

Children's Object Manipulation: A Tool for Knowing the External World and for Communicative Development

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Abstract The progressive acquisition of manipulative skill is an important developmental milestone. It provides infants with an increasing set of opportunities for knowing the external world and for acquiring abilities also relevant to other domains, most especially social interaction. The ability to use the hands to grasp and extend an object in a directed fashion toward an interlocutor facilitates the establishment of shared attention. Thus, the progression in manipulative ability can serve as an agent of change, not only for motor development in general, but also for communication. This chapter will consider the progressive acquisition of manipulative skills during development, their significance for knowing the external world and, in particular, their close relation to the communicative development of children.

Keywords Motor development • Communicative development • Infants

1 Introduction

In recent years, there has been growing scientific interest in the development of motor skills in children, and in particular the importance of motor competencies for general development (e.g., Thelen 1995; Campos et al. 2000; von Hofsten 2007; Karasik et al. 2011; Libertus and Needham 2010). One theme that has emerged from this body of research is that the acquisition of new motor skills (e.g., object manipulation) creates opportunities to acquire and refine abilities that are relevant for learning in other domains (e.g., language development; Iverson 2010). On the one hand, attention to specific features of the object during manipulation prepares

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the infant to map specific meanings to specific referents in the process of lexical acquisition. On the other hand, the ability to grasp and extend an object in a directed fashion toward a social partner facilitates the establishment of shared attention to that object. The progressive acquisition of motor skills, the exploration of spaces, and the practice of new activities thus serve as an agent of change for the development, promoting the development of functional actions for the individual's needs (Thelen 2004).

The present chapter considers the development of manual skills and object exploration in children and is organized into two main sections. The first considers the developmental progression of children's manipulation and describes the role of other, crucial skills relevant to manipulation (e.g., postural control). The second section addresses the interdependency between object manipulation and development in the linguistic and social domains, highlighting the impact of multiple motor developments on children's knowledge of the world and sharing of objects with caregivers. In the final section, we discuss data about the influence of object manipulation, which deeply affects the general human development.

2 The Development of Object Manipulation

Reaching and grasping. Ordinary actions such as object manipulation develop over an extended period of time. Efficient manipulation requires the development of two motor acts: reaching and grasping. These behaviors are expressions of the integration between different sensorimotor systems combining perceptual discrimination of an object located in space and a goal-oriented manual action toward the object (Rochat and Goubet 1995). In order to perform a successful reaching action, infants need to coordinate visual, auditory, and proprioceptive stimuli (Clifton et al. 1994), modifying their movement depending on the goal of the activity. Therefore, the manipulation of an object requires both motor control and motor planning abilities.

Over development, reaching and grasping movements become gradually more coordinated: At 2 months of age, improved head control facilitates this path, and from 4 months, a new developmental phase appears due to the emergence of abilities such as eye-hand coordination and improved trunk and postural control, which provide a stable base for the reaching movement. By 6 months, infants can adjust their reaches as a function of perceived spatial and physical properties of the object, such as its size (von Hofsten and Rönqvist 1988), its orientation (Lockman et al. 1984), and whether or not it is reachable (Clifton et al. 1991; Field 1976; McKenzie et al. 1993; Yonas and Granmd 1985; Yonas and Hartman 1993).

Like reaching, the ability to grasp an object is refined slowly over time. Infants must learn to start closing the hand before touching the object and not as a post-encounter reaction. Studies have shown that when infants start to acquire this skill, they begin to adapt the orientation of the hand to the orientation of the object. Lockman et al. (1984) presented dowels oriented both horizontally and vertically to

5- and 9-month-olds, in order to determine at what point during the reach hand orientation approximated that of the dowel. Both groups of children approached the dowel with the appropriate final hand orientation at the grasp, but the 9-month-olds did so earlier during the reach, before they had tactile information about the dowel's orientation. Later on, between 9 and 13 months, infants also acquire the ability to adapt the hand depending on the size of the object. According to von Hofsten and Ronnqvist (1988), this ability increases significantly at 13 months of age: Children showed larger distance between the thumb and the index finger (measured during the presentation of objects different in size) for bigger objects than for the smallest ones.

An additional developmental change in grasping involves the switch from power to precision grip (Halverson 1931). When children perform a power grip, the object is tightly closed between the lower part of the fingers and the palm, while in precision grip the object is held between the thumb and one or more fingers. This transition starts at around 20 weeks of age. Both power and precision grips are apparent at 6 months, but the precision grip becomes gradually predominant during the second year of age, also adapting to the object size (Butterworth et al. 1997).

In sum, multiple systems required by action performance become future oriented and integrated during development. When reaching emerges, movements that are initially jerky and take a circuitous path to the object gradually become smoother and more direct (e.g., Thelen et al. 1993), grasping rapidly improves (e.g., Wimmers et al. 1998), and infants begin to manipulate objects for effective examination. By around 13 months, grasping and reaching become integrated skills, constituting a single action.

Postural control. The development of movements such as reaching and grasping also require the acquisition of abilities necessary for the management of multi-sensory information. Among these essential abilities, adjusting body posture during movements to anticipate upcoming events is crucial. In fact, maintaining postural control while performing other behaviors is one of the most important challenges that infants must face. Every performed action creates inertial forces that move the center of gravity of the body, and therefore infants need to stabilize themselves in advance in order to maintain balance. When a force causes an unexpected disturbance, posture is destabilized, but when infants are able to anticipate upcoming destabilization, they can implement control strategies prior to the disturbance. In the case of forces generated by voluntary movements, anticipatory strategies are required both before and during the execution of movements. Thus, postural control is a critical component of the functional execution of reaching.

Fallang and co-authors (2000) studied the interaction between reaching and posture in infants between 4 and 6 months of age. They assessed postural behavior during reaching in supine via reaching kinematics and center of pressure. Results showed that at 6 months, infants passed from the phase in which motor paths are explored without precise adaptation to environmental constraints, to a phase in which they gradually learn to adapt motor activity to the features of the context. The connection of postural activity and reaching performance in supine at 6 months of age, as suggested by the authors, "it may represent the emergence of a finely tuned

relationship between posture and reaching performance once an increased flexibility between postural control and the skill of reaching is achieved” (Fallang et al. 2000, pp. 17).

The development of postural control allows also the acquisition of new postures: The progression from supine to sitting posture also affects object exploration. For example, when infants lie supine, arm movements are more effortful and less easily controlled as they must constantly work against gravity to hold an object within the line of sight (Soska and Adolph 2014). When seated, however, the hands and arms are free to move in less biomechanically challenging ways, the upright head position enlarges the field of view and stabilizes gaze, thereby promoting eye–hand coordination (Bertenthal and von Hofsten 1998; Rochat 1992). When infants can sit independently (self-sit), hands no longer needed for support are free to move, and possibilities for object exploration are enhanced (Harbourne et al. 2013). Rochat and Goubet (1995), found that while pre-sitters and new sitters typically use one hand for object exploration and focus on centrally located objects, experienced sitters expand the exploration of space, using both hands to examine both centrally and laterally positioned objects. Furthermore, when self-sitters explore objects, they typically engage in more combined visual-manual behaviors (e.g., looking at objects while rotating or fingering) that provide critical multimodal information about object properties (Soska et al. 2010).

Object-directed reaching, grasping, and postural control underlie increasingly sophisticated object exploration behaviors that yield information about objects in the world and about the effects of the infant’s own actions on those objects. In the next section, we review and discuss its relations to the development of communicative and social domains.

3 Human Hand and Language: The Impact of Manipulation Skill on Communicative and Social Development

Object exploration via reaching and grasping movements and the knowledge it generates are foundational for the later development of language and communication. For instance, Fagan and Iverson (2007) found infant object mouthing during vocalization to be related to greater variety in consonants, especially supraglottis (e.g., [d]), known to be a reliable predictor of subsequent language growth and delay (e.g., Stoel-Gammon 1992). Ruddy and Bornstein (1982) found a strong positive correlation between object exploration (e.g., fingering, squeezing, banging) at 4 months of age and parent-reported vocabulary at 12 months. This led Ruff and colleagues (1984) to suggest that infants who more frequently engage in object examination have enhanced opportunities to extract information about object categories critical for lexical development.

The relationship between children's handedness and manipulation activity has been investigated by Kotwica and co-authors (2008). They showed that infants aged between 7 and 13 months with a stable hand preference are better multiple object users than infants with an inconsistent hand preference. Authors assessed the infants' handedness by presenting 21 objects to infants, one at a time, and the hand used for the initial grasp of the toy was recorded (the procedure is detailed in Michel et al. 1985). Infants with stable hand-use preferences more readily acquired another object after storing an object than did infants without stable hand-use preferences. This generates new instances with objects and a different experience of the external world that may promote further development of other motor skills and cognitive abilities. Along these lines, Nelson and colleagues (2014) investigated the timing of lateralization for manipulative actions in infancy and the relation with later language acquisition. Studying the relationships between early handedness and advances in language development, they observed that children with a consistent hand preference (measured from 6 to 14 months) scored higher on the language scale of the Bayley when tested at 24 months compared to children who showed an inconsistent hand preference.

The exploration and sharing of objects also foster the development of shared attention that is foundational for the communicative development and for the learning of words (Tomasello and Todd 1983). Ruddy and Bornstein (1982) found that mothers who more frequently draw their child's attention to objects at 4 months of age had children with larger vocabularies at 12 months of age. Early language acquisition happens mainly during the interactions between caregivers and child (Bruner 1981). Bruner (1983) suggested that children learn language in familiar contexts during social exchanges in what he calls "object-play formats."

In this regard, the development of motor abilities creates significant changes in infants' experience of the world, enriching social interactions between infant and caregiver and providing productive opportunities for language learning and social development (Iverson 2010). The development of independent locomotion radically changes experiences with objects and social partners (Karasik et al. 2011). Through locomotion, an infant can bring an object to the caregiver and sharing attention to it with the adult. A child that can walk has a greater range of exploration and greater access to objects, while infants who cannot yet walk have more limited interactions with objects because they are limited to more proximally located objects.

In addition, reaching and manipulating objects are also crucial for the development of gestural skills. In particular, Fischer and Zwaan (2008) highlighted the correlation between the manipulation of objects during actions, children's understanding of the proper use of them, and the development of semantic meanings. Capiirci and colleagues (2005) showed that children produced communicative manual actions from 10 months of age, and that in most cases corresponded in meaning with representational gestures that appeared later. They showed that expressive manual actions have a semantic connection with symbolic gestures (Longobardi et al. 2014). Children's gestures and communication can also be influenced by object properties, as demonstrated by Bernardis and colleagues (2008), who showed that during manipulation activities, children regulate their

vocalizations depending on the object size. In particular, the repetition of vocalizations was found to increase when a pointing gesture was used to obtain a large object than a small one.

Thus, while gestures mediate the relationship between early motor abilities and later vocabulary, object manipulation affects gesture and communication development. Therefore, the frequency of manipulative activities, which increases due to refinements in reaching, grasping, and postural control, together with greater participation of the caregiver during social interaction, increases opportunities to hear new verbal input, paving the way for the comprehension of objects and actions that are foundational for both gesture and word production (Longobardi et al. 2014).

The progressive acquisition and development of motor skills such as prehension, object manipulation, and locomotion significantly increase children's opportunities to explore the external world which have fundamental implication for communicative development. Children's propensity to use objects and to explore them, using both hand and mouth, provides information not only about objects but also about their vocalizations, confirming that experiences in the motor domain foster development in other domains (Iverson 2010).

4 Conclusion

The study of motor development has recently received increasing interest in the field of human developmental research. Motor skills provide children with means to explore the environment and to acquire knowledge about the external world, fostering development in other domains, such as communicative and language skills. In this chapter, we examined the development of the ability to manipulate objects, a fundamental motor skill typically acquired during the first year of life that is foundational for acquiring knowledge about features of objects. Scientific research clearly showed that the motor, perceptual, and cognitive domains are linked and influence one other during development (e.g., Gibson and Pick 2000; Thelen and Smith 1993). The findings reviewed here show that the acquisition of a new motor skill such as reaching, grasping, postural control, or walking has consequences for infants' abilities in the perceptual, cognitive, social, and language domains.

As foreseen by Berkeley (1709) in the early eighteenth century, in order to acquire information about the external world, humans need an extended tactile experience together with the possibility to move and act in the environment. Piaget (1952) confirmed this philosophical assumption, stating that infants gradually understand the features of the objects through their manual actions. In this sense, he stressed the role of motor skill acquisition, conceptualizing it as a facilitator for perceptual and cognitive development, and highlighting the fact that the development of our intelligence is grounded in "doing." Therefore, exploratory actions become crucial since they are performed in order to acquire information that enable individuals to know their surroundings (de Campos et al. 2012).

Far from being a transparent “glass” between the world and the self, the body organizes human experience of the world and models the way to be into the world. Children's being in the world is characterized by performing or trying to perform actions. Infants have a sense of their bodies as entities incorporated in the environment, and they have an early sense of their selves based on perception; Rochat calls it the *ecological self*. The ecological self provides, through early explorations of the body and the environment, the development of sense of self as something different from the external world, thus developing a more explicit awareness of him/herself. In this dynamic process of mutual influence between action and cognition, living beings not only acquire knowledge about the external world but implicitly receive information about the self (Gibson 2014; Gallagher and Zahavi 2013).

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