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Empirical study

Making a difference to children's reasoning skills before school-entry: The contribution of the home learning environment

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ABSTRACT

Children's cognitive development is facilitated by interactions with more knowledgeable others. Such interactions occur in children's families in the context of the home learning environment (HLE). Consequently, quality enhancements of the HLE may also improve children's cognitive abilities. A non-intensive intervention was developed to improve both the HLE and children's cognitive abilities in a sample of 116 four-year-old Australian children and their parents. The intervention consisted of parents or caregivers attending a parents' evening at which the importance of the HLE was discussed, and an additional individual session that introduced the principles of counting and dialogic reading. The HLE and children's fluid reasoning were assessed before and twice after the intervention. Families and their children in the intervention group showed significantly greater gains in both the quality of the HLE and children's fluid reasoning than members of the control group and these differences were sustained over time. Consequently, non-intensive family interventions may positively impact on the HLE and children's cognitive abilities and thus influence children's learning trajectories.

1. Introduction

Psychometric theories of intelligence are based on the belief that intelligence can be described in terms of mental factors, which in turn can be assessed with appropriate tests (cf. Bjorklund, 2005). Since the emergence of psychometric test constructions at the end of the nineteenth century, the definition of the term "intelligence" aroused controversy, mainly because there were different views regarding the structure and organization of this construct (cf. Berg, 1992). However, there is consensus that a critical component of intelligence is the ability to reason, form concepts and solve problems, whilst simultaneously incorporating novel information and rules; an ability that can be described as fluid reasoning (Au et al., 2015).

Studies have shown gains in young children's fluid reasoning when children rehearse non-verbal reasoning on computers (Bergman Nutley et al., 2011) or participate in interventions that use guided practice and demonstrations (Klauer, Willmes & Phye, 2002). Such early interventions need not necessarily be conducted in formal educational settings, but may also be implemented in the context of the home learning environment (HLE). The HLE includes all aspects of a child's home that influence the child's learning, such as frequency and quality of reading to a child or of playing games designed to support learning, behaviors modeled by family members that demonstrate the value they attach to literacy and mathematics or, in general, parental support for children's learning (Niklas, 2015; cf. Cohrssen & Niklas, 2016).

Yet, few studies have focused on the association between the HLE and children's intelligence. It has been demonstrated that fluid reasoning can be trained with computer-based and other games (e.g., Bergman Nutley et al., 2011; Mackey, Hill, Stone & Bunge, 2011), however we do not know whether supporting parents to create a more favorable HLE for their children with the aim of enhancing their fluid reasoning is successful in changing children's learning trajectories. This study analyses the immediate and follow-up impact of a non-intensive intervention in the HLE on the HLE and on Australian children's concept formation, as an indicator for fluid reasoning, in the year prior to starting school.

1.1. Children's cognitive abilities and academic achievement

Numerous studies have demonstrated the impact of individual differences in psychometric intelligence on academic achievement in school and later life (e.g., Deary, Strand, Smith & Fernandes, 2007; Schneider & Niklas, 2017; Schneider, Niklas & Schmiedeler, 2014; cf. Strenze, 2007). For instance, a comprehensive, prospective longitudinal study of the psychometric intelligence of more than 70.000 English children who were recruited at age 11 assessed the children's educational achievement in national examinations at age 16 (Deary et al., 2007). The authors found a correlation of 0.81 between the latent

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constructs of intelligence and educational achievement, indicating that general mental ability assessed at the beginning of secondary education contributed substantially to academic achievement assessed five years later. Similarly, Schneider et al. (2014) showed that intelligence was not only a stable trait from early childhood to early adulthood in a German sample, but that participants with higher initial IQ scores were more likely to attain higher educational tracks and thus greater academic success.

More specifically, Floyd, Evans, and McGrew (2003) reported that fluid reasoning as an important aspect of intelligence shows moderate associations with calculation skills and moderate to strong associations with mathematical reasoning throughout childhood and adolescence. Similarly, Finn et al. (2014) found medium to large size correlations between fluid reasoning and scores in standardized tests in mathematics ($r = 0.53$) and in English language arts ($r = 0.36$). Consequently, it is not surprising that the importance of children developing problem-solving skills and processes is a key tenet of the Early Years Learning Framework for Australia (Department of Education, Employment and Workplace Relations, DEEWR, 2009). Given the high stability of intelligence in older children (Schneider et al., 2014; Schneider, Stefanek & Niklas, 2009; Watkins & Smith, 2013), and evidence that young children's learning and development trajectories can be changed (Campbell & Ramey, 1994; Pungello et al., 2010) early interventions may alter the course of children's later academic achievement. Consequently, the kindergarten and pre-school years seem to be a good age for interventions that support young children's evolving cognitive abilities.

1.2. Interventions to improve children's cognitive abilities

Induction and fluid reasoning consist of reasoning, forming concepts and solving problems, whilst making generalizations by engaging in a process of analysis and comparison in order to identify underlying rules by detecting regularities (Klauer et al., 2002). These abilities are key for a person's intelligence and influence their further learning. Indeed, training studies that promote children's cognitive abilities have been successfully applied (e.g., Au et al., 2015; Bergman Nutley et al., 2011; Klauer et al., 2002; Mackey et al., 2011).

For instance, Mackey et al. (2011) implemented an eight-week cognitive training program comprising 60-min training sessions conducted twice weekly. During each of these sessions, children were provided with a variety of new reasoning games that included a mix of commercially available computerized and non-computerized games. These games demanded simultaneous consideration of several task rules, relations, or steps required to solve a given problem. This training improved performance on a matrix reasoning problems task (large effect size, *Cohen's* $d = 1.51$).

Klauer et al. (2002) found that an intervention that focusses on connecting prior knowledge with new concepts, and that provides specific feedback on performance appears to make a great difference to children's development improving child performance on non-inductive and, in particular, inductive tasks. Further, Klauer and Phye (2008) reported an average effect size of $d = 0.52$ in a meta-analysis of 74 intervention studies, targeting children's intelligence development. In addition, positive effects were not only found for different aspects of intelligence such as fluid reasoning, but also for academic achievement, indicating positive transfer effects for these kinds of interventions.

1.3. Home learning environment and the development of children's cognitive abilities

Child learning is influenced by innate abilities (Gelman & Butterworth, 2005), yet a child's interactions with people, objects and events in their environment are also highly influential (Cohrssen & Niklas, 2016; Cooke & Buchholz, 2005). Early cognitive development thus also depends on social processes. In the context of the HLE, caregivers provide these social processes. Children who participate in playful exploration of their world, with access to a range of play resources and engaged adults, are supported in their meaning-making, reasoning and learning (Yelland, 2011). As children develop abilities such as problem solving and reasoning, integrating new ideas with existing knowledge, they develop understanding of concepts (cf. Vygotsky, 1978). Consequently, both play and human interactions are important for children's learning and for advancing their thinking. During early childhood, most of children's learning happens in the context of their family and the HLE families provide.

Research shows that the HLE is a significant predictor of young children's numeracy (e.g., Anders et al., 2012; Niklas & Schneider, 2014), literacy (e.g. Niklas & Schneider, 2013; Sénéchal & LeFevre, 2002), and behavioral outcomes (e.g., Niklas, Nguyen, Cloney, Tayler & Adams, 2016; Schmiedeler, Niklas & Schneider, 2014). There is much interest in the HLE and in optimal models for engaging with families to support children's development (see for example, Nicholson et al., 2016) with attention focusing on parental responsivity, confidence, wellbeing, child communication, and socio-emotional and general development.

However, the quality of cognitive stimulation provided by families at home differs vastly (e.g., Niklas & Schneider, 2013; Votruba-Drzal, 2003). Families with higher incomes and educational backgrounds often provide high quality support for their children's competencies development, yet this association does not necessarily hold true for all families. Further, many children, in particular those with low socio-economic status (SES) backgrounds may not receive the home support needed to develop to their full potential (Niklas & Schneider, 2017a). Consequently, interventions enriching the home learning environment may equip parents to support children's cognitive abilities.

Young children typically spend most of their waking hours interacting with their caregivers in their home environment (Cohrssen & Niklas, 2016). Therefore, unlike SES, the HLE is a prime target for intervention as it is more readily manipulated (Molfese, DiLalla & Bunce, 1997). Further, the HLE has proven to be a good predictor of later academic achievement (e.g., Melhuish, 2010; Niklas & Schneider, 2017a).

Most intervention studies in the context of the HLE have focused on the home literacy environment and children's literacy development (cf. Sénéchal & Young, 2008). For instance, in a recent study Niklas and Schneider (2015, 2017b) showed that a non-intensive intervention improved the quality of the home literacy environment in families immediately after the intervention and at a follow-up assessment six months later and, in addition, improved children's vocabulary and phonological awareness. Non-intensive intervention refers to interventions that consist of just a few sessions that are readily accessible for parents (e.g., the intervention may be conducted at the children's kindergarten). Such non-intensive interventions have the advantage that parents do not need to spend much time and effort on burdensome interventions of long duration and thus may be more willing to participate.

In recent years, studies have also investigated the impact of interventions in the HLE supporting mathematical competencies (e.g., Booker & Goldman, 2016; Niklas, Cohrssen & Tayler, 2016a; Sheldon & Epstein, 2005). However, few studies have focused on the association of the HLE with cognitive abilities such as fluid reasoning. In a study by Molfese et al. (1997), the early HLE predicted children's intelligence, even when controlling for SES and biomedical risk conditions. Further, Frumkin (2013) reported that the HLE significantly explained variance in the Bracken Basic Concept Scale scores (cf. Bradley & Caldwell, 1980). Howard, Powell, Vasseleu, Johnstone, and Melhuish (2017) showed that shared reading with embedded cognitive activities such as remembering some story content and recalling it later in reverse order led to improved executive functioning and working memory. Other studies report small to medium effect size associations of various measures of intelligence with the HLE (e.g., Kleemans, Peeters, Segers &