KINDERGARTNERS’ PERSPECTIVE TAKING ABILITIES

Aaltje Berendina Aaten*, Marja van den Heuvel-Panhuizen*, Iliada Elia^*

*Flsme, Utrecht University, the Netherlands
^Department of Education, University of Cyprus, Cyprus

This study investigated kindergartners’ imaginary perspective taking (IPT) abilities by examining their ability to imagine whether an object is visible from another viewpoint (IPT Competence 1) and how an object looks from another viewpoint (IPT Competence 2). The participants were 308 4- and 5-year-old kindergartners in the Netherlands. A paper-and-pencil test of various perspective-taking pictorial tasks was developed and administered to the children. The results show that IPT Competence 2 is more difficult than IPT Competence 1, and that both competences develop during the kindergarten years. Also, for both IPT Competences 1 and 2 a positive relationship was found with mathematics performance, while no gender difference was found on either IPT Competence.

Key-words: Kindergartners, Spatial reasoning, Perspective taking ability, Gender

SPATIAL GEOMETRY FOR YOUNG CHILDREN

Geometry is an indispensable part of contemporary early childhood curricula and educational programs (Sarama & Clements, 2009). It is not confined to plane geometry, but spatial abilities play an important role as well. For example, in the Standards of the National Council for Teachers of Mathematics (NCTM, 2000) in the K-2 grades much attention is paid to Specifying locations (which includes interpreting relative positions in space) and Using visualization (which includes creating mental images of geometric shapes using spatial memory and spatial visualization and recognizing and representing shapes from different perspectives). Similarly, the TAL teaching/learning trajectory for geometry (Van den Heuvel-Panhuizen & Buys, 2008) includes the subdomain Orienting which focuses on localizing and taking a point of view in both the first and second year of kindergarten (K1 and K2).

This emphasis on a spatial interpretation of geometry for young children is not surprising. It is the natural way in which children encounter geometry. They discover the world around them while they walk, play, and look around. They are in fact investigating their environment all the time; by doing so, they learn to find their way, to determine their own location within the environment, to describe to others their own position or the position of an object such as their teddy bear. Also visualization and spatial reasoning abilities develop through children’s activities, such as playing hide-and-seek. Children try to hide in a place in which they will not be visible to the child that is looking for them. As such, they try to imagine or to reason what the other child will and will not be able to see while wandering around.
Although the above seems very plausible now, in the past the teaching of geometry to children started with plane geometry. It was Freudenthal (1973) who argued strongly for changing this and starting with spatial geometry at an early age.

“Geometry is grasping space . . . that space in which the child lives, breathes and moves. The space that the child must learn to know, explore, conquer, in order to live, breathe and move better in it.” (Freudenthal, 1973, p. 403)

Enhancing young children’s spatial abilities is important for several reasons. As described above, spatial abilities help children to understand their environment. Furthermore, the development of spatial abilities is important for the development of mathematics ability in general. According to Clements (2004, p. 267), “[g]eometry and spatial reasoning form the foundation of much learning of mathematics and other subjects.” Spatial reasoning in particular is recognized by mathematicians as a useful strategy in mathematical problem solving, for example through the use of diagrams and drawings to solve problems (Casey, Andrews, Schindler, Kersh, Samper, & Copley, 2008). Moreover, teaching spatial ability enhances children’s mathematical attitude (Casey et al., 2008; Van den Heuvel-Panhuizen & Buys, 2008).

Altogether, spatial abilities are important for young children to learn and therefore, it is worthwhile to gain more insight into how they develop these abilities. In this study, we focused on a specific spatial ability of kindergartners, namely their competence to mentally take a particular point of view.

**IMAGINARY PERSPECTIVE TAKING**

Important research on imaginary perspective taking (IPT) has been done by Piaget and Inhelder (1956). One of the tasks that they used to investigate children’s IPT was the “Three Mountain task”. In this task children were positioned on one side of a table and asked to describe how the scene on the table would look from the opposite side. In this way it was found that children up to the age of nine tended to describe the way the scene looked from their own position. They were not able to take a perspective from another position than their own.

Flavell, Everett, Croft, and Flavell (1981) came up with a distinction into two abilities of perspective taking. The so-called Level 1 competence concerns the visibility of objects: a child that has achieved this competence is able to deduce which objects are or are not visible from the other viewpoint. The Level 2 competence relates to the appearance of objects: a child that has attained this competence is able to indicate how an object looks as it is observed from a different viewpoint. Hughes (1975, as cited by Donaldson, 1980) has independently proposed a very similar model, in which “projective” and “perspective” abilities correspond respectively to Level 1 and Level 2 competence.

In connection to the distinction into two abilities, Flavell et al. (1981) also found that the abilities differ in their rate of development. Children of three years of age performed well on the Level 1 tasks but had difficulties with the Level 2 tasks.
FACTORS THAT POSSIBLY INFLUENCE IPT

Mathematics performance
Many studies (e.g. Burnett, Lane, & Dratt, 1979; Casey, Nuttall, & Pezaris, 1997; Geary, Saults, Liu, & Hoard, 2000) have found positive correlations between mathematics performance and spatial ability, but most of these studies were done with high school and university students. Only a few studies were carried out with young children. For example, Robinson, Abbot, Berninger, and Busse (1996) found a high correlation between two-dimensional reasoning and quantitative skills in precocious preschoolers and kindergartners. Guay and McDaniel (1977, as cited by Lean & Clements, 1981), who did a study with primary school students, focused on a broader range of spatial abilities not only compassing two-dimensional visualization tasks, but also tasks involving three-dimensional mental images and mental transformation of these images. The results indicated a positive correlation between mathematics performance and two- and three-dimensional spatial tasks in primary school students.

Gender
The findings with respect to the relation between gender and spatial ability are various. Several studies found a male advantage for three-dimensional mental rotation (Casey et al, 2008), two-dimensional mental rotation as well as translation (Levine, Huttenlocher, Taylor, & Langrock, 1999), and spatial visualization (Tracy, 1987) already in existence at kindergarten age. Horan and Rosser (1984) investigated children aged 4, 6, and 8 years who were offered dimension-transcending tasks in which the questions and the answers were formulated in a different dimension: a three-dimensional object was shown and the child was asked how this object looked to an observer in another position after the object was rotated 90º. The child could answer the question by selecting the correct two-dimensional picture. In these dimension-transcending tasks, boys performed better than girls. However, if the question and the answer were both presented in the form of two-dimensional pictures, girls performed better than boys. Some studies, though, did not reveal a gender effect for spatial ability. For example, Lachance’s and Mazzocco’s (2006) longitudinal study on children in lower primary school did not show sustainable gender differences in spatial ability in general. Also, Newcombe and Huttenlocher (1992) did not find gender differences with respect to perspective taking in their study in which they asked young children which object would be in a certain position relative to another observer.

RESEARCH QUESTIONS AND HYPOTHESES
In light of the above, we formulated three research questions to gain more insight into kindergartners’ imaginary perspective taking abilities:
1. How able are kindergartners in IPT Competence 1 (determining whether an object is visible from another viewpoint) and IPT Competence 2 (imagining how an object looks from another viewpoint)?

2. How are these IPT competences related?

3. How are these IPT competences related to kindergarten grade, mathematics performance and gender?

Based on previous research we could only formulate two hypotheses:

1. Kindergartners will perform better on tasks requiring IPT Competence 1 than on tasks requiring IPT Competence 2.

2. There will be a positive relation between mathematics performance and the IPT competences.

METHOD

Assessment Instruments

Assessment of IPT. To answer our research questions, we developed a paper-and-pencil test to measure kindergartners’ perspective taking abilities. This test contains two booklets of test items, and was administered in two test sessions. The test items consist of a picture illustrating what each question is about and four pictures depicting the possible answers.

In Figure 1a, an example of a test item is given. This Basket item is meant for measuring IPT Competence 1. Figure 1b shows the Mouse item, meant for measuring IPT Competence 2.

![Figure 1a: Basket item](image1)

![Figure 1b: Mouse item](image2)

The questions were read to the children by trained test administrators. For the Mouse item, the question was: “How do you see Mouse if you look at him from above like a bird?” Children answered the question by underlining the picture that shows the correct answer. Correct responses were coded as 1, and incorrect ones as 0.

Six items in the test concerned IPT Competence 1 and five items concerned IPT Competence 2.
**Assessment of mathematics performance.** To assess children’s mathematics performance, we made use of a standardized mathematics test for kindergartners, the CITO Test Ordering, which is in nation-wide use. This test has separate versions for the first (K1) and second year of kindergarten (K2); the Cronbach’s alphas of both versions are .85 and .81 respectively (Van Kuyk & Kamphuis, 2001).

**Participants**

Our study involved 384 Dutch kindergartners. Children who did not do both test booklets were excluded from the analysis, which diminished our sample to 308 children, 146 girls and 162 boys; 109 children attended K1 and 199 children were in K2. The K1 children had an average age of 4 years and 8 months and the K2 children were on average 5 years and 8 months old.

**RESULTS**

**Kindergartners’ abilities in IPT Competences 1 and 2**

The data analysis showed that the kindergartners achieved a significantly higher success rate on test items that require IPT Competence 1 (M=.73, SD=.20) than on the IPT Competence 2 items (M=.34, SD=.22) \[t(307) = 26.42, p < .01\], see Figure 2.

![Figure 2: Mean performance on IPT Competence 1 and IPT Competence 2 items](image)

**Relationship between IPT Competences 1 and 2**

A statistical implicative analysis (Lahanier-Reuter, 2008) was used to investigate the relationship between the two competences based on the children’s responses to the test items. Statistical implicative analysis leads to results such as “if we observe success on item a in a subject, then in general we observe success on item b in the same subject”. We conducted this analysis for both kindergarten grades separately. In Figure 3 the results for K1 are depicted on the left and the results for K2 on the right. The figure shows how the items are related. The item names indicate what competence the item measures. For example, the item \textit{C2cucumber} requires IPT Competence 2. The diagram shows that in K1, success on this item implies success on two IPT Competence 1 items. The probabilities of these implications are 90% for the grey arrows (e.g. \textit{C2cucumber}→\textit{C1tower}) and 95% for the blue arrows (e.g. \textit{C2cucumber}→\textit{C1hole}).
The implicative diagrams for the K1 and K2 data show a similar pattern. In both diagrams, the items that measure IPT Competence 2 are high up in the diagrams, whereas the IPT Competence 1 items are positioned below them, i.e. success on the IPT Competence 2 items implies success on the IPT Competence 1 items.

**Development of IPT Competence 1 and 2**

To gain more insight into the development of IPT Competences 1 and 2, we compared the performance on items measuring these IPT competences between kindergartners in K1 and K2 by carrying out independent samples t-tests.

As illustrated in Figure 4, K2 children’s performance on IPT Competence 1 items (M=.77, SD=.18) was significantly higher than the K1 children’s performance (M=.67, SD=.21) \[ t(306) = -4.44, p < .01 \]. Also on IPT Competence 2 items, K2
children performed better (M=0.39, SD=0.22) than K1 children (M=0.25, SD=0.19) \([t(306) = -5.59, p < .01]\).

**Mathematics performance and IPT**

To investigate a possible relation between IPT Competences 1 and 2 with mathematics performance, one-way analyses of variance (ANOVA) were carried out with the IPT competences as the dependent variables and children’s mathematical achievement level as the independent variable. Children’s mathematical achievement level was based on their score on the CITO Mathematics Test. The scores on this test are indicated by a letter. An A-score means that the test score belongs to the highest 25% scores of the complete Dutch population of kindergartners, a B-score stands for the next 25%, a C indicates that the score is in the third quartile, while D concerns the next 15% of scores and E the 10% lowest scores. The results of the analyses are shown in Figure 5.

![Figure 5: IPT Competence 1 (left) and IPT Competence 2 (right) relative to mathematics performance](image)

For IPT Competence 1 \([F(4, 298) = 14.56, p< .01]\) as well as for IPT Competence 2 \([F(4, 298) = 3.12, p = .02]\) we found a significant relationship with the children’s mathematics performance level.

**Gender and IPT**

Independent-samples t-tests were used to compare boys’ and girls’ performances on the items measuring the two IPT competences. The results indicated no gender difference on either IPT Competence 1 (Boys: M=0.73, SD=0.20; Girls: M=0.74, SD=0.21) \([t(306) = -0.12, p = 0.90]\) or on IPT Competence 2 (Boys: M=0.34, SD=0.22; Girls: M=0.33, SD=0.22) \([t(306) = 0.57, p = 0.57]\), as is illustrated in Figure 6.
DISCUSSION

In this study we investigated kindergartners’ competences in determining the visibility and appearance of objects as seen from another point of view. In particular, we examined how these abilities are related, how they develop, and how they are related to gender and mathematics performance.

Concerning kindergartners’ ability to determine whether an object is visible from a different viewpoint (IPT Competence 1), we found an overall success rate of 73% while the success rate on items that require the ability to determine the appearance of an object from a different point of view (IPT Competence 2) was significantly lower, i.e. 34%. This result indicates that the IPT Competence 2 items are more demanding for the children than the IPT Competence 1 items (Hypothesis 1), which is in line with previous studies (e.g. Flavell et al., 1981).

Statistical implicative analysis showed that success on several of the IPT Competence 2 items implied success on either other IPT Competence 2 items or on IPT Competence 1 items. The other direction, an implicative relation of an IPT Competence 1 item and an IPT Competence 2 item, was not found. This suggests that the development of IPT Competence 1 precedes the development of IPT Competence 2. This conclusion is in agreement with our finding that the children performed better on the IPT Competence 1 items than on the IPT Competence 2 items.

Children at kindergarten age experience major development in many fields. This turned out to be the case for the IPT competences as well. In our study we found that both IPT competences increase significantly from K1 to K2.

With respect to factors that possibly influence IPT we found that the children’s mathematics performance level is significantly related to their IPT competences. This is in line with earlier findings on the relation between spatial ability and mathematics.
performance. However, in our study the relationship between mathematics performance and IPT was stronger for Competence 1 than for Competence 2. Future research could explore the causes of this difference and whether it changes over time.

Comparison of IPT competences from the view of gender did not reveal significant differences. Both for the IPT Competence 1 items as well as for the IPT Competence 2 items, the results were similar for boys and girls. This finding is in agreement with previous studies on perspective taking, but contrasts with studies into the relationship between gender and spatial ability as assessed, for example, by rotation and translation tasks. Spatial ability clearly has a multi-dimensional structure of which the different aspects might have a different gender profile. Further research is indicated on this topic.

REFERENCES


