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Theory and Research

Prediction of Early Literacy by Analogical Thinking Modifiability Among Kindergarten Children

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Previous research has emphasized phonological, morphological, and syntactical awareness, naming, and phonological working memory as specific domain determinants of early literacy. General cognitive processes and intelligence have not usually been considered important in the early stages of acquisition of early literacy. The main objective of this study was to assess the power of a major cognitive process: analogical reasoning, to predict early knowledge of writing as evaluated by kindergarten teachers. 103 kindergarten children, randomly selected from 10 kindergartens, were administered the *Children's Conceptual and Perceptual Analogical Modifiability (CCPAM) test*. The children were also evaluated for their primary knowledge of writing by their kindergarten teachers as part of a routine didactic assessment. Early writing was significantly predicted by analogical reasoning above and beyond age and gender. Analogical reasoning and early writing may have similar cognitive components requiring inferential processing and closing of information gaps.

Keywords: early literacy; early writing; analogical thinking; dynamic assessment; cognitive modifiability; mediated learning experience

The fact that kindergarten children experience early writing has been well documented (e.g., Aram & Levin, 2001; Bodrova & Leong, 2006; Clay, 1966, 1975; Ferreiro & Teberosky, 1982; Korat, 2005; Levin, Share, & Shatil, 1996; Mandel-Morrow & Schickedanz, 2006; McKeown & Beck, 2006; Pontecorvo & Zucchermaglio, 1990; Teale & Sulzby, 1986). Early writing has been considered to be an important determinant of later skills in reading and writing (e.g., Barnett, 2001; Landesman-Ramey & Ramey, 2006; Levin

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et al., 1996; Shatil, Share, & Levin, 2000; Whitehurst & Lonigan, 2001). While part of the early knowledge in writing is attributed to structured learning experiences, most of it develops spontaneously and intuitively during natural daily exposure to print (e.g., Clay, 1966). The current research belongs to the trend of research dealing with understanding of the psychogenic mechanisms (as opposed to sociogenic mechanisms) of early literacy. Most of the psychogenic research dealing with identification of the cognitive components of reading and writing is carried out at a stage at which children have already been exposed to the formal principles of graphophonemic coding. The main objective of the current study is to assess the prediction of early literacy of kindergarten children by perceptual versus conceptual analogical thinking. Stanovich (1986, 1991, 2000) has already noted that in order to understand the cognitive components that are at the basis of academic knowledge and skills they should be studied as early as possible before being "contaminated" by other factors.

The major theoretical conception and research behind early literacy is presented here, followed by a review of research on analogical thinking. Because we examined analogical thinking by dynamic assessment (DA), the efficacy of DA in revealing accurately the nature of cognitive functioning and academic skills is also presented.

EARLY LITERACY

The phenomenon of early literacy as a consolidated concept has been described extensively and widely in educational and psychological research. In early studies, investigators were interested in documentation of early literacy (e.g., Goodman, 1984), identification of stages (e.g., Ferreiro, 1990; Ferreiro & Teberosky, 1982; Teale & Sulzby, 1986), and the influences of home and community on early literacy (e.g., Bus, 2001; Landry & Smith, 2006; Roberts & Burchinal, 2001; Roskos & Neuman, 2001). Very soon researchers moved to investigate the optimal environmental conditions at home and kindergarten that facilitate the development of early literacy (e.g., Barnett, 2001; Bodrova & Leong, 2006; Farran, Aydogan, Kang, & Lipsey, 2006; New, 2001; Strickland, 2001) and to develop specific tools and tasks that might improve it (e.g., Britto, Fuligny, & Brooks-Gunn, 2006; Mandel-Morrow & Gambrell, 2001; Mandel-Morrow & Schickedanz, 2006; McKeown & Beck, 2006; Landesman-Ramey & Ramey, 2006; Roskos & Vukelich, 2006).

The aim of the current research is to revive and reopen the discussion about the cognitive mechanisms and components that are at the basis of early literacy. Moreover, from all the cognitive components we are interested in general thinking mechanisms and not in the common well documented and specific domains such as phonological awareness and naming. The reason for our focus on thinking components is related to the premise that early literacy develops during daily, natural, and spontaneous experiences. Very young children are often exposed to partial aspects of writing, so they may complete knowledge gaps by exploring the writing process and by creating personal hypotheses about its rules and principles. Young children have an active role in understanding principles of written systems and invest active effort in understanding how to encode spoken language into written language and how to transform knowledge into a meaningful skill that can be applied in different settings. This exploration process is of great importance in future acquisition of written language and in becoming skilled readers and writers (Hall, 1987; Juel, 2006; Vellutino & Scanlon, 2001).

Learning by natural spontaneous experiences, in contrast to formal directed learning, relies on a child's intuition, hypotheses, inferential thinking, and active processing of environmental events. Hence, it is reasonable to assume that basic general thinking components will play a major role in early literacy.

From all thinking mechanisms that children may use at early ages we chose to focus on the role of analogical thinking in creating early writing structures and knowledge.

One of the cognitive mechanisms by which children create new hypotheses and solve problems is analogical thinking (Gentner, 1977, 1983; Goswami, 1995; Tzuriel & George, 2009; Tzuriel & Klein, 1985). Such thinking is conceived as one of the main operative modes children might use to decode words, especially irregular/sight words (Goswami, 1986, 1988, 1992). Many researchers have shown how children use opportunities that enable them to understand laws of encoding and decoding. Several investigators have suggested that by using these opportunities, children might be using a process of analogical thinking to encode spoken language into written language (Brown & Ellis, 1994; Campbell, 1985; Deavers & Brown, 1997; Duncan, Seymour, & Hill, 1997; Goswami, 1986, 1988, 1991, 1993; Goswami & Brown, 1990; Goswami & Mead, 1992; Seymour & Evans, 1994; Snowling, 1994).

It should be noted that the role of analogical thinking in early literacy is not self-evident as there is an extensive debate about the relative contribution of general cognitive components (e.g., language and thinking skills) versus specific components (e.g., phonological awareness, automatic naming, working memory) in the development of early literacy (e.g., Aaron, 1997; Fodor, 1983, 1985; Lucas, 1999; Nation, 1999; Nation & Snowling, 1998; Perfetti, 1999; Share & Stanovich, 1995; Shatil & Share, 2003; Siegel, 1989; Stanovich, 1986, 1991, 1996, 2000). Most researchers argue that in the first stages of language acquisition, when children are dealing with encoding and interpretation, specific rather than general thinking mechanisms are crucially important for early literacy. These researchers have argued that later on, in more advanced stages of development of reading comprehension and writing, general components take a more dominant role (Stanovich, 1986, 1991, 2000). On the basis of these studies one would expect no relationship to exist between analogical thinking and early literacy.

There is contradictory evidence, however, for the role of analogical thinking in processes of encoding and decoding in early literacy (Brown & Ellis, 1994; Campbell, 1985; Deavers & Brown, 1997; Duncan et al., 1997; Goswami, 1986, 1988, 1991, 1993; Goswami & Brown, 1990; Goswami & Mead, 1992; Holyoak, 1984; Seymour & Evans, 1994; Snowling, 1994).

Early studies on the use of analogy for spelling acquisition have been focused on reading. One of the questions asked was whether children who read correctly a word that is not based on phonological law (e.g., "fight") are using an analogical process when comparing it to other words (e.g., "night") (e.g., Frith, 1985; Goswami, 1986, 1988, 1991, 1993). These studies paved the way for later studies on spelling (Brown & Ellis, 1994; Campbell, 1985; Deavers & Brown, 1997; Snowling, 1994). The question of whether or not children use analogy for spelling in their first steps of reading brought about conflicting evidence. Whereas some researchers demonstrated that analogical reasoning is basic for any reading process (Goswami, 1986, 1988; Goswami & Brown, 1990; Snowling, 1994), other researchers showed that analogical reasoning is a sophisticated mechanism characterizing only experienced readers (Duncan et al., 1997; Frith, 1985; Marsh & Desberg, 1983; Marsh, Desberg, & Cooper, 1977; Seymour & Evans, 1994). A third group of researchers argued that early readers' ability to use an analogy for reading and spelling, at one level or another, depends on the children's age, the specific situation, and type of task (e.g., Deavers & Brown, 1997). Marsh et al. (1977) showed that 39% of 10-year-old children and 46% of 16-year-old adolescents used analogy when asked to read meaningless words that sound similar to meaningful words (e.g., *puscle-muscle*). Thus, the ability to use analogy for spelling increases as a function of age. In a later study, with 7- and 9-year-old children, it was shown that reading performance increased to 78% and 96%, respectively, when the children were told that the meaningless words are analogous to meaningful

words. Thus, it is evident that when children are offered a strategy of analogical comparison, performance level increases drastically (Marsh, Friedman, Desberg, & Saterdahl, 1981).

Unlike other researchers (Frith, 1985; Marsh et al., 1977), Goswami (1986, 1988, 1993) argued that children's use of analogy in reading is a spontaneous natural mechanism used from an early age. In a study with 5- to 8-year-olds, Goswami (1986) found that children spontaneously used an analogy even when no explicit strategy was presented to them. Goswami's conclusion was that analogy plays an important role in reading and should not be seen as a sophisticated strategy increasing with age.

Due to the contradictory evidence regarding the role of analogical inference in early literacy development we decided to reinvestigate how analogical thinking, in general, predicts early literacy. One of the possible explanations for the contradictory evidence for using analogical thinking as a component in reading and writing acquisition might be related to the different types of analogies, so in the current study we decided to employ two major types of analogies: *perceptual* and *conceptual*. In perceptual analogies the cue for understanding an analogy is based on visual clear cue that requires only description. Conceptual analogies on the other hand require verbalization or construction of a hidden third concept that must be projected by means of cognitive processing. Following the disagreement about the necessity of teaching and mediation of analogical thinking strategies in order to enhance use of early reading and writing, we chose a dynamic method of evaluation of analogical thinking rather than a static one. The choice of DA of analogical thinking allowed us to investigate also the effect of mediation on the pattern of early literacy prediction.

PREDICTING ACADEMIC SKILLS BY DA

The term DA refers to an assessment of perception, learning, thinking, and problem solving by an active teaching process aimed at modifying the individual's cognitive functioning (Tzuriel, 2001a, 2002b). The idea of actually intervening in testing situations in order to discover individuals' learning potential has been introduced by many (i.e., Feuerstein, Feuerstein, Falik, & Rand, 2002; Guthke & Stein, 1996; Haywood & Lidz, 2007; Haywood & Tzuriel, 1992, 2002; Lidz & Elliott, 2000; Sternberg & Grigorenko, 2002; Tzuriel, 2000, 2001a, 2002b; Vygotsky, 1978).

In a DA context, the examiner mediates the rules and strategies for solving specific problems, and assesses the level of internalization (i.e., deep understanding) of these rules and strategies as well as their transfer value to other problems of increased complexity, novelty, and abstraction (Tzuriel, 2001a). One of the key concepts in DA is *cognitive modifiability,* which is defined as the individuals' propensity to learn from new experiences and learning opportunities and to change one's own cognitive structures. Similar ideas are found in the concepts of the *zone of proximal development* (ZPD) (Vygotsky, 1978) and *scaffolding* (Wood, Bruner, & Ross, 1976). Usually cognitive modifiability is indicated in DA by the performance change from pre- to post-teaching phases. In this study we expected early literacy to be better predicted by post-teaching performance than by preteaching performance on analogies tasks. The rationale is that what an individual does initially without mediation (preteaching) might be determined by factors that are not necessarily related to his/her cognitive ability (e.g., lack of previous experience, impulsivity, reduced motivation). On the other hand, that individual's performance after a mediation process better reflects his/her "true" ability than does initial unaided performance. The higher accuracy of the post-teaching than the preteaching test

has been validated in many DA studies (Guthke & Stein, 1996; Hesseld, Berger, & Bosson, 2008; Resing, 1997; Tzuriel, 2000, 2001a). In addition to the advantages of DA in assessing abilities accurately, the dynamic methodology is relevant to the content domain of early literacy because of the nature of acquisition of early literacy. Clay (1966) already claimed more than 40 years ago that early literacy is not just a result of potential, maturity, and initiated environmental opportunities. It is mainly a result of the active processing by the learner of available environmental cues and opportunities. This means that acquisition of early literacy is based on the way the child is processing new information and transforming it into new formal knowledge. This idea fits very well the concept of DA where children are examined for their cognitive modifiability.

To summarize the main points that led to the current study: (a) Children use hypotheses in the early steps of acquiring literacy; (b) Analogical thinking is considered to be a basic mechanism in the construction of hypotheses, (c) There is a need to clarify whether different types of analogies predict early literacy differentially; (d) There is conflicting information regarding young children's abilities to use analogical thinking in the first steps of written language acquisition; (e) DA reflects children's ability more accurately than does standardized static testing.

OBJECTIVES OF THE STUDY

The major objectives of the current study were: (a) to assess, in general, the strength of analogical thinking to predict early literacy; (b) to evaluate the strength of perceptual versus conceptual analogies in prediction of early literacy, and (c) to determine whether DA can explain more adequately than does standardized testing the relation between analogical thinking and early literacy. A different pattern of prediction might give a clue to the contradictory evidence reported in earlier studies.

Hypotheses of the Study

1. Early literacy is significantly predicted by analogical reasoning components.
2. Early literacy is better predicted by conceptual than by perceptual analogies.
3. Early literacy is better predicted by dynamic than by static measures.

In order to examine our hypotheses we carried out a pilot study aimed at developing an *Early Literacy Didactic Test* (ELDT; Flor, 2003; Tzuriel & Flor, 2003) based on the Infrastructure toward Reading and Writing: Curriculum in Kindergartens of the Israeli Ministry of Education (Ministry of Education, 2007). We also conducted a pilot study to establish some aspects of the *Children's Conceptual and Perceptual Analogical Modifiability* test (CCPAM, Tzuriel & Galinka, 2000; Tzuriel, 2002b, 2003, 2007). It should be noted that although we use the term *early literacy* throughout the article, our focus is on the writing skill that is a component of literacy.

METHOD

Sample

The sample was composed of 103 kindergarten children (54 boys and 49 girls) who were drawn randomly from 10 kindergartens. All children were normally developing and had no record of learning disability or emotional disturbance. They all came from middle-to-high

educational backgrounds: 96% of the parents had at least 12 years of formal education and 55% had an academic degree. The occupational level of the parents was commensurately high and showed that 70% had occupations requiring semiprofessional training. The mean age of the sample was 70 months ($SD = 4.90$) with a range of 58–78 months.

Measures

CCPAM—Closed Analogies Version. The CCPAM is a DA measure composed of two versions of analogies: *Closed* (Tzuriel & Galinka, 2000) and *Construction* (Tzuriel, 2002a, 2003, 2006). Both versions of the CCPAM are based on Piaget's (1952) developmental theory, Vygotsky's (1978) concept of the ZPD, and Feuerstein's theory of *mediated learning experience* (Feuerstein et al., 2002).

The *CCPAM closed version* represents classical analogies in a pictorial mode divided into two types of analogies: *conceptual* and *perceptual*. The set of conceptual analogies is composed of 40 items, 20 items for each of the pre- and postteaching tests. The set of the perceptual analogies is composed of 32 items, 16 items for each of the pre- and postteaching tests. Each problem is formatted in a 2 × 2 matrix (A: B:: C: D) and presented in a colored pictorial modality. Each problem in the preteaching test parallels a problem in the postteaching test in terms of the relation expressed in the analogy (i.e., functional, categorical, part-whole). For each item the problem is presented at the top of the page and four alternative answers are shown at the bottom. The child is required to think about the relationship between the first pair of pictures in the problem, apply it to the second pair, and choose the right answer from the four given alternatives. For example, the conceptual functional analogy *Bird: Nest:: Dog: Doghouse* in the preteaching phase parallels the analogy *Bee: Beehive:: Parrot: Cage*; both analogies represent the same relationship, that is, the first dwells in the second. For each subtest there are two sample analogies used for instruction before administration of the test. Examples of closed conceptual and perceptual analogies are presented in Figures 1 and 2, respectively.

The *Conceptual Analogies Subtest* is composed of three types of analogies according to the relationship expressed in the analogy: *functional* (e.g., bird—nest), *part-whole* (e.g., beak—bird), and *categorical* (banana—apple). The *Perceptual Analogies Subtest* is based on an adaptation of Goswami's (1992) geometric shapes, but instead of using geometric shapes the analogies in the CCPAM are based on familiar objects. In each analogy the relation between terms in the analogy is of three types: (a) *difference* (change of color, position, number, or type of object), (b) *existence* (an object appears or disappears), and (c) *opposite* (i.e., object is above the chair changes to object under the chair).

It should be noted that although the conceptual analogies are presented in a visual pictorial mode they are considered conceptual because the relation between pairs of pictures cannot be inferred simply by viewing them. The answer requires extracting some abstract principle that connects them. In contrast, the perceptual analogies are based mainly on simple perceptual distinctions, although some conceptualization is required (e.g., distinction between a ball on a table or under it requires understanding of the concept of "on" versus "under" even though the distinction is mainly perceptual).

The teaching phase in each subscale was carried out using the analogies of the preteaching test and included the following strategies: (a) *Search for relevant dimensions required for the analogical solution* (e.g., color, size, quantity, position, and type of object), (b) *Understanding*

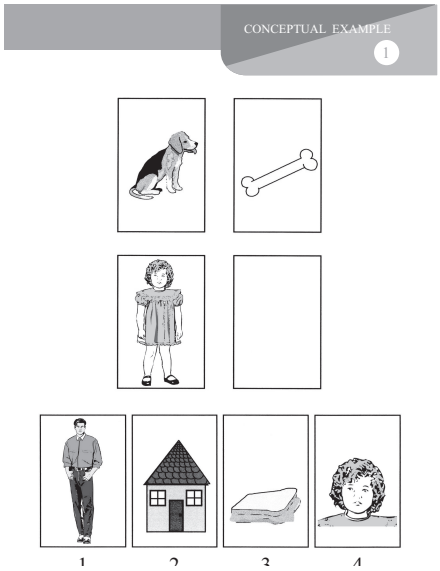

FIGURE 1. Example of closed conceptual analogy.

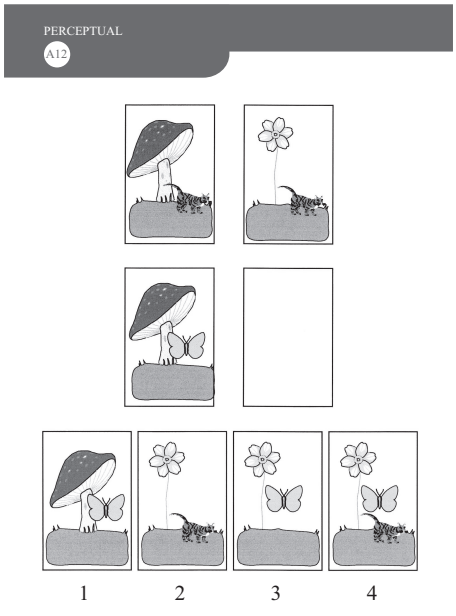

FIGURE 2. Example of closed perceptual analogy.

transformational rules (i.e., some components change but at least one component stays the same across the A and B terms), (c) *Verbal anticipation before actual choice of solution;* a strategy found to be helpful in controlling impulsive behavior, (d) *Justification of correct and noncorrect answers;* a strategy found to encourage metacognitive skills, and (e) *Systematic search for the correct answer* (i.e., looking at all the possible alternatives). A break of 5 minutes was

given between the teaching and postteaching phases. Children were taught to look simultaneously for changes between the A and B terms as well as between the A and C terms of the analogy.

Each correctly solved analogy gets a score of 1 and the maximal score for each of the conceptual and perceptual subtests is 20 and 16, respectively. Cronbach's α reliability coefficients were obtained in different samples of kindergarten children between the ages of 4 and 6 years (Tzuriel, 2000, 2006; Tzuriel & Galinka, 2000). The Cronbach-alpha reliability coefficients based on the present sample ($n = 103$) for the *Conceptual Analogies* subtest were 0.73 and 0.84 for the pre- and postteaching phases, respectively. The reliability coefficients for the *Perceptual Analogies* subtest were 0.82 and 0.89 for the pre- and postteaching phases, respectively.

CCPAM—Construction Analogies Version. The CCPAM—Construction Analogies version (Tzuriel, 2002) is composed of two sets of problems, *conceptual* and *perceptual*, with each set consisting of nine problems: one example problem and eight test problems. In each problem the child is presented with six cards, in a mixed order, and is asked to build an analogy with only four cards formatted in a 2 × 2 pattern, sorting out the two distracting cards. The distracting cards contain stimuli that are related to the analogy but are not part of it. The distracting cards are based on categorical, part-whole, or associative relations. Examples of construction conceptual and perceptual analogies are presented in Figures 3 and 4, respectively. The child is presented first with an example problem in which the principles of analogy construction strategies are demonstrated. The construction analogies were administered by a clinical/educational version of administration (Tzuriel, 2001a, 2002), using the

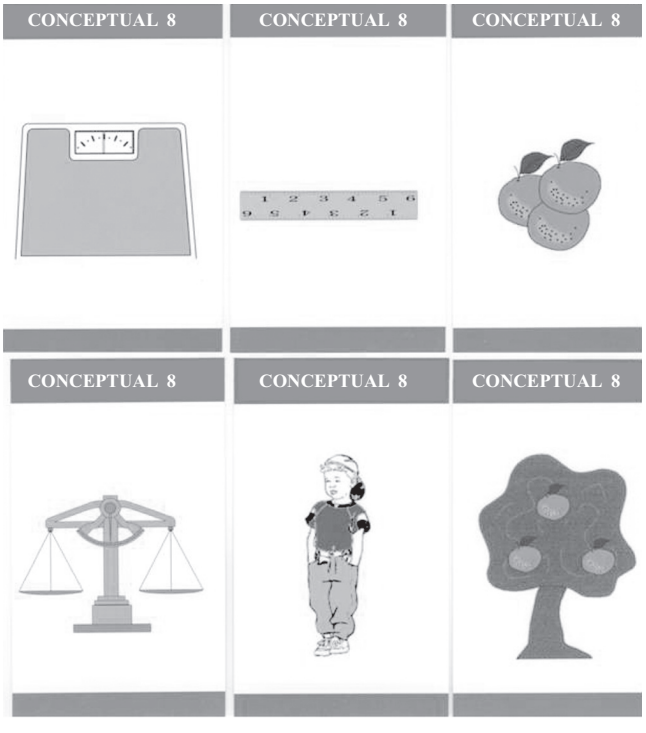

FIGURE 3. Example of construction conceptual analogy.

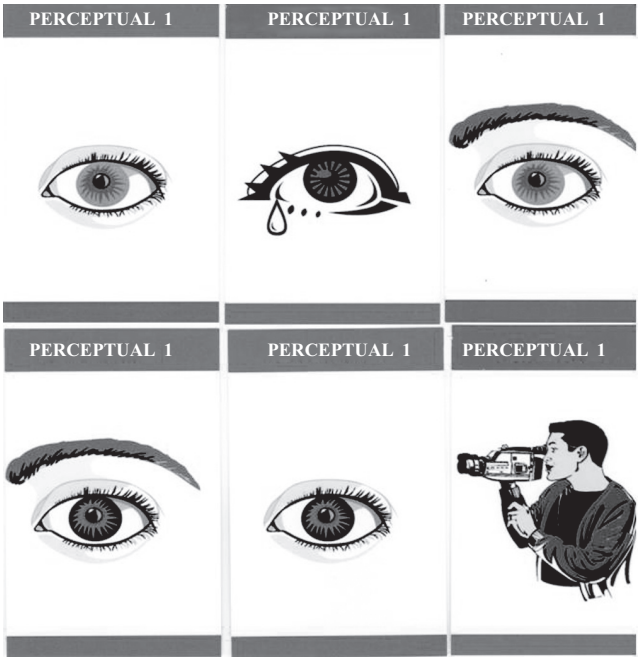

FIGURE 4. Example of construction perceptual analogy.

graduated prompt approach (Campione & Brown, 1987). The principle behind the graduated prompt procedure is basically to help the child in a gradual manner until he/she solves the task. Mediation in this approach is delivered by a set of predetermined hints that range from general to specific. The examiner stops providing hints when the child reaches the level of independent task solution. The amount of aid needed in order to solve the problem is taken as an indication of the subject's ZPD. The outcome measure in the graduated prompt approach is not the amount of improvement in the child's performance, but rather the amount of help or mediation needed to reach a specified criterion. Consequently, one can infer how much additional help is needed to transfer the learned principles to novel situations. A profile of the outcome measure is taken as an indication for the child's ZPD. The assumption is that a child with a broad ZPD profits more from the mediation and needs less help than a child with a narrow ZPD. The score for each problem ranges from 0 to 6 based on the amount of mediation required to provide the answer. For example, a maximal score of 6 points is given when the child constructs the problem independently with no mediation. If the child does not solve the problem, a small hint is given and the child is shown the A and B terms of the analogy with no verbal explanation. If the child solves the problem after this hint, a score of 5 points is given. The graduated prompt continues in a structured progressive procedure of five steps. For each step of mediation the score is reduced by 1. If after receiving all of the mediation, the child still does not solve the problem, a score of 0 is given. The reliability of the construction analogies was studied previously with a sample of kindergarten children (n = 148, Tzuriel, 2003) as well as in the current sample (n = 103). In both samples children were given the closed analogies prior to the construction analogies. Cronbach-alpha reliability coefficients of 0.87 and 0.87, respectively, were found in the earlier study (Tzuriel, 2003),

for the Conceptual and Perceptual analogies. For the current sample, the alpha reliability coefficients were 0.83 and 0.84, respectively. Validity of the CCPAM has been shown in earlier studies (Lifshitz, Tzuriel, & Weiss, 2005; Tzuriel, 2001b, 2006; Tzuriel & Shamir, 2010; Tzuriel & Zilber, 2001).

ELDT. The ELDT (Flor, 2003; Tzuriel & Flor, 2003) was constructed for the purpose of this study since other existing measures in Hebrew pertain mostly to partial aspects of early writing. There was a need to establish a new measure that refers to all parameters that come from the existing curriculum in early literacy in kindergarten. The ELDT is based on two pilot studies on kindergarten children. The first study was a qualitative study ($n = 14$) aimed at evaluating the suitability of the items for 5- to 6-year-old children. Following that study, some of the items were deleted, others were modified, and a quantitative evaluation questionnaire was added. In the second pilot study the ELDT—together with the CCPAM—Closed Analogies test, was administered to a sample of kindergarten children ($n = 24$). Pearson correlations of the ELDT with pre- and post-teaching conceptual analogies were 0.37 (p = ns) and 0.55 ($p < .0001$), respectively. The correlations of the ELDT with pre- and post-teaching perceptual analogies were 0.00 (p = ns) and 0.39 (p = ns), respectively. These preliminary analyses, as expected, showed that the ELDT was more related to post-teaching than to preteaching scores of the CCPAM and that the ELDT was correlated more highly with conceptual than with perceptual analogies. Based on these two pilot studies, some items were modified to avoid ceiling effects. The final ELDT version is composed of three sections: (a) worksheets for the child to perform 15 tasks, (b) an examiner's section, which includes description of tasks and instructions for qualitative evaluation of children's processes and responses, and (c) a quantitative questionnaire composed of 160 items for evaluating the children's performance and strategies of coping with literacy tasks. The ELDT tasks are of two types, simple and complex. In simple tasks, the child is required to write and name letters of the alphabet, write familiar proper names (friends from kindergarten) and other words ("father," "mother"), identify one- to multisyllable unfamiliar words, and pairs of words with contents that might affect the format of their writing (e.g., "short," "long"). In complex tasks the child is required to complete analogous words based on morphological rules (e.g., hand:hands:: leg - ?), write new sentences based on previously learned sentences (e.g., the sentence "Little Dan eats every morning" is based on "Dan eats and drinks every morning"), and perform complex writing tasks (e.g., letter, story). Scoring of performance is divided into four subscales according to the following early writing dimensions.

Awareness of Basic Characteristics of Written Language (16 items). This section refers to characteristics of attribution of meaning to writing, type of signs that are used (letter like/random letters/formal letters), differentiation between the meaning of a word and its graphic representation, understanding the principle of reading line by line, recognizing the limited number of signs in a word, and awareness of the need for spaces between words (e.g., consistent use of space between words).

Understanding of Phonological Lawfulness (13 items). The second section deals with aspects of phonology, such as the size of the phonological unit (segment) represented in writing and maintenance of phonological lawfulness for tasks of varying syllables, levels of complexity, and referential meaning. For example, an item aimed at evaluating writing of words with three syllables or more is given the highest score (3) if representation was carried out on a level of subsyllabic auditory units or phonemic auditory units. A score of 2 was given for representation based on the syllabic auditory units level, and the lowest score (1) was assigned

when there was no phonetic reference to the sound structure of the word or reference to sound units bigger than a syllable.

Formal Knowledge (77 items). This section deals with the graphophonemic integration, amount of orthographic knowledge (e.g., number of primary words that the child can write), writing from memory names of friends and family members, use of special vowels, awareness of homophonic representations, understanding the concepts of *letter*, *word*, and *sentence*, and awareness of genre in writing. A higher score is given for writing a word accurately, using proper alphabetic letters for all consonants and vowels, than for writing a word using random letters or even when using correct letters, but only for the consonants, leaving out letters for the vowels.

Spelling With Alphabetic Letters (54 items). In this section the child is evaluated for spontaneous writing and correct naming of each of the letters. The highest score is given for writing an alphabetic letter with no difficulty and naming it properly, a lower score (2) is given when the child does not write the letter but does identify it from among a choice of presented letters. The lowest score is given when the child neither writes nor identifies the letters.

The test can be scored for each of its subscales after weighting for number of items. In this study we used only the total ELDT score (based on 160 items), being quite aware that our procedure gave heavy weight to the subscales: *Formal Knowledge and Spelling with Alphabetic Letters*. In each item there are three hierarchical operative levels describing the child's functioning. The total ELDT score ranges between 160 and 480. While the whole ELDT test is administered in four sessions with no time limit, it usually takes between one hour and one and a half hours for administration. The Cronbach-alpha reliability coefficients of the ELDT subscales are as follows: Awareness of basic characteristics 0.88; phonological lawfulness, 0.98; formal knowledge, 0.98; specific knowledge of alphabetic letters, 0.98.

Procedure

All tests were administered during seven individual sessions of about one-half hour each, for a total of about 5 hours. The tests were administered in the following order: the CCPAM Closed Analogies and CCPAM Construction Analogies tests (three sessions), and ELDT (four sessions). In each of the CCPAM versions, the conceptual and perceptual analogies subtests were administered in a counterbalanced design to avoid possible order effects. The counterbalanced design was applied for the preteaching, teaching, and postteaching of closed analogies. In all analogies the teaching and postteaching phases were administered consecutively in the same session with a break of 15 minutes. Thus, memory and/or motivation effects, as well as immediate effects of teaching on postteaching performance, were avoided. The tests were administered by two graduate students who were trained for 30 hours in the procedures of the test administration. All tests were administered within a 3-week period.

RESULTS

Prediction of Early Literacy by CCPAM Analogies

Based on preliminary findings showing significant correlations between age and ELDT performance, $r = 0.34–0.48$, $p < .01$, and gender differences on the ELDT subscales, $t_{(99)} = 1.98$, $p < .05$, with girls scoring higher, it was decided to control the effects of age and gender in subsequent analyses.

In order to evaluate the relative strength of prediction of early literacy by conceptual *versus* perceptual analogies and the relative prediction of static versus DA we applied hierarchical regression analysis with four steps. In order to control age and gender we introduced these variables in the first step. In the second step we introduced concurrently the conceptual and perceptual preteaching analogies. In the third step we introduced concurrently the conceptual and perceptual postteaching analogies. In the fourth step we introduced concurrently other postteaching analogies (Post-2): the perceptual and conceptual construction analogies. The criterion variable was the total ELDT score. The results of this heirarchical regression analysis are presented in Table 1.

The findings show clearly that the block of analogies (steps 2–4) was associated with 19% of the variance in early literacy above and beyond the contribution of age and gender that together contributed 26%. Conceptual analogies were stronger than perceptual analogies in predicting early literacy in steps 2 (preteaching) and 3 (postteaching). In step 4, however, when the postteaching construction analogies entered, the perceptual construction analogies were stronger predictors of early literacy than were the construction conceptual analogies; this step added 9% to the prediction above and beyond the earlier steps.

DISCUSSION

The findings of this study indicate clearly that analogical thinking among preschool children, as examined by the CCPAM test, is related to early writing. Overall, conceptual and perceptual analogies added 19% of the variance in early writing above and beyond that associated with age and gender (26%), thus supporting Hypothesis 1. These findings might add to the debate about the relative contribution of general cognitive components (e.g.,

TABLE 1. Hierarchical Regression Analysis of Total ELDT Scores by CCPAM Analogies: The Differential Contribution of Conceptual Versus Perceptual Analogies in Pre, Post-1, and Post-2 Phases

Predicting Variable	β	*t*	*R*	R^2	ΔR^2
Step 1			.51	.26	.26**
Controlled variables					
Age	.50	5.37**			
Gender	.14	1.55			
Step 2—Pre			.59	.34	.08**
Conceptual	.29	2.44*			
Perceptual	.02	.20			
Step 3—Post-1			.60	.37	.02
Conceptual	.20	1.52			
Perceptual	.03	.20			
Step 4—Post-2			.68	.46	.09**
Conceptual	.14	1.36			
Perceptual	.25	2.24*			

*$p < .01$. ** $p < .01$.

language, thinking skills) versus specific components (e.g., phonological awareness, phonological working memory, automatized rapid naming) in the development of early literacy (for a review see Shatil & Share, 2003). The findings may also shed light on a separate debate regarding the role of analogical thinking with young children in promoting their reading and writing skills. Unlike studies that show that young children can use analogical comparison for reading and spelling (Goswami, 1986, 1988, 1992), there are opposing studies according to which complex analogy manipulation does not characterize young children and it is possible only with older children (Duncan et al., 1977; Frith, 1985; Marsh & Desberg, 1983; Marsh et al., 1977; Marsh et al., 1981; Seymour & Evans, 1994). Our findings showing significant prediction of early writing by different aspects of analogical thinking support the view that general thinking components might play an important role in determining early literacy

In an attempt to reconcile the two sides of the debate, Stanovich (1986) suggested that in the first stage of acquisition of reading and writing the relevance of specific factors is dominant, whereas in later stages, when the relative involvement of reading comprehension increases, the role of general factors becomes more important. Based on the present study's findings we suggest a possible extension of Stanovich's two-stage solution to a three-stage model that explains the relative role of general versus specific factors in development of literacy acquisition. In the first stage of *preformal* acquisition, when children begin to comprehend the existence of the written word and its necessity for communication, although without knowing how exactly it is formally done, both general and specific factors play important roles. In the second stage, the formal acquisition of literacy, when learning is focused on principles of encoding and decoding phonemes to graphemes, the role of specific factors becomes dominant and the role of general factors decreases, although it might still contribute to a certain degree. In the third phase, with transition to reading comprehension, the role of general factors re-emerges, and both specific and general factors are important in determining literacy development.

In order to examine the applicability of such a three-stage developmental model we suggest that future research use two research models: a prediction regression model and an intervention model. In the regression prediction model the predictors of early literacy should include both general and specific domains. Shatil and Share (2003) did a longitudinal study in which they tried to predict literacy skills at the end of Grade 1 by specific versus general factors. They found that specific literacy factors predicted encoding and decoding processes whereas general factors predicted reading comprehension. It has already been suggested by Stanovich (2000) that when trying to explain the role of specific cognitive mechanisms against general cognitive mechanisms in prediction of reading and writing, there is an advantage for selection of primary literacy skills that do not involve measures of thinking and comprehension.

In the intervention model we suggest applying a program for enhancing analogical thinking with kindergarten children and observing how the acquired analogical skills are used in the early literacy domain.

Comparison of conceptual to perceptual analogies (Table 1) revealed an interesting tendency for preteaching conceptual analogies to be stronger than preteaching perceptual analogies in predicting early literacy, thus supporting Hypothesis 2. Early literacy was predicted more powerfully by conceptual than by perceptual analogies in both preteaching ($\beta = 0.29$ *versus* $\beta = 0.02$, respectively) and postteaching ($\beta = 0.20$ *versus* $\beta = 0.03$, respectively) phases;

however, in the third step of the analysis, when postteaching construction analogies were introduced, early literacy was predicted more powerfully by perceptual analogies than by conceptual analogies ($\beta = 0.25$ *versus* $\beta = 0.14$, respectively). A possible explanation for the dominance of conceptual over perceptual analogies in predicting early literacy is related to the nature of each type of analogy. Conceptual analogies require creation of a relevant linguistic connection between two components that is not seen in the analogy's problem, whereas perceptual analogies require description of existing visual cues with minimal requirement to use abstract linguistic terms. For example, in conceptual analogies (see Figure 1) children are requested to create the appropriate connecting verb or word that will serve as a basis for the analogical comparison (e.g., "the dog eats a bone and the girl eats ... a sandwich"). In perceptual analogies (see Figure 2), on the other hand, children are requested to anticipate the solution by just describing the existing visual cues without creating a new relevant term (e.g., "at the top, there is a picture with a mushroom and a cat and next to it there is a flower and a cat; at the bottom there is a picture of mushroom and a butterfly so next to it there should be ....a flower and a butterfly"). The conceptual analogies in contrast to perceptual analogies are more related to early literacy achievements which by themselves are also based on creation of new connections between phonemes and graphemes and understanding the principle by which phonological segments are translated to a visual segment.

It is interesting to note that the postteaching construction analogies, entered in the third step of the hierarchical regression analysis, added 9% to the prediction of early literacy above and beyond the pre- and postteaching phases (closed analogies which together explained 11% of the variance). The fact that the third phase of the DA contributed significantly to the prediction of early literacy indicates two important aspects. The first is related to the effectiveness of DA above and beyond static standardized testing, thus supporting Hypothesis 3, and the second is related to the contribution of perceptual construction analogies beyond the conceptual analogies found in the previous steps. It is plausible to assume that the significant contribution of the construction analogies to the prediction of early literacy is due to the *unique and active* pattern of thinking that is used to solve the analogies task (see Measures and Figures 3 and 4). The active feature of the construction analogies is also characterizing the active nature of encoding phonemes to graphemes. The fact that in the third step the perceptual analogies came into the picture might be due to the nature of the hierarchical regression analysis. After early literacy was explained in the first and second steps by conceptual analogies, in the third step a new component has emerged as a significant predictor.

This pattern of prediction involving a combination of *conceptual analogies* with *perceptual analogies* might suggest that the nature of early literacy skills requires both conceptual and perceptual components with some dominance of the conceptual analogies. Further studies are needed in order to understand the functionality of conceptual versus perceptual analogies in prediction of early literacy processes as well as the contribution of closed versus construction analogies.

The literature on cognitive mechanisms that are at the basis of early formal steps in reading and writing does not indicate, in general, analogical reasoning as a central cognitive mechanism (see Shatil and Share, 2003, for a review), and certainly does not suggest training of analogical reasoning as an important factor in development of reading skills (e.g., Adams, 1990). Most research deals with mechanisms such as phonological processing, including phonological awareness (e.g., Bentin & Leshem, 1993), memory of phonological sequence (e.g., Baddeley, 1986, 2003), automatized rapid naming (e.g., Denckla & Rudel, 1976; Felton &

Brown, 1990; Wolf & O'Brien, 2001), and lexical processes such as grammatical and morphological alertness (e.g., Snyder & Downey, 1997). It is plausible to assume that since analogical thinking has not been considered a potential cognitive mechanism in reading and writing processes, it has also been ignored in the literature of early literacy; as far as we know it has never been discussed. Researchers in the field of early literacy have usually focused on defining its developmental stages, on the contribution of socioeconomic and personality factors, and on the role of teachers and curriculum in enhancement of early literacy. Another possible reason for ignoring the role of analogical thinking in early literacy might be related to the different conceptualizations of early literacy and readiness for reading and writing skills. While the concept of early literacy and related research have evolved out of the theoretical framework of *whole language*, the concept of the cognitive mechanisms that are at the basis of reading and writing processes is a by-product of the *reading readiness* concept which is focused on the cognitive mechanisms necessary to enhance successful reading and writing.

In the present study we investigated only the role of one general factor, analogical thinking, without comparing it to the role of specific known factors, such as phonological awareness, phonological working memory, and automatized rapid naming. In further research both types of factors should be explored simultaneously in each of the proposed developmental stages. Furthermore, experimental research is required in which the effects of training of general versus specific factors are compared in relation to their effects on early literacy and more specifically on writing acquirement.

The findings of this study have practical implications that are beyond the theoretical contributions of understanding the role of cognitive components in early literacy. In general we can conclude that developing children are perceived as active constructors of knowledge by creating hypotheses and solving problems. The investigation of the use of analogies for understanding the lawfulness by which spoken language is coded into written language is of immense importance. We suggest exploring further the effect of training in analogical reasoning as part of the early literacy activity, especially with typically developing children who are experiencing difficulties in phonological awareness and working memory. For these children, understanding of general analogical rules by which spoken language is translated to written linguistic codes might circumvent their difficulty. Longitudinal studies based on intervention programs of developing analogical reasoning translated into written linguistic contents might help in understanding the specific processes by which literacy is acquired. Also, further research is needed to explore the relative contribution of analogical thinking in the first steps of literacy acquisition as compared with other mechanisms such as phonological alertness, phonological memory, phonological processing, automatic naming, and automatic auditory processing—processes that have been shown to contribute to reading and writing (Baddeley, 1986, 2003; Bentin & Leshem, 1993; Denckla & Rudel, 1976; Felton & Brown, 1990; Snyder & Downey, 1997; Wolf & O'Brien, 2001).

The findings of the present study also have implications related to the question of assessment of cognitive skills by DA versus static measures. It is plausible to assume that a short teaching phase during evaluation of the early literacy test would reveal a different modifiability pattern of different individuals and more accurate prediction in future success. Children's linguistic achievement is affected very often by non-intellective factors, an effect that depresses the prediction level by cognitive factors or cognitive processes by "soaking up" a significant portion of the variance in the criterion variable. Addition of a dynamic component to the predicted and to the predictive variables would enhance the accuracy of prediction

(Haywood & Lidz, 2007; Hessels, Berger, & Bosson, 2008; Sternberg & Grigorenko, 2002; Tzuriel, 2001a).

The question of the type of test includes also the content, the modality of administration, and the method of scoring. Our claim is that a relationship between a cognitive domain and an academic skill would depend on the type of content (e.g., linguistic-visual, linguistic-auditory), modality of administration (e.g., closed analogies, construction analogies, nonverbal analogies), and method of scoring (e.g., "graduated prompt," "none-or-all," "partial credit"—see Tzuriel 2001a). Moreover, one has to consider the specific strategies activated by children during their cognitive processing, not only their final achievements. The specific strategies used are probably responsible for the relation or predictions found and not necessarily the cognitive ability *per se*.

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