Learning and Individual Differences 64 (2018) 22–32

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

# Intrinsic motivation and academic performance in school-age children born extremely preterm: The contribution of working memory

L. Pascoe[a,b,*], M. Spencer-Smith[a], R. Giallo[c], M.L. Seal[b,d], N. Georgiou-Karistianis[a], C. Nosarti[e], E.K. Josev[b], G. Roberts[b,d,f], L.W. Doyle[b,d,f,g], D.K. Thompson[b,d,h], P.J. Anderson[a,b,d,f]

[a] School of Psychological Sciences, Monash Institute of Cognitive and Clinical Neurosciences, Monash University, Melbourne, Australia
[b] Victorian Infant Brain Studies, Clinical Sciences, Murdoch Children's Research Institute, Melbourne, Australia
[c] Healthy Mothers Healthy Families, Population Health, Murdoch Children's Research Institute, Melbourne, Australia
[d] Department of Paediatrics, University of Melbourne, Melbourne, Australia
[e] Department of Psychosis Studies, Institute of Psychiatry, Psychology and Neuroscience, King's College London, United Kingdom
[f] Premature Infant Follow-up Programme, Royal Women's Hospital, Melbourne, Australia
[g] Department of Obstetrics and Gynaecology, University of Melbourne, Melbourne, Australia
[h] Florey Institute of Neuroscience & Mental Health, Melbourne, Australia

ARTICLE INFO

*Keywords:*
Intrinsic motivation
Working memory
Academic performance
Preterm children

ABSTRACT

Intrinsic motivation is associated with better academic performance. Working memory abilities may contribute to this association, especially in children at risk for learning and academic difficulties such as those born extremely preterm. This study examined whether verbal and visuo-spatial working memory abilities mediate the relationship between intrinsic motivation for school learning (mastery, challenge and curiosity) and academic performance (word reading, spelling and mathematics) in 7-year old extremely preterm or extremely low birth weight children (n = 91). Structural equation modeling revealed verbal short-term memory to mediate associations between aspects of intrinsic motivation and literacy performance. Positive associations between mastery and verbal short-term memory, reading and spelling, and a positive association between challenge and mathematics performance were also identified. These findings highlight potential pathways linking intrinsic motivation for school learning, working memory, and academic achievement in early school-age children at risk of academic impairments. Examination of individual characteristics such as motivation and cognitive skills is important for understanding factors that shape children's learning and performance.

## 1. Introduction

### 1.1. Intrinsic motivation and children's academic performance

The contribution of intrinsic motivation to academic performance has long been of interest among education researchers and theorists. According to self-determination theory, intrinsic motivation is the inherent propensity to engage in an activity due to interest and a desire to extend one's abilities and knowledge (Deci & Ryan, 1985; Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000a). Intrinsic motivation has been shown to positively affect academic performance, learning and achievement (Cerasoli, Nicklin, & Ford, 2014; Gottfried, 1985; Gottfried, 1990; Ryan & Deci, 2009; Taylor et al., 2014). Specifically, intrinsic motivation has been reported to predict school report card grades in reading and mathematics in primary school children (Gottfried, 1990), grade point averages in adolescent students (Steinmayr & Spinath, 2009), and school achievement over time from grades 5 through 10 (Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2013; Taylor et al., 2014).

Intrinsic motivation has been conceptualized to comprise several specific components, namely independent mastery, curiosity, and challenge towards tasks (Harter, 1981; Lepper, Corpus, & Iyengar, 2005). While independent mastery is the desire to develop abilities or accomplish something challenging through mostly independent work (Dweck, 1986; Elliot, 1999; Nicholls, 1984), curiosity relates to enjoyment or curiosity for engaging in tasks, and challenge is centered on a preference for activities that require effort (Lepper et al., 2005). It has been suggested that intrinsic motivation is highest, and learning most efficient, when an individual has a desire to master skills (Covington, 2000; Harackiewicz, Barron, Tauer, & Elliot, 2002), finds the task

* Corresponding author at: Monash Institute of Cognitive and Clinical Neurosciences, School of Psychological Sciences, Monash University, 18 Innovation Walk, Clayton Campus, Clayton, VIC 3800, Australia.
*E-mail address:* lsin4@student.monash.edu (L. Pascoe).

https://doi.org/10.1016/j.lindif.2018.04.005
Received 29 May 2017; Received in revised form 29 March 2018; Accepted 8 April 2018

interesting (Harackiewicz et al., 2002; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Hulleman, Durik, Schweigert, & Harackiewicz, 2008), and tasks are more challenging than an individual's current level of ability (Green & Bavelier, 2008).

### 1.2. Working memory

Working memory is also important for children's learning and academic performance. Working memory is the cognitive system responsible for the temporary storage and manipulation of information during complex activities (Baddeley & Hitch, 1974; Miyake & Shah, 1999). One of the most widely applied models of working memory for learning and development is the multicomponent model (Baddeley, 2010; Baddeley & Hitch, 1974), which proposes two separable, domain-specific short-term storage systems for verbal and visuo-spatial information (the phonological loop and visuo-spatial sketchpad, respectively), and a domain-general store that coordinates and monitors information from the short-term stores (the central executive) (Baddeley, 1992; Baddeley, 2010; Baddeley & Hitch, 1974; Baddeley & Hitch, 2000). In early childhood (ages 6–7 years), the phonological loop and central executive are considered related but separable, while the visuo-spatial sketchpad and central executive are less separable (Gathercole, Pickering, Ambridge, & Wearing, 2004). Tasks tapping the short-term storage of visuo-spatial information and the central executive (which coordinates information from both short-term stores) are therefore thought to be closely associated earlier in childhood (Alloway, Gathercole, & Pickering, 2006).

Both verbal and visuo-spatial working memory abilities are thought to be important for children's learning and academic performance (Alloway & Alloway, 2010; Bull, Espy, & Wiebe, 2008; Gathercole, Alloway, Willis, & Adams, 2006; Johnson, Wolke, Hennessy, & Marlow, 2011). There is some suggestion that verbal working memory abilities play a particularly important role in reading (Baddeley, Gathercole, & Papagno, 1998; Nevo & Breznitz, 2011), with verbal working memory impairments associated with spelling difficulties (Brandenburg et al., 2015) and poorer writing and reading skills (Swanson & Berninger, 1996). For mathematics, study findings have been inconsistent about whether young children rely more on visuo-spatial or verbal working memory resources (McKenzie, Bull, & Gray, 2003; Meyer, Salimpoor, Wu, Geary, & Menon, 2010; Rourke, 1993; van der Ven, van der Maas, Straatemeier, & Jansen, 2013), or whether both are equally strong predictors of mathematics performance (Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2015). Discrepancies in findings may reflect different measures of working memory, with numerical measures of verbal working memory more frequently associated with mathematical difficulties than non-numerical measures (Raghubar, Barnes, & Hecht, 2010). Further study is required to delineate the involvement of verbal and visuo-spatial working memory abilities in academic performance.

### 1.3. Intrinsic motivation and working memory

Given both intrinsic motivation and working memory are thought to contribute to children's academic performance, the relationship between intrinsic motivation and working memory is of interest. It has been suggested that intrinsic motivation influences the extent to which cognitive resources are allocated to tasks (Pintrich, Roeser, & De Groot, 1994). Understanding this association is important for identifying whether factors like intrinsic motivation maximize executive resources needed for demanding tasks, such as school learning. To date, positive correlations between intrinsic motivation and working memory abilities have been reported in junior high school students (ages 12–14 years) (Mizuno, Tanaka, Fukuda, Imai-Matsumura, & Watanabe, 2011) and young adults (20–31 years) (Brose, Schmiedek, Lövdén, Molenaar, & Lindenberger, 2010), although this positive relationship appears reduced in older adults (65 to 80 years) (Brose et al., 2010). While these correlational studies suggest a relationship between intrinsic motivation and working memory, application of more sophisticated modeling and methodology is required to better understand the nature and directionality of this relationship, particularly for specific aspects of intrinsic motivation and in the context of academic achievement.

Path analysis and experimental studies examining mastery have reported this component of intrinsic motivation to have a positive effect on working memory abilities in children aged 10–12 years (Lee, Ning, & Goh, 2013), and enhance working memory processing in adults (18–65 years) (Avery & Smillie, 2013). To date, only one study has looked at mastery and working memory abilities in relation to academic performance in children (Lee et al., 2013). Lee et al. (2013) examined the interrelations between working memory, goal orientations and mathematical performance in 10–12 year old children, focusing on the central executive component of working memory (inclusive of both verbal and visuo-spatial tasks) and two types of achievement goals for school motivation (mastery and performance goals). Using structural equation modeling, the authors tested three competing models of associations between working memory, achievement goals and mathematics performance. They found the model where the effect of goal orientations on mathematics was partially mediated by working memory to be the best fitting model compared with two alternate models where 1) working memory and goal orientations contributed independently to mathematics performance, and 2) the effect of working memory on mathematics was partially mediated by goal orientation (Lee et al., 2013). These findings further suggest that mastery has an important role in children's working memory, and that working memory may mediate the relationship between mastery and mathematical performance. Specifically, a mastery orientation may enable a child to expend more working memory resources to successfully perform mathematical tasks. However, little is known about these associations in the context of reading or spelling performance, and currently, no evidence exists on the effects of curiosity or challenge on children's working memory abilities. Furthermore, exploring the different components of the working memory system (e.g. phonological loop and visuo-spatial sketchpad) may help to disentangle their involvement and importance in the relations between intrinsic motivation and academic functioning.

### 1.4. Current study

To date, no study has simultaneously examined intrinsic motivation, working memory abilities, and academic functioning more generally, or examined whether the association between intrinsic motivation and academic performance is at least partly due to the influence of working memory in early school-age children. Understanding these associations in populations likely to experience cognitive and academic difficulties is of interest given these children stand to benefit most from approaches that promote academic growth.

Children born extremely preterm (prior to 28 weeks' gestational age) are a vulnerable population at risk of both working memory (Anderson & Doyle, 2003; Ford et al., 2011; Hutchinson et al., 2013) and academic impairments (Anderson & Doyle, 2008; Hutchinson et al., 2013; Johnson et al., 2009). To date, no research exists on the effect of intrinsic motivation on working memory and academic performance in any such at-risk group of children. Considering that approximately 780,000 livebirths worldwide are extremely preterm, survival rates are increasing (Blencowe et al., 2012), and the majority of children born early attend mainstream schools (Larroque et al., 2011), extremely preterm children are an important at-risk population to understand and support. Investigating intrinsic motivation, working memory abilities and academic performance simultaneously in this population will enable us to investigate if low intrinsic motivation for school learning is associated with academic difficulties commonly seen in these children, and whether working memory abilities have a mediating effect on these associations.

In this study we aimed to examine associations between intrinsic