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Solving conceptual and perceptual analogies with Virtual Reality among kindergarten children of emigrant families

Abstract

The goal of this study was to examine whether an intervention program of an immersive 3D VR simulation could improve the analogical thinking of kindergarten children enrolled in public education. The sample included 56 children aged 4 to 7 years whose parents immigrated to Israel during the last ten years from Ethiopia.

The research instrument we employed for evaluating the Analogical thinking of the children was the CCPAM measure (Tzuriel & Galinka, 2000), which includes 10 questions on Conceptual Analogies and 10 questions on Perceptual analogies. We designed the intervention program according to the CCPAM test. The CCPAM test was administered in three intervals:

a. Prior to the beginning of the intervention.
b. Immediately after the intervention, which included two meetings of 15 minutes each, in which the children were given exercises in solving analogies.
c. Three weeks after the end of the intervention, in order to test the ability to preserve the solution strategy (the follow-up test).

The experimental group (n=28) practiced the solution of analogies that were presented in 3D VR, while the control group (n=28) practiced the solution of the same analogies with a pictorial version of the items, that were presented with cards. The results show that both programs of intervention – VR and picture cards – improved significantly their ability to solve both kinds of analogies – perceptual and conceptual. However, the children in the experimental group, who practiced analogies within an immersive VR environment, improved their achievements, and also preserved the solution strategy three weeks after the intervention, to a statistically significant degree more than did the children, who practiced solutions with picture cards. The improvement in solving conceptual analogies was higher than the improvement in solving perceptual analogies.

Keywords: immersive Virtual Reality, immigrants, perceptual analogies, conceptual analogies, kindergarten children.

Introduction

Emigrants who emigrated from developing to developed countries tend to experience tremendous challenges in their early years in their new country (Shany, et al., 2010). This research focused on the Ethiopian Jews abrupt transition from village life in Ethiopia to Israel, which occurred en masse within the past three decades. This challenge has been accompanied by adjustment crises which have in turn immensely affected their learning and integration into Israeli society. Numerous reports show the low educational performance of this population and a high number of dropouts. Ethiopian students are disproportionately represented in special education streams (Berhanu,2006). On the other hand studies demonstrate that extra-curricular activities with students of Ethiopian origin in purpose to improve academic abilities, both at the kindergarten stage and at any other stage in school, are highly successful and show that the majority of participants were capable of closing the gap that existed between Ethiopian and Israeli students within short period (Avinor, 1995; Kozulin, 2005; Berhanu, 2006).

One of the gaps reported in the literature refers to analogical thinking. Similar to the mathematical equation of relations, analogical thinking expresses the ability to identify relationships: *e.g.*, A:B::C:D, which means that A relates to B in the same way that C relates to D (Sternberg, 1977). The ability to think analogically is central in the process of learning and understanding reality. Studies show that analogical thinking abilities at kindergarten age are predictors of reading and math readiness (Tzuriel & Flor-Maduel, 2010).

According to Piaget (1969), the ability to identify the similarity between the relations of the analogy happens only between 11 and 12 y/o. At younger ages children are inclined to think about analogical relationships in successive terms (this after that). They choose one relation in order to make a connection between terms A and B of the analogy, and another relation to make a connection between terms C and D. A conclusion of this sort is termed as a lower order or first-order relational processing.

According to the initial Sternberg's componential theory of human intelligence, the process of analogical reasoning includes a continuity of several stages from *encoding stimuli* at the beginning, to *response* at the end of this process of thinking. The more experience the child has in solving analogies, and as age increases, the higher the level of efficiency those stages are employed. Both Piaget and Sternberg agree that analogical thinking develops by the age increases, but according to

Sternberg, some level of analogical reasoning occurs already at younger ages (Sternberg, 1977; Tzuriel, 2006; Gentner, Holyoak & Kokinov, 2001).

In this study we designed an intervention program to improve analogical thinking ability of kindergarten children of Ethiopian origin. Researches that examined intervention programs to improve analogical thinking, usually used pictorial mode of representation (Tzuriel, 2006).

Bruner described three modes of representation, which appear in children in the continuum of their development (Bruner, 1973). The first mode that appears in early childhood is *Enactive mode* – in which objects are represented by means of immediate sensory perception. The second mode that appears at kindergarten age is *Iconic mode* – which requires the use of mental representations, and is based on visual images, such as pictures, models, and drawings. Iconic representation allows the child to recognize an object which has changed slightly – a mountain with or without snow at its summit, for example. This mode is important for achieving distancing from the enactive representation, and coming closer to the symbolic representation. The third mode is *Symbolic mode* – It expresses conceptual understanding, which is seen also in spoken language. These representations are a sort of tool which people use when they are processing the information needed for transmitting their intentions, and in streamlining their ways of thinking.

Bruner's model is related to the way the child develops representation modes. According to this model, the child can interpret a picture without difficulty if s/he has gone through the normative development stages without interruption (Bruner, 1973). In our study we claim that the children of immigrant Ethiopian families did not exercise enough interpretation of pictures in their early childhood stage. Therefore, the VR exercises of 3D objects close the gap of the enactive stage they are lacking.

Our assumption is that this concrete experience assists them in interpreting the pictures.

The unique nature of the VR technology, which we used in this study, lies in the way in which the concrete and three-dimensional presentation of the analogical terms is expressed. This can be attributed to its high level of interactivity which creates an active learning experience, and in the unique interface of the Head Mounted Display (HMD) which empowers the experience of immersion, and assists the attentiveness of learning (Passig, 2010).

Our hypothesis is that training with VR technology will help to improve analogical thinking of children from Ethiopia origin, significantly better then training with pictures cards. It is based on earlier studies, which pointed out that training with immersive VR technology brought about improvement in thinking skills significantly better than other modes of representation (Passig & Eden, 2010).

The Ethiopian Jews

The story of how the Ethiopian Jews – known as Falasha, meaning 'gone to exile' survived for so many centuries in exile clinging to their Jewish tradition and how, finally, they came to Israel is fascinating. As to their history and origin, there are contradictory statements and theories, and it had been an intensely debatable issue, especially in Israel among different religious Jewish authorities, pertaining to, for instance, their rights to Israeli citizenship and authenticity of their Jewishness. It was not until 1973 that they were officially accepted as having the right to “return” to Israel and become Israeli citizens. It is important to recognize that while in Ethiopia, the Ethiopian Jews have lived most of their lives in isolation both in time and space.

They have a singular, defined traditional way of raising and educating children (Berhanu, 2006).

The daily occupations of Ethiopian Jews generally did not require reading and writing, and therefore not many children were sent to school. Learning was executed through oral stories and songs – mainly through mimicking what the elders or teachers are saying or singing, not through exercising general thinking principals such as classification and analogical thinking (Kozulin, 2005). In Israel immigrants were referred to Hebrew language classes. For many of them it was the first encounter with the written word in any language, that is to say they are illiterate in their mother tongue too. Even though the curriculum is tailored to the needs of this population a large number of immigrants still lack the ability to read and write effectively. Moreover, most of the parents in these families are living under the poverty line which adds to their hardship (Shany et al. 2010).

Similarly, the results of various recent studies indicate that kindergarten-age children from the Ethiopian community present statistically significant deficiencies in *cognitive literacy, environmental, and language disabilities*. Thus, some researchers maintain that there is a need for children of this community to be exposed frequently at an early age to children's books with the mediation of adults that covers conversation about the stories, the vocabulary, and additional contextual knowledge (Shany et al. 2010). As mentioned above, in purpose to help to find efficient ways to close those gaps, we chose one of the gaps reported in the literature, analogical thinking, and designed this study to examine a way to improve this ability in children from Ethiopia origin, using IVR technology.

Analogical Thinking,

A child's ability to use analogical thinking is one of the measures of his or her cognitive abilities and level of intelligence. This ability is expressed in all aspects of life – from reaching conclusions and expressing them, to creating new hypotheses and theories (Sternberg, 1977; Inhelder & Piaget, 1958).

According to Piaget, analogical reasoning is characterized by thinking from the "second order" that emerges at the stage of formal operations only at the ages of 11-12 (Piaget, 1969). In the past few years this theory, which was propounded by Piaget, came under criticism (Goswami & Brown, 1989). Nowadays, numerous researchers are in agreement that children exhibit analogical reasoning abilities already at a younger age. This is contingent upon the manner by which the problem is presented to the children and the degree to which they are familiar with the terms of the analogy (Gentner, Holyoak & Kokinov; 2001). In addition, studies show that by mediation and training, young children improve their ability to solve analogies (Tunteler & Resing, 2007).

The research literature distinguishes between two different kinds of analogies – conceptual and perceptual analogies. Conceptual analogies refer to semantic relationships between objects. A prior knowledge is necessary in order to solve them. In contrast, perceptual analogies express the relationship between visual perceptions and objects. In perceptual analogies all the relevant information is given in the framework of the task at hand, so that there is no need to access information from long-term memory. Various studies have indicated that there are differences between the ability to solve conceptual analogies as opposed to perceptual analogies (Tzuriel, 2006).

There is no consensus, however, which of the kinds of problems is solved more successfully by the children, or what are the factors which allow success in one kind or another. Different researchers attribute success in solving different kinds of analogies in young children to the method of the mode of representation, to age, to the subjects' familiarity with the problem, and to the way in which the intervention was mediated (Goswami & Pauen, 2005). It would appear that there is a distinction between the manners of working through the different processes which are required for solving each one of the different kinds. Moreover, many researchers maintain that each kind represents a different aspect of intelligence. According to this, it would seem that conceptual analogies express semantic relationships between objects, so that in order to solve them, prior knowledge is required, while perceptual analogies express visual, perceptual relationships. In that case, all the relevant knowledge must be given in a task, and there is no need to access knowledge from the long-term memory (Tzuriel, 2006; Goswami, 1992).

Sternberg (1977) defined the process of analogical reasoning as including a continuity of several stages from encoding stimuli at the beginning, to response at the end of this process of thinking. First the child identifies the significant characteristics of each of the components of the analogy, and stores them in the working memory. Then he detects the relation between the terms A and B of the analogy, and seeks the higher-order relationship between the first half of the analogy (A and B) and the second half of the analogy (A and C). He seeks the correct answer from among the presented elements. During his process of thinking, he maps out the relations between the term C and each of the elements. He uses the relations between terms A and B of the analogy and the decision made about them to help him make current decisions. He seeks to verify the better or best of the available options. At the end of this process, the child communicates a solution to the analogy. The more experience the child has in solving analogies, and as age increases, the higher the level of efficiency those stages are employed.

However, according to Piaget (1969), as opposed to Sternberg, reaching an analogical conclusion is a much more complex task, whose ability to perform is developed only in the stage of formal operations; at the age of 11 to 12 y/o. According to Piaget, the ability to reach conclusions regarding relations begins to develop around age 7. At that age, children begin to solve problems that require sorting items into groups. The ability to build groups testifies to the ability to understand the connection between objects within a group. When the ability to understand the relations between objects exists, the ability to build new relations between these relations has begun to develop. In other words, the child begins to generate conclusions of a higher-order or second-order thinking skills, and understand the principle of identity in relationships: identifying the similarity of the relations between terms A and B of the analogy and terms C and D of the analogy. According to Piaget that happens only between 11 and 12 y/o. At younger ages children are inclined to think about analogical relationships in successive terms (this after that). They choose one relation in order to make a connection between terms A and B of the analogy, and another relation to make a connection between terms C and D. A conclusion of this sort is termed as a lower order or first-order relational processing. In Piaget's opinion, higher-order relational processing demands a higher level of conclusion than does lower-order relational processing.

Over the years, a debate developed between proponents of Piaget's approach and those of Sternberg's approach. Researchers who criticize Piaget's theory of development, for example, claim that it is possible that the youngsters who were examined had difficulty solving the analogies because it was hard for them to understand the relationships with which they were presented, and not because of any difficulty with the process of conclusion making. For the critics, the presentation of abstract relationships (such as *black:white* is similar to *hard:soft*, when the distracters are white-solid-blue) or the presentation of connections which are alien to the children's world (*e.g.*, *auto:fuel* is analogous to *sailboat:wind*, when the distracters are cruise-sails-rudder) is the reason for the children's failure to solve the analogies. More than that, the utilization of pictorial cards are not sufficient to summon up the children's analogical abilities, as they lacked relevant experiences, which allowed the children to explain them (Goswami, 1992).

Two central approaches took form over the years among those who criticized Piaget's research of analogical thinking. One approach is known as *relational-primacy*, which sees the ability to reach conclusions as an innate ability that helps the child acquire knowledge in the first stages of life (Goswami, 1992). According to this approach, while the ability to think analogically develops as the child grows, with the aggregation of knowledge and new experiences, the change in the manner of thinking expresses itself in the areas of knowledge in which the child succeeds in making transitions, and not in the transition between stages of mapping.

The second approach, known as the *relational-shift* approach (Ratterman & Gentner, 1998), maintains that children are able to think analogically at an age younger than that posited by Piaget. However, similar to Piaget's approach, they say that that ability develops with the aggregation of knowledge, experiences, and the enrichment of language. That knowledge includes prepositions and morphological a well as compositional knowledge that the children need for formulating correct answers (Gentner & Ratterman, 1991). Acording to the *relational shift* approach, the stage in which the child identifies similarities between objects is the stage, like Piaget, in which the ability to identify lower-order relationships appears (Inhelder & Piaget, 1958).

Studies that researched the development of analogical thinking emphasize the importance of exposing children to stimuli in an active learning experience for advancing those children's analogical thinking (Tzuriel, 2000; Goswami, 1992). These studies also indicate the advantage inherent in visual presentation and in concretization by means of concrete concepts chosen from the children's world for their achievements in understanding analogies. The dynamic assessment approach emphasizes the importance of meaningful experiences in mediated learning for the improvement of cognitive and learning skills. When the experience in mediated learning is inadequate to the child’s individual needs, gaps in learning achievement and in cognitive development occur (Tzuriel, 2000).

For the kindergarten children from Ethiopia origin, the utilization of pictorial cards was not sufficient to summon up the children's analogical abilities, as they lacked relevant experiences, which allowed the children to explain them. The conclusions of these studies are that in order to test analogical thinking among young children, particularly among children from Ethiopia origin, there is a need to have them perform tasks adapted to their age and background, and to accompany them with the proper mediation that is relevant to the tasks (Goswami, 1992; Gentner, Holyoak & Kokinov, 2001).

The basic claim underlying our study is that the contemporary diagnostic tools are built in such a way that the questions that are presented are viewed in a pictorial mode. However, the pictorial mode is best suited to western cultures (Bruner, 1973), and it does not suit the needs of immigrant children without any mediation. We suspect that the children of immigrants from Ethiopia are not exposed to similar pictures as the children of western cultures. Thus, when they are asked about something that requires initially some kind of decoding, their achievement in understanding the analogies are lower compared to children that do not need to decode any information before extrapolating the analogies embedded in the pictures. We believe, therefore that these achievements do not reflect the genuine abilities to understand analogies and they are more linked to the representation mode than to their cognitive abilities.

In many western homes children are playing with cards to exercise their abilities to memorize or sort things. Such cards were not in the possession of rural children in Ethiopia that used to play with other means in their disposal.

The need for cultural mediation we are pointing at refers to these aspects: the representation mode and the familiarity with the type of questions.

Therefore, we suggest that VR exercises of 3D objects close the gap of the concrete stage they are lacking. Our assumption is that this concrete experience assists them in interpreting the pictures, and helps them to become familiar with the type of questions.

Enhancement of Learning Potential

The theory known as the Enhancement of Learning Potential theory stresses the ability to change via mediating and training. According to this theory, young children could improve their abilities to solve analogies (Feuerstein, *et al*., 2002). Thus, intelligence (considered to be an inborn trait) by itself does not promise efficiency in perception, thinking, and learning problem solving. For this theory, there are a limited number of basic thinking processes that together with emotional, motivational, attitudinal factors, and certain work habits, make up the "basic, cognitive processes" that are necessary for perception, thinking, and methodical, efficient problem solving. Therefore, one must acquire the basic cognitive processes through learning in order to further develop his abilities to solve analogies.

From this point of view, it seems that there are two kinds of cognitive learning – direct exposure to things that happen, and mediated learning experiences, and every child needs to experience mediated learning. The quantity, the quality, the degree of intensity, the frequency, and amount of time needed for cognitive development to take place differ according to the individual differences of each child (for example, level of inherited genetic intelligence, soundness of the child's sensory systems, emotional stability, and environmental support). When there is insufficient mediated learning for all the child's individual needs, the result is delay on cognitive development, or to the point of this study involving children from Ethiopian background, the development of the "socially impoverishment " syndrome, and relatively low social and educational achievements. When mediated learning experience answers the children's individual needs, the negative influences of various situations (poverty, mental retardation, emotional disturbance, and a low degree of parental education) on educational and social achievement are diminished to a significant extent. For the Enhancement of Learning Potential theory, older siblings, grandparents, and parents have a vital role to play in providing mediated learning experiences in the course of cultural transfer across generations. Cross-generational transfer exists in all cultures, and in all cultures, there are elements, which are crucial to the cognitive development with which children are provided. The failure to transfer ways of thinking typical of the culture is characteristic of the cultural impoverishment syndrome (Feuerstein, *et al*., 2002).

When certain facets of cognitive development fail to receive sufficient stimulation through mediated learning experiences, it is possible to make up for the deficiencies with carefully planned, constructive teaching. In other words, according to this theory, teachers can exploit opportunities to provide mediated learning experiences, which parents have missed (Haywood & Lidz, 2007).

Studies demonstrate that extra-curricular activities with student of Ethiopian origin in purpose to improve academic abilities, both at the kindergarten stage and at any other stage in school, are highly successful and show that the majority of participants were capable of closing the gap that existed between Ethiopian and Israeli students within short period (Avinor, 1995; Kozulin, 2005; Berhanu, 2006).

Some researchers have been claiming that it is possible to describe and reconstruct mediated learning processes. For them, these processes make up an important style of teaching which is identified as a mediated teaching style. Mediating the children's learning experiences include functions such as choosing stimuli, helping children to minimize the number of stimuli available to them, focusing on the relevant aspects of the available stimulus, multiple exposures to important stimuli, perception of shared and different denominators, cause and effect, shared elements in different experiences, and operations such as comparison, classification, the continuation from the past to the present, and to the future, and transfer (Haywood & Lidz, 2007). From this theory the dynamic assessment model developed (Tzuriel. 2000).

Similar ideas are found in the approach of Zone of Proximal Development (ZPD) (Vygotsky, 1978), and in the theory of Scaffolding (Wood, Bruner, & Ross, 1976). It seems that the instruments for testing the abilities for solving different kinds of analogies were developed on the basis of these different theories, according to the traditional approach of static testing (such as the Raven test: Raven, 1965), and, according to the theory of mediated learning, by dynamic testing (Tzuriel, 2000; Haywood & Lidz, 2007).

Researchers who emphasized the importance of the way in which the analogies were presented to the subjects referred to the advantage inherent in concrete, three-dimensional, full-color representations that are game-like, and can be manipulated when the analogical problems are presented. They found that when a child is able to perform motor manipulations with parts of the test and to change them until one reaches a satisfactory solution, the achievements tend to increase (Tzuriel, 2000). According to various researchers, the process of change that the child makes in reaching an answer reflects the process of thinking, and indicates the cognitive factors which contribute to the solving of a problem or interfere with finding the solution (Tzuriel, 2000; Tunteler & Resing, 2007).

For this reason, we had chosen, in this study, to examine how VR technology can advance achievements in conceptual and perceptual analogies. The VR intervention was based on the model in Passig and Eden's study (2010). The analogical terms were expressed by concrete and three-dimensional presentation in high level of interactivity that created an active learning experience. The unique interface of the Head Mounted Display (HMD) empowered the experience of immersion, and assisted the attentiveness of learning (Passig, 2010).

The main hypothesis was that there would be a significant improvement in the participants' achievements after the intervention in the experimental group and in the control group, but the level of improvement would be higher in the experimental group, with children who would practice analogies using 3D IVR technology, than in the control group, with children who would practice analogies using pictorial version of the items, both immediately after the intervention, and after a period of three weeks following the end of the intervention.

This hypothesis based on the dynamic assessment model that suggests that after a teaching and mediating phase we would find an improvement in the participants' achievements (Tzuriel, 2000), but as mentioned above with the aid of IVR technology we assumed the improvement in the achievements will be significantly higher (Passig. 2010).

The second hypothesis was that significant interaction would be found between the participants' scores in the conceptual analogies test and the participants' scores on the perceptual analogies test, in the different methods of training, before and after the intervention.

This hypothesis based as mentioned above, on various studies that indicated that there are differences between the ability to solve conceptual analogies as opposed to perceptual analogies (Tzuriel, 2006). Different researchers attribute success in solving different kinds of analogies in young children to the method of the mode of representation, to age, to the subjects' familiarity with the problem, and to the way in which the intervention was mediated (Gentner & Rattermann, 1991; Goswami & Pauen, 2005).

Finally, the third hypothesis was that we would find a correlation between the subjects' ages and their success in solving analogies. The assumption was that the older children would achieve higher scores than those achieved by the younger children, in both kinds of analogy.

This hypothesis based on the *relational shift* approach that suggests that children are able to think analogically at an age younger than that posited by Piaget, but similar to Piaget's approach, they say that that ability develops with the aggregation of knowledge, experiences, and the enrichment of language, and increases with age (Gentner & Ratterman, 1991).

Methods

The participants

The participants in this study included 56 kindergarten children, whose parents immigrated to Israel during the last ten years from Ethiopia. We communicated with the children's parents with the help of a liaison assistant – a woman of the Ethiopian community who spoke both Amharic and the native language, who is usually employed in this capacity throughout the school year. In order to obtain the parents' agreement for their children's participation in the research, a demonstration meeting was prepared, in which the teachers and the parents were able to experiment putting on the 3D gear and to play with the virtual worlds. After this meeting, the parents' signatures were collected expressing their consent to their children's participation in the research. Only children whose parents agreed to their participation took part in the research. The children were divided to research and control groups only after the first set of tests as described bellow at the research procedure. Each group consisted of 28 children. The age range of the participants in the *research group* was: 58-80 months (4y/o and 10 months to 6 y/o and 6 months). Average: 70.75 (5 y/o and 10 months). SD: 6.02 months. The age range of the participants in the *control* group was: 57-80 months (4y/o and 9 months to 6 y/o and 8 months). Average: 70.78 (5 y/o and 10 months). SD: 6.43 months. The children were pre-schoolers. Since the children were of immigrant families, there were some of them that repeated the pre-school year as part of the adjustment process that the teachers recommended for them. Thus, we could see that some of them were of 6 y/o and above.

The research instrument

The research instrument we employed for evaluating the Analogical thinking was the CCPAM measure (Tzuriel and Galinka, 2000), which includes 20 questions of a pre-learning test and 20 questions of a post-learning test.

We also used the classic Raven's colored matrices test (Raven, 1965) to evaluate the child’s level of intelligence.

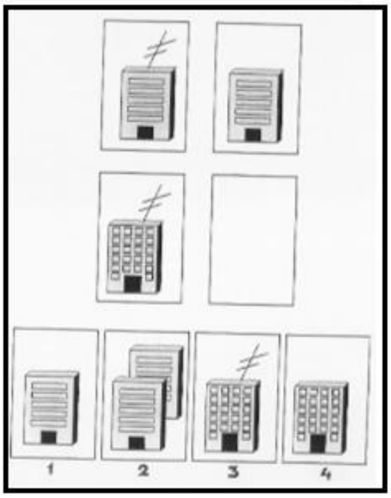
Raven's colored matrices test (Raven, 1965).

The Raven's test has a high reliability and validity as a measure for intelligence. This test is based on abstract shapes. The child has to choose the most appropriate form for completing the matrix. By that it evaluates abstract thinking abilities such as analogical thinking. There are three series in the test, A, AB and B, where each has 12 items. We used only series B, which focus more of analogical thinking. Each correct answer is worth one point, so the range of scores was from 0 to 12.

The CCPAM test

The conceptual and perceptual analogies subtest from the CCPAM test that we employed, was developed by Tzuriel and Galinka (2000). There are two versions of this test: closed analogies and construction analogies. Both versions are based on Piaget's developmental theory (1952), Vygotsky's concept of the ZPD (1978), and Feuerstein's theory of mediated learning experience (2002).

We used the closed version, which includes classic analogies in a pictorial mode. We graded the answers based on correct or incorrect solutions. Each section of the test had 20 items, where 10 items were administered in the pre-learning phase, and 10 administered in the post-learning phase. Each problem was presented in a 2X2 matrix (A:B::C:D) in the colored pictorial modality. In each item, the problem was presented at the top of the page, while four possible answers were presented underneath (Figure 1). The child was asked to think about the relation between the first pair of pictures presented in the problem, and match the picture to a second pair out of the four, which were presented, according to the relation between the pictures of the first pair. For example, the conceptual analogy of *bird:nest*::*dog:doghouse* is parallel to the analogy of *bee:beehive*::*parrot:cage*, in the pre-learning phase that present identical relationships. In each subtest, the children were given two examples prior to the beginning of the test in order to give them an example of what was expected of them.

z 

Item from the perceptual test Item from the conceptual test

Figure 1. A sample of items from the CCPAM (Tzuriel & Galinka, 2000)

While The Raven's test is based on abstract shapes, the CCPAM however, is based on familiar and daily objects that are familiar in Western cultures and less in the Ethiopian culture, such as a knife to cut bread. This point further emphasizes our research question whether the use of pictures without proper mediation for diagnosing the level of analogical thinking is proper for such immigrants' children.

Conceptual analogies test

In the original test of conceptual analogies (Tzuriel & Galinka, 2000), there are three types of connections: categorical relations, part-whole relations, and functional relations. In this study, both the amount of time devoted to administering the test and practice was limited to 15 to 20 minutes, in order not to push the children beyond the attention span of kindergarten-age children (Tzuriel & Glinka, 2000). For that reason, only 10 of the original items on the test were selected from series A, and 10 from series B. Eight of the ten in each series had functional relations, and two had part-whole relations, but in such a way as to understand them on the functional level, as well. For example, a lid covers the pot, and the roof covers the house. We decided not to use the items, which were based on categorical knowledge with focus on solely functional relations. This was because the goal of mediation to conceptual analogical thinking in this study was to mediate to the children the syntax and morphological tools needed for the solving of analogies (Gentner & Rattermann, 1991). Each item in the test was based on a short sentence whose subject was shared with the analogy parallel to it. The sentences were presented orally by the mediator during the intervention. The focus of the mediation was in the child’s formulation of a parallel question, and finding a matching answer, *i.e.*, in identifying the shared subject (for example, A eats B::What eats C?). During the test, the child formulated the sentence with the solution on his own, and pointed to the correct answer from among the four given alternatives. The distracters were objects that have a relation to C that was different from the relation between A and B. If the relation between A and B was functional of one type, then the distracters relate to C by a different functional relation or were relating by categorical relation or part-whole relation. During the intervention, after the child formulated the relation between A and B, the researchers mediate to the child the way to reject the answers that didn't have the same relation as the relation between A and B, and to chose the object that has a relation that is parallel to the relation between A and B. During the test the child has been asked to point at the right answer and explain the reason for his choice.

Perceptual Analogies Test

The perceptual analogies test was based on Goswami's Geometric Forms Test (Goswami, 1992), but instead of using geometric forms, the forms in our test were based on objects that can be named, for example, a table, a ball, flowers, etc. In every analogy, the relationship between the analogy's terms were based on three types: a) in differences (change in color, place, number, or type of object), b) in presence (whether the object is present or missing), and c) in position (for example, the object is on the chair or under the chair).

It must be noted that despite the conceptual analogies' being presented in a visual mode, they are considered conceptual since understanding the relationship between them is not based solely on looking at them. The answer requires understanding of the abstract principles that connect them. In contrast, perceptual analogies are based primarily on relationships which are easily distinguished visually, although a certain degree of conceptual understanding is required (for example, understanding that a ball is on or under a table requires the grasp of the difference between on and under, even though making that distinction is essentially conceptual).

Each correct solution in the perceptual analogies test and in the conceptual analogies test, received a score of 1 point. The maximum score was 10 points in conceptual analogies, and 10 in perceptual analogies.

Reliability of *Cronbach's Alpha*, which was tested in a number of different samples in kindergarten was .64 - .74 on the pre-learning conceptual analogies measure, and .70 - .85 for the post-learning. For the perceptual analogies, the pre-learning results were .83 - .87, and for the post-learning .90 - .91 (Tzuriel & Galinka, 2000; Tzuriel, 2000, 2006).

The instrument's external validity can be found in a number of different studies (Tzuriel, 2006). One of them tested the predictability of reading and writing skills of kindergarteners using this instrument. the authors have found that the scores in both subtests of the analogical thinking tests (CCPAM) predicted 19% of the participants' achievements in the reading and writing tests beyond the other variables such as age and gender (Tzuriel & Flor-Maduel, 2010).

These findings underscore the importance of doing research on the subject of analogical thinking among kindergarten-age children, as well as the devoting of resources to develop innovative ways of nurturing these thinking skills.

Research procedure

We first administered the pre-intervention tests. After realizing that there are no significant differences in the Raven scores among the control and research groups we engaged in the intervention program. They were 28 children in each group that were drawn from 4 kindergartens. In two kindergartens the children experienced VR worlds and in the other 2 kindergartens the intervention employed pictures.

These 4 kindergartens were chosen through the opportunity sampling method. We were looking at clusters of children from Ethiopian families and we found such a convenient cluster of kindergartens that many of their children were of such a background in the Tel-Aviv metropolitan area.

We did not include in the sample children that were reported by their teachers to be HDHD and as such received reinforcement by an Amharic language speaker.

The tests and the intervention program were administered in a quiet corner at the kindergarten library under the supervision of the kindergarten staff. The researchers set in the corner the hardware needed for the study which included a computer and an HMD (Head Mounted Display) with which the children have experienced the 3D immersive worlds. The same was in the kindergartens in which the program was administered to the control group just without the HMD. One child in the research group reported on difficulties to put on the HMD and therefore was subtracted from the study.

The number of meetings and their length were as follows: First we met once to administer series A of the two tests—conceptual and perceptual. In the first meeting we administered the Raven's test too. After a week we met for two consecutive meetings in which we practiced the analogies. The duration of each meeting was about 15 minutes. In the third week we met to administer series B of the tests. Three weeks later we administered series A again.

Table 1 shows the time line of the meetings with the children and the kind of test or intervention that was administrated in each meeting.

Table 1: Research Plan

Type of intervention	First week	Second week	Third week	Fourth week	Fifth week	Sixth week
VR	Raven & CCPAM - series A	2 intervention meetings of 15 minutes each	CCPAM - series B	-	-	CCPAM - series A
Pictures	Raven & CCPAM - series A	2 intervention meetings of 15 minutes each	CCPAM - series B	-	-	CCPAM - series A

The order of the tests was similar in both groups. The children were initially tested in the conceptual and then in the perceptual test. The order of the question was also similar. The study did not aim at comparing between the two tests, therefore we decided to simplify the procedure and employed a similar order, and the results were analyzed as cumulative scores, so the order of questions was the same for all participants.

The children were given feedback for the mistakes or correct answers only during the intervention and not during the tests. The mediation during the intervention included the reference to the above relations.

The Intervention

The learning phase for both groups, the experimental group (n=28) which practiced the solution of analogies that were presented in 3D VR, and the control group (n=28) which practiced the solution of the same analogies with a pictorial version of the items, in cards, consisted of the use of six items from among the analogical tests from the pre-learning phase, and included the following strategies:

- Looking for the required dimension for solving the analogy (for example, in perceptual analogies, distinguishing between the dimensions of color, size, quantity, or kind of object).
- Mapping the transformational rules (for example, in perceptual analogies, some of the elements change, but some remain the same in A and B).
- Verbal expression of the solution before making a choice.
- Justifying the correct answer and the incorrect one.
- Methodical searching for the correct answer (looking at all the alternative answers).

The questions and syntax in the mediated learning were equated between the experimental and control groups.

At the first meeting, series A of the CCPAM of analogies test was administered, by means of pictures. During the next two meetings, which took place one week later, the participants practiced the solution of analogies for 15 minutes. The experimental group practiced the solution with the use of VR technology while the control group practiced with the use of pictures. One week later an additional meeting was held, in which series B of the CCPAM test was administered. Three weeks later, the participants did the A series once again (see table 1).

We chose two meetings of 15 minutes each for practice reflecting the conclusions of those who developed the instrument (Tzuriel & Glinka, 2000). According to their findings, short but intensive training using the pictures produced a significant improvement in the children's ability to solve analogies. They concluded that examination should be made also following an interval of time after the intervention. An acclimatization period was taken into account, bearing in mind the children's unfamiliarity with VR technology. In order to make a comparison of the research conditions, we decided that the number of practice sessions with VR would be the same as the number of practice sessions for the control group, who were working with picture cards. Our final decision was that the intervention phase, for the control group and the experimental group, would include two practice meetings of 15 minutes each, and that the ability to preserve solution strategy would be tested by administering series A a second time, three weeks after the end of the intervention (the follow-up test).

The intervention in the experimental group:

The VR intervention was based on the model in Passig and Eden’s study (2010). The first intervention meeting with the children in the experimental group was devoted to being acquainted with the VR interfaces.

In this first intervention meeting, first we examined the child ability to control the mouse, by trying pressing the buttons and dragging the cursor in a drawing program. Then, wile introducing the child to the HMD (Fig 2) we fit it to his head with an elastic strap tied on to the back in order to balance the HMD on his head and enable him to be immersed in the virtual worlds without external distractions.

For each exercise we have built a different VR world with its corresponding objects that were presented to the child in 3D through the HMD and were monitored through the laptop screen too, in order to let the researchers follow the child's actions and to guide him. The experience in the VR worlds involved having the eyes of the children being covered by the HMD, thus they could not see the researchers. In order to communicate with them we have used a special application called ActiveInspire with which we could draw the attention of the children to a special place in the VR world without having them to take of the HMD. For example, when we thought that it is appropriate to draw the attention of a child to the similarity of the colors, we were able to draw a circle around the objects with the drawing tools of ActiveInspire.

Figure 2. The Head Mounted Display

The virtual worlds of the conceptual analogies:

In each of the worlds we built for the experimental group, the first presentation was of two objects A:B between which a relationship existed, one another object C, and, next to it an empty space to fill. The relation between A and B was concretized by an action in the virtual world. In order to match a solution D to C the child was asked to describe verbally his actions in the virtual world. The sentences were formulated orally by the researcher and the child. The intervention included having the child identify the similarity between two sentences and activities. For example, chalk is drawing on a blackboard—paint is drawing on a piece of paper. The similar word is "drawing".

While the activity was going on, we broadened the conversation to touch on the possibilities of using additional actions such as writing and coloring. The researchers helped the child write his or her name on the board in the 3D virtual world using the white chalk. Thereafter, the child was able to color, using the colors on the painting page on the screen in the virtual world. The activity's goal was to sharpen analogical thinking by enriching the child's world of concepts, and provide him/her with experience in formulating appropriate syntax while minimizing the overload of information. For that, we emphasized sentences in which the action word was the same, as in the example mentioned above: the chalk draws on the blackboard *the same as* the markers draw on the paper.

After this phase, four different objects were presented on the screen of the virtual world. They included the solution and three distracters (incorrect answers). Each of the distracters has a different relation to C such as categorical, functional or part-whole relation. The child was asked to choose the object that matched the analogical solution with the same relation to C as B to A. The goal of this phase was to practice the ability to transfer and reject incorrect answers. He was then asked to formulate independently the matching sentence, to choose the object, and to drag it to the proper place (Fig 3).

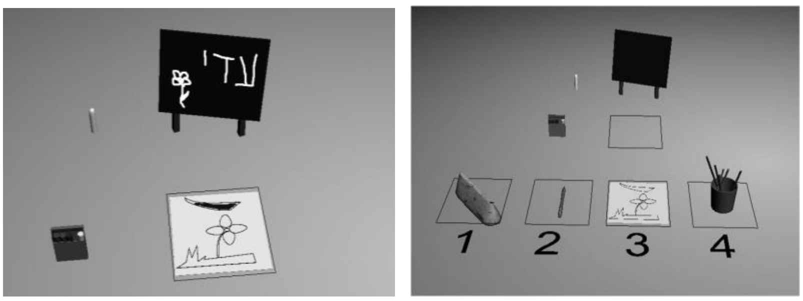


Figure 3. Practicing in 3D VR world the chalk and the blackboard analogy.

The chalk draws on the blackboard, *just as* the colors draw on the paper

In the second exercise (Figure 4), a plank of wood appeared, and next to it a saw, then a loaf of bread appeared, and next to it a blank space. After naming the items, the child was asked to imagine what was missing in the empty space. Afterwards, four objects were presented: a pair of scissors, a knife, a fork, and the bread. By using the mouse, the child was able to manipulate and play with the objects, while making mistakes and formulating the appropriate sentence with the researchers. The following actions were presented in this way: the saw saws the wood, the knife cuts the bread, the scissors cut the paper, and the fork spears a vegetable. In the next phase, the child was asked to choose the object, which should be dragged to the empty space next to the bread.

In the course of the conversation with the child, during the VR exercises, the common action was emphasized – the act of cutting, and the common subject, the word "cut, was said out loud,." Stress was placed on the matching pairs: knife-bread, saw-plank, scissors-paper. The correct answer in this exercise was the knife. In addition, the child was given the opportunity to build a different analogy: if, instead of bread, there was paper, what would be the right answer? Scissors, of course. Special attention was given to the understanding of the question: Are we looking for something unusual, or a parallel action? In other words, it is an analogy. The goal of this phase was to practice employing the strategy of rejecting incorrect answers.

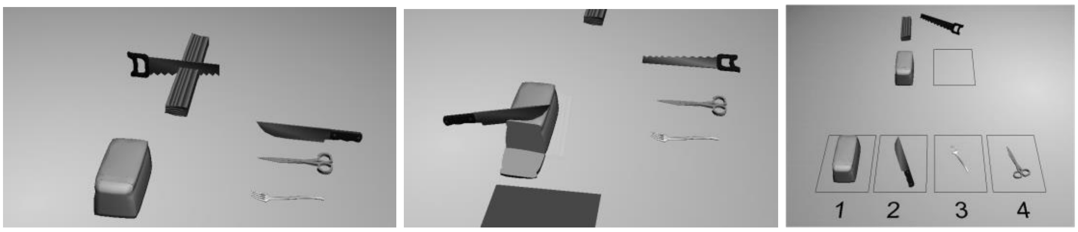


Figure 4. Practicing in 3D VR world of the saw and bread analogy.

The saw cuts the plank *just as* the knife cuts the bread

The intervention in the control group on conceptual analogies:

The control group practiced solving analogies by using cards on which were items identical to those practiced by the experimental group. The exercises were performed individually as a game with the researchers during 15 minutes with each child. In the course of the game, each child was asked to name the items in the picture, and to formulate sentences that were questions and answers in accordance with the instructions. Emphasis was placed on identifying similar questions and answers, while focusing on shared subject words, the same as in the experimental group as described above.

The participants in the experiment group and in the control group practiced first the conceptual analogies as described above, and then practiced the perceptual analogies.

The intervention in the experimental group on perceptual analogies:

At the beginning, the participants were presented with a paved open space in 3D VR world, which looked like a large and open plaza (Figure 5). Two tables were placed in the center of the space, parallel to each other. A red telephone was located on the table on the left, and an identical telephone was located under the table on the right. Another table was placed in front of the table on the left, on which a purse was put. The child was asked to think what was supposed to be in the space to the right of the table with the purse on it. After looking at the items, naming them, describing their color and location, on the right side of the open space appeared the following items: an oblong table which was identical to the three tables which had already been placed in the open space, a round table, a phone, and a purse. The child was then asked to drag the appropriate objects to the empty place. The right answer was: the oblong table, with the purse underneath it.

Figure 5. The telephone exercise – Perceptual analogies in virtual reality

At this phase, the child actively built the analogy and was able to test additional possibilities. It was also possible to move around in the open plaza, to approach objects and to move away from them, and even to change the position from which the observer views them. All the actions were performed with the accompaniment of verbal explanations and the naming of concepts of color, shape, and relation.

We employed in this research an additional helping tool, in order to better focus the child's attention on the task – a drawing tool from the ActiveInspire software. Since the children were immersed in the VR worlds through the HMD they were not able to see the researchers who conversed with them. Therefore, the visual communication in the 3D VR world between them and the researchers was mediated using this instrument. When the researchers wanted to signal a child, and to emphasize the similar and different objects, they signaled him on the screen by means of the drawing tool.

To progress to the next phase of the exercise, the child had to click on one of the keys on the keyboard by the help of the researchers, and then s/he was presented with four possible answers. They were, essentially, four different combinations of objects on the screen. The child had to identify the correct combination, and to drag it to the empty place on the screen.

Making the correct combination was based in every exercise that the experiment group took on the identification of two similar and two different characteristics. Besides the color trait that appeared in all the virtual worlds, in the other exercises the child had to identify the aspect of condition of presence vs. absence (the ball and telephone exercise- figure 5), the aspect of quantity (the cake exercise – figure 6), and the aspect of the difference between two kinds of the same type (the fence and flowers exercise- figure 7).

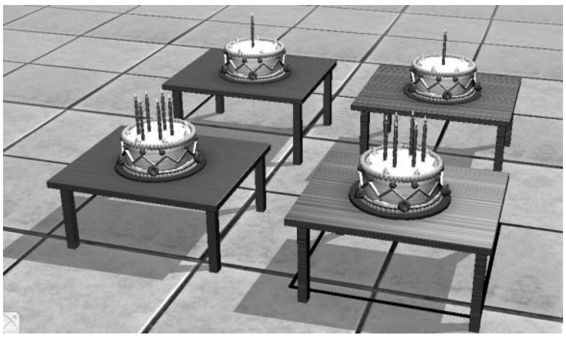


Figure 6. The cake exercise – Perceptual analogies in a 3D VR world.

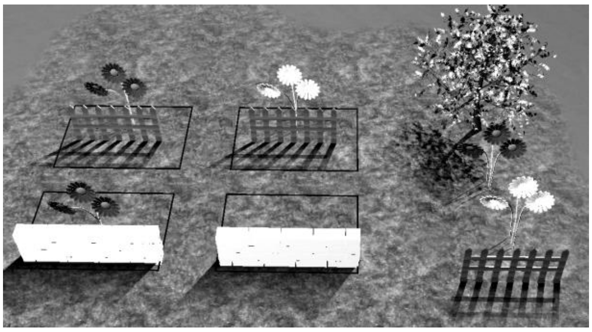


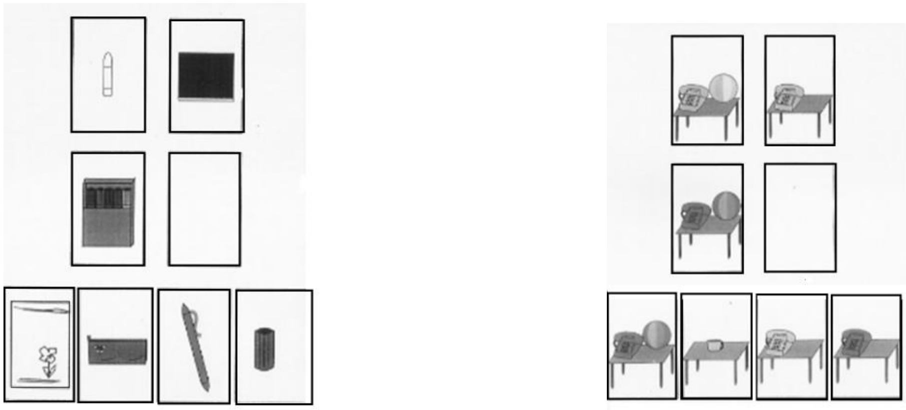
Figure 7. The fence and flowers exercise – Perceptual analogies in a 3D VR world.

The research assumption in developing an intervention in perceptual analogies in virtual reality was based on a theoretical model that points to the advantage inherent in the use of means which are concrete, 3D and colorful, and which have an air of manipulating control and games about them. The child can carry out motor manipulations in parts of the test, and can change them until s/he arrives at a satisfactory and correct decision. The process of changing the answer reflects the thinking process, and indicates the kind of cognitive factors, which contribute or hinder the finding of a correct answer (Tzuriel, 2000). In the instructional and mediating phase, the researcher can identify those factors that could, with proper instruction, impart thinking skills to the child. The goal of conceptualizing actions while performing them is to give meaning to the concepts of relations, to the names of colors, and to the counting of the items.

The intervention with the control group on perceptual analogies:

As with the conceptual analogies, the control group practiced solving analogies by using cards (Figure 8) which showed pictures of items identical to those on the test.

The exercises that were presented were identical to those of the experimental group. The exercises were conducted with each child individually, following practicing with conceptual analogies and in the same time period. They included a game with one of the researchers. In the course of the game, the child was required to name the items in the picture and to describe their characteristics, while using prepositions, counting, and the names of colors. The emphasis was on the identification of the similarities and the differences between the pictures wile using the same syntax as in the experimental group.



Conceptual analogies: The chalk and board exercise

Perceptual analogies: The ball and telephone exercise

Figure 8. A sample of game cards

Results

In order to examine the reliability of the tests we did a first analysis, in which we found that the coefficient of Cronbach's α in the conceptual analogies before the intervention was $\alpha=.48$, directly after the intervention: $\alpha=.83$, and three weeks after the end of the intervention (the follow-up test): $\alpha=.83$.

Similarly, the Cronbach's α on the perceptual analogies test before the intervention was α=.61, immediately after the intervention: α=.76, and three weeks after the intervention: α=.86. The tests therefore became more reliable with training, suggesting the children's level of understanding increased over random guessing.

These findings support the Dynamic Assessment model (Tzuriel, 2000) on which the instrument is based.

In order to test the research hypotheses regarding the impact of the intervention program on the experimental group in comparison with the control group, two separate ANCOVA analyses of difference were performed, with repeated measurement, one for the conceptual analogies, and one for the perceptual analogies, while taking level of intelligence into account by means of a Raven test (Raven, 1965). A 2x3 matrix of measurements was carried out, where 2 expressed the kind of intervention: intervention using pictures in comparison with intervention using VR, and 3 expressed the repeated measurements over time: before intervention, immediately after intervention, and three weeks after the end of intervention (the follow-up test). Averages, standard deviations, and sample size are presented in Table 2.

Table 2. Averages and standard deviations distributed according to kind of intervention and type of test (n=28)

	Virtual Reality		Pictures	
Time	Mean	SD	Mean	SD
Conceptual pre-intervention	4.39	1.57	4.42	1.47
Conceptual post-intervention	8.35	2.02	4.96	1,83
Conceptual	8.39	1.54	6.35	1.88

follow-up test				

	Virtual Reality		Pictures	
Time	Mean	SD	Mean	SD
Perceptual pre-intervention	2.96	2.39	2.78	1.75
Perceptual post-intervention	6.00	2.01	4.57	2.15
Perceptual follow-up test	5.39	2.76	4.32	3.22

In the analyses of differences we found that the interaction between the time factor and the kind of training was significant, $F(1,53)=6.25$, $p<.01$; $eta^2=.10$. In other words, the improvement in the experimental group was significantly higher than that in the control group, in both the conceptual and perceptual tests.

The interaction between the kind of test and the kind of training was also found to be significant, $F(1,53)=3.96$, $p<.05$; $eta^2=.07$. In other words, the subjects responded differently to the intervention in the conceptual and perceptual tests. The level of achievements in the conceptual test was higher than the level of achievement in the perceptual test as a result of the intervention.

Similarly, the three-sided interaction between the time factor, the kind of test, and the kind of training was found to be almost significant, $F(1,53)=3.33$, $p<.07$; $eta^2=.05$, meaning that there were differences as a factor of time, the kind of training, and the type of test.

Post-Hoc range tests analyses was performed for the 2-way interactions, while it refers to all the means in the analysis, to get a meaningful explanation for the results. The analyses pointed to five sources of the differences in the interaction:

1. Immediately after the intervention significant differences were found between the experimental group and the control group in the conceptual test (M=8.35 in the experimental group, compared with M=4.96 in the control group), and in the perceptual test (M=6.00 in the experimental group, compared with M=4.57 in the control group).

2. Three weeks after the end of the intervention (at the follow-up test) significant differences were found between the experimental and control groups only on the conceptual test (M=8.39 for the experimental group, compared with M=6.35 in the control group). In the perceptual test no significant differences were found three weeks after the termination of the intervention.

3. Similarly, it was found that in the control group significant differences were found on the conceptual test between the pre-intervention (M=4.42) test and the test administered three weeks after the intervention (M=6.35), but not between the pre-intervention and post-intervention results (M=4.96).

4. In the control group, on the perceptual tests, differences were found in the achievements before the intervention and the achievements three weeks after the termination of the intervention (M=4.32).

5. In the experimental group significant differences were found between the results of the pre-intervention conceptual test (M=4.39), the results achieved immediately after the intervention (M=8.35), and the results obtained three weeks after the intervention's end (M=8.39). Similarly, significant differences were found between the results of the perceptual test pre-intervention (M=2.96), the results immediately after the intervention (M=6.00), and at the follow-up test. (M=5.39). No significant differences were found for the achievements

immediately after the intervention and the achievements obtained three weeks after the intervention.

Regression analyses were calculated to examine additional factors, such as age and gender, as predicted variables of the level of achievements, after the intervention. (Tables 3-4).

Table 3. Summary of the regression analyses of the predicted variables: The score in the Perceptual follow-up test (percentages)

Predictor variables	In the experimental group	In the control group
Perceptual test pre-intervention	-	14.6**
Perceptual test post intervention	30**	54.3***
Raven	-	-
Age	-	5.7*
Gender	-	-

*P<.05 **p<.01 ***p<.001

Table 4. Summary of the regression analyses of the predicted variables: The score in the Conceptual follow-up test (percentages)

Predictor variables	In the experimental group	In the control group
Conceptual test pre-intervention	-	-
Conceptual test post-intervention	38***	-
Raven	9.1*	31.1**
Age	-	-
Gender	13*	-

*P<.05 **p<.01 ***p<.001

Discussion

The main hypothesis was that there would be a significant improvement in the participants' achievements after the intervention in the experimental group and in the control group, but the level of improvement in the participants' analogical thinking tests would be higher in the experimental group, with children who would practice solving analogies using 3D IVR technology, than in the control group, with children who would practice solving analogies using pictorial version of the items, both immediately after the intervention, and after a period of three weeks following the end of the intervention.

The findings supported this assumption (Table 2). There was a significant improvement in the experimental group and in the control group achievements after the intervention, but the improvement in the experimental group was significantly higher than that in the control group, in both the conceptual and perceptual tests.

As described above the CCPAM tool with which we assessed the analogical thinking, contains 10 questions of conceptual analogies and 10 questions of perceptual analogies. The conceptual questions are based on functional relations. For each question the children were presented with 4 optional answers. Each of them represented a different relation to the object. The correct answer was the one that pointed to its functional relation. The distracting answers expressed categorical relations, part-whole or as identity relations. The data collected from the answers before the intervention indicates, as reflected by the low figure of Alpha-Cronbach's analysis that the children guessed on their answers more than they understood what they were answering. We did not find a pattern for their mistakes. However, in the conceptual test after the intervention, we could see significant improvements in the experimental group, that also were significantly higher, than in the control group, both immediately after the intervention, and after a period of three weeks following the end of the intervention (Table 2). We could also see that the mistakes were mainly in their understanding of relations, and there was a tendency to find functional relations among objects in both groups.

In the perceptual test we could also see that the level of improvement was significantly higher in the experimental group than in the control group (Table 2).

The similarities in the relations of the perceptual analogies were based on two visual characteristics of the objects; for example, location and color. The distractions were: a picture similar to B, a picture similar to C, and a picture that does not express any relations. The mistakes that the children did were more at pointing to pictures similar to B or C. This pattern of mistakes was much less significant in both groups after the intervention.

These results place our study together with those of earlier studies, who pointed out that training brings about improvement in thinking skills (Turiel, 2000), but with immersive VR technology the improvement can be significantly higher (Passig, Eden & Bezer, 2009; Passig & Eden, 2010; Passig, 2010).

The theoretic assumption at the base of these studies was that the advantage of VR technology is its ability to make abstract concepts concrete. This is the nature of presentation in immersive 3D VR, which is unique to this technology.

The ability to explore/manipulate was the key to the intervention also in our study with VR. The language mediation was carried out through oral description of the actions during their execution. The oral description was carried out while the pictures were presented with both groups but in the control group the children were asked to imagine the actions by interpreting the pictures, and that's what made the difference. As we underlined above the basic claim of our study is that the pictorial mode is best suited to western cultures and does not suit the needs of immigrant children without any mediation. We suspect that the children of immigrants from Ethiopia are not exposed to similar pictures as the children of western cultures. Thus, when they are asked about something that requires initially some kind of decoding, their achievement in understanding the analogies are lower compared to children that do not need to decode any information before extrapolating the analogies embedded in the pictures.

In addition, our study joins other studies in the field of the development of analogical thinking in early childhood, which demonstrated that when analogical problems were presented to children in the form of images which have concrete meanings to them, the children succeed in solving the analogies (Goswami, 1992; Tzuriel, 2000; Goswami & Pauen, 2005).

As we remarked above we also assumed that participants who practiced solving conceptual and perceptual analogies with VR would preserve solution strategies better, and would present a higher improvement in solving analogies even a number of weeks after the termination of the intervention in comparison with participants who would practice solving analogies solely with the aid of picture cards. Here, also, the findings supported the research assumption. (Table 2).

We did not find many cases reported in the research literature that tested the ability to preserve solving strategies over time after the end of an intervention with mediating for analogical thinking. Most of the research touching on this topic tested the influence of short term intervention, while conducted with the Dynamic Diagnosis Approach. One such a study conducted recently, tested the ability to preserve the strategies for solutions with analogical thinking in children aged 5 to 7 (Tunteler & Resing, 2007). That research used microgenetic research method to study the process of change in the domain of analogical reasoning at geometric forms tasks. They note that the variability in children's strategy indicates that the ability to reason by analogy on this type of analogy tasks develops over a protracted age range. They underlined the importance of a microgenetic research method in order to gain more insight into the nature of young children's analogical reasoning ability.

Our research focused on the method of intervention. We suggested that the method of intervention influenced significantly on the ability to preserve the strategy of thinking that solving conceptual and perceptual analogies needs, even over time following the intervention. Our study showed that mediation via the means of the VR technology, which was built according to the recommendations of earlier research, and which took into consideration the needs of kindergarten-age children of the immigrant community from Ethiopia, brought about improvement in the participants' achievements, even after the elapse of a period of time from the date of the intervention.

The second research assumption was that significant interaction would be found between the participants' scores in the conceptual analogies test and the participants' scores on the perceptual analogies test, in the different methods of training, before and after the intervention. The research findings indicate that this assumption was corroborated by indicating an advantage for the experimental group in the conceptual test, as opposed to the perceptual test. The subjects reacted differently to the intervention in the conceptual and perceptual tests. The level of achievements in the conceptual test was higher than the level of achievements in the perceptual test following the intervention.

It should be noted that the beginning level of scores on both of the tests were not identical, and indicated a relative advantage on the part of the conceptual. The average scores in the total sample of the conceptual test before the intervention were $M=4.23$, $SD=1.84$, and in the perceptual test before the intervention $M=2.89$, $SD=2.08$.

Similarly, differences were found as a result of the time factor, according to the kind of training and type of test.

Significant differences were found in the conceptual test in the achievements of participants who practiced with VR, between the test that was administered before the intervention, and the tests administered immediately after the intervention and three weeks later. Since they preserved the achievement level, no statistical differences were found between the test that was administered immediately after the intervention, and the test administered three weeks later. In contrast, in the control group, the statistical differences were recorded only between the test that was administered before the intervention and the test, which was conducted three weeks after the intervention. In any event, the achievement level was significantly lower than that of the experimental group, three weeks later, as well.

To the best of our understanding, the improvement we have seen in the conceptual scores of the control group after three weeks from the intervention indicate that learning analogies with pictures was also effective. However, it took some time to surface. One possible reason that the control group improved only on conceptual test at follow-up can be referred to the fact that the test administered after 3 weeks was similar to the test administered initially. Thus, it is possible that this has contributed to the improvement of the scores in both groups. However, it could be also due to the fact that after 3 weeks the control group absorbed the logic behind conceptual analogies and thus improved their scores while they were retested.

In the perceptual test, both groups improved their achievements significantly in the test conducted immediately after the intervention. It is important to note, that the achievements of the experimental group were significantly higher than those of the control group. Afterwards, in the test that was administered three weeks after the intervention, the control group preserved its achievements, so that there were no significant differences between the test conducted immediately after the intervention and the one conducted three weeks after the end of the intervention (the follow-up test). In contrast, in the experimental group, there was a lower level of achievement in the follow-up test. Nonetheless, the achievements of the experimental group were higher in comparison with those of the control group, but the difference in achievement level was not statistically significant (Table 2).

The author of the CCPAM (Tzuriel, 2000) has indicated that he did not find a great difference when sizes of the samples with which he developed and established the reliability of the tools were different. We believe that the size of the sample was the reason the results were not statistically significant.

The differences between to conceptual ant perceptual tests could stem from a number of factors. The first factor is the process of absorbing the different kinds of information needed for the two tests, and from a different kind of intelligence that takes place in these processes.

When solving a perceptual analogy, there is a different process of working with information. The mapping process which takes place puts the information into a classification matrix which demands an ability to place things into a hierarchical order. According to Piaget (Piaget, 1969), this ability appears only at about the age of 8 or 9, and still relates to objects and concrete situations. Abstract understanding of this sort appears later, between the ages of 11 or 12. According to Gentner & Rattermann (1991), age is an important factor in the appearance of those abilities. In their opinion, however, the presentation of objects and concrete situations to children can lead even younger children to success in solving analogies of this sort. Problems of matrix classification in abstract forms are typical of series B in Raven's colored matrices, which we used as a control variable. Problems of matrix classification of concrete objects characterize the perceptual analogies test of the CCPAM (Tzuriel & Galinka, 2000). It should be noted that the Raven test was not found to be a general predictor in the perceptual test. We suggest putting again the mode of representation in focus. Thus while the Raven test is based on abstract shapes, the perceptual analogies at the CCPAM test are based on objects that can be named, for example, a table, a ball, flowers, etc. and on relationships which are easily distinguished visually, although a certain degree of conceptual understanding is required (for example, understanding that a ball is on or under a table).

Obviously these findings contribute to the discussion about the level of understanding that kindergarten children have with analogies as perceived with different modes of representation and different type of analogies.

Compared with perceptual analogies, a mapping of the knowledge that the child uses for solving conceptual analogies is based on prior knowledge and on familiarity with the terms of the analogy. For example, in the question of the chalk and the board, the child has to understand from the pictures that chalk and a blackboard are before him, and that there is a connection between them. The connection is that with the chalk one may draw on the blackboard. Afterward, when the child is presented with a picture in which colored markers appear, and when he is asked: Which object is missing next to the markers? He must understand that the missing object is a piece of drawing paper, just as one uses chalk to draw on a board. The child must be able to bring the pictures to life, and to tell a story about them. Research findings indicate that active experiencing with VR has a significant advantage to interventions based on verbal mediation concretized by the use of pictures. This is similar to the findings of studies that examined the influence of interventions that employed VR, as opposed to interventions which used pictures, on the ability to arrange events in the correct, chronological order (Passig, Eden, & Bezer, 2009).

In our opinion, the second factor that may led to differences in the level of improvement, which was achieved by the intervention with VR in both tests, was the degree to which we matched the intervention we built to specific information overload processes, as noted above. It appears that we succeeded in focusing the children's thinking on the information required for solving conceptual analogies. Emphasis was placed on finding the similarity in the structure of the sentence. Formulation of the similar sentences was performed during the activities in virtual worlds. This method helped the children to solve successfully the tests following the intervention.

At the same time, it's possible that in the VR worlds in which the children were trained for solving perceptual problems, there was an overburdening of data and information. It may be that the large amount of training sessions – four for the perceptual test, with only two for the conceptual test, caused confusion, and became an obstacle to focused thinking.

The third factor that may lay behind the differences in the tests maybe located in differences in the computer skills needed for the training in VR worlds, and in the various kinds of interactions. At the time of the intervention in VR the children donned their HMDs, through which they saw the screen display. The activities in the VR worlds were performed by moving the mouse. This situation required the participants to be able to control a mouse without being able to see it. The intervention in VR for the conceptual test included two exercises. In the chalk and board exercise, the children had to operate the program's drawing tools, to draw on the blackboard, and to color the drawing paper. The children were quite familiar with these operations, and most of them demonstrated relative mastery of the situation. In the second exercise, we used animation in order to concretize the activity by pressing on a key on the keyboard. This activity, as well, was easy to carry out with the help of the mediator that lead the child to press on the keyboard. On the other hand, the practice in VR worlds for the perceptual analogies test consisted of four exercises. The computer skills expected from the children were pressing on the left side of the mouse, selecting and dragging objects with the mouse, turning the objects around by simultaneously pressing a key on the keyboard, and dragging objects with the mouse, approaching and distancing them selves by scrolling backward and forward with the moving wheel of the mouse. We note here that most of the children achieved partial control of the mouse, and needed help in controlling it. It could be that the encounter with new technology, over-focusing on using the mouse, and on mastering the computer skills that the exercises required interfered with the thinking processes, and thereby caused a lowering of the level of improvement more than was the case with the conceptual test.

In summary, there is a consensus among researchers that there are differences between the ability to solve conceptual analogies, as opposed to perceptual analogies, in kindergarten-age children. There is no consensus, however, regarding which of the kinds of problems are solved more successfully by the children, or what are the factors which allow success in one kind or another (Gentner & Rattermann, 1991; Goswami & Pauen, 2005; Tzuriel, 2006; Goswami, 1992).

According to the results of the present research, it is evident that worlds which were built in VR were an effective tool for conceptual thinking, and also for perceptual abilities, although clearly less so.

We feel that it is correct to point out these differences for the sake of continued study in the future.

Finally, the third research assumption was that we would find a correlation between the subjects' ages and their success in solving analogies. The assumption was that the older children would achieve higher scores than those achieved by the younger children, with both kinds of analogy. The age range of the participants was 4 y/o and 9 months to 6 y/o and 8 months.

This assumption was based on many studies which indicated that the ability to solve analogies improves with increased age, but opinions are still divided on whether the ability of analogical thinking develops with age, or if it is a innate ability (Goswami & Pauen, 2005). However, there is a consensus among researchers that the more a child accumulates knowledge and experience, the more his/her abilities to conclude and to solve analogies will improve (Tunteler & Resing, 2007).

In order to test this assumption, we performed a regression analysis and examined the variables that predicted success in the tests. We decided to examine the participants' achievements at the follow-up test, as the achievements would express the degree of effectiveness of the intervention.

The results show that age was found to be a predictor only in the perceptual test only in the control group, and with a level of prediction of only 5.7% (Table 3 & 4).

That shows that the means of intervention have a crucial influence, even more than age, and that focused mediation directed at the individual child's needs, both with VR technology or with picture cards, prepare children for successful solving of analogical thinking tasks.

Summary

This study addressed the abilities of kindergarten-age children to solve classic analogies – conceptual and perceptual. A review of the research literature raised a question, whose answer has yet to achieve consensus: At what age does this ability appear? According to Piaget's theory (1969) of child development, analogical thinking is abstract thinking, which develops relatively late in childhood, between the ages of 11 to 12 years. Piaget maintains that children of kindergarten age are in the stage of concrete operations, and have difficulty in understanding relationships. Many researchers who came after him take issue with his theory. Today, many agree that a certain level of analogical thinking appears as early as kindergarten age. Beyond that, the findings of studies performed recently show that analogical thinking abilities at kindergarten age are predictors of reading and math readiness (Tzuriel & Flor-Maduel, 2010), and that places the importance of developing analogical thinking from early childhood ages.

In the same direction, the results of the present research supported today's prevailing opinions that analogical thinking appears as early as kindergarten age. Moreover it is possible to improve significantly the abilities of kindergarten children of an immigrant community to solve conceptual and perceptual analogies in a short time, with the help of focused mediation and VR technology.

In this respect, the present study joins the ranks of studies, which examined the contribution of intervention by means of VR for developing cognitive abilities, and supported its degree of effectiveness. It is clear that there is a need for continued examination of this question in relation to additional cognitive abilities, and for finding ways of making this technology available for educational needs.

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