Assistive Technology Labs
3-59 Corbett Hall – University of Alberta Edmonton, AB T6G 2G4
Ph: (780) 492-5422 Fx: (780) 492-1696 Email: atlab@ualberta.ca

Alberta Health Services

UNIVERSITY OF ALBERTA

The role of motor experience in cognitive development: Challenges and insights from atypical development

Liliana Alvarez[1], Albert Cook[1], Kim Adams[1]
[1] Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB, Canada

Summary:

The most well-known form of learning and knowledge acquisition is motor experience [1]. Although models and theories have found it difficult to account for the wide range of empirical evidence in developmental studies [2], motor experience appears to be critical for cognitive development of typically developing children [3- 6]. Through physical manipulation, exploration and interaction with the environment a child develops perceptual and social skills that will allow him/her to learn and act on the world [7- 9].

The role of motor experience is highlighted in some of the most influential accounts of cognitive development. Piaget considered cognitive development to be a result of the construction of networked concepts and schemes derived from action on the environment [4]. For Piaget, the incorporation of new categories of knowledge encountered through physical experience determines adaptation and learning [10]. According to Piaget the sensorimotor stage of development during the first two years of life, is critical for the achievement of cognitive milestones such as object permanence and means end analysis [8]. In this period, the child actively manipulates objects, explores them individually and sequentially and finally realizes that one object can be used as a means to reach the other [11]. For example, a child can use a stick [8] or a string [12] to retrieve an object out of reach.

The classic Piagetian A-not-B task has been widely used and studied in light of its correlation with motor development [13- 15]. Different approaches to the study of development yield different explanations of perseverative errors in the A-not-B task and the role of independent motor experience [16- 18]. Piaget's explanation for perseveration was based on the child's lack of cognitive understanding of object permanence of children less than 12 months [4]. A dynamic systems theory explanation of perseverative errors is that the child establishes a motor pattern of reaching to one target (e.g., A) that interferes with the child's correct retrieval when the target is

moved (e.g., to B) (19). Berger [17] suggests a cognition-action trade off due to overtaxed attention resources of the child as the cause of perseveration.

The question of whether motor experience plays a necessary or facilitatory role in cognitive development is long standing [20]. Since cognitive and motor domains do not develop in isolation [17] our understanding of the relationship between motor and cognitive development and what can be accomplished by the infant is limited.

Studies of children with atypical development can provide a view of cognitive development in the presence of altered motor experiences. Simon [21] studied object permanence in 34 children with quadriplegic cerebral palsy. Severity of physical handicap accounted for less than 15% of the variation in scores. Children in a wide range of ages were included making it difficult to determine the developmental stage at which the children acquired these skills and to compare performance with typically developing children.

More recent studies show that older children with motor impairments perform as well as their typically developing peers in several domains of cognition [22- 25]. Children with physical disabilities are not able to explore the world in the same way as typically developing children, yet they can display cognitive skills associated with motor experience [25, 26]. If they acquire early cognitive skills typically related with motor experience at the same time as their typically developing peers, it raises the question of how the developmental pathway they employ differs from that of typically developing children. [25].

Vygotsky addressed the issue of alternative developmental pathways through his "Fundamentals of Defectology" in which he presented his theory of "dysontongenesis", as he referred to the understanding of what he called deficient versus normal development [3]. This approach was based on his focus on the role of social interaction in the construction of knowledge, and communicative and interactive practice as the means for development of knowledge and understanding [3]. Vygotsky's view was that a disorder alone does not constitute a disability, but exclusion from social, cultural and educational interactions caused by impairment leads to a disability. A child with a disability needs to be provided with social situations of development in which the child can explore and learn how to use tools and representations. Establishing that children with disabilities are using developmental detours or alternative paths for learning and development of cognitive skills might be possible by providing opportunities for tool use [3].

The developmental detours concept is related to Gibson's "perceiving to learn" postulate [1]. In contrast to the typical concept that experience drives perceptual development, Gibson postulated that perception can lead to a consequent change in learning and experience. Similarly, Bandura's Social Cognitive theory highlighted observation as a way of learning [27]. He postulated that individuals can learn through observation, and that when given the opportunity and motivation to do so, they can demonstrate a motor behavior that they learned through observation.

Observational forms of learning need to be explored to see if they are a detour that might be leading to cognitive development in the absence of motor experience. This approach might also allow further understanding of the development of cognition in general. In order to begin to explore this, the A not B study can be performed with typically developing children and those with disabilities. The children with disabilities could use assistive robots in order to have an opportunity to participate in the classic version of the task, which requires motor experience. The use of assistive robots enables a comparison of observational and experiential learning. Comparing the performance of children with typical development and children with motor impairments, can offer insights on the extent to which motor experience contributes to perseverative errors.

Motor, cognitive and perceptual skills appear to be related in a continuous interaction that is mediated by maturation and environmental interactions and enhances learning [28]. Exactly the way these relationships are built or how they shape our understanding of the world we see and experience remains unclear. Atypical development may provide insights to our understanding of the complex phenomena of development.

References

1. Pick, H. (1992). Eleanor Gibson: Learning to Perceive and Perceiving to Learn. *Developmental psychology, 28* (5), 787- 794.
2. Thelen, E.(1989). Self- Organization in developmental processes: can systems approaches work?. In *Gunter & Thelan (Ed.), Systems and development: The Minessota Symposia on Child Psychology*, Volume 22 (Minnesota Synposia on Child Psychology Series), pp. 77- 113.
3. Vygotsky, L. (1978). *The Fundamentals of defectology*. In: *The Collected works of L.S Vygotsky, Volume 2.* (R. Rieber, A. Carton, Eds., J. Knox, & C. Stevens, English Trans, 1993) New York: Kluwer Academic/ Plenum Publishers.
4. Piaget, J. (1952). The Origins of Intelligence in Children. New York: International Universities Press. (Originally published 1936.)

5. Bronfenbrenner, U. (1979). (1979). *The Ecology of Human Development: Experiments by Nature and Design*. Cambridge, MA: Harvard University Press.
6. Smith, L.B., & Thelen, E. (2003). Development as a dynamic system. Trends in Cognitive Sciences, 7, 343–348
7. Vauclair, J. (1984). Phylogenetic Approach to Object Manipulation in Human and Ape Infants. *Human Development Vol. 27*, 321-328.
8. McCarty, M. E., Clifton, R. K., & Chollard, R. (2001). The beginnings of tool use by infants and toddlers. *Infancy*, 2(2): 233- 256.
9. Flanagan, J. R., Bowman, M. C., & Johansson, R. S. (2006). Control strategies in object manipulation tasks. *Current opinion in Neurobiology* , 16:650-659
10. Ackerman, E. (2001). Piaget's Constructivism, Papert's constructionism: What's the difference?. In: Constructivism Uses and Perspectives in education. Volumes 1 and 2. Conference Proceedings, Geneva, Research Center in Education CAHIER.
11. Piaget, J. (1954). *The construction of reality in the child.* Great Britain: Routledhe.
12. Chen, Z., Sanchez, R., & Campbell, T. (1997). From beyond to within their grasp: Analogical problem solving in 10 and 13 month-olds. *Developmental Psychology, 33,* 790–801.
13. Diamond, A. (1988). Abilities and neural mechanisms underlying A-not-B performance. Child Development, 59, 523-527
14. Berger, S.L. (2004). Demands on finite cognitive capacity cause infants' perseverative errors. Infancy, 5, pp 217- 238
15. Lew, A; Hopkins, B; Owen, L; Green, M. (2007). Postural change effects on infants' AB task performance: Visual, postural, or spatial?. Journal of Experimental Child Psychology, 97, pp. 1–13
16. Kermonian, R; Campos, J. (1988). Locomotor Experience : A facilitator of spatial cognitive development. Child Development, 59, pp. 908- 917.
17. Berger, S.E. (2010). Locomotor Expertise predicts infants' perseverative errors. *Developmental Psychology*, Vol. 46, No. 2, 326- 336.
18. Stedron, J; Sahni, S; Munakata, Y. (2005). Common mechanisms for working memory and attention: The case of perseveration with visible solutions. Journal of Cognitive neuroscience, 17, 623- 631

19. Clearfield, M., Diedrich, F., Smith, L., & Thelen, E. (2006). Young infants reach correctly in A-not-B tasks: On the development of stability and perseveration . *Infant Behaviour & Development , 29*, 435-444.
20. Gottlieb G. The psychobiological approach to developmental issues. In: Haith M, Campos J, editors. *Handbook of child psychology: Infancy and developmental psychobiology.* Vol. 2. New York: Wiley; 1983. pp. 1–26.
21. Simon, R. (1985). Deprivation of Early Sensorimotor Experience and Cognition in the Severely Involved Cerebral-Palsied child. *Journal of Autism and Developmental Disorders* , Vol. 15, No. 3.
22. Billard, C; Gillet, P; Barthez, M.A; Hommet, C; Bertrand, P. (1998). Reading ability and processing in Duchene muscular dystrophy: A reappraisal and comparison with spinal muscular atrophy. Developmental Medicine and Child Neurology, 40, 12- 20.
23. Baillargeon, R. (1999). Young infants' expectations about hidden objects: A reply to three challenges. Developmental Science, 2, 115- 163.

24. Von Gontard, A; Zerres, K; Backes, M; Laufersweiler-Plass, C; Wendland, C; Melchers, P; Lehmkuhl, G; Rudnik- Schoneborn, S. Intelligence and cognitive function in children and adolescents with spinal muscular atrophy. Neuromsucular disorders, 12, 130- 136.
25. Riviere, J., & Lecuyer, R. (2002). Spatial Cognition in Young children with spinal muscular atrophy. *Developmental Neuropsychology , 2* (3), 273-283.
26. Bandura, A. (1986). *Social Foundations of Thought and Action.* US: Prentice Hall.
27. Haywood, K., & Getchell, N. (2009). *Life Span Motor Development, 5ed.* Illinois: Human Kinetics.