Research in Developmental Disabilities 33 (2012) 600–607

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

# Strengths and weaknesses in executive functioning in children with intellectual disability

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ARTICLE INFO

*Article history:*
Received 8 November 2011
Accepted 9 November 2011
Available online 6 December 2011

*Keywords:*
Executive functioning
Intellectual disability
Inhibition
Executive-loaded working memory
Switching
Fluency
Planning

ABSTRACT

Children with intellectual disability (ID) were given a comprehensive range of executive functioning measures, which systematically varied in terms of verbal and non-verbal demands. Their performance was compared to the performance of groups matched on mental age (MA) and chronological age (CA), respectively. Twenty-two children were included in each group. Children with ID performed on par with the MA group on switching, verbal executive-loaded working memory and most fluency tasks, but below the MA group on inhibition, planning, and non-verbal executive-loaded working memory. Children with ID performed below CA comparisons on all the executive tasks. We suggest that children with ID have a specific profile of executive functioning, with MA appropriate abilities to generate new exemplars (fluency) and to switch attention between tasks, but difficulties with respect to inhibiting pre-potent responses, planning, and non-verbal executive-loaded working memory The development of different types of executive functioning skills may, to different degrees, be related to mental age and experience.


## 1. Introduction

The aim of the present study was to investigate a comprehensive range of executive functioning measures, systematically varied in terms of verbal and non-verbal demands, in children with intellectual disability, and to compare their performance to groups matched on mental age and chronological age, respectively. Executive functioning (EF) refers to processes that control and regulate thought and action. There is increasing evidence that EF can be divided, or “fractionated”, into different subcomponents. Miyake et al. (2000) used factor analysis of several tasks assessing three proposed EF subcomponents: updating/working memory, inhibition, and switching. They found that these subcomponents were separable but still partially correlated constructs. Other examples of EF tasks are problem solving, fluency, planning, decision-making, and working memory-related dual tasks (e.g. Pennington & Ozonoff, 1996).

Several investigators have reported that EF is related to intelligence tasks (e.g. Carpenter, Just, & Shell, 1990; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001; Salthouse, Fristoe, McGuthry, & Hambrick, 1998), which makes the investigation of EF in individuals with intelligence levels outside the typical range an important issue. However, this picture has become

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0891-4222/$ – see front matter 
doi:10.1016/j.ridd.2011.11.004

more nuanced with the division of EF into subcomponents. Friedman et al. (2006) found that fluid intelligence was highly correlated with updating, but not switching and inhibition. Furthermore, Arffa (2007) found correlations between full-scale IQ and EF measures of planning, fluency, and inhibition, but not trail-making (often described as assessing switching).

Mähler and Schuchardt (2009) investigated the distinction between *learning* and *intelligence* by including two groups with learning difficulties in their study, one with typical IQ scores (together with a specific learning difficulty), and one with generally low IQ scores. No differences were found between the two groups on EF measures, but both groups performed more poorly than a comparison group with typical IQ and no learning problems. This was interpreted as evidence that EF is related to learning *ability* instead of being related to intelligence.

The few studies of EF in individuals with intellectual disability (ID) present an inconsistent picture. Some investigations of young adults with ID have reported performance levels *below* mental age (MA), for example on the problem solving task Tower of Hanoi (e.g. Borys, Spitz, & Dorans, 1982; Byrnes & Spitz, 1977; Spitz, Webster, & Borys, 1982; Vakil, Shelef-Reshef, & Levy-Shiff, 1997). Other studies have reported mental age appropriate performance on Tower tasks (Numminen, Lehto, & Ruoppila, 2001). By contrast, in a recent study, no differences were found on the Tower of Hanoi or on dual tasks with ret rieval demands between adults with ID and a group matched for chronological age (CA), sex, years of education, and type of education (Danielsson, Henry, Rönnberg, & Nilsson, 2010). Regarding executive-loaded working memory (ELWM) tasks, MA appropriate performance has been reported (Numminen, Service, & Ruoppila, 2002), but see Carretti, Belacchi, and Cornoldi (2010) for an argument that difficulties in this area might be more apparent for 'high demand' ELWM tasks. In relation to fluency tasks and dual tasks, Danielsson, Henry, Rönnberg, and Nilsson (2010) reported lower performance for adults with ID compared to adults matched for CA and other attributes (see earlier).

In relation to children with ID, Van der Molen, Van Luit, Jongmans, and Van der Molen (2007) carried out a comprehensive EF assessment. They included measures of letter fluency, category fluency, dual task performance, mazes, and random number generation. Children with ID performed at the same level as typically developing MA-matched comparisons on all tasks. This study appears to be the only one on children with ID that has included a broad range of EF measures. Several other studies of children with ID have included measures of ELWM, generally reporting MA appropriate performance for children with ID (e.g. Brown, 1974; Conners, Carr, & Willis, 1998; Henry & MacLean, 2002; Henry & Winfield, 2010; Mähler & Schuchardt, 2009). Yet some inconsistency in the literature is also apparent: a few authors have reported that children with ID perform *more poorly* than MA comparisons (Russell, Jarrold, & Henry, 1996; Van der Molen, Van Luit, Jongmans, & Van der Molen, 2009). With respect to verbal fluency, Conners et al. (1998) found no differences in performance between children with ID and MA comparisons on a *letter* fluency task; similarly, Henry (2010) found no group differences using a *category* fluency task. Overall, there is some evidence for MA-appropriate performance on EF tasks in children with ID, yet when we look at performance levels in relation to typically developing comparison groups matched for CA, research findings are consistent: children with ID have lower EF abilities than CA comparisons (e.g. Conners et al., 1998; Levén, Lyxell, Andersson, Danielsson, & Rönnberg, 2008).

In sum, research on *adults* with ID presents a mixed picture of EF abilities: some EF areas appear to be well-preserved with performance levels reaching CA levels; but other EF areas involve greater difficulties even though there are inconsistencies in the findings. The more consistent literature on EF in *children* with ID suggests performance in line with MA for generative tasks such as fluency and random number generation, but difficulties with problem-solving and planning tasks. The less consistent ELWM literature suggests MA-appropriate levels of performance.

Because it is rare for a comprehensive range of EF measures to be included in studies of children with ID, there are uncertainties about the EF profile in this group. The Van der Molen et al. (2007) study assessed four different EF tasks, but these were largely in the verbal domain. Therefore, in the present study measures of five different EF sub-domains was investigated to provide a comprehensive assessment of EF skills in children with ID. The areas assessed included ELWM, switching, fluency, planning, and inhibition. Because the profile of abilities in children with ID may vary according to verbal and visuo-spatial/non-verbal abilities, EF tasks that assessed both these dimensions were included. This methodological improvement compared to previous studies allowed us to investigate differences between performance on verbal and non-verbal tasks. Some investigators have reported relatively good performance on visuo-spatial simple working memory tasks such as Corsi span in children with ID, together with relatively weak performance on verbal simple working memory tasks such as word span (e.g. Henry & MacLean, 2002; Henry & Winfield, 2010). Therefore, a secondary aim of the current study was to explore potential differences between verbal and non-verbal EF measures.

Thus, the principal research question concerned whether children with ID perform differently on tests of five EF subcomponents compared to groups matched on mental age and chronological age, respectively.

The use of MA and CA comparison groups also allowed us to address issues related to the developmental model of intellectual disability (Zigler & Balla, 1982; Zigler, 1969). This model states that the cognitive development of 'cultural-familial' children with ID (i.e. no organic disorder) proceeds through the same sequence of cognitive stages as in typically developing children. It also states that children with ID have the same cognitive structures as typically developing children. The difference model of intellectual disability (Ellis, 1969; Ellis & Cavalier, 1982; Milgram, 1973) assumes qualitatively and quantitatively different cognitive functioning in children with ID compared to typically developing children due to key differences in cognitive architecture and cognitive processes (Bennett-Gates & Zigler, 1998).

To test these two models adequately, both MA and CA matched typical comparison groups are required, although the premise for the comparison groups differs between the models (Bennett-Gates & Zigler, 1998). In general, the developmental model predicts a reasonably flat EF profile with significant EF correlations with mental age level for the ID group, although