.WAFL (l‡©ˆQ MœÍ%N´Ê›^“LFj[¬ntry(SLvàƒøÇ¨ç6›Þ♂ œÍ%N´Ê›^“LFj[¬PD‹url Fhttp://cogprints.ecs.soton.ac.uk/archive/00001223/00/cpl_zabalia2.htm mime text/htmlhntt"1ab3e6-4f39-3d3eaab8"hvrsdata

THE ROLE OF ACTION IN THE REPRESENTATION OF MOVING SHAPES

IN CHILDREN WITH CEREBRAL PALSY

Marc Zabalia

LPCP, ModeSCO, Maison de la Recherche en Sciences Humaines

Université de Caen , Esplanade de la paix F-14032 Caen cedex

tél: 02 31 56 62 19 ; Fax: 02 31 56 62 60 ; e-mail: zabalia@mrsh.unicaen.fr

The aim of the present study is to provide evidence for the role of action used mainly by children with cerebral palsy to get over difficulties in some mental rotation tasks. 25 children with cerebral palsy and 25 able children were given a task inspired from the Tétris video game consisting in fitting together geometrical figures. Results show that children with cerebral palsy are able to anticipate mentally the motion of the object, but they can not mentally break down the motion. This may be explained by the use of an object manipulation strategy necessary to actualize the properties of the object motions. These findings have implications in the understanding of the role of action in the development of mental imagery.

Keywords : cerebral palsy, mental imagery, action, representation.

Introduction

From Piaget's early work to current theories of cognition, theoretical and empirical data in the area of mental imagery show a divergence of points of view (Lautrey & Chartier, 1987 ; see also Dean, 1990). This opposition concerns the mental rotation process that is to say the relations between spatial operations and the capacity for representation of motions. In the Piagetian's theory, the representation of motions is only possible when the mental image is sustained by the operations of thought (Piaget & Inhelder, 1966). This position is not tenable any longer, ever since findings have shown that children perform mental rotation task as young as 5 (Marmor, 1975 ; Kosslyn & *al*., 1990) and provide convincing verbal reports of this mental process (Estes, 1998). In order to eliminate these contradictions in the literature, theoretical positions adopt a new framework to understand the representational format involved in the tasks presented to the children. Lautrey (1990) notes that experimental situations imply an analog processing when mental imagery is evaluated by chronometric methods with familiar objects. Tasks may elicit a propositional processing when mental imagery is evaluated by a verbal response or a drawing or the use geometric stimuli.

Recent empirical and theoretical advances in the study of mental imagery highlight that action is a source of mental imagery (see Bideaud & Courbois, 1998). Currently, theoretical proposals increase convergences and complementarity between the Piaget's theory and works of cognitive neurosciences. Kosslyn (1994) suggests that the motor system is involved in the images of motions because it guides the motion itself. Much indirect evidence supports the hypothesis that transformations of mental images are guided, at least in part, by a motor process, even in the cases involving images of abstract objects rather than images of body parts (Parsons *et al*., 1995 ; Cohen *et al*., 1996 ; Parsons, 1994 ; Wexler, Kosslyn & Berthoz, 1998).

Thus, the aim of a comparative approach between able children and children with cerebral palsy is to reexamine the theory in which mental imagery emerges from a repertoire of sensorimotor behaviors that are gradually integrated and internalized (Piaget, 1945). Such an approach is consistent with alternative proposals.

In this perspective, we have already concluded that the capacities to use an analog mental rotation in children with cerebral palsy are preserved. By contrast, they show important difficulties to actualize a propositional processing in a task that consists in arranging of rotational events (Zabalia, 1999). According to Marmor (1977) and Dean, Scherzer & Chabaud (1986), this research suggests that mental images of rotation do not necessarily imply the operations of thought in chronometric tasks involving familiar stimuli. But it is perhaps even more evident that these operations of thought are essential when the task requires an understanding of the motion and a breaking down of its structure.

The aim of the present study is to provide evidence for an object manipulation strategy used mainly by children with cerebral palsy. This strategy seems to be used to overcome difficulties in the process of " breaking down - reconstitution "of rotational motions. We hypothesized that the representation of the properties of figures motions emerges from the actions accomplished by children with cerebral palsy.

Method

Participants : Cerebral Palsy is caused by a perinatal lesion of the brain and affects mainly locomotor, gesture and postural control. In this study, children had develop a periventricular leucomalacia. Data suggest that periventricular leucomalacia involve lesions in the periventricular white matter and in the posterior putamen (Rutherford & *al.*, 1992 ; de Vries & *al.*, 1998). The white matter and the putamen nuclei control gross intentional movements and patterns of motions. Children with cerebral palsy suffer from a variety of disabling conditions. They are schooled in a " *Institut d'Education Motrice* " since 6 years old. According to estimates by the teaching staff their intelligence was within the normal range. 25 handicapped children aged 6;8 to 16;6 years (mean = 10;1 years) participated in the study. The mean gestational age is 31 weeks (27 weeks to 36 weeks) and the mean birthweight is 1,500g (1,100g to 2,600g). 25 children aged 6;6 to 9;6 years (mean = 7;8 years) were normal controls.

Procedure : The task is inspired by the Tétris video game (Zabalia & Mellier, 1996). It consists in fitting together geometrical figures. The objects are two-dimensional in form. Each geometrical figure appears at the high top center of the screen and it goes down to the bottom at constant speed. As shown in Figure 1, children have to modify the shape motion either by a translatory movement (two key presses) or by a rotational movement (two key presses) or they have to combine translatory and rotational movements (four key presses). The object translate only one unit of distance for each key press, and one press cause 90 degrees of rotation. In this study, the three colored keys (12 cm diameter) are grouped and can be easily manipulated by physically disabled children. The right key for right translations, left key for left translations and a central key for rotations. The keys are pushed serially.

The software pilots the presentation of 30 successive patterns (5 figures, 3 patterns presented twice). Manoeuvres and the temporal distribution of the key strikes are recorded, time between the arrival of the stimulus at the high top center of the screen and the first press of the child and time between each key press.

This task offers the possiblity for children to anticipate the future position of the moving shapes and to see directly the result of their actions. The object may be mentally moved and it may be moved on the screen. However, in these dynamic events, children detect objects properties and develop their representation of the shape motion.

Figure 1 : samples of patterns of the task presented to the children,

requiring 2 translations, 2 rotations or combining both motions

Results

Figure 2 : mean reaction times (RT) in function of patterns

for children with cerebral palsy (CP) and control.

Mean reaction times of children are illustrated in Figure 2. It is apparent that disabled children and able children did not differ significantly on this measure ($F(2,48)= 0.65$, $P= .4$). Note that mean reaction time is significantly longer for both groups when the shifting implies both movements - both two rotations and two translations - in comparison to patterns with one kind of motion - only two rotations or only two translations ($t(24)= 7$, $P= .0001$ for children with cerebral palsy ; $t(24)= 5.24$, $P= .0001$ for able children). This result suggests that children use a mental rotation or a representation of the motion to anticipate the future position of the object.

Figure 3 : mean number of handles in function of patterns

for children with cerebral palsy (CP) and control.

Figure 3 clearly shows that the mean numbers of manipulations for both groups were very different. The number of manipulations for disabled children is significantly higher than those for the control group in patterns with only one kind of motion ($t(48)= 3.48$, $P= .001$ for rotations and $t(48)= 2.94$, $P= .005$ for translations). We can not conclude to a significant difference in patterns with a combination of both motions ($t(48)= 0.79$, $P= .4$).

Children of control group handle as required to fit the object in the empty place (on average 2.5 presses for rotational motions ; 2.64 presses for translatory motions and 4.07 presses for the combination of both motions). The difference between mean number of manipulations in patterns with two motions and patterns with four motions is significant ($t(24)= 5.33$, $P= .0001$). By contrast, the mean number of manipulations of different patterns do not show any significant differences in children with cerebral palsy ($F(2,48)= 0.27$, $P= .7$; on average 4.65 presses for rotational motions ; 4.43 presses for translatory motions and 4.56 for the combination of both).

Discussion

These observations suggest that able children mentally anticipate the object motion before the first key press. Motion seems to be represented before any action, that is the reason why mean response time increases for the motion involving four presses, and why mean number of manipulations corresponds to the number of presses required. A mental anticipation of the future position of the moving object is also amphasised by mean response time of disabled children. Furthermore, children with cerebral palsy and able children did not differ significantly on this measure. This finding is consistant with our previous conclusions (Zabalia, 1999) showing that children with cerebral palsy were able to actualize an analog representation in a mental rotation task. Additional result of the same work revealed that children with cerebral palsy failed when the task may elicit a propositional processing. Children were given a task in which they had to arrange seven pictures of a rotating character. Disabled children showed difficulties both in breaking down and in reconstituting the rotation. Results illustrated in Figure 3 inform us that children with cerebral palsy, even though they could mentally anticipate the object motion, could not mentally break down this motion to act on the object. It would be misleading to think that mean number of manipulations of children with cerebral palsy suggest that they act randomly. The patterns involving a combination of both motions - four presses - are performed with a correct number of manipulations. These observations may be explained by an object manipulation strategy used by disabled children to actualize properties of the object motion. This strategy seems to require few presses to extract the spatio-temporal properties of the object motion. I believe that the number of manipulations is not linked to the complexity of the motion structure. That is the reason why the patient's movement difficulties seem impair their performance on the rotation-only and translations-only trials but not the rotation and translation trials. To act supports the " breaking down - reconstitution process " that is to say the mental organization of the motion spatio-temporal properties.

These findings are consistent with the view of an analog representation independent from the operations of thought. Lautrey (1990) suggests that it exists a dissociation between two processing systems of mental rotation. The dissociation is not meant to imply that these two processing systems are completely independent. Mental imagery is an analog representation which assures a guidance in the development of the operations themselves. Clearly, the two processing modes interact at some levels, and developmental changes in one system affect the other. Knowledges about the final state of motions could help the integration of intermediate states. But the conclusion emerging from this research concerns the role of action in the representation of moving objects. Action contributes to the development of analytic representations and they make possible a logical understanding of object motions. A recent theoretical position emphasised the role of action in mental imagery (Kosslyn, 1994). A reconciliation between current proposals and the Piagetian’s theory leads us to investigate when and how new representations emerge from action in the developmental process.

Conclusion

The results for the children with cerebral palsy allow us to postulate that action is involved differently in the development of the two formats of representation. An analog representation both holistic and undifferenciated would emerge from the gradual coordination of movements and locomotion. Although the experiences to learn and integrate spatial knowledges are poor and practiced in a more passive manner by disabled children. Apparently, these experiences would offer sufficient features to develop holistic mental imagery of motions. One may speculate that children with cerebral palsy actualized analog representations from the motor experiences that involve the whole body. But the motor disabilities affect mainly the analytic representations emerging from internalization and coordination of motor skills such as motor imitation, reaching, object manipulation and exploration, all internalizable and reversible actions at the origin of the thought operations.

References

Bideaud, J., & Courbois, Y. (1998). *Image mentale et développement.* Paris: Presses Universitaires de France.

Cohen, M. S., Kosslyn, S. M., Breiter, H. C., DiGirolamo, W. L., Thompson, W.L., Anderson, A. K., Bookheimer, S. Y., Rosen, B. R. & Belliveau, J. W. (1996). Changes in cortical activity during mental rotation. A mapping study using functional MRI. *Brain*, *119*, 89-100.

Dean, A. L. (1990). The development of mental imagery : a comparison of piagetian and cognitive psychological perspectives. *Annals of Child Development*, *7*, 105-144.

Dean, A. L., Scherzer, E., & Chabaud, S. (1986). Sequential ordering in children's representations of rotation movements. *Journal of Experimental Child Psychology*, *42*, 99-114.

Estes, D. (1998). Young children’s awareness of their mental activity: The case of mental rotation. *Child Development*, *69*, 5, 1345-1360.

De Vries, L.S., Eken, P., Groenendaal, F., Rademaker, K.J., Hoogervorst, B. & Bruinse H.W. (1998) Antenatal onset of haemorrhagic and/or ischaemic lesions in preterm infants : prevalence and associated obstetrics variables, *Arch. Dis. Child. Fetal Neonatal Ed. 78*, 51-56.

Kosslyn, S. M. (1994). *Image and brain : the resolution of the imagery debate.* Cambridge: MIT Press.

Kosslyn, S. M., Margolis, J. A., Barrett, A. M., & Goldknopf E.J. (1990). Age differences in imagery abilities. *Child Development*, *61*, 995-1001.

Lautrey, J. (1990). Unicité ou pluralité dans le développement cognitif: les relations entre images mentales, action et perception (p. 71-89), *In* G. Netchine-Grymberg (Edit.), *Développement et fonctionnement cognitifs chez l’enfant*. Paris: Presses Universitaires de France.

Lautrey, J., & Chartier D. (1987). Images mentales de transformations et opérations cognitives, une revue critique des études développementales. *l’Année Psychologique*, *87*, 581-602.

Marmor, G. S. (1975). Development of kinetic images : when does the child first represent movement in mental images ? *Cognitive Psychology*, *7*, 548-559.

Marmor, G. S. (1977). Mental rotation and number conservation: Are they related ? *Developmental Psychology, 13*, 4, 320-325.

Parsons, L. M. (1994). Temporal and kinematic properties of motor behavior reflected in mentally simulated action. *Journal of Experimental Psychology : Human Perception and Performance*, *20*, 709-730.

Parsons, L. M., Fox, P. T., Downs, J. H., Glass, T., Hirsch, T. B., Martin, C. C., Jerabek, P. A., & Lancaster, J. L. (1995). Use of implicit motor imagery for visual shape discrimination as revealed by PET. *Nature*, *375*, 54-58.

Piaget, J., & Inhelder, B. (1966). *L'image mentale chez l'enfant.* Paris : Presses Universitaires de France.

Piaget, J. (1945). *La formation du symbole chez l’enfant.* Neuchâtel : Delachaux et Niestlé.

Rutherford, M.A., Pennock, D.M., Murdoch-Eaton, F.M. & Dubowitz, L.M. (1992) Athetoid cerebral palsy with cyst int the putamen after hypoxic-ischaemic encephalopathy. *Archives of Disease in Chilhood*, *67*, 846-850.

Wexler, M., Kosslyn, S. M., & Berthoz A. (1998). Motor processes in mental rotation. *Cognition*, *68*(1), 77-94.

Zabalia, M. (1999). Traitement analogique et traitement propositionnel des rotations mentales chez les enfants IMC. *l’Année Psychologique*, *99*, 75-97.

Zabalia, M., & Mellier, D. (1996). Effets d'exercice de rotation mentale sur le traitement des relations topologiques élémentaires chez des enfants handicapés moteurs. *Les Archives de Psychologie*, *64*, 67-82.

@http://cogprints.ecs.soton.ac.uk/archive/00001223/00/Image4.gif bsrlFhttp://cogprints.ecs.soton.ac.uk/archive/00001223/00/cpl_zabalia2.htm mime
image/gifhntt"1ab3e9-a82-3d3eaab8"hvrsdataGIF87aQ÷
@http://cogprints.ecs.soton.ac.uk/archive/00001223/00/Image1.gif bsrlFhttp://cogprints.ecs.soton.ac.uk/archive/00001223/00/cpl_zabalia2.htm mime
image/gifhntt"1ab3e7-1411-3d3eaab8"hvrsdataGIF87a
@http://cogprints.ecs.soton.ac.uk/archive/00001223/00/Image2.gif bsrlFhttp://cogprints.ecs.soton.ac.uk/archive/00001223/00/cpl_zabalia2.htm mime
image/gifhntt"1ab3e8-12de-3d3eaab8"hvrsdataGIF87a
MSURLEhttp://cogprints.ecs.soton.ac.uk/archive/00001223/00/cpl_zabalia2.htm