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Thinking maps enhance metaphoric competence in children with autism and learning disabilities

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ABSTRACT

The primary goal of the current study was to examine the ability of children with autism (ASD) and children with learning disabilities (LD) to improve their metaphoric competence by an intervention program using "thinking maps". Twenty ASD children, 20 LD, and 20 typically developed (TD) children were tested on metaphors and idioms comprehension tests, homophone meaning generation test, and fluency tests. Both ASD and LD groups performed poorly compared with TD on all tests, with the LD group outperformed the ASD group in the executive function tests. The results indicate that the LD group was able to use the "thinking maps" to understand metaphors that were encountered for the first time more efficiently than the ASD group. Furthermore, in the autistic group the homophone meaning generation test, associated with mental flexibility mechanism, correlated with novel metaphors understanding, which do not rely on prior knowledge. In the learning disabilities group, conventional metaphors understanding correlated with the homophone meaning generation test.

1. Introduction

Pragmatic aspects of language are important modes of human communication. In everyday communication some verbal messages convey meanings that go beyond the straightforward word-by-word analysis of the message (i.e., the literal meaning). Thus, sometimes, an accurate grasp of meaning requires interpreting the intention of the speaker and the ability to distinguish between "what is said and what is meant" (Levorato & Cacciari, 2002). This is the case with figurative language that introduces intentional ambiguity to convey messages the meaning of which differs from their literal meaning. A deficit in the processing of non-literal language may result in a fail to use or comprehend this language, which is remarkably frequent in everyday discourse (Gibbs, 1994). Difficulty understanding nonliteral language devices, such as metaphors and idioms has been observed in individuals with learning disabilities (LD) (e.g., Friemoth Lee & Kamhi, 1990) and autism (ASD) (e.g., Happé, 1993, 1995). The aim of the current study is to examine the ability to disambiguate meanings of several figurative forms (e.g., metaphor, idiom, homophones) in these two special population, ASD and LD children, and to test the effects of an intervention program that uses thinking maps in order to enhance metaphor comprehension.

A metaphor is a prototypical form of non-literal language that forms linkages between two seemingly unrelated domains of knowledge. Some theorists suggest that the manner in which a metaphor is comprehended depends on its level of conventionality (e.g., Bowdle & Gentner, 1999, 2005; Giora, 1997; Glucksberg & Keysar, 1990). According to the Career of Metaphor model (Bowdle & Gentner, 2005), novel metaphors are comprehended via a comparison process (i.e., simple matching) in which the semantic features of both concepts (the base term and the target term) are extracted and then are

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matched with one another (Bowdle & Gentner, 2005). The common attributes as well as those that are not in common are then used to establish the ground for the comparison. Conventional metaphors, on the other hand, are understood via categorization, in which the target term becomes a member in a super-ordinate abstract metaphoric category, represented by the base term (Glucksberg, 2001; Glucksberg & Keysar, 1990). Since the meanings of familiar metaphors are lexicalized, i.e., stored in the mental lexicon, the process of understanding conventional metaphors relies mainly on meaning retrieval of stored knowledge and thus may exert less cognitive demands. Like metaphors, the meaning of an idiomatic expression cannot be derived compositionally from the interpretation of its parts. According to the lexical representation hypothesis (Swinney & Cutler, 1979), the computation of the literal interpretation of the expression runs in parallel with the idiomatic expression. Thus, the comprehension of both metaphors and idioms involves pragmatic abilities and higher cognitive functioning that may impose considerable interpretive demands, especially for schoolchildren in the special education, since different interpretations may be available.

Individuals with autism sometimes interpret figurative language literally (Rapin & Dunn, 2003) and hence encounter difficulty in understanding various aspects of figurative language such as idiom (Kerbel & Grunwell, 1998), humor (Ozonoff & Miller, 1996), metaphor, and irony (Happé, 1993, 1995). Children with learning disabilities also tend to interpret figurative expressions literally and fail to combine two distant concepts into a novel metaphoric meaning (e.g., Friemoth Lee & Kamhi, 1990; Nippold & Fey, 1983). This evidence suggests that pragmatic impairment is highly pervasive in individuals with autism and learning disabilities and thus, deserves more attention so that an appropriate intervention can be developed.

One psychological theory that has been tried to explain the high-order language deficits in autism is the executive dysfunction theory (Russell, 1997). The executive dysfunction theory suggests that deficits in executive functions—i.e., the functions responsible for the control of thought and action, such as planning, mental flexibility, inhibition, and shifting set—are the cause of the autism disorder, and not the result of impairments in understanding mental concepts (Pennington & Ozonof, 1996, for review; Russell, 1997). The behavior deficits addressed by the executive function approach are rigidity and perseveration, manifested by a paucity of new non-routine action initiations and the tendency to persist using one strategy (Hill, 2004). However, evidence for executive dysfunction in ASD is equivocal probably due to the different tasks applied and the nature of the autism and/or control (Spek, Schatorje, Scholte, & Berckelaer-Onnes, 2009). The few studies which examined executive functions in children with LD indicate a relationship between inferior executive functions and a deficiency in reading and comprehension of written and spoken language (Cutting, Materek, Cole, Levine, & Mahone, 2009; Whitney, Mahone, Levine, Eason, & Cutting, 2009).

Executive functions may play an important role in metaphor comprehension since figurative language comprehension engages higher order cognitive functions such as mental flexibility (i.e., select the common attributes of the vehicle and the target term; switch between the literal and the metaphoric meanings) and inhibition control (suppression of the irrelevant literal interpretation). One of the aims of the study was therefore to examine whether metaphoric competence in children with ASD and LD is related to some aspects of executive dysfunctions.

Tests tapping executive function abilities include word fluency tests, where an individual has to produce as many words as possible in one minute. Two common types of fluency tests are in use: phonemic fluency and semantic (category) fluency. Performance on word generation is most strongly correlated with measures of vocabulary, auditory attention, strategic search, and mental flexibility (Kavé, 2005). On a category fluency task, individuals with autism (age 15–40) have been shown to be impaired in relation to non-autistic, age, and ability matched controls (Minshew, Goldstein, Muenz, & Payton, 1992) as well as on letter fluency tasks (Rumsey & Hamburger, 1988). In other studies, individuals with autism did not differ from controls (Boucher, 1988; Hill & Bird, 2006). In Boucher's study (1988), children with autism (mean age 14.2) were asked to generate words belonging to a specific category (e.g., colors, animals) and were found unimpaired as compared with both learning-disabled and age-matched control groups. Thus, most of the findings regarding the performance of individuals with autism on fluency tasks show an overall impairment, consistent with a deficient mental flexibility. However, studies linking fluency tasks and figurative language comprehension in ASD and LD children are remarkably scarce.

1.1. The intervention program

In the current study, we examined the possibility of developing a strategic tool that improves the communication deficits associated with metaphoric language comprehension in ASD and LD children. The development of the intervention tool was motivated by previous pilot results showing that patients who displayed characteristics associated with right-hemisphere damage improved their metaphoric comprehension (Lundgren, Brownel, Soma, & Cayer-Meade, 2006). The intervention program was based on a simple visual mode of representing semantic relations between words using thinking maps. Thinking maps are visual-verbal learning tools that provide graphic representations of the features shared by both words that comprise the metaphoric expression (e.g., *train of thought*), thus providing an explicit basis for metaphor understanding. For example, each of the two concepts "train" and "thought" evokes several associations, as illustrated in Fig. 1. Participants were instructed to generate a broad range of associations for each concept and then to identify the appropriate shared associations that give rise to the shared properties, which in turn evoke the correct interpretation (e.g., a series of connected thoughts). The generation of multiple associations enhances flexible thinking and requires switching from one semantic feature to another until the correct interpretation is achieved.

The objectives of the present study are three-fold: (1) to examine whether children with autism have a similar figurative language profile to children with learning disabilities. (2) To test the efficiency of using thinking maps as a strategic tool to

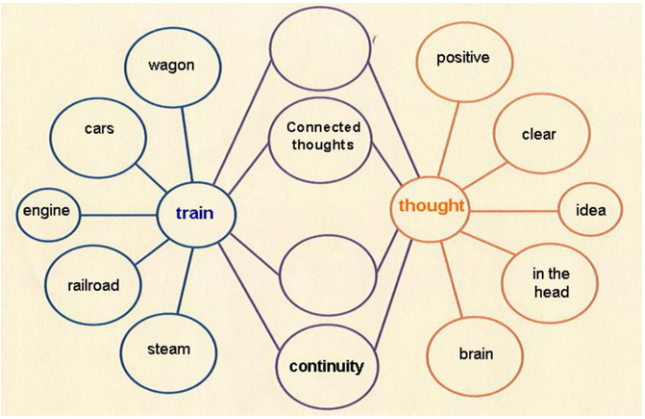

Fig. 1. An example of the thinking maps used to improve metaphoric understanding. The children write the concepts ('train', 'thought') of the expression (*train of thought*) in the central bubbles and then their associations in the surrounding bubbles. The researcher instructs the children to write the appropriate shared associations (in the bubbles connected to both concepts), such as 'continuity' and 'connected thoughts' in order to grasp the correct interpretation (a series of connected thoughts).

enhance metaphoric understanding in ASD and LD children and (3) to examine the relation between metaphor comprehension and executive functions (as will be assessed by fluency tests and homophone meanings generation test).

2. Methods

2.1. Participants

The participants of the present study included 60 children that belong to three groups: ASD, LD, and TD children. All participants underwent word and non-word reading tests (Table 1). All children were asked to read accurately as many words and non-words as they can within 45 s from three lists (words, non-words with punctuation, and words with punctuation). Differences between groups on the reading test were analyzed by one-way ANOVA followed by Scheffe post hoc analyses (with $p < .05$). As can bee seen in Table 1, the LD group read significantly fewer words and non-words as compared with the ASD and the TD group. No significant differences were found between words and non-words with punctuation correctly read by the ASD and the TD group.

2.1.1. Screening tests: synonyms and similarities tests

In the first phase of the study, all participants underwent screening tests to adjust vocabulary knowledge and analogical thinking within the normal range as assessed by the synonyms and the similarities subtests of MEM test (a Hebrew abstract verbal reasoning test) (Glantz, 2008). The MEM was found to be highly correlated with the verbal Wechsler intelligence test in ninth graders (Glantz, 2008, p. 78). MEM consists of nine subtests, which are normalized to Hebrew speakers according to data collected from 2407 students between the ages 12–18 years. Only children scored within the normal range (standard score of 7 or above) included in the study. Table 1 presents the data for the synonyms and similarities tests according to group. The performance on the synonyms test differ between the groups ($F(2,58) = 3.96$, $p < .05$, $\eta^2 = .11$). The TD group outperformed the LD group, as Scheffe post hoc analysis revealed ($p < .05$). No difference was found between the ASD and TD ($p = .3$) and between the ASD and the LD ($p = .48$). The performance on the similarities test also differ between the three groups ($F(2,58) = 24.12$, $p < .001$, $\eta^2 = .45$). The TD group performed significantly better than both the LD and the ASD group, as Scheffe post hoc analysis revealed ($p < .001$, $p < .001$, respectively). No difference was found between the ASD and the LD group ($p = .97$). Thus, both ASD and LD performed within the normal range in the synonyms and the similarities tests and the performance of the two groups did not differ.

Table 1
Summary of mean correct responses (and SD) in the synonyms, similarities, and reading tests in the three groups before the intervention.

	ASD (1)		TD (2)		LD (3)		$F(2,58)$	η^2	Scheffe
	Mean	SD	Mean	SD	Mean	SD			
Synonyms	9.89	2.00	11.14	1.35	9.55	1.39	3.96*	.11	2 > 3, 1 = 3
Similarities	10.25	2.59	13.90	1.92	9.60	1.73	24.12***	.45	2 > 1 = 3
Words	64.59	10.92	68.95	15.17	47.45	14.69	16.40***	.36	1 = 2 > 3
Non-words with punctuation	17.54	2.68	18.62	1.56	8.40	3.52	101.94***	.77	1 = 2 > 3
Words with punctuation	48.86	6.35	56.29	2.76	34.50	10.33	53.73***	.65	2 > 1 > 3

* $p < .05$.
*** $p < .001$.

Fifteen autistic children and 10 learning disable children who were not scored within the normal range in the similarities and the synonyms subtests of MEM test were excluded from the study.

The ASD group included 20 children with autism (18 boys and 2 girls; mean age 13.02 years, range 12–15 years). Children were recruited from classes of children with autism (ASD). These classes are integrated within regular junior high schools and located in the center of Israel. Children were selected for the study if in addition to the screening tests (1) they had been diagnosed with autism by a psychiatrist (in line with the Diagnostic and Statistical Manual of Mental Disorders – Text Revision [4th ed.]; American Psychiatric Association, 2000); (2) teachers reported that they speak fluently; (3) monolingual Hebrew-speaking home environment; (4) no evidence of neurological impairment.

The LD group included 20 children aged 12–13 with learning disabilities (17 boys and 3 girls). The children were recruited from classes of learning disabilities integrated within regular junior high schools and located in the center of Israel. In line with the Israeli Law of Special Education (Ministry of Education, Culture, and Sports, 1996), the 20 students with LD were assessed in their schools, diagnosed by the school district psychological services, and identified by an interdisciplinary placement committee as in need of remedial help or special education services. Children's IQ scores were not available to the research team, owing to Israeli regulations for privacy protection. However, by definition, for an LD diagnosis, these IQ scores were in the normal range (Ministry of Education, Culture, and Sports, 1996). Students received an LD diagnosis based on the criteria in Israel for LD classification (in line with the Diagnostic and Statistical Manual of Mental Disorders – Text Revision [4th ed.]; American Psychiatric Association, 2000), which includes (a) achievement test scores at least 2 years below grade level and (b) average or above-average intelligence with a marked deficit in academic achievement.

Twenty additional children of healthy development, aged 12–13 from two different schools from central Israel constituted the TD group.

All parents received an introductory letter about the experiment through teachers and signed an informed consent as approved by the Israeli Ministry of Education.

2.2. Figurative language comprehension tests

Children's comprehension of idioms and metaphors was assessed by two questionnaires.

2.2.1. Idioms

This questionnaire investigated comprehension of idioms and the tendency to choose the literal interpretation of an idiomatic expression. Only idioms with plausible literal interpretation were selected for the study. Children were presented with a list of 20 idioms (e.g., *he got cold feet*) each followed by four interpretations: One was a correct idiomatic interpretation (*he lost courage*); one was a literal interpretation of the idiomatic expression (*the temperature of his feet got lower*); another interpretation was a literal distracter related to or repeating the verb of the idiom (*he got a present*); and finally an unrelated interpretation (*he explained himself*). Children were instructed to read carefully each idiom and choose the correct interpretation. The number of correct idiomatic interpretations and literal interpretations were counted for each participant.

Idioms were selected from a previous study (Mashal, Faust, Hendler, & Jung-Beeman, 2008). The procedure to select the expressions is briefly described here (for more details see Mashal et al., 2008). Two pretests were performed to determine the linguistic nature of the idioms. In the first pretest 32 students rated the familiarity level of the idioms on a seven-point familiarity scale ranging from one (highly non-familiar) to seven (highly familiar). Mean familiarity level of the selected idioms was 6.45. In the second pretest, an additional 15 participants were asked to write down the first meaning that came to mind. All the participants wrote the same non-literal meaning, suggesting that the idiomatic meaning is highly familiar and more salient than the literal meaning.

2.2.2. Metaphors

This questionnaire investigated children's ability to understand conventional metaphors (e.g., *defense line*), novel metaphors (e.g., *transparent moment*), and unrelated word-pairs (e.g., *sport lemon*). For each metaphoric expression, four interpretations were offered: a correct metaphoric interpretation, a literal distracter interpretation, an unrelated interpretation, and a fourth choice: "this expression is meaningless." Participants were instructed to choose the one answer they thought was the best of the four alternatives.

Metaphoric two-word expressions were selected from a pool of expressions used in a different study (Faust & Mashal, 2007). The procedure to select the expressions is briefly described here (for more details see Faust & Mashal, 2007). These expressions underwent three pretests to determine the type of semantic relationship between the two words in each expression and the word frequency. The first pretest involved determining the type of each two-word expression (metaphoric or unrelated word pairs). In this test, 46 students were presented with a list of two-word expressions and asked to decide, for each expression, whether it was metaphorically plausible or not plausible. Every expression that was rated by at least 72% of the judges as either metaphorically plausible or not plausible was selected as, respectively, a metaphoric or an unrelated word pair. The second pretest aimed to distinguish between unfamiliar novel metaphors and conventional metaphors. A list of the plausible metaphors was presented to 36 students, who were asked to rate the degree of familiarity of each metaphoric expression on a 7-point familiarity scale ranging from 1 (highly nonfamiliar) to 7 (highly familiar). The mean score of the novel and the conventional metaphoric expressions was 1.78 and 6.17, respectively. In addition,

expressions were matched across conditions (i.e., novel and conventional metaphors, and unrelated word pairs) for word frequency, concreteness, and grammatical forms (i.e., number of noun-noun and adjective-noun phrases). No significant differences were found between the two conditions on any of these variables.

For each participant, we counted the number of correct answers (i.e., the metaphoric interpretation for the metaphoric expressions and the choice "this expression in meaningless" for the unrelated word-pairs).

2.3. Executive functions

Executive functioning was assessed by semantic fluency test, phonemic fluency test, and homophone meanings generation test.

2.3.1. Fluency tests

The fluency tests investigated word knowledge but more importantly flexible search strategies (Kavé, Kigel, & Kochva, 2008) and executive control (Hurks et al., 2006). Children completed two fluency tasks: semantic and phonemic fluency tests. Participants were asked to provide as many words as possible within 60 s in each of three letters (the letters bet (/b/), gimel (/g/), and shin (/š/)) in the phonemic test and in three categories (animals, fruits and vegetables, and vehicles) in the semantic test. The phonemic test was scored by the number of words generated on the three letters together and in the semantic test by the number of words generated on the three categories together. These tests have been normalized to Hebrew speakers (Kavé, Kukulansky-Segal, Avraham, Herzberg, & Landa, 2010).

2.3.2. Homophone meaning generations test

This test investigated children's ability to activate (and shift between) the different meanings of an *homophone*. Children were presented with a list of 20 short unbiased sentences that ended with an *homographic homophone* (e.g., "Look at this bank"). Children were instructed to say aloud all meanings of the final word. The examiner wrote down the words. The homophones were selected from a pool of homophones used in a previous study (Peleg & Eviatar, 2009). Words were selected so that children would be familiar with both word meanings. For each homographic homophone, an unbiased sentence was constructed. To ensure that the context did not bias any specific meaning (dominant or subordinate), relatedness of the sentence context (including the final ambiguous word) and its two possible meanings was rated by 20 subjects on a 5-point scale ranging from very related (5) to very unrelated (1). Half of the subjects were presented with the dominant interpretation (e.g., financial institute) and the other half with the subordinate interpretation (e.g., river). No difference was found between the ratings of the dominant and the subordinate meaning for relatedness to the sentence context (3.05, 3.11, respectively, $p > .05$), suggesting that the sentence did not bias any specific meaning.

2.4. Procedure

The study comprised three stages: (1) pre-intervention tests: assessment of figurative language (idioms and metaphor) and executive functions (word fluency and homophone meaning generation test) in the three groups (ASD, LD and TD), (2) intervention program to enhance metaphor understanding in the autistic group and LD group and (3) post-intervention test: assessment of metaphor comprehension one month following the intervention in order to examine the effectiveness of the program (in both groups of children with autism and LD group).

Participants completed the idiom and the metaphor comprehension tests in small groups and marked their answers on the questionnaires. The homophone meaning generation test and the two fluency tests were administrated individually.

Next, the groups of autistic and learning disabilities participated in the intervention program which comprised of two meetings. The intervention was performed on small groups of 2–4 children. In each meeting, children were using "thinking maps" (Lundgren et al., 2006) to study five different metaphoric expressions (a total of 10 metaphors). The researcher wrote on the board the metaphoric expression (e.g., "train of thought") and the children wrote the words in two central bubbles. Then they were encouraged to write associations for each word within the correct bubbles (e.g., "engine," "cars," "idea," etc.). Next, the researcher asked that the children think of other words that might have features in common with the two words of the expressions (e.g., "continuity," "connected") and write them in the central bubbles that are connected to both words (Fig. 1). Next, after establishing the common features, the researcher discussed with the children whole expression's interpretation ("sequence of interconnected ideas").

In order to enhance metaphoric understanding, on the one hand, and encourage suppression of meaningless interpretations, on the other hand, children were presented with 10 metaphoric expressions (that were learned in the intervention program) embedded within a contextual sentence (e.g., "During the exam children heard noisy knocks on the door and their *train of thought* was disrupted") and 10 meaningless expressions (e.g., "The 10-year-old boy won first prize for *cheek brains* competence"). Children were instructed to read the sentences and pay attention to the expressions in bold. Children were asked to decide whether these expressions made sense or not. The researcher and the children discussed the meaningfulness of the expressions.

Finally, one month later, the children of both the ASD and the LD group were tested on a metaphoric comprehension test. The test included 10 metaphors (five novel, five conventional), that were taught in the intervention and 10 that were not (five novel, five conventional), and 10 meaningless expressions.

Table 2
Summary of mean correct responses (and SD) in the idioms (maximum score = 20), metaphors (maximum score = 10), homophones, and the fluency tests in the three groups before the intervention (NM = novel metaphors, CM = convectional metaphors, UR = unrelated word pairs, TD = typically developed).

	ASD (1)		TD (2)		LD (3)		Scheffe
	Mean	SD	Mean	SD	Mean	SD	
Idioms							
Correct answers	15.75	3.80	18.95	1.16	14.20	3.40	2 > 1 = 3
Literal answers	4.57	3.59	1.33	0.50	4.94	3.36	2 > 1 = 3
Metaphors							
CM	6.65	2.50	8.67	1.15	5.70	2.03	2 > 1 = 3
NM	7.05	1.99	7.95	1.40	6.75	1.71	2 = 1 = 3
UR	3.9	3.09	7.24	1.81	3.35	2.23	2 > 1 = 3
Homophones	11.15	5.19	18.90	1.22	14.40	4.12	2 > 3 > 1
Semantic fluency	32.40	7.03	47.52	7.17	37.00	6.60	2 > 3 > 1
Phonemic fluency	16.9	7.17	28.62	6.00	19.16	7.49	

3. Results

3.1.1. Pre-intervention tests: figurative language comprehension

The results of the figurative language comprehension tests are summarized in Table 2. Both ASD and LD groups performed worse than TD children on all tests as assessed by a series of three-way ANOVAs (with the group as a between-subjects factor) for each variable separately (idioms, literal interpretations of idioms, and metaphors). Significant differences were followed by Scheffe post hoc analyses.

In the idiom comprehension test we performed two three-way ANOVAs, for the number of correct responses and for the number of literal interpretations. We found a significant group effect for both correct responses ($F(2,58) = 13.49$, $p < .001$, $\eta^2 = .32$) and choosing the literal interpretation ($F(2,58) = 9.77$, $p < .001$, $\eta^2 = .25$). Scheffe post hoc analyses found that the ASD group and the LD group understood fewer idiomatic expressions than TD children ($p < .01$, $p < .001$, respectively). No significant difference was found between the ASD and the LD group ($p = .26$). Both ASD and LD chose more often the literal interpretation as compared with TD children ($p < .05$, $p < .001$ respectively). No significant difference was found between the ASD and the LD group ($p = .40$) in interpreting the idioms literally.

In order to compare metaphoric understanding between the three groups we performed a 2×3 repeated measures ANOVA with the type of metaphor as within subject factor (novel, conventional) and the group as between subject factor (ASD, LD, TD). We found a main effect of group ($F(2,58) = 10.72$, $p < .001$, $\eta^2 = .27$). Scheffe post hoc analysis indicates that both ASD and LD groups understood less metaphoric expressions than TD children ($p < .05$, $p < .001$, respectively). No significant difference was found between the ASD and the LD group ($p = .41$). The main effect of type of metaphor was not significant ($F(1,58) = .77$, $p > .05$).

The interaction between group and type of metaphor was significant ($F(2,58) = 3.44$, $p < .05$, $\eta^2 = .11$). Scheffe post hoc analysis revealed that the source of the interaction was that ASD children understood less conventional metaphors than the TD children ($p < .01$) and the LD children understood less conventional metaphors than the TD group ($p < .01$). No significant difference was found metaphors between the ASD and the LD group in conventional metaphors understanding ($p = .58$). These results suggest that as opposed to conventional metaphors, the understanding of novel metaphors did not differ between the three groups.

A separate three-way analysis with group as between subject factor (ASD, LD, TD) was performed for the unrelated word pairs. We found a group effect in understanding the unrelated word pairs ($F(2,58) = 15.49$, $p < .001$, $\eta^2 = .35$). The TD group demonstrated better understanding than both the ASD group ($p < .001$) and the LD group ($p < .001$) of the unrelated two-word expressions. Thus, whereas the TD children more often chose the correct answer—"this is a meaningless expression"—for the unrelated expressions, both ASD group and LD group more often interpreted the meaningless expressions as meaningful.

Thus, typically developed children demonstrated as expected, better understanding of idioms, conventional metaphors, and meaningless expressions compared with autistic and learning disable children. However, both the ASD and the LD did not differ from the TD groups in understanding novel metaphors, which do not rely on prior knowledge. Furthermore, ASD and LD groups did not differ in the figurative language understanding tests.

3.1.2. Pre-intervention tests: executive functions

The results of the executive function tests are summarized in the bottom of Table 2.

3.1.2.1. Homophone meaning generation test

The three groups generated a significantly different number of homophone meanings, as three way ANOVA revealed ($F(2,58) = 20.88$, $p < .001$, $\eta^2 = .42$). Children of the TD group outperformed both the ASD group ($p < .001$) and the LD group ($p < .01$) and the LD generated significantly more words than the ASD group ($p < .01$).

3.1.2.2. Semantic and phonemic fluency tests

Children of the three groups generated a significantly different number of words during both fluency tests, as a three way ANOVA with the fluency test (semantic and phonemic) as repeated measure and with the three groups as between subject factor revealed ($F(2,58) = 31.09$, $p < .001$, $\eta^2 = .51$). Children of the TD group (MEAN = 38.07, SD = 11.59) performed significantly better than both the ASD group (MEAN = 24.65, SD = 10.52) ($p < .001$) and the LD group (MEAN = 29.01, SD = 10.10) ($p < .001$) which in turn generated significantly more words than the ASD group ($p < .05$). The three groups generated significantly more words during the semantic (MEAN = 38.97, SD = 9.37) compared with the phonemic fluency task (MEAN = 22.24, SD = 7.95). The interaction between the fluency tests and the groups was not significant ($p = .26$).

Based on Hebrew norms (Kavé et al., 2010), the mean *z*-scores of the autistic group on the phonemic and the semantic fluency test was −1.63, and −1.69, respectively, suggesting these children perform in the border. The mean *z*-scores of the LD group on the phonemic and the semantic fluency test was −1.01, and −1.12, respectively, suggesting that children with learning disabilities perform in the low average. As expected, TD children were scored −.01 and −.11, i.e., within the average.

Thus, the three groups of children demonstrate a different profile of executive functioning: the typically developed children perform better than both autistic and learning disable children but children with learning disabilities outperform the autistic children in both fluency tests and the homophone meaning generation test.

3.1.3. Post-intervention metaphoric tests

The main goals of the current study were to examine the effects of the intervention program on the ASD and LD group in learning metaphoric expressions and in adopting the "thinking maps" as a strategic tool that will assist them in comprehending items to which they had not previously encountered. In order to do so, we performed two $2 \times 2 \times 2$ ANOVAs with group (ASD, LD) as between subject factor, and learned (learned, not learned during the intervention), and time (before, after the intervention) as repeated measures. These analyses were performed separately for the conventional metaphors and the novel metaphors. The results of the intervention program are summarized in Table 3.

3.1.3.1. Conventional metaphors

A $2 \times 2 \times 2$ ANOVA found a significant main effect of time $F(1,38) = 60.71$, $p < .001$, $\eta^2 = .62$, indicating that conventional metaphors understanding was improved following the intervention regardless of group or whether the expressions were learned or not during the intervention. All other effects were not significant. Specifically, the three way interaction of the group × learn\not learned × time was not significant, $F(1,38) = .68$, $p > .05$. Thus, both the ASD and the LD improved the understanding of conventional metaphors to the same extent.

3.1.3.2. Novel metaphors

A $2 \times 2 \times 2$ ANOVA found a significant main effect of time $F(1,38) = 45.59$, $p < .001$, $\eta^2 = .55$, indicating that novel metaphors understanding was improved following the intervention. The two way interaction of time × learned was also significant ($F(1,38) = 5.77$, $p < .05$, $\eta^2 = .13$): regardless of group, children understood more novel metaphors that were taught during the intervention as compared to their performance before the intervention ($p < .001$) and understood more novel metaphors that were not taught in the intervention ($p < .001$) as compared to their performance before the intervention. Fig. 2 represents the changes in novel metaphors understanding by the two groups and by the type of novel metaphors (learned, not learned).

Furthermore, the three way interaction of group × time × learned was significant ($F(1,38) = 6.78$, $p < .05$, $\eta^2 = .15$). Scheffe post hoc analysis revealed a significant improvement in understanding novel metaphors that were taught during the intervention by the autistic group ($p < .001$) and by the LD group ($p < .001$). However, metaphors that were not taught during the intervention were not improved by the ASD group ($p = .91$). Contrary to the ASD group, children in the LD group improved their metaphoric understanding also for novel metaphors that were not learned during the intervention ($p < .001$).

These results suggest that following the intervention both groups improved their metaphoric understanding (of both familiar and unfamiliar) but the ASD group did not generalized the thinking maps to novel metaphors not previously encountered.

Table 3
Comprehension scores of the metaphors that were learned or not learned during the intervention program according to group (children with autism and children with learning disabilities).

	Conventional metaphors				Novel metaphors			
	Learned		Not learned		Learned		Not learned	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
ASD	4.60	0.60	4.15	0.93	4.95	0.22	4.10	1.21
LD	4.35	0.88	4.60	0.73	4.85	0.37	4.85	0.37

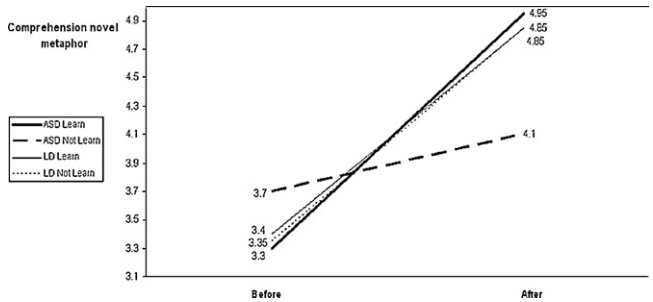

Fig. 2. Mean metaphor comprehension scores tested before and after the intervention program for the novel metaphors, according to group and type of novel metaphors (learned or not learned during the intervention).

3.2. Correlation analysis

The contribution of performances in the fluency tests and the homophone meanings generation test to idiom and metaphoric comprehension (in the pre- and post intervention tests) was assessed via correlation between these variables for each group separately.

Significant correlations in the autistic group were found between novel metaphors comprehension that were not taught during the intervention and both the homophone meanings generation test ($r = .48$, $p < .05$) and the phonemic fluency test ($r = .47$, $p < .05$). Children with learning disabilities showed a different pattern of correlations. Significant correlations in the LD group were found between the homophone meanings generation test and conventional metaphors understanding ($r = .48$, $p < .05$) and between conventional metaphors comprehension that were taught during the intervention and the semantic fluency test ($r = .58$, $p < .01$).

The results of the correlation analyses suggest that switching between different word meanings is associated with improved novel metaphoric language understanding in children with autism and with conventional metaphors understanding in children with learning disabilities.

4. Discussion

In the current study individuals with autism and with learning disabilities demonstrated difficulty in interpreting non-literal expressions as compared with typically developed children. In particular, the differences were found in the understanding of idioms, conventional metaphors, meaningless word pairs, and in providing more literal interpretation to idioms. Our findings corroborate with cumulative evidence showing specific difficulties in understanding metaphoric language in autism (Happé, 1993, 1995; Norbury, 2005; Roundblad & Annaz, 2010) and learning disabilities (Friemoth Lee & Kamhi, 1990; Nippold & Fey, 1983; Seidenberg & Bernstein, 1986).

However, no difference was found between the groups on novel metaphors understanding. Novel metaphor interpretations, unlike conventional metaphors, are not coded in the mental lexicon, and hence are not dependent on previous knowledge. When encountering novel metaphor, the metaphoric interpretation should be computed "on line" in such a way that prior semantic knowledge does not apply to novel metaphor comprehension and is not advantageous as in the case of conventional metaphors. We have showed that when this prior knowledge is neutralized, autistic children and children with learning disabilities perform as well as TD. This finding may suggest that the metaphoricity per se, i.e., the ability to create novel semantic connections between seemingly unrelated concepts, is not deficient in autism and in learning disabilities. Rather, ASD and LD children were underscored in metaphor comprehension when the expressions were probably more familiar and accessible to the TD group.

The current study aimed to examine ways to improve metaphor comprehension in autism and learning disabilities from a psycholinguistic perspective. Our results indicate that both groups improved the metaphoric comprehension of items that were learned during the intervention. Understanding metaphors relies on comparison processes of selecting the "ground" of the metaphors, i.e., matching and selecting the common features shared by the topic and the vehicle terms. This comparison process entails a flexible search of the appropriate features and inhibition of irrelevant ones. The current intervention program enables the child to "visualize" those various stages: the initial stage of activation of word meanings is implemented by encouraging the child to write the associations and the features of the words in the surrounding bubbles. The next step of selecting the ground of the metaphor, while inhibiting irrelevant interpretations, is promoted by directing the child to write the appropriate common features in the central bubbles. The various interpretations are then discussed until the appropriate interpretation emerges. A subsequent questionnaire with meaningless and meaningful expressions is then given to the children in order to enhance awareness for meaningless interpretations and inhibition of inappropriate interpretations.

Furthermore, ASD children and LD children were able to use the "thinking maps" to understand metaphors that were encountered for the first time with the exception that children with autism were not able to generalize this skill to novel

metaphors. Thus, LD children demonstrated a better "transfer" (generalization) ability than the ASD children, suggesting that the "thinking maps" are effective intervention tool, especially for children with learning disabilities. A possible explanation for this improved performance is higher executive functioning in the learning disability group, which includes mental flexibility to shift between different word meanings. Indeed, the LD group was scored higher than the ASD group in the fluency tests as well as on the homophone meaning generation test.

It has been suggested that non-literal language deficits, and specifically novel metaphors, is related to a failure of executive control functioning (Amanzio, Geminiani, Leotta, & Cappa, 2008; Pennington & Ozonof, 1996). The current study demonstrates that children with autism and learning disabilities were underscored on both the figurative language tasks and executive function tests, and these scores were nevertheless correlated. More specifically, the homophone meaning generation test, which highlights the mental ability to shift between word different meanings, was correlated with novel metaphors understanding in the autistic group and with conventional metaphors understanding in the learning disabilities group. Thus, if the executive control is damaged, the ability to combine vehicle and topic to create a new association required to understand a novel metaphor may be defective. In addition, an impaired ability to suppress irrelevant features of the vehicle term or the salient literal interpretation may hamper figurative language understanding. ASD and LD children indeed tend to interpret meaningless word pairs, as compared to TD children, suggesting a reduced ability to suppress irrelevant meanings. Our results also showed that higher performance in the phonemic fluency test, a task that tapping word retrieval intertwined with controlled search of the mental lexicon, is associated with novel metaphor understanding in the ASD group. Thus, the reduced ability of the ASD children to produce as many words as TD children was associated with pragmatic deficits. It may be that word retrieval using flexible strategies is a necessary condition to non-literal language understanding. This observation is supported by the positive correlation that was found between the semantic fluency test and conventional metaphor understanding in children with learning disabilities. Further examination needs to establish the exact role of word generation, and executive control functions, in non-literal language comprehension using multiple tasks and a larger sample of participants.

Our intervention program proposes an efficient tool to enhance metaphoric competence in children with autism and children with learning disabilities. The use of a cognitive visualized tool seems to be adequate to these special populations and the "thinking maps" can be potentially extended to other forms of non-literal language and perhaps to different neurological impaired populations.

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