 2014). Indeed, in a previous study (Saban-Bezael and Mashal 2015), adults with ASD exhibited similar idiom comprehension ability as their vocabulary-matched TD peers. The difference between the previous and current study's findings may be linked to participant age. Participants in the current study were children and adolescents, unlike Saban-Bezael and Mashal's (2015) study of adults. It is known that the ability to comprehend idioms is associated with age in TD population (Nippold and Taylor 2002). Hence, it is possible that the ability to comprehend idioms is an evolving ability among individuals with ASD that continues to develop beyond childhood and adolescence, suggesting that idiom comprehension may reach maturity at an older age among individuals with ASD compared to those with TD.

Nonetheless, Whyte et al. (2014) also did not find group differences in idiom comprehension among children with ASD who were matched by syntax abilities to their TD peers. However, Whyte et al. (2014) examined idioms *in context*, whereas the current study presented idioms without context. Previous studies have found that participants benefit from context when processing idioms (Cain and Towse 2008; Norbury 2004). In addition to context, the format of the idiom comprehension task may also have influenced performance. Previous research has shown that adolescents with TD score higher on conventional metaphor comprehension compared to adolescents with ASD (matched by language and executive function) when using a multiple choice questionnaire (Kasirer and Mashal 2016). In sum, in addition to language skills, age, task features (e.g., context) and format (e.g., multiple choice) may affect idiom comprehension in ASD.

Another aim of the current study was to examine idiom comprehension in light of three theories suggesting that figurative language difficulties in ASD stem from deficits in: general language ability (assessed by vocabulary), mentalizing ability (assessed by the Hinting test and mental state comprehension task), and executive functioning (assessed by the TMT-B). Our findings point to a different pattern of correlation with idiom comprehension scores within each group. Within the TD group, positive correlations were found between idiom comprehension and age, vocabulary, mental flexibility, Hinting test scores, and mental state irony comprehension scores. These findings are compatible with the expectation that children and adolescents with TD will rely on their various "intact" abilities. Nevertheless, the results of the regression analysis revealed that only mental flexibility predicted idiom comprehension among the TD participants. In the processing of figurative language, flexibility is required to allow a transition between the different meanings of the expression, namely, the literal and the figurative meanings (Berman and Ravid 2010; Mo et al. 2008; Rapp 2009). This finding, that mental flexibility predicted idiom comprehension among TD participants, is consistent with previous studies that highlight the importance of executive processes in processing other types of figurative language (Roger and Silvia 2013). Moreover, in a mediation analysis we found that executive functions indeed serve as a mediating variable between participant age and idiom comprehension, but only in the TD group.

Our participants with ASD demonstrated a different pattern of correlation with idiom comprehension. Significant positive correlations were found only between idiom comprehension and language abilities (i.e., vocabulary), and between idiom comprehension and mental state irony comprehension. However, only vocabulary abilities predicted idiom comprehension in the regression analysis. The correlation between the mental state irony comprehension and idiom comprehension scores is not surprising given the fact that irony comprehension has been associated with second order ToM ability, whereas idiom comprehension has been associated with first order ToM ability (Happé 1995). Furthermore, the mental state comprehension task for irony incorporates both language abilities and ToM ability with special emphasis on ironic situations. Indeed, mental state literal comprehension questions did not correlate with idiom comprehension in both groups. Moreover, consistent with our hypotheses, neither ToM ability per se (Hinting test) nor executive functioning, which is known to be impaired in ASD, correlated with idiom comprehension in the ASD group. Our finding is also consistent with previous studies that argue that ToM ability is not enough to sufficiently facilitate idiom comprehension among individuals with ASD (Norbury 2004). Indeed, findings from our regression analysis show that only vocabulary predicted idiom

comprehension in the ASD group. It is possible that, as argued by the Lexical Representation Hypothesis (Swinney and Cutler 1979), when individuals with ASD apprehend idioms they consider them a single unit (i.e., one huge word) and store and retrieve them as any other word. Our findings thus reinforce the importance of language abilities for idiom comprehension among individuals with ASD.

The current findings suggest that, although our participants were matched by their executive functioning and vocabulary abilities, children and adolescents with ASD relied on different cognitive abilities during idiom processing than TD participants. Evidence from neuroimaging studies indicates that participants with ASD rely on different brain mechanisms as well. For instance, larger N400 amplitudes were found while processing both familiar and unfamiliar metaphors in participants with Asperger syndrome as compared to those with TD, pinpointing the greater difficulties in metaphor comprehension among the ASD group (Gold and Faust 2010). Different patterns of hemispheric involvement were also observed during an idiom comprehension task using the divided visual field technique in adults with ASD and TD (Saban-Bezelel and Mashal 2015). Although no difference was found in idiom comprehension ability between the groups, they differed in their pattern of hemispheric processing. A typical advantage for the left hemisphere was found during idiom processing in the TD group, whereas adults with ASD exhibited atypical bilateral hemispheric processing (Saban-Bezelel and Mashal 2015). Thus, our findings support the claim that individuals with ASD and TD rely upon different cognitive processes while attempting to comprehend idioms. Future studies should test whether these differences reflect different underlying neural processes.

The current study has several limitations that should be mentioned. Participants with ASD had been diagnosed according to DSM-4 or DSM-5 criteria, but were not diagnosed by robust diagnostic measures for autism spectrum disorders, such as the Autism Diagnostic Interview-Revised (ADI-R; Lord et al. 1994) or the Autism Diagnostic Observation Schedule (ADOS-G; Lord et al. 2000). We believe more in-depth clinical diagnoses could have further clarified the association between autistic traits and idiom comprehension. Additionally, in this study, we used the mental state comprehension task, a unique task that requires language comprehension combined with mentalizing ability. In light of the correlation between performance on this task and idiom comprehension in the ASD group, future studies should disentangle the contribution of language ability and mentalizing abilities to idiom comprehension. In our study, participants' linguistic abilities were examined vis a vis vocabulary based on evidence of a link found in previous studies between figurative language comprehension (e.g., idioms and metaphors) and vocabulary (Mashal and Kasirer

2011; Saban-Bezelel and Mashal 2015). We note that in accordance with other studies that examined other language abilities such as syntax (Gernsbacher and Pripas-Kapit 2012; Whyte et al. 2014), future studies are recommended to extend their linguistic testing of figurative language abilities. Finally, idiom comprehension should be tested using not only a multiple-choice questionnaire (as in the current study) but also by an open questionnaire; similarly, idiom comprehension should be tested both in the presence and absence of context in order to examine the effect context on task performance. The use of idioms in context is especially intriguing as it may rely upon more general cognitive abilities than comprehension skills (e.g., searching for relevant cues in a phrase, inhibition of the idioms literal interpretation, inferring the meaning of an expression in context) (Vulchanova et al. 2015).

In summary, the current study examined factors that predict idiom comprehension in light of the various theories that attempt to explain the difficulty of individuals with ASD to comprehend figurative language. Contrary to previous findings among adults, TD participants outperformed their age- and vocabulary-matched peers with ASD on idiom comprehension. It is possible, therefore, that idiom comprehension is a developing ability among children and adolescents with ASD, and only in adulthood is the gap in performance eliminated. In addition, while vocabulary abilities predicted idiom comprehension in participants with ASD, mental flexibility predicted idiom comprehension in those with TD. Our findings support approaches that focus on general language abilities as a basis for figurative language comprehension among those with ASD.

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## Compliance with Ethical Standards

**Conflict of interest** We have no conflict of interest to report.

**Research Involving Human and Animal Participants** Research involving human participants was conducted under the appropriate institutional ethics committee approval of [masked for revision] University as well the [masked for revision] Ministry of Education. Prior to their children's participation in the study, all parents received an explanation of the study, and provided signed informed consent. The study was also explained to the children, whose assent to participation was solicited and received. Participant confidentiality and data privacy were protected as required by ethical guidelines and practices.

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