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Development of exploration of spatial-relational object properties in the second and third years of life

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ABSTRACT

Within a perception–action framework, exploration is seen as a driving force in young children's development. Through exploration, children become skilled in perceiving the affordances in their environment and acting on them. Using a perception–action framework, the current study examined the development of children's exploration of the spatial-relational properties of objects such as the possibility of containing or stacking. A total of 61 children, belonging to two age cohorts, were followed from 9 to 24 months and from 20 to 36 months of age, respectively. Exploration of a standard set of objects was observed in five home visits in each cohort conducted every 4 months. A cohort-sequential augmented growth model for categorical data, incorporating assumptions of item response theory, was constructed that fitted the data well, showing that the development of exploration of spatial-relational object properties follows an overlapping waves pattern. This is in line with Siegler's model (*Emerging Minds*, 1996), which suggested that skill development can be seen as ebbing and flowing of alternative (simple and advanced) behaviors. Although the probability of observing the more complex forms of exploration increased with age, the simpler forms did not disappear altogether but only became less probable. Findings support a perception–action view on development. Individual

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differences in observed exploration and their relations with other variables, as well as future directions for research, are discussed.

Introduction

According to perception–action theory, such as elaborated by Eleanor Gibson, children play an active role in their own development. They perceive information that elicits actions, and these actions in turn provide new information to be perceived, specifying new actions. Children's growing knowledge of the world and their increasing ability to act adaptively and skillfully in it are grounded in these continuously recurring perception–action loops, referred to as exploration (Adolph, Eppler, Marin, Weise, & Wechsler Clearfield, 2000; J. J. Gibson, 1979; E. J. Gibson, 1988; E. J. Gibson & Pick, 2000).

Exploration is in many ways the key to development. Extensive empirical work shows that young children's exploration behavior is related to advances in several domains of development (e.g., Needham, 2000; Needham, Barrett, & Peterman, 2002; Soska, Adolph, & Johnson, 2010). Exploration of the spatial properties of objects and of the spatial relations between objects (henceforth spatial-relational object properties) is a special kind of exploration, referring to the perceiving of and acting on properties of objects such as the possibility of containing, stacking, fitting into each other, and pulling out. Correlational evidence suggests that the exploration of objects and spaces is strongly related to the development of spatial cognition (Campos, Anderson, & Telzrow, 2009; Campos et al., 2000; Clearfield, 2004; Oudgenoeg-Paz, Leseman, & Volman, 2014, 2015). Spatial cognition in turn has been shown to be highly relevant for success in various academic disciplines such as science, mathematics, and language as well as for complex social behaviors involving perspective taking (Creem-Regehr, Gagnon, Geuss, & Stefanucci, 2013; Gathercole, Alloway, Willis, & Adams, 2006; for a review, see Newcombe, Uttal, & Sauter, 2013).

Research on the development of object exploration has predominantly focused on the exploration of single objects during the first year of life (e.g., Eppler, 1995; Galloway & Thelen, 2004; Soska et al., 2010). Less is known about the development of object exploration after the first year of life. Moreover, research into children's object exploration has rarely focused on exploration of the spatial-relational properties of objects or on the possibilities of combining objects entailed by these properties. The current study adds to the evidence by examining the development of children's exploration of the spatial-relational properties of objects from the end of the first year into the third year of life.

Studies investigating single object exploration in infants have mainly focused on actions such as fingering, mouthing, and shaking that enable infants to acquire different kinds of information about the objects through different sensory modalities (e.g., Eppler, 1995; Lobo & Galloway, 2008; Ruff, 1984). Exploration of multiple objects simultaneously (e.g., holding two objects at the same time) has been reported to appear in infants as young as 7 or 8 months, but multiple object exploration seems to become an established part of the behavioral repertoire of typically developing children only from the age of 11 months onward (Kotwica, Ferre, & Michel, 2008). During the second year of life, once two or more objects can be manipulated together, exploration becomes gradually more complex as infants start to explore the spatial relations between objects and become increasingly skilled in making combinations of increasing complexity (e.g., inserting an object into another object, pulling an object out of another object, stacking objects). Exploration of spatial-relational properties is displayed to a greater extent when infants are presented with objects with complementary spatial properties that afford such combinations, suggesting that the information structures in the environment play a critical role in the development of exploration (for a review, see Greaves, Imms, Krumlinde, Dodd, & Eliasson, 2012; see also Fagard & Jacquet, 1989; Kimmerle, Ferre, Kotwica, & Michel, 2010; Ramsay, 1985).

In line with Lockman (2000), who applied a perception–action perspective to tool-use development, we argue here that the development of exploration from exploring single objects to exploring multiple objects without combining them, and to combining objects, requires detecting