Research in Developmental Disabilities 53-54 (2016) 19–31

Contents lists available at ScienceDirect

Research in Developmental Disabilities

The interrelationships between motor, cognitive, and language development in children with and without intellectual and developmental disabilities

Suzanne Houwen *, Linda Visser, Annette van der Putten, Carla Vlaskamp

University of Groningen, Department of Special Needs Education and Youth Care, Grote Rozenstraat 38, 9712 TJ Groningen, The Netherlands

ARTICLE INFO

Article history:
Received 5 March 2015
Received in revised form 30 October 2015
Accepted 18 January 2016
Available online 4 February 2016

Keywords:
Motor skills
Language
Cognition
Bayley-III
Intellectual disability
Developmental disability

ABSTRACT

It is generally agreed that cognitive and language development are dependent on the emergence of motor skills. As the literature on this issue concerning children with developmental disabilities is scarce, we examined the interrelationships between motor, cognitive, and language development in children with intellectual and developmental disabilities (IDD) and compared them to those in children without IDD. In addition, we investigated whether these relationships differ between children with different levels of cognitive delay. Seventy-seven children with IDD (calendar age between 1;0 and 9;10 years; mean developmental age: 1;8 years) and 130 typically developing children (calendar age between 0;3 and 3;6 years; mean developmental age: 1;10 years) were tested with the Dutch Bayley Scales of Infant and Toddler Development, Third Edition, which assesses development across three domains using five subscales: fine motor development, gross motor development (motor), cognition (cognitive), receptive communication, and expressive communication (language). Results showed that correlations between the motor, cognitive, and language domains were strong, namely .61 to .94 in children with IDD and weak to strong, namely .24 to .56 in children without IDD. Furthermore, the correlations showed a tendency to increase with the severity of IDD. It can be concluded that both fine and gross motor development are more strongly associated with cognition, and consequently language, in children with IDD than in children without IDD. The findings of this study emphasize the importance of early interventions that boost both motor and cognitive development, and suggest that such interventions will also enhance language development.

1. Introduction

Early in life, children go through a period of incredible growth and learning. The emergence of motor milestones is an important part of typical development in infants (Adolph & Joh, 2007; Leonard & Hill, 2014). However, the importance of motor development goes beyond the attainment of new motor skills. The development (and thus improvement) of motor skills provides infants with new opportunities for learning about their environment (Adolph & Joh, 2007; Von Hofsten, 2009).

* Corresponding author. Tel.: +31 503639716.
E-mail addresses: s.houwen@rug.nl (S. Houwen), linda.visser@rug.nl (L. Visser), a.a.j.van.der.putten@rug.nl (A. van der Putten), c.vlaskamp@rug.nl (C. Vlaskamp).

http://dx.doi.org/10.1016/j.ridd.2016.01.012
0891-4222/

Being able to act upon their environment allows children to gain knowledge about their surroundings, which leads to changes in various perception-action systems (Von Hofsten, 2009). These changes bring about advances in cognition and language[1], which in turn will affect how children examine and manipulate their environment (Campos et al., 2000; Iverson, 2010). The idea that there is a relationship between motor and cognitive development, and consequently between motor and language development[2], stems in part from the embodied cognition perspective, in which cognition, and language as a subdomain of cognition, are considered to occur in the context of the individual's bodily interaction with the physical and social environment (Barsalou, 1999; Gibbs, 2005; Oudgenoeg-Paz, Volman, & Leseman, 2012; Smith & Gasser, 2005).

There is a growing body of neurophysiological and neuroimaging evidence that is consistent with this perspective. Neuroimaging techniques have shown that regions important to motor performance and cognition such as the cerebellum, dorsolateral prefrontal cortex, and the connecting structures (including the basal ganglia) are co-activated in certain motor and cognitive tasks. This confirms the mutual association between these two domains (Abe & Hanakawa, 2009; Diamond, 2000; Hanakawa, 2011). Furthermore, areas of the brain implicated in language functions (e.g., Broca's area) are also activated during motor tasks (i.e., action planning, action observation, action understanding, and imitation; Nishitani, Schürmann, Amunts, & Hari, 2005) and the activation of motor areas has been observed during language tasks (e.g., Hauk, Johnsrude, & Pulvermüller, 2004; Pulvermüller, 2005; Willems & Hagoort, 2007).

Evidence for the relationship between motor and cognitive development and between motor and language development can also be found in behavioural studies. Recent developmental work has revealed associations between motor maturity in infancy and changes in cognition (Woodward, 2009) and language (Oudgenoeg-Paz et al., 2012). Moreover, embodied effects on cognition and language are prevalent throughout childhood and into adulthood as well (Kontra, Goldin-Meadow, & Beilock, 2012). Both normative studies and those examining children with atypical development have shown a link between motor performance and cognition (Estil, Whiting, Sigmundsson, & Ingvaldsen, 2003; Marlow, Hennessy, Bracewell, & Wolke, 2007; Piek et al., 2004; Piek, Dawson, Smith, & Gasson, 2008; Rigoli et al., 2013; Wassenberg et al., 2005) and between motor performance and language (Alcock & Krawczyk, 2010; Cheng, Chen, Tsai, Chen, & Cherng, 2009; Wang, Lekhal, Aarø, & Schjølberg, 2014b). Similar results have been found in healthy adults and adult patients (e.g., Camicioli, Wang, Powell, Mitnitski, & Rockwood, 2007; García & Ibáñez, 2014). This evidence highlights the enduring nature of the relationship between the motor domain and the cognitive and language domains, although studies vary in sample characteristics and the particular skills that were examined.

Although motor, cognitive, and language development may share several underlying processes in both typical and atypical populations, the correlation between these developmental domains might be stronger in children with atypical development than in typically developing children (Dyck, Piek, Hay, Smith, & Hallmayer, 2006; Roebers & Kauer, 2009). It has been suggested that the stronger correlations between developmental domains in children with atypical development reflect abnormal dependences between neurocognitive processes (Dyck et al., 2006; Martin, Tigera, Denckla, & Mahone, 2010). More specifically, Martin et al. (2010) argued that a relationship between novel and complex movements and cognitive processes can be found in typically developing and atypically developing samples due to shared neural substrates and neurological integrity in general, whereas a relationship between simple movements and cognitive processes will only be found in clinical samples, based on underlying neurodevelopmental weakness. It would be interesting to measure and compare the strength of such relationships in typically developing children and specific populations (e.g., children scoring higher/lower on cognitive skills and/or motor skills; Van der Fels et al., 2015).

In addition, there are discrepancies concerning whether or not there is a global-to-global relationship between the motor domain and the cognitive and language domains. Some studies have found that certain cognitive skills are only associated with gross (relatively 'big' movements such as throwing and jumping) and not fine motor skills (relatively delicate movements, such as grasping and putting beads on a rod) (Piek et al., 2008; Rigoli, Piek, Kane, & Oosterlaan, 2012), while other studies found results to the contrary (Livesey, Keen, Rouse, & White, 2006; Rigoli et al., 2013). A recent review showed that there is little evidence to support a global relationship between the motor and cognitive domain in typically developing children aged 4–16 years (Van der Fels et al., 2015). More support has been found for specific associations: results from studies using cross-sectional designs have shown associations between specific aspects of motor performance and cognition. Specifically, fine motor skills showed the strongest relationship with higher order cognitive skills (Van der Fels et al., 2015). Whether these findings also hold true for younger children or children with disabilities is not yet clear. It has been suggested that whether or not a relationship is found between certain motor and cognitive skills may depend on the assumed direction of the relationship, the presence of movement difficulties, and the developmental level of the child (Rigoli et al., 2013). With regard to language, the question of whether there are specific relationships between different sub-areas of motor development (i.e., fine and gross) and different domains of language (i.e., expressive or receptive language skills) remains to be answered.

[1] Cognition and language are broad concepts that have been defined in a number of different ways. In the current article, 'cognition' is defined as the mental acts or processes for acquiring knowledge and understanding through thought, experience, and the senses. 'Language' is seen as a systematic means of communicating ideas or feelings through the use of conventionalized signs, sounds, gestures, or marks which have understood meanings. In broad terms, language can be divided into two categories: receptive language (understanding what is said or written) and expressive language (use of words, sentences, gestures and writing to convey meaning and messages to others).

[2] Cognition and language are interrelated, both practically and conceptually, although there is considerable disagreement among experts about the precise nature of this relationship. This discussion is, however, beyond the scope of this article, and therefore will not be dealt with here.