VISUAL COGNITION: CONTENT KNOWLEDGE AND BELIEFS OF PRESCHOOL TEACHERS

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The present study investigates some aspects of preschool teachers’ prior content knowledge and beliefs in the area of visual cognition, before they taught the Agam Program for Visual Cognition in their schools. Results show that teachers do not possess well-developed visual cognition abilities in some areas (e.g. estimation, visual memorization, reproduction of visual stimuli etc.) and in some areas their performance is similar to that of third grade students, suggesting that visual cognition abilities do not necessarily develop spontaneously with age without directed practice. Teachers believe that visual abilities develop with practice, but some are sceptical about young children’s abilities to cope with complex visual tasks. The implications of these findings to the professional development of preschool teachers in the area of visual cognition are discussed.

INTRODUCTION

In recent years there has been a growing recognition of the importance to include visual cognition as part of preschool education. Although the training of visual cognition has been traditionally neglected, research indicates that early and systematic training in this area is desirable. For example, research shows that the early development of visual cognition contributes to the development of basic skills in geometry and mathematical thinking (Clements and Sarama, 2000; Denton and West, 2002) and also to other fields, such as writing, mapping skills and school readiness (Clements and Sarama, 1999; Eylon and Rosenfeld, 1990).

One of the most systematic programs that develop visual cognition in young children is the Agam Program for Visual Cognition. The central goal of the Agam Program is to help children develop their visual thinking, as a means to improve their over-all cognitive development. The vehicle for achieving this goal is through a curriculum, created by the artist Yaacov Agam and refined, implemented and evaluated by staff of the Department of Science Teaching at the Weizmann Institute of Science. The Agam Program is based upon 36 units each of which deals with a different visual concept or a combination of concepts. The program integrates the acquisition of each of these concepts with specific skills, i.e., identification, memorization, reproduction and reproduction from memory. In achieving its goals of teaching a visual language and educating the eye, the Agam

Program uses several distinguishing didactic means which include (1) a structured approach, (2) multiple models of representation (3) a cumulative presentation strategy and (4) minimal use of verbal language.

Research conducted on the program (Eylon and Rosenfeld, 1990; Razel and Eylon, 1990) showed that preschool children in the experimental group significantly outperformed similar children in the comparison group, on tests measuring visual concepts, spatial skills and transfer effects. Moreover, children in the experimental group demonstrated a statistically significant improvement on tests measuring general intelligence and math readiness. In other words, the Agam Program enhanced children's learning in a wide variety of areas. These positive effects were found equally for boys and girls, as well as for children from privileged and underprivileged backgrounds. The research on the Agam Program strongly suggests that when preschool children undergo a systematic program aimed at developing their visual cognition, they develop thinking tools and general abilities which improve their overall “cognitive competence” (Eylon and Rosenfeld, 1990). Spatial intelligence, identified by Gardner (1983) as one of the multiple intelligences, has components that are very similar to those incorporated in the Agam Program.

This year the Israeli Ministry of Education and the Weizmann Institute of Science are conducting a study with 40 preschools in an attempt to identify the necessary conditions for up-scaling the implementation of this program. Preschool teachers are a central focus of this study. In this paper we report on an investigation of preschool teachers' knowledge and beliefs regarding visual cognition and how it can be enhanced. One would assume that in order to help children to develop competencies in this important area, teachers need to possess such knowledge themselves. Content knowledge (Shulman, 1986) has been proven to be a significant factor affecting students’ learning and achievements (e.g. Ball, 1988). Although studies show that elementary school teachers of mathematics lack specific content knowledge in different areas they teach, they are expected to have at least the content knowledge which they gained through training and experience as teachers. Since the subject of visual cognition is not a part of teachers' training and is usually not practiced intentionally in school, it seems that teachers’ content knowledge in this area is the one developed by themselves as human beings. Thus it is important to investigate to what extent do preschool teachers possess the necessary prior knowledge to help their students in the area of visual cognition.

Teachers’ beliefs play an important role in what teachers teach, on the ways that they teach and on the ways that their students learn (e.g., Leder, Pehkonen and Torner, 2002). Thus, revealing teachers’ beliefs regarding visual cognition and its enhancement is important since it might have an impact not only on their abilities to teach this subject but also on their willingness to do so.

In this study we focus on the following questions:
RESEARCH QUESTIONS

1. What is the prior knowledge of preschool teachers in selected areas of visual cognition? How well can they cope with visual tasks and what are their strategies in performing such tasks?

2. What are the prior beliefs of these teachers regarding children’s visual cognition and ways for developing children’s abilities in this domain?

METHODOLOGY

Subjects

Twenty five preschool teachers participated in this study. These teachers have been chosen to implement the Agam Program for Visual Cognition in Israeli preschools, but had no prior experience with this program. All of them were experienced teachers with 6-33 years of experience (with an average of 19 years). Most of them with B.Ed or B.A (64%), some with M.Ed credential (12%), and the others with preschool senior teachers' credentials. The preschool teachers received their education in different colleges and universities in Israel.

Test Items

The subjects were given a test which included items aimed to investigate their knowledge in some areas of visual cognition and items aimed to investigate their beliefs. The test was administered during a three-day workshop, in which the teachers met for the first time with the Agam Program for Visual Cognition. The test included three parts; a) 4 “knowledge” tasks b) 4 “knowledge” tasks, each followed by “belief” questions c) 4 belief questions. We describe here in detail only those items that we analyze in this paper.

Visual cognition “knowledge” items

1. Visual Estimation - three pictures with dots (see Figure 1) were shown, one at a time, for a very short period of time (about 2 seconds). The teachers were asked to write down the number of dots they saw and to explain how they reached that number.

The dot pictures are part of the “Numerical Intuition” Unit (unit # 28) in the Agam Program.

![Figure 1 – Dot pictures](image)

2. Free Recall - Teachers were presented with 4 flash cards (see Figure 2) one at a time. They were asked first to look at all four cards, and then to find them among 18
such cards which they had in front of them. The teachers were shown cards number: 22, 20, 26 and 18. Card 26 was rotated by 90º before it was shown to the teachers.

3. **Graphical Reproduction** - Teachers were given a dotted paper equally distanced (11 dots x 16 dots) and were asked to draw as many squares as they can such that the squares differ in size.

Tasks #2 and #3 are part of the “Square” Unit (unit # 2) in the Agam Program.

The first two tasks are part of the "memorization" tasks of the Agam program. They are different in nature. While the first task requires reproduction of some aspects of the stimulus stored in memory, the second is a direct identification task. The third task is a typical reproduction task dealing with visual stimuli.

![Figure 2 – Flash cards](image_url)

**Visual cognition “belief” items**

**Flash Cards**

Two questions were given following the second “knowledge” task.

1. In your opinion, what does such a task develop among preschool children?
2. In your opinion, how many such flash cards can be given in such a way to the children that they will be able to recall?

The tests included more “knowledge” items, investigating abilities in additional areas of visual cognition. Some of the items were followed by “belief” questions similar to the questions above. Other “belief” questions asked teachers about the importance of developing visual cognition abilities in general, and among preschool children in particular. Teachers were also asked to write down names of children whom they think will succeed with visual cognition tasks and children who will have difficulties and to explain the reasons for each child.

**RESULTS**

The analysis of the data is both quantitative and qualitative. For some of the items we looked at the numerical answers. For example in “knowledge” item #3 we counted
the number of different squares. For the open-ended items, categories were established according to teacher responses.

**Visual cognition ”knowledge” items**

**Visual estimation**

The relative percentage of errors for pictures a, b and c was 20%, 26% and 28.5%, with an average of 25%. The dots in picture b appear in a structured arrangement which suits a known figure (square). This is probably the reason why picture 2 was easier for the teachers to cope with.

Five strategies were used by the teachers:

- **Counting strategy** – Teachers counted as many dots as they could in the short period of time available and added some more
- **Grouping strategy** – Teachers mentally divided the dots into small groups, usually of equal number, which they then multiplied by the total number of groups.
- **Comparison strategy** – Teachers compared the number of dots to that in a previous picture.
- **Spatial strategy** – Teachers estimated the number of dots according to the size of the dots, their arrangement and the space they hold.
- **Global perception strategy** – It seems that teachers who used this strategy could not explain how they arrived at their answer. Some of them glanced at the picture and gave their estimate.

Table 1 presents the strategies expressed by the teachers in the three visual estimation pictures. There were 73 strategies altogether (in two cases teachers did not explain the strategy) and the figures in Table 1 present the number of explanations per strategy for each picture.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Picture a</th>
<th>Picture b</th>
<th>Picture c</th>
<th>Overall in percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counting</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>5.5%</td>
</tr>
<tr>
<td>Grouping</td>
<td>6</td>
<td>23</td>
<td>10</td>
<td>53.4%</td>
</tr>
<tr>
<td>Comparison</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4.1%</td>
</tr>
<tr>
<td>Spatial</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>13.7%</td>
</tr>
<tr>
<td>Global perception</td>
<td>7</td>
<td>0</td>
<td>6</td>
<td>17.8%</td>
</tr>
<tr>
<td>Something else</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

Table 1 – Strategies demonstrated on the Visual estimation tasks

As can be seen from Table 1 the most popular strategy was the grouping strategy.

The counting strategy was present mostly for the first picture where teachers had to cope with this kind of task for the first time and probably found counting to be familiar. The comparison strategy was used in very few cases and only in pictures b
and c, where there was something to compare with. In picture b almost all teachers used the grouping strategy, since picture b “invites” division of the dots into groups. Teachers were not consistent in the use of strategy. Only three of the teachers used the same strategy, the grouping strategy, for all 3 pictures.

It is interesting to compare these results to results we obtained in a previous study in which third grade students were presented with the same dot pictures (Markovits and Hershkowitz, 1997). The average relative error of the third graders was 27%, which is very similar to that of the preschool teachers. As to the strategy used, the third graders used four strategies: counting (42%), grouping (31%), comparison (11%) and global perception (16%). The teachers used the counting strategy only in very few cases. They used much more the grouping strategy and also used the spatial strategy which was not used by the children at all. This comparison might suggest that visual estimation abilities of this kind do not necessarily improve with age, but with age there is a change on the kind of strategy being used for estimation.

**Free Recall**

84% of the teachers recognized flash card #18, 72% card #20, 56% card #22 and only 40% card #26. Card # 18 had the most correct answers both because it is not too much similar to one of the other 18 cards on the flash card board, the squares are “regular” squares (not rotated) and it was the last card presented in the series of four, thus the best remembered (recency effect). Card #22 is very similar to card #23 which is located just next to it on the flash card board, and indeed 44% of the teachers mentioned card #23 instead of #22. Card #26 was the most difficult, not only because of the relationship between the two given squares, in which one is not in the “regular” position, but also because the flash card was rotated with 90º, and the subjects had to do one more visual operation in their minds.

Only three preschool teachers correctly recognized all 4 cards, 11 recognized 3 cards, 7 teachers recognized 2 cards and 4 teachers recognized only 1 of the four cards. Since we had experience with kindergarten children (ages 5-6) who were able, after practice, to recognize 6 and even more flash cards, we expect that many of the preschool teachers will improve with practice.

**Graphical Reproduction**

Most of the teachers drew “regular” squares of different shapes. By “regular” we mean squares which are formed of two vertical and two horizontal lines in relation to the position of the given dotted paper. Only 4 teachers drew squares by connecting the dots with slope lines.

Table 2 presents the sizes of “regular” squares drawn by the teachers. The largest possible square was of 10X10 “dot spaces”.

<table>
<thead>
<tr>
<th>1x1</th>
<th>2x2</th>
<th>3x3</th>
<th>4x4</th>
<th>5x5</th>
<th>6x6</th>
<th>7x7</th>
<th>8x8</th>
<th>9x9</th>
<th>10x10</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>96%</td>
<td>84%</td>
<td>88%</td>
<td>68%</td>
<td>92%</td>
<td>56%</td>
<td>76%</td>
<td>48%</td>
<td>76%</td>
</tr>
</tbody>
</table>

Table 2 – Percentages of appearance of each square size
It can be seen that teachers drew squares of all sizes with an even number of “dot spaces” on each side. They did have difficulties in finding squares with dimensions of 5x5, 7x7 and 9x9. This occurred since many of the teachers drew a series of squares one placed inside the other, starting with 10x10, and this kind of series includes squares with even number of “dot spaces”. Then they added outside this pattern some more squares, with odd number of “dot spaces”, but only the small once.

**Visual cognition ”belief” items**

**Beliefs regarding the flash cards item**

Eighty percent of the subjects said that this task develops memory, 56% said that it develops concentration, 40% mentioned visual thinking or visual cognition, 24% said that it develops focus and the ability to pay attention to details and 16% mentioned retrieval from memory. It seems that the subjects realized what are the main abilities needed to carry out successfully this task and mentioned them as having the potential to develop.

In the second question, where the preschool teachers were asked about the number of flash cards which can be shown to children, the following answers were given:

a) I do not know until I try it with my children – 8%.

b) Very few because for children at this age is very difficult to cope with such a task – 20%.

c) We should start with 1 or 2 and then progress – 32%.

d) We should start with 2 or 3 and then progress – 28%.

e) More than 4 since children can learn and be better than us – 12%.

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It seems that about three quarters of the teachers conceive visual cognition expressed in this task as an ability that can develop with practice. Some are more sceptical about children's initial performance saying they would start with 1 card or two, while others suggest that one should start with three cards even with small children. Three teachers (12%) even suggest that children will be able to cope with a large number of flash cards in this task, stating that visual abilities are not necessarily related to age. On the other hand, 4 teachers seem to be very sceptical, giving no much chance to the children on this task.

It is interesting to mention that only 4 teachers related to individual differences and suggested that the number of cards, children are able to deal with, depends on the child’s visual abilities. Most teachers judged that all children in their preschool would perform at the same level.

**DISCUSSION**

Visual cognition develops with practice. Research shows that young children improve their visual abilities when they participate in a systematic program such as the Agam Program. Teachers are usually not exposed to programs that develop visual cognition in a directed manner neither during the pre-service training, nor during in-
service programs. They also do not usually experience the systematic treatment of visual cognition in their practice. Thus it is not surprising that their performance on visual estimation tasks was about the same as that of third graders, and on the free recall task, very few were able to remember four cards while kindergarten children, after practice, are able to remember six and even more cards. These results are probably typical of the condition of many adults who do not develop the various visual cognition abilities and remain at the level of younger children. Thus it seems necessary to provide teachers with opportunities to develop their visual cognition through the in-service training accompanying the implementation of the program. However, because of time limitations, the practice that teachers can have through this training is limited. It is plausible to assume that in addition to this training, the teachers participating in this study will undergo “on the job training”, meaning that they will probably develop their visual cognition abilities as they implement the program with their preschool children. It is interesting to investigate whether, and if so in what ways, being involved in the teaching of visual cognition will affect teachers’ visual cognition. The tests we plan to give teachers at the end of the year will help us answer this question. These tests will also enable us to compare prior teachers’ beliefs as revealed in this study to their beliefs at the end of the year, as they can observe the development of visual cognition of their students.

References


