



Visual-motor integration, visual perception, and fine motor coordination in a population of children with high levels of Fetal Alcohol Spectrum Disorder



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ABSTRACT

Background: Visual-motor integration (VMI) skills are essential for successful academic performance, but to date no studies have assessed these skills in a population-based cohort of Australian Aboriginal children who, like many children in other remote, disadvantaged communities, consistently underperform academically. Furthermore, many children in remote areas of Australia have prenatal alcohol exposure (PAE) and Fetal Alcohol Spectrum Disorder (FASD), which are often associated with VMI deficits.

Methods: VMI, visual perception, and fine motor coordination were assessed using The Beery-Buktenica Developmental Test of Visual-Motor Integration, including its associated subtests of Visual Perception and Fine Motor Coordination, in a cohort of predominantly Australian Aboriginal children (7.5–9.6 years, $n = 108$) in remote Western Australia to explore whether PAE adversely affected test performance. Cohort results were reported, and comparisons made between children i) without PAE; ii) with PAE (no FASD); and iii) FASD. The prevalence of moderate (≤ 16 th percentile) and severe (≤ 2 nd percentile) impairment was established.

Results: Mean VMI scores were 'below average' ($M = 87.8 \pm 9.6$), and visual perception scores were 'average' ($M = 97.6 \pm 12.5$), with no differences between groups. Few children had severe VMI impairment (1.9%), but moderate impairment rates were high (47.2%). Children with FASD had significantly lower fine motor coordination scores and higher moderate impairment rates ($M = 87.9 \pm 12.5$; 66.7%) than children without PAE ($M = 95.1 \pm 10.7$; 23.3%) and PAE (no FASD) ($M = 96.1 \pm 10.9$; 15.4%).

Conclusions: Aboriginal children living in remote Western Australia have poor VMI skills regardless of PAE or FASD. Children with FASD additionally had fine motor coordination problems. VMI and fine motor coordination should be assessed in children with PAE, and included in FASD diagnostic assessments.

What this paper adds

This study is the first to report VMI, visual perception, and fine motor coordination skills in a population-based cohort of Aboriginal children in a remote region of Australia. It is also the first to consider whether visual perception or fine motor coordination impairments are present, which could account for VMI difficulties in children with PAE or FASD. The outcomes identified that many children in remote Australia have VMI impairment, even those without PAE or FASD, suggesting that PAE is just one of many neurodevelopmental risk factors which may cause VMI impairment. Children with FASD had significantly lower fine motor coordination scores, and higher rates of moderate impairment. It seems that, for children with FASD, they either have a fine motor coordination impairment which exists independently of the VMI impairment, or alternatively, that their problems contribute, in part, to observed VMI difficulties. However, given the poor VMI score of children without PAE, it is likely that other factors also contributed to VMI difficulties in children with FASD in our cohort. The study shows that many children in the region require therapeutic support for VMI impairment, and it is important to assess both VMI and fine motor coordination in children with PAE and/or FASD.

1. Introduction

Alcohol consumption during pregnancy may result in a range of irreversible, clinically distinguishable, lifelong conditions, collectively called Fetal Alcohol Spectrum Disorder (FASD) (Centers for Disease Control and Prevention, 2005). FASD is an umbrella term which includes the diagnoses of Fetal Alcohol Syndrome (FAS); partial FAS (pFAS); and Alcohol Related Neurodevelopmental Disorder (ARND), also known as Neurodevelopmental Disorder – Prenatal/Alcohol Exposed (ND-PAE/ND-AE) (Astley & Clarren, 2000; Chudley et al., 2005). Individuals diagnosed with FAS or pFAS have characteristic dysmorphic facial features and/or growth impairment, while those with ARND/ND-AE diagnoses do not necessarily have these impairments. However, individuals with any of the FASD diagnoses have significant neurological damage which can cause mild to severe deficits in cognition, executive function, memory, language, attention, social and adaptive function, and soft neurological signs, including fine and gross motor skills and visual-motor integration (Chudley et al., 2005). These deficits can lead to social and adaptive problems at home, school or work, and in society (Streissguth et al., 2004).

Visual-motor integration (VMI) is the ability to use input from the visual perceptive system (which includes visual acuity, accommodation, binocular fusion, stereopsis, and convergence/divergence) to coordinate fine motor skills (which require the use of the smaller muscles of the wrist and hand, including dexterity, precision, coordination, and manual control) (Schneck, 2010). VMI underpins many everyday functions such as handwriting and drawing, catching a ball, dressing, eating, and driving (Tomchek & Schneck, 2006). There are two types of VMI: i) constructional VMI, which includes tasks such as using blocks to build a 3D shape, and ii) graphomotor VMI, which includes paper and pencil tasks such as drawing a series of lines to form geometric shapes. Different neural processes underpin constructional and graphomotor VMI, so they should be considered separate skill sets (Benton & Tranel, 1993). Impairment of graphomotor VMI can be due to underlying problems with visual perception or fine motor skills, but impairment can also exist when visual perception and fine motor skills are intact, meaning the problem lies with the integration of these skills (Beery & Beery, 2010; Kulp, 1999; Milner, 2006).

In Australia, students in Years 3, 5, 7, and 9 annually complete the National Assessment Program – Literacy and Numeracy (NAPLAN) assessment, which assesses reading, writing, language, and numeracy skills. Children in very remote areas of Western Australia, including the Fitzroy Valley, consistently under-perform compared to national averages (Australian Curriculum, Assessment and Reporting Authority, 2015). Although the NAPLAN does not specifically assess VMI or handwriting skills, other studies have shown that VMI impairment is associated with poor handwriting performance (Kulp, 1999; Weil & Cunningham Amundson, 1994), and students with poor handwriting skills often receive lower grades on written assessments despite adequate content (Chase, 1986). Therapeutic interventions which aim to improve handwriting, especially those which are integrated into the classroom, have successfully improved VMI and handwriting skills (Case-Smith, 2002).

Neurological damage resulting from prenatal alcohol exposure (PAE) may affect brain regions involved in VMI. Neuroimaging studies have shown that the corpus callosum, basal ganglia, cerebral cortex, and cerebellum may all be damaged by PAE (Riley, Infante, & Warren, 2011; Sowell et al., 2002). Within the cerebral cortex, the parietal and temporal lobes are particularly affected by PAE (Archibald et al., 2001; Sowell et al., 2002). Children with FASD with reduced parietal lobe white matter have been shown to have reduced VMI abilities (Sowell et al., 2008). Optic nerve hypoplasia (Stromland, 2004) has been reported following PAE, which may also impair visual perception, as have skeletal malformations (Jones et al., 2010),

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