THE INFLUENCE OF SYMMETRIC OBJECTS ON SPATIAL PERSPECTIVE-TAKING – AN INTERVIEW-STUDY WITH YOUNG ELEMENTARY SCHOOL CHILDREN

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Symmetric objects are known to be perceived easier than asymmetric objects, because less information has to be processed. Therefore, symmetric objects are often used for spatial tasks. However, in perspective-taking the use of symmetric objects can also cause difficulties, as two side-views of these objects are mirror-images of each other. To examine this influence, 95 children at the beginning of first grade were asked to solve a systematically varied set of tasks in interview sessions. It was assumed that they have more difficulties to solve the tasks with symmetric objects than with asymmetric ones. Against expectation, this effect could not be confirmed based on the number of correct answers. However, the types of errors and the children's explanations show the difficulties of perspective tasks with symmetric objects.

INTRODUCTION

Spatial perspective-taking is an essential component of spatial ability. Children's spatial perspective-taking was initially studied in the famous "three-mountains-task" of Piaget and Inhelder (1999; French first edition in 1948). Subsequent studies varied many different task characteristics; the effects of these variations on the ability to coordinate perspectives are well known (for an overview see Fehr 1978 and Newcombe 1989). However, the effects of symmetry, which are suggested by some results of Lüthje (2010) in a spatial perspective task with preschool-children, have not been studied yet – although in research as well as in school symmetric objects like animals or vehicles are used often.

This study examines, with a systematically varied set of tasks, if the use of symmetric objects influences spatial perspective-taking and under which circumstances this can be observed. Since symmetric objects have two side views that are mirror-images of each other and differ only in their left-right-orientation, we suppose that spatial perspective tasks with symmetric objects are solved less often or less well than tasks with asymmetric objects. In symmetric tasks, we also assume that the two side views, which are symmetric to each other, are more often confused with each other.

THEORETICAL FRAMEWORK

Spatial perspective-taking is defined as the ability to imagine how objects appear from another point of view than one's own (see Cox 1977). There are two essential components for successfully solving spatial perspective tasks. First, one needs to know that one particular view of an object corresponds with one particular position. Therefore,

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two persons in the same position perceive the object in the same way. If they differ in their positions, their views also differ from one another. Second, spatial perspective-taking also requires the ability to figure out mentally how exactly the other view looks like. In other words, one must be able to imagine *what* can be seen from the other position and especially *how* and *where*, in relation to other objects, this particular object is seen (see Coie et al. 1973; Fishbein et al. 1972; Salatas & Flavell 1976).

To succeed in perspective tasks with symmetric objects, the subject must distinguish between the two side views that are symmetric to each other with respect to a vertical axis. These side views differ only in their left-right-orientation. However, the discrimination between left and right is difficult even for adults (see e.g. Ofte & Hugdahl 2002; Storfer 1995) and develops later than the discrimination in the two other dimensions, front-back and top-bottom (see Shepard & Hurwitz 1984).

Studies about the perception of orientation observed that subjects often confuse an oriented object with its mirror-image, for example the letters “b” and “d” or “p” and “q”, as well as pictures of common objects (see Davidson 1935; Gregory et al. 2011; Gregory & McCloskey 2010). Interestingly, the confusion of mirror-images appears especially with respect to a vertical axis (but see for a different interpretation of research results Gregory & McCloskey 2010) whereas the perception or construction of symmetry is seen as particularly easy if the axis is vertical (see Grenier 1985). In reproduction tasks with dot pattern, symmetry (especially with respect to a vertical axis) even seems to be a facilitative factor (see Bartmann 1993; Bornstein & Stiles-Davis 1984; Liu & Uttal 1999).

DATA AND METHOD

Subjects and context

95 first-graders (average age: 6 years 8 months) in Germany participated in this study. During individual interviews, every child was asked to solve 32 perspective tasks and to explain its solution after each task. The interviews took place in a separate room during lessons, lasted about 15 to 25 minutes, and were videotaped.

The tasks

For all tasks, a square base (40cm×40cm) with four differently coloured toy figurines, placed in the center of each side, was used. In the middle of this plate, the interviewer placed 16 different objects one after another. Four photographs of the object (depicting the object’s four different sides) were positioned between the child and the plate. For every task, the child was asked which of the pictures would correspond to the view of one of the toy figurines, saying: “Which of the photographs did the green man take?” When the children gave their answers, they were invited to explain their decisions, before being asked about another toy figurine’s view. In every situation, only two views were tested to limit subsequent mistakes that are rooted in a previous mistake.

Two different types of objects were used for the study: toy animals that are well-known to children and have clearly determined sides (front, back, left side, right side) and arrangements of two differently colored cuboids of the same size as abstract objects without distinguishable front/back and sides. For each object type, eight symmetric and eight asymmetric objects were used. The natural symmetry of the animals was abolished by lifting one leg and adding an item from a circus-context. The symmetric animals were also extended with items from the circus-context to minimize the differences between symmetric and asymmetric animals (see figure 1). For cuboid tasks, first a symmetric arrangement was built; then an asymmetric arrangement was created by sliding one cuboid orthogonal to the mirror plane (see figure 2).

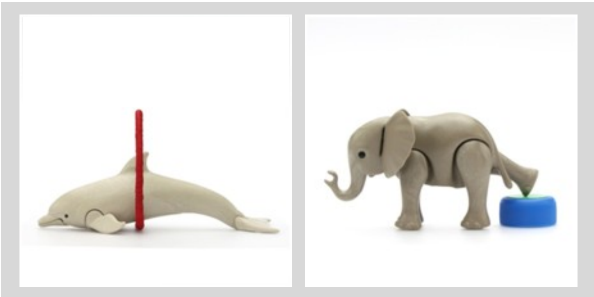

Figure 1: Examples for symmetric and asymmetric animals

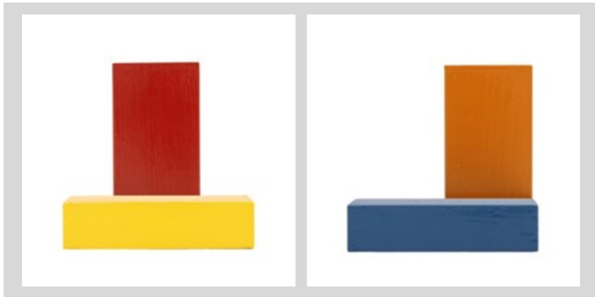

Figure 2: Examples for symmetric and asymmetric cuboid arrangements

Besides symmetry and type of object, two other factors were varied: the object's orientation (parallel or orthogonal to the child's line of sight) and the type of view (side view or front/back view). To ensure comparability, every symmetric object was paired with an asymmetric object of the same object type and within such a pair of tasks all other variables were kept constant: the orientation, the arrangement of the pictures, and the two toy figurines, whose views should be figured out.

Procedure of analysis

The interview data was analysed in two ways: the children's decisions were classified with respect to the type of mistake made, and the explanations were transcribed and categorized by qualitative content analysis.

The answers of the children were classified as follows:

- Correct answer: the child chose the picture that shows the toy figurine's view.
- Egocentric mistake: the child chose the picture that shows its own view in-stead of that of the toy figurine.
- Inversion mistake: being asked about a side view the child chose the wrong one.
- Ambiguous mistake: if the child was asked about the view opposite to its own of an orthogonal aligned object (so it was a question about a side-view) and it chose the picture that shows its own view, this mistake could either be classified as an egocentric mistake or as inverting the side views. Therefore, this mistake was named "ambiguous mistake".
- Other: all other mistakes.

The children's explanations were transcribed, including their gestures. In a second step, these explanations were sorted by likeness. The analysis of difficulties and similarities lead to a category system that is explicated in the following section.

RESULTS

Solution rates and error rates

On average (∅), children solved 70% of all items correctly (this corresponds to 22 out of 32 items) with a minimum of 37% and a maximum of 100%. The solution rates of the different items are similar: on average, the items were solved correctly by 70% of all children (see table 1 for further information).

animals	symmetric	asymmetric	sum
front/back views	92.3%	93.8%	93.1%
side views	65.8%	62.8%	64.3%
sum	79.3%	78.3%	78.8%

cuboids	symmetric	asymmetric	sum
front/back views	82.5%	70.5%	76.5%
side views	45.8%	45.8%	45.8%
sum	64.2%	58.2%	61.2%

animals and cuboids combined	symmetric	asymmetric	sum
front/back views	87.0%	82.1%	84.6%
side views	56.1%	54.3%	55.2%
sum	71.6%	68.2%	69.9%

Table 1: Average solution rates

As known from other perspective-taking studies, differences between the two objects types were significant ($p<.001$): children solved the tasks with animals (∅78.8%) more often than the tasks with cuboids (∅61.2%). It was also hypothesized that the side views (∅55.2%) would be more difficult than the front and back views (∅84.6%) ($p<.001$). However, a significant difference in the solution rates could be observed between symmetric and asymmetric objects in the other direction than expected ($p<.005$): the symmetric tasks (∅71.6%) were solved slightly more successfully than the asymmetric ones (∅68.2%). Further analyses showed that this difference is grounded in the tasks with front and back views of cuboids. The symmetry of the views seemed to help children to concentrate on relevant details of the views and to distinguish them from the asymmetric side views. In other groups of tasks (side views of cuboids, side views and front/back views of animals) no significant differences between tasks with symmetric and tasks with asymmetric objects were found.

The assumption that children would solve spatial perspective tasks less often with symmetric objects than with asymmetric objects cannot be confirmed. However, the comparison of the error rates shows an interesting difference: the side views of parallel-aligned symmetric objects were inverted more often than those of asymmetric objects, with animals as well as with cuboids (see table 2).

animals	symmetric	asymmetric
egocentric	36.1%	57.1%
inverted side views	56.9%	36.4%

cuboids	symmetric	asymmetric
egocentric	45.0%	71.0%
inverted side views	35.8%	19.4%

Table 2: Rates of mistake-types in relation to all mistakes at side views with parallel-aligned objects[1]

Thus, the difficulty that symmetric objects pose can be seen in the inversion of the side views. A more thorough analysis of the children's explanations will give hints for better understanding these difficulties and differences.

The children's explanations

In analysing the transcripts of the children's explanations, three main categories could be extracted for both conditions. Since the children's explanations differed according to the objects types, the categories are presented separately for animal and cuboid tasks before a comparison as well as frequencies are given.

Categories for the animal tasks

Category 1: Reference to details In statements subsumed under this category, the children referred to details of the animal and said what can be seen from a special view: "He sees the face."; "She takes a picture of the tail." Usually they name that part of the animal that is nearest to the toy figurine and therefore appears in the front.

Category 2: Reference to intrinsic alignment of the animal This category contains statements that do not refer to special details, but to particular sides of the animal: "You see it only from behind."; "Because he is standing in front of it."; "He takes a photo of the side." In this category, the words "behind", "in front" and "side" could also refer to other frames of reference than the intrinsic alignment of the animal: to the child's view or to the toy figurine's view. However, in most cases the children referred to the intrinsic alignment of the animal: if they said "He stands behind the animal," they did not mean the toy figurine opposite to themselves, but the toy figurine that is standing next to the animal's tail.

Category 3: Reference to extrinsic alignment of the animal This category includes all explanations about how the animal was oriented without referring to details or the intrinsic alignment of the animal: "The elephant looks to the man."; "It walks there (showing the direction of the animal)."; "Because it stands that way (making a motion from the back to the front of the animal)."

Categories for the cuboid tasks

[1] The side views of the orthogonal aligned objects were excluded because in this condition the mistakes could not be classified as egocentric or inverting of side views (see above "ambiguous mistake").

Category 1: Reference to the front-back-relation The explanations in this category showed awareness of what can be seen in the front from the position of the toy figurine or if a part of one cuboid is hidden by the other cuboid: “The red one is in front of the yellow.”; “He couldn’t see the blue block well.”; “She can see the black one better than the green one.”

Category 2: Reference to different sides of the cuboids Although cuboids have no intrinsic alignment, some of the children’s statements are similar to statements of category 2 of the animals in that way that they refer to different sides of the cuboids: “Because there the block is narrow.”; “The block appears wide.”

Category 3: Reference to the extrinsic alignment of the cuboid building This category includes all explanations by which children described how the cuboids were positioned: “There is the black one, and there is the green one (showing both cuboids either at the arrangement or at the photographs).”; “Because this is here (pointing to one of the cuboids) and the other one is beside it.”; “The blue block is on THAT side (pointing to the blue block) and not there (pointing to the other side of the second block).”

Apart from some categories that occurred very rarely and are therefore not presented, there is one frequently observed category in both object-groups, which may be called “Just because!” Statements subsumed under this category are not arguments but rather claims: “Because it is the same.”; “I know it.”; “They fit together.”

<u>Frequencies of categories</u>

The analyses of frequency distributions showed that all described categories are re-presented in both object-type conditions (animals and cuboids) and also in symmetric as well as in asymmetric tasks. The following descriptions focus on the comparison between symmetric and asymmetric items.

Front/back views of animals: There was no difference between symmetric and asymmetric tasks. Both were predominantly justified with statements of category 1 (reference to details): ∅51.5% [2] (symmetric) and ∅52.9% (asymmetric) of all explanations could be assigned to this category. The second most common category was category 2 (reference to intrinsic alignment) with a frequency of ∅34.9% (symmetric) / ∅31.6% (asymmetric). Every other category accounted for less than 8%. The dominance of the first two categories is comprehensible because of the intrinsic alignment of the animals, which does not differ between symmetric and asymmetric animals.

Side views of animals: For these tasks, differences in reasoning could be observed. The tasks with asymmetric animals were mostly justified with category 1 (reference to details) (∅41.7%), whereas with symmetric animals, category 1 accounted for only ∅7.9%. With symmetric animals category 3 (reference to extrinsic alignment of the

[2] The following percentages refer to all explanations that could be assigned to one of the categories. Situations, in which the child gave no explanation or the explanation could not be allocated, are not included in the frequencies.

animal) was the most frequent one (∅30.8%) and statements like "Just because!" were also very frequent (∅25.8%). This result reflects the problems that children often have in distinguishing the side views of symmetrical animals.

Side views of cuboids: In this condition, a difference between symmetric and asymmetric tasks appeared as well. Category 1 (reference to details) occurred more often with asymmetric arrangements, in which one cuboid appears at the front or back of the other one (∅45.7% vs. ∅15.6%). For symmetric arrangements, category 3 was the most frequent one (∅40.0%). Interestingly the category "Just because!" was not as frequent as in the side-views-condition of animals (∅15.0%).

Front/back views in cuboid tasks: Children justified their decisions in these tasks predominantly by category 1 (reference to the front-back-relation), but more often in symmetric (∅66.1%) than in asymmetric arrangements (∅52.9%). Asymmetric arrangements lead more often (∅14.4%) to category 3 (reference to extrinsic alignment) than symmetric arrangements (∅6.1%). These results confirm the interpretation of the solution rates, that the symmetry of the views helped the children to concentrate on relevant aspects (here: the front-back-relation).

CONCLUSION

Two different directions of the influence of symmetric objects on spatial perspective-taking could be observed in this study: On the one hand symmetry has a simplifying effect, probably because it helps perceiving relevant aspects of the task. This could be seen in the condition of front and back views of cuboids, in which tasks with symmetric objects were solved more often than tasks with asymmetric objects. On the other hand symmetric objects complicate the solution of the tasks, if the two side views that are symmetric to each other have to be distinguished. This effect was not reflected in the solution rates, but could be observed in the distributions of types of mistakes and of the children's explanations: In symmetric conditions, the children more often interchanged the side-views and had more difficulties to justify their decisions than in the asymmetric ones. The statements for the asymmetric side views showed that the differences between the two side views, which lay in the front-back-dimension, helped the children to distinguish between them.

For further research of perspective-taking the influence of symmetric objects should be considered carefully, especially if asymmetric and symmetric objects are used in the same study. For working with perspective-taking tasks in school, teachers should be sensitive to the difficulties of side views of symmetric objects. It could be useful to start perspective-taking with young pupils with asymmetric objects. Teachers should also stress the importance of considering the orientation of the objects, especially the left-right relation, because the strategy of referring to what can be seen is not always successful.

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