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The relationship between visual metaphor comprehension and recognition of similarities in children with learning disabilities

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ABSTRACT

Previous studies have shown metaphoric comprehension deficits in children with learning disabilities. To understand metaphoric language, children must have enough semantic knowledge about the metaphorical terms and the ability to recognize similarity between two different domains. In the current study visual and verbal metaphor understanding was assessed in 20 children with learning disabilities (LD) and 20 typically developed (TD) children. Results showed that LD children scored significantly lower than TD children in the comprehension of conventional metaphors, and idioms. However, visual and novel metaphor comprehension, which does not rely on prior knowledge, did not differ between the two groups. Furthermore, our results suggest that higher analogical thinking facilitates visual metaphor comprehension in the LD group. In the TD group, metaphor comprehension correlates with higher semantic knowledge.

1. Introduction

Metaphorical language is pervasive in everyday language and discourse and it is important for both communicating and reasoning about abstract concepts (e.g., Gibbs, 1994; Lakoff & Johnson, 1980). Understanding non-literal language forms, such as metaphors and idioms, requires the listener to go beyond what is said (i.e., the literal meaning) to infer what is meant. In a metaphor, properties of the vehicle term are attributed to the target term on the basis of some similarities. When we said "this seller is a leech", the leech (representing the vehicle term) properties of sticking and clinging are attributed to the seller (representing the target term), and the metaphoric interpretation – this seller sticks to customers as leech to its victim – is derived. Thus, metaphor understanding requires some necessary knowledge about the vehicle term (e.g., leech is a parasite that sticks and sucks blood) and in addition, the construction of similarity between the vehicle and the target term (Ortony, 1979). Winner and Gardner (1998) argued that metaphor comprehension is constrained by the availability of the semantic knowledge, and that children can perceive metaphoric language as long as they have sufficient knowledge of the domains involved. In the current study, metaphoric language comprehension is used to probe the relation between language and cognition in typically developing (TD) children and children with learning disabilities (LD). More specifically, the aim of the current study is to examine the relation between both semantic knowledge and the ability to recognize similarities and the understanding of verbal and visual (pictorial) metaphors.

Metaphor comprehension gradually evolves throughout childhood, adolescence, adulthood, and even into aging (Berman & Ravid, 2010; Gardner, Winner, Bechhofer, & Wolf, 1978; Mashal, Gavrieli, & Kave, 2011; Thomas et al., 2010). Gentner (1988) proposed that children aged around 6 or 7 years interpret metaphorical comparisons first in terms of perceptual

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similarity and then in terms of relational similarity. In perceptual metaphors both objects share noticeable, physical properties (e.g., ''her hair is spaghetti''). Here, the perceptual property of spaghetti's length is mapped onto one's hair. In relational metaphors, i.e., non-perceptual metaphors, the similarity between the objects cannot be perceived by our senses (e.g., ''this lawyer is a shark''). Instead, the similarities are based on functions, properties, or internal structures that can be attributed to the target term. In the lawyer-shark example, cruelty and tenacious of the shark are mapped onto the lawyer. By the age of 11–12, children can interpret most types of metaphors, including those that require fairly precise conceptualization (Winner, Rosenstiel, & Gardner, 1976).

A considerable number of experimental studies and models have been made on the time-course of literal and nonliteral language comprehension. The two main models of non-literal processing are the serial model and the parallel (direct) model. According to the serial model, e.g., the standard pragmatic model (Grice, 1975), the metaphorical interpretation is computed through a sequence of processing stages that gives priority to literal meaning. First, the literal interpretation of the phrase is derived. Then, the literal interpretation is checked against the context of the phrase. Finally, if the literal interpretation is found incongruous then it is rejected and the metaphoric interpretation is computed. On the other hand, the parallel model argues that both the literal and the metaphoric interpretation are computed without rejecting the literal interpretation. According to this view, metaphorical and literal meanings are computed in parallel, with neither having unconditional priority, and in addition, both are processed automatically, i.e., neither meaning can be ignored (Glucksberg, 2008). Following these models, Giora and Fein (1999) proposes that the serial/parallel debate can be reconciled by the graded salience hypothesis in which regardless the type of meaning (either metaphorical or literal) more salient meaning is processed before less salient meaning. This view suggests that no priority is assumed with respect to literality. Although there is little consensus on the time course of metaphorical interpretation, all models view metaphors as cross-domain mappings between concepts from disparate domains of knowledge.

When verbal and pictorial information are contrasted in an explicit verbal recall task, visual information is recalled better. This effect is known as the picture-superiority effect. A recent study demonstrated a developmental trend in the picture superiority effect in recognition memory (Defeyter, Russo, & McPartlin, 2009). According to this study, whereas 7-year-old children did not show the picture superiority effect, it was significant among 9-year old, 11-year old, and adults. Several models have attempted to explain the picture superiority effect (e.g., McBride & Dosher, 2002). One influential account is Paivio's dual coding theory (Paivio, 1991). This theory proposes that pictures hold an advantage over words because semantic information is encoded through two separate routes. Whereas words are processed only through a verbal route, pictures are processed via both an image pathway and a verbal code. That is, when people process an image, they attend its visual features as well as spontaneously verbalize its label. Thus, according to the dual coding theory, pictorial information increases the strength of encoding by accessing semantic knowledge via two parallel pathways. Another explanation for the advantage of pictures over words is that pictures have more attention-inducing qualities than words. Given language and sometime attention deficits, children with learning disabilities may benefit from these advantages.

Visual metaphors are analogous to verbal metaphors in their ability to shape information and make sense of abstract concepts and relationships. Very little is known about visual metaphor processing in children with learning disabilities (Lee & Kamhi, 1990) studied verbal and visual metaphoric understanding in children with LD, children with LD with a history of spoken language impairments, and TD children ranging in age from 9 to 11 years. In the verbal metaphoric task in Lee and Kamhi's study, children read a sentence (''I went into the kitchen and ate up a storm'') followed by four possible interpretations (''1. I ate a lot; 2. I drank some white lightning from the refrigerator; 3. I ate so much it rained; 4. I like to eat when it's raining''). The results indicated that the performance of both LD groups was poorer than the performance of the typically developed children on the verbal task. Possible explanations for the poor performances of LD children in the verbal metaphoric tasks may result from one (or more) of the following prerequisites needed for metaphoric comprehension: First, the child must have enough knowledge about the vehicle and the target terms (Keil, 1986). Second, the child must recognize some form of target–vehicle similarity (Gentner, 1988; Ortony, 1979). And third, a mental flexibility that switches between the two meanings (the intended metaphoric meaning and the literal interpretation) is required (Berman & Ravid, 2010; Mashal & Kasirer, 2011). Despite the lower scores of the LD children in Lee and Kamhi's study in the verbal task, understanding the visual metaphors did not differ between the LD and the TD group. In another study, visual and verbal metaphor comprehension was tested in 12 children with language disorders (mean age of 10.3 years) and 12 control subjects matched for age (Highnam, Wegmann, & Woods, 1999). TD children provided more metaphoric explanations than children with language disorders, regardless of modality (verbal or visual). These findings suggest that visual metaphors are not advantageous for children with language impairments. However, when no language impairments are present, children with LD perform as well as TD children in visual metaphor comprehension. Although the study of Lee and Kamhi provided valuable information regarding the ability of LD children to process visual metaphors compared to TD children, it was not clear from the study whether LD or TD children demonstrate the picture superiority effect.

Studies that tested the picture-superiority effect using metaphoric items are remarkably scarce. While there is a little evidence that the picture superiority effect is not found for metaphoric items (Kogan & Chadrow, 1986), this effect is well established in studies of typically developed participants using non-metaphoric items (e.g., Whitehouse, Maybery, & Durkin, 2006). For example, participants from middle childhood to adolescence showed better recall of pictorial relative to word stimuli (Whitehouse et al., 2006). On the other hand, Kogan and Chadrow (1986) did not find evidence for the ''picture-superiority effect'' when visual metaphor understanding was compared with verbal metaphor understanding in second and fifth grade children. The lack of advantage may be related to the different processes involved in the comprehension of visual and verbal metaphors. In visual metaphors, the target term and the vehicle term are entirely rendered in the visual domain. Therefore, there is no grammatical rule (like in the case of verbal metaphors) for disambiguating target and vehicle. Consequently, target and vehicle should be identified as such based on other considerations (Forceville, 2008). In addition, once the target and vehicle terms are identified, the visual information has to be translated into both the conceptual and the verbal domains.

Thus, verbal metaphor differs from visual metaphor comprehension and based on the existing evidence we can conclude that: (1) there is no pictorial advantage in TD children's metaphoric comprehension; (2) LD children perform more poorly on verbal but not visual metaphor understanding tasks compared with TD children. However, the picture superiority effect, i.e., higher performances in the visual as compared with the verbal metaphoric tests, in LD children still remains elusive. The aim of the current study is therefore twofold: first, to examine whether both TD and LD children show pictorial advantage as compared to three types of verbal metaphors: conventional metaphors, novel metaphors, and idioms. Previous studies that used visual and verbal metaphors (e.g. Lee & Kamhi, 1990; Kogan & Chadrow, 1986) did not make the distinction between novel and conventional metaphors; and second, to examine the relation between metaphor comprehension (verbal and visual) and three fundamental cognitive resources required for metaphor comprehension: semantic knowledge, analogical thinking, and mental flexibility in both groups. Semantic knowledge will be assessed by the synonyms test, analogical thinking by the similarities test, and mental flexibility by the homophone meaning generation test.

2. Methods

2.1. Participants

The participants of the present study included 20 children with learning disabilities (LD) and 20 typically developed (TD) children, all children were native Hebrew speakers. The TD group consists of children of healthy development, aged 12–14 (17 boys and 3 girls), from two different schools from central Israel. The LD group included 20 children aged 12–14 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, the children 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). According to this diagnosis children are underscored at least 2 years below grade level and have average or above-average intelligence with a marked deficit in academic achievement.

All participants underwent screening tests of vocabulary knowledge, analogical thinking, and mental flexibility as assessed by the synonyms, the similarities subtests of MEM test (a Hebrew abstract verbal reasoning test) (Glantz, 2008), and the homophone meaning generation test (HMGT), respectively. 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 and 18 years. Only children scored within the normal range (standard score 7 or above) included in the study (Table 1).

The homophone meaning generations test is a test of retrieval flexibility that was originally devised to diagnose executive dysfunction (Warrington, 2000). This test investigates children's ability to activate (and shift between) the different meanings of a *homophone*. Children were presented with a list of 20 short unbiased sentences that ended with a *homographic homophone* (e.g., ''Look at this bank''). Children were instructed to say aloud all meanings of the final word. The examiner

Table 1
Summary of mean correct responses (and SD) in the synonyms, similarities, HMGT, and three reading tests (words, non-words with punctuation, and words with punctuations) according to group.

	TD		LD		Scheffe
	MEAN	SD	MEAN	SD	
Synonyms	11.14	1.35	9.55	1.39	.01
Similarities	13.90	1.92	9.60	1.73	.001
HMGT	18.79	1.23	14.95	3.41	.001
Words	68.58	15.17	47.26	15.02	.001
Non-words with punctuation	18.63	1.66	8.58	3.63	.05
Words with punctuation	56.42	2.76	35.79	11.03	.001

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. One LD child performed two standard deviations below the group mean and therefore was removed from further analyses.

In addition, all participants underwent word and non-word reading tests. 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). Reading performance of one TD child was two standard deviations below the mean group and therefore was excluded from the study.

Thus, after excluding two children, the study included 19 children with learning disabilities and 19 typically developed children. 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. Material

Children completed three figurative language comprehension tests that included the Metaphoric Triad Test (MTT), idioms, and a metaphoric questionnaire.

2.2.1. Metaphoric Triad Test (MTT)

This visual metaphoric test was developed by Kogan, Connor, Gross, and Fava (1980). The current study used 16 picture triads (e.g., a baby, a rose bud, a funnel). Each triad consists of two pictures that form a metaphoric relation (a baby, a rose bud) and a third picture that forms a non-metaphoric relation with each of the two pictures (a funnel). Children were presented with a power point presentation that presented the three pictures in a raw (order of pictures was randomized between sets). Children were asked to select two pictures that made the best pair and describe the relation between the two. If the pair of pictures that form the metaphoric relation were not chosen, the experimenter asked the child whether he or she can find another pair of pictures that form a relation and describe it. If the child did not choose the metaphoric pair, the experimenter asked once again whether he or she can find another pair of pictures that form a relation and describe it. If the child did not select the metaphoric pair the experimenter asked the child to explain the relation between the metaphoric pair.

Responses were scored according to a three-point scale: 0 – the child could not find a metaphoric relation between a pair of pictures or provide a correct metaphoric explanation for the metaphoric pair; 1 – the child provided a metaphoric explanation only after the experimenter pointed to the metaphoric pair; 2 – the child selected the metaphoric pair and provided a metaphoric explanation. The maximum score in the MTT was 32 points.

2.2.2. Idioms

This questionnaire investigated comprehension of Hebrew idioms and the tendency to choose the literal interpretation of an idiomatic expression. Only highly familiar 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*; "*kibel raglaim karot*") 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.

2.2.3. Metaphors (verbal)

The metaphoric questionnaire tested children's ability to understand conventional metaphors (e.g., *sharp tongue*) and novel metaphors (e.g., *pure hand*). 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. The use of novel metaphors was aimed to explore metaphoric comprehension of items that do not rely on prior knowledge, as compared to familiar metaphors, that are coded in the mental lexicon. For each participant, we counted the number of correct answers (i.e., the metaphoric interpretation for the metaphoric expressions).

2.3. Procedure

Participants completed the idiom and the metaphor comprehension tests in small groups and marked their answers on the questionnaires. The MTT was administrated individually.

3. Results

3.1. Results of the screening tests

The performance on the synonyms and the similarities test differ between the groups ($F(1, 36) = 44.36$, $p < .001$, $\eta^2 = .58$). The TD group (MEAN = 12.53, SD = 2.11) outperformed the LD group (MEAN = 9.66, SD = 1.53) in both tests. The interaction between test (synonyms, similarities) and group (TD, LD) was significant, $F(1, 36) = 16.56$, $p < .001$, $\eta^2 = .31$. As can be seen from Table 1, Scheffe post hoc analysis indicates that the TD group outperformed the LD group in both the synonyms and the similarities test.

Children in the TD group generated a significantly higher number of homophone meanings than the LD group ($t(36) = 4.62$, $p < .001$).

Finally, differences between the two groups on the reading tests were analyzed by 2 $\times$ 3 ANOVA with a group as between subject factor (TD, LD) and the reading test (words, non-words with punctuation (i.e., vowel points and diacritics), words with punctuation) as within subject factor, followed by Scheffe post hoc analyses. The group effect was significant: the TD children read significantly more words and non-words (MEAN = 47.88, SD = 23.15) than the LD group (MEAN = 30.54, SD = 18.23), $F(1, 36) = 65.42$, $p < .001$, $\eta^2 = .61$. The interaction between the reading test and group was also significant ($F(2, 72) = 5.83$, $p < .01$, $\eta^2 = .13$). As can bee seen in Table 1, the LD group read significantly fewer words and non-words as compared with the TD group in each reading test.

3.2. Results of the figurative language comprehension tests

The results of the figurative language comprehension tests (visual metaphors, verbal novel and conventional metaphors, idioms) are summarized in Table 2. Metaphor comprehension was examined by using multivariate analysis of covariance (MANCOVA) with 4 metaphoric tests (visual metaphors, idiom, novel and conventional metaphors) as dependent variables, with group as independent variable (LD, TD), and reading skills as covariates in order to control for the differential reading skills between the groups. A recent study has shown that reading comprehension skills predicted children's idiom understanding in second and fourth graders (Lavorato, Nesi, & Cacciari, 2004).

We found a main effect of test ($F(3, 108) = 13.64$, $p < .001$). Children understood more idioms (MEAN = 82.50%, SD = 17.22) than both novel metaphors (MEAN = 72.89%, SD = 16.55) ($p < .001$) and conventional metaphors (MEAN = 72.63%, SD = 22.08) ($p < .01$). Children also understood more visual metaphors (MEAN = 86.76%, SD = 8.61) than both novel and conventional metaphors ($p < .0001$). The main effect of group was not significant ($F(1, 35) = .98$, $p = 33$).

The interaction between group and type of expression was significant ($F(3, 108) = 5.70$, $p < .01$). As can be seen in Table 2, Scheffe post hoc analysis revealed that the source of the interaction was that LD children understood less idioms and conventional metaphors than TD children. Our results show that as opposed to conventional metaphors, the understanding of novel metaphors and visual metaphors did not differ between the two groups. Furthermore, TD children understood more idiomatic expressions than novel metaphors ($p < .05$), and LD children understood more visual metaphors than conventional metaphors.

We also compared the number of literal interpretations made by the LD and the TD children. t-Test for independent samples found that LD children more often chose the literal interpretation (MEAN = 22.25%, SD = 17.20) as compared with TD children (MEAN = 2.86%, SD = 3.73) ($t(36) = 4.57$, $p < .001$).

Thus, typically developed children demonstrated better understanding of idioms and conventional metaphors and made fewer literal interpretations to idioms compared with learning disable children. Importantly, LD children understood visual metaphors better than conventional metaphors, hence demonstrating pictorial advantage.

3.3. Regression analysis

We conducted four separate multiple regression analyses in order to examine the contribution of the independent variables (synonyms, similarities, and HMGT) for each of the four figurative language comprehension test (visual metaphors, idioms, conventional metaphors, and novel metaphors) for each group separately. Table 3 shows the results of the multiple regression analysis for predicting visual metaphor and idiom comprehension in each group.

Table 2
Summary of mean percent correct responses (and SD) for the visual metaphor, novel metaphor, conventional metaphor, and idiom comprehension tests and results of Scheffe post hoc analyses after controlling for reading skills.

	TD		LD		Scheffe
	MEAN	SD	MEAN	SD	
Visual metaphors	92.21	5.84	81.72	7.67	$p = .32$
Verbal tests					
Novel metaphors	77.89	13.57	67.89	17.51	$p = .45$
Conventional metaphors	86.84	12.04	58.42	19.79	$p < .0001$
Idioms	94.21	5.84	70.79	17.42	$p < .0001$

Table 3
Summary of multiple regression statistics for the two dependent variables visual metaphors and idioms in each group with similarities, synonyms and HMGT as independent variables.

	Predictor variable	*B*	SE *B*	β	$t(15)$
LD visual metaphors	Similarities	0.03	0.01	0.60	2.91*
	Synonyms	0.00	0.01	0.08	0.38
	HMGT	0.00	0.00	0.16	0.75
Idioms	Similarities	−0.12	2.23	−0.01	−0.06
	Synonyms	3.19	2.94	0.25	1.08
	HMGT	2.04	1.19	0.40	1.72
TD visual metaphors	Similarities	0.82	0.88	0.28	0.93
	Synonyms	0.60	1.25	0.14	0.47
	HMGT	−0.01	1.48	0.00	−0.01
Idioms	Similarities	0.89	0.70	0.31	1.26
	Synonyms	2.52	1.00	0.60	2.52*
	HMGT	−1.98	1.18	−0.42	−1.67

HMGT: homophone meaning generation test; *B*: un-standardized beta coefficient; SE *B*: standard error; β: standardized beta coefficient; *t*: *t*-test statistic; *p*: significant value of *t*.
* $p < 05$.

For the LD group, the regression model was significant only for the visual metaphors, $F(3, 15) = 3.26$, $p < .05$. Thus, synonyms, similarities, and HMGT were found to account for 39% of the variance in the visual metaphor comprehension test. One of the independent variables contributed significantly to visual metaphor comprehension in the LD group: similarities ($p < .05$). The regression models for the other dependent variables were not significant: idioms ($F(3, 15) = 2.04$, $p < .15$), conventional metaphors ($F(3, 15) = 1.41$, $p < .28$), and novel metaphors ($F(3, 15) = 1.73$, $p < .20$).

For the TD group, the regression model was significant only for the idioms, $F(3, 15) = 3.50$, $p < .05$. The three independent variables (synonyms, similarities, and HMGT) were found to account for 41% of the variance. As can be seen in Table 3, synonyms accounted a significant and a greater share of the variance in idiom performance ($p < .05$) than did similarities and HMGT. The regression models for the other dependent variables were not significant: visual metaphors ($F(3, 15) = 2.04$, $p < .15$), conventional metaphors ($F(3, 15) = 1.41$, $p < .28$), and novel metaphors ($F(3, 15) = 1.73$, $p < .20$).

4. Discussion

Previous research on the comprehension of metaphoric language in LD has focused mainly on verbal expressions that are used in daily life. However, the cognitive resources underlying the more novel uses of figurative language such as visual metaphors and novel metaphors in children are relatively unknown. The aim of the current study was to investigate the relationship between metaphoric comprehension and semantic knowledge, recognition of similarities, and mental flexibility in children with learning disabilities as compared with TD children.

LD children scored significantly lower than TD children in the comprehension of conventional metaphors and idioms (after controlling for reading skills). The meaning of both conventional metaphors and idioms are coded in our mental lexicon and therefore, their understanding involves the retrieval of pre-established (lexicalized) interpretations. However, no significant difference was found between the LD and the TD groups in novel metaphor and visual metaphor comprehension. The meaning of a novel metaphor has not yet been formulated and therefore it is not coded in the mental lexicon. As such, interpreting novel metaphors does not depend on previous knowledge. When computing the novel metaphoric interpretation TD children cannot fully benefit from higher vocabulary knowledge and therefore, prior semantic knowledge is not advantageous as in the case of conventional metaphors and idioms. Our findings show that children with learning disabilities perform as well as TD on items that are not coded in the mental lexicon (conventional metaphors and idioms). In other words, when the interpretation involves the on-line generation of metaphoric mappings between the two concepts (target and base term) LD perform as well as TD children. This finding entails that the ability to think metaphorically, i.e., the ability to create novel semantic connections and metaphorical mappings between two disparate semantic domains, is not deficient in children with LD. Rather, LD children were underscored in metaphor comprehension when the expressions were probably more familiar and accessible to the TD group (idioms and conventional metaphors). In support for the role of semantic knowledge in understanding familiar metaphoric language, the results of the regression analysis indicate that semantic knowledge accounted a greater share of the variance in the idiom comprehension test in the TD but not in the LD group.

One of the main findings is the observation that in the LD group, visual metaphors were better understood than conventional metaphors, indicating a pictorial advantage to visual metaphors for LD children. In the TD group, however, visual metaphors were not better processed than any of the other verbal expressions (conventional metaphors, novel metaphors, idioms). The lack of advantage in the TD group is consistent with Kogan and Chadrow (1986) study, who did not find the picture superiority effect in second and fifth graders. Given the poor performance of the LD group in conventional metaphor understanding, our results show that visual metaphors are advantageous for the LD group but not for the TD group, who perform equally well in both the visual metaphors and the conventional metaphors. The pictorial advantage found in the LD group may be related to the finding from the regression analysis which shows an association between visual metaphor comprehension and recognition of similarities. It could be that images facilitate the recognition of similarities between the pictorial source and target domain of the visual metaphors but printed words (i.e., the conventional metaphors) do not.

Consistent with Lee and Kamhi (1990), we found that visual metaphor understanding did not differ between the LD and the typically developed group. Pictures as opposed to words are encoded through two parallel pathways: visual and verbal codes (Paivio, 1991). That is, when people process an image, they attend its visual features as well as verbalizing its label. Based on latest research using eye tracking that shows that dyslectic children have visual deficits of many types (e.g., Jones, Obregón, Kelly, & Branigan, 2008; Xiu-hong et al., 2009) our finding is somewhat surprising. One of the approaches that address the neurological and cognitive cause of dyslexia is the sensorimotor theory. This theory, also known as the magnocellular deficit hypothesis, associates reading difficulties to irregularities in magnocellular neurons projecting visual information to the primary visual cortex (Livingstone, Rosen, Drislane, & Galaburda, 1991). It has been proposed that some dyslexic readers have impaired functioning of magno cells in the lateral geniculate nucleus that detect transient movement information in the visual field (Galaburda & Livingstone, 1993). Impaired mango cell function may cause unstable fixations and concomitant difficulty in processing orthographic information (e.g., Stein & Talcott, 1999) as well as processing of multiply presented visual items (Omtzigt, Hendriks, & Kolk, 2002). However, magnocellular impairment is not always concurrent (see Skottun, 2005 for reviews). It is therefore unclear whether LD children performed successfully on the visual metaphoric task despite their magnocellular impairment or because they rely more on the alternative pathway, i.e., the verbal code. Future studies with a larger number of participants and more sensitive method (e.g., eye tracking) should examine the role of the visual pathway during visual metaphor comprehension in LD children. Furthermore, LD children showed that they are not impaired in the process of forming novel metaphoric mappings between two concepts but rather have difficulties with retrieving lexicalized metaphoric meanings. We therefore suggest to test whether memory impairment leads to retrieval deficits in LD children during conventional metaphor understanding in a future study.

Our results also suggest that the two groups rely on different cognitive resources when they process visual metaphors and idiomatic expressions. Whereas visual metaphor comprehension is associated with the recognition of similarities in the LD group, semantic knowledge is associated with better idiom comprehension in the TD group. Based on our finding that similarities test accounted for a greater share of the variance in visual metaphor understanding in the LD group it may be concluded that analogical thinking ability is associated with better visual metaphor understanding. Thus, LD children rely on the process of recognition of target–vehicle similarity during visual metaphor understanding (Ortony, 1979), and it seems that this ability plays a more important role in the LD group than the TD group.

Our findings also show that LD children provided more literal interpretations to idioms than the TD group. This tendency to be concrete is in line with other studies showing specific difficulties in understanding metaphoric language in children with learning disabilities (Lee & Kamhi, 1990; Seidenberg & Bernstein, 1986). The observed tendency of LD children to select the literal interpretation may reflect the difficulty of LD children to go beyond the literal meaning in order to extract the intended meaning (Berman & Ravid, 2010). According to Levorato (1993), in order to grasp the correct idiomatic meaning, the child has to construct a coherent semantic representation of the text in light of the intended meaning and at the same time suppress the inappropriate word-by-word literal interpretation. It is possible that the ability to suppress the literal interpretation of the idiomatic expression had not yet maturated in the LD group.

Taken together, the results of the present study suggest that children with learning disabilities are impaired in verbal but not visual metaphor comprehension. This impairment is confined to conventional metaphors and idioms, i.e., to lexicalized meanings. Thus, LD and TD children may rely on different cognitive processes when they interpret metaphoric language: better comprehension of visual metaphor understanding in children with learning disabilities is facilitated by analogical thinking ability. In contrast, typically developed children demonstrated that better comprehension of familiar metaphoric language is linked to higher semantic knowledge. Our findings may have educational implications in terms of the need for intervention for LD children who exhibit impaired verbal metaphoric and semantic knowledge.

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