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Common mechanisms in intelligence and development: A study of ability profiles in mental age-matched primary school children☆

Frank D. Baughman [a,*], Michael S.C. Thomas [b], Mike Anderson [c], &, Corinne Reid [c]

[a] Curtin Neuroscience Laboratory, School of Psychology and Speech Pathology, Curtin University, Perth, Western Australia, Australia
[b] Developmental Neurocognition Laboratory, Centre for Brain and Cognitive Development, Department of Psychological Sciences, Birkbeck, University of London, London, United Kingdom
[c] School of Psychology and Exercise Science, Murdoch University, Perth, Western Australia, Australia

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ABSTRACT

Background and aims: We examine the relationship between individual differences and cognitive development in order to address the question of whether variability in each might be due to common mechanisms. In two experiments, we compare the cognitive profiles of groups of younger and older children matched on overall mental age (MA) using standard tests of intelligence (British Abilities Scales-II; BAS-II, and Wechsler Intelligence Scale for Children, 3rd edition; WISC-III).
Results: In both experiments, MANOVAs revealed few differences in the profiles of younger and older MA-matched children. In Experiment 1, no reliable differences were found on the six BAS-II core scales, and only one group difference was found on the supplementary, Speed of Processing diagnostic test, where the older children outperformed the younger children. In Experiment 2, analyses of the 10 core scales of the WISC-III revealed two group differences. These were on Coding, where the younger children's performance was superior to the older children, and on Arithmetic, where the older children outperformed the younger children.
Conclusions: The degree of similarity between cognitive profiles of younger and older MA-matched groups suggests that a common mechanism may indeed underlie variability in individual differences and development. The findings further suggest that children of different ages, who are of the same overall ability level, are at the same developmental and intellectual level. However, further research is needed to determine just how similar ability-matched children remain over the course of development.

1. Introduction

Is being more intelligent like having more development? Or, are the two things different? If one took a group of children, varying in chronological ages but matched on overall mental age, would they be found to be equivalent in their thinking? Or, would, for example, the younger children show advantages over the older children on some tests, and the older children show advantages over the younger children on other tests of abilities? These questions have relevance both at practical (e.g., educational) and theoretical levels. However, in part because they have been studied separately, intelligence and cognitive development have been conceptualized as separate forms of cognitive variability, with separate causal accounts of their underlying mechanisms. Within intelligence research, the emphasis has long been on quantifying the abilities of large numbers of individuals of the same age (here, the term psychometrics is often used). The focus of this approach is primarily on measuring *within-age* individual variability. By contrast, the field of cognitive development has focused on attempting to understand the processes underlying age-related changes in ability. That is, the central interest within this approach is explaining how variability emerges *between-ages* for the average child.

While descriptions of various candidate mechanisms have been offered at both the brain level (see e.g., Andreasen et al., 1993; Deary & Caryl, 1997; Geake & Hansen, 2005; Haier, Jung, Yeo, Head, & Alkire, 2004; Mabbott, Noseworthy, Bouffet, Laughlin, & Rockel, 2006; Posthuma et al., 2002; Szameitat, Schubert, Muller, & von Cramon, 2002) and the genetic level (see e.g., Plomin, DeFries, & McClearn, 2008; Posthuma & de Geus, 2006), it is the convergence of these descriptions at the *cognitive level* that motivates the current study. Additionally, given the divergence in paths taken to the study of intelligence and development, it is noteworthy that within their separate literatures, theoretical accounts bear several similarities with regard to the

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* Corresponding author at: Curtin Neuroscience Laboratory, School of Psychology and Speech Pathology, Curtin University, GPO Box U1987, Perth, Western Australia 6845, Australia.
E-mail address: frank.baughman@curtin.edu.au (F.D. Baughman).

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mechanisms held to underlie variability. For example, at the cognitive level, within the literature on intelligence, one can find causal accounts for single mechanisms such as *speed of processing* (e.g. Anderson, 1992, 1998, Burns, Nettelbeck, & Cooper, 1999, Jensen, 1993, Nettelbeck, 1987, Wright et al., 2001), *inhibition* (e.g., Dempster, 1991), *capacity* (see e.g., Ackerman, Beier, & Boyle, 2005; Jensen, 1998) and *complexity* (Halford, 1999). Similarly, within the literature on cognitive development, one can also find descriptions of *speed of processing* (e.g. Hale, 1990, Kail, 1996, Nettelbeck, 1987, Wellman & Gelman, 1992), *inhibition* (Houdé, 2000), *capacity* (e.g., Jensen, 1998) and *complexity* (Halford, 1999). This raises the question of whether, for example, the speed of processing mechanism referred to within the literature on intelligence is the same mechanism that has been described in the literature on development. If so, differences in intelligence and differences in cognitive development may be explained by variability on a single dimension — a proposal Davis and Anderson referred to as the 'uni-dimensional hypothesis' (see Davis & Anderson, 1999, 2001).

It is also timely to address the question of the relationship between intelligence and development for practical reasons. For example, there has been growing interest within the educational setting concerning plans to adopt strategies to teach children in classes based on ability and not age (Ong, Allison, & Haladyna, 2000; Paton, 2008; Tomlinson, 2012; Ungoed-Thomas, 2005). This involves that curricula be designed so that in each of the core subjects (i.e., English, mathematics, science and history) classes are taught to children of a variety of ages, but who share similar overall levels of cognitive ability. Thus, within the 'ability not age' approach, one might find, at primary school level for example, classes of 6-year-olds through to 10-year-olds being taught together.

Proponents of the view that younger, more able and older, less able children are equivalent in their learning needs might be expected to argue that intelligence and cognitive development constitute variation on the same dimension. However, empirical support for this view is lacking. Indeed, it directly contradicts one crucial piece of foundational research carried out by Merrill (1924); later reviewed by Spitz (1982) in which a mental age (MA) matching design was used to examine the abilities of children of different chronological ages (CA). Using the Stanford–Binet test (Binet, 1916), Merrill showed that groups of younger, more able children and older, less able children arrived at their overall similar level of ability via *different strengths and weaknesses* on the variety of sub-tests comprising the Stanford–Binet. We present these findings shortly. However, the key point is that if differences in intelligence and cognitive development are caused by variability to a single common mechanism, then we might expect there to be no differences in the performance profiles of the two groups on any of the sub-tests: age differences would be compensated for by intelligence in the younger group, and differences in intelligence would be compensated for by age in the older group. Fig. 1 presents a comparison between Merrill's younger (n = 15, mean CA = 5.5 years) and older (n = 54, mean CA = 11.9 years) groups, on 11 sub-tests within the Stanford–Binet (Binet, 1916). The two groups were matched on an overall mean mental age of 8.0 years. On the y-axis, tasks are divided according to the age-level for which they were intended (i.e., the categories VII, VIII and IX contain the tests typically suited for 7, 8 and 9 year olds, respectively). On the x-axis, bars represent reliable differences in percentage points between younger and older children on a given task (i.e., the performance score for one group, subtracted from the performance score of the other group). Bars to the left of zero represent the tasks where the younger children were reliably better than the older children and, conversely, bars to the right of zero represent the tasks where the older were reliably better than the younger group. The figure shows that the younger children reliably outperformed the older children on six sub-tests. These were: (1) *Comprehension* (showing knowledge of appropriate behavior in various social situations); (2) *Similarities* (explaining the relationship and similarities between two objects); (3) *Superior Definitions* (providing definitions of words); (4) *Rhymes* (finding as many words as possible within one minute that rhyme with a given word); (5) *60 words* (recalling as many words as possible in 3 min from a list of 60 items); and (6) *Weights* (ordering objects of the same size but different weights in ascending order). Fig. 1 also shows five tasks in which the older children were reliably better than the younger children. These were: (1) *Fingers* (without counting, the child tells the experimenter how many fingers he/she has on one, then both hands together); (2) *Counting Backwards* (the child counts backwards from 20 to 0 in 40 s, making no more than one error); (3) *Change* (how much change should be expected from a given purchase); (4) *3 words* (using three words provided by the experimenter to produce a sentence); and, (5) *Date* (knowing and correctly stating the date).

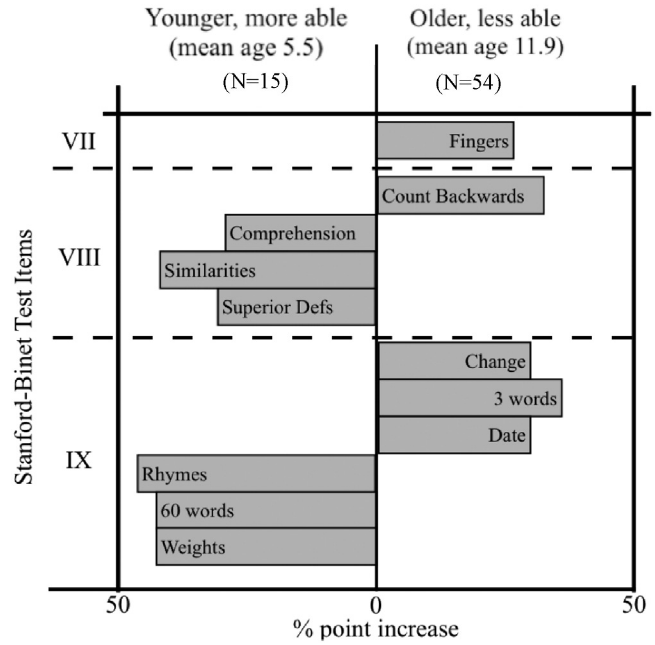

Fig. 1. Spitz's comparisons of Merrill's (1924) younger more able (CA = 5.5 years) and older less able (CA = 11.9 years) groups of children, on sub-tests of the Stanford–Binet (Binet, 1916) test. Groups were matched on a MA of 8.0 years. Bars on the left hand-side represent the sub-tests on which the younger group was superior to the older group ($p < .05$, chi square). Bars on the right-hand side represent sub-tests on which the older group was superior to the younger group ($p < .05$, chi square). On the y-axis, the categories VII, VIII and IX refer to the age-level tasks were originally intended (i.e., 7, 8 and 9 year olds, respectively). See text for explanations of sub-tests.

While both groups exhibited the same overall MA, Fig. 1 shows different profiles of abilities in the younger and older groups. From this data, Spitz (1982) concluded that younger, more able children would be more likely to excel on tasks involving *verbal reasoning* and *abstraction* while older, less able children would excel at tasks tapping *experience*, *maturation* and *rote learning*. On the basis of this, Spitz argued that it is inaccurate to characterize the two groups as being of the same developmental, or the same cognitive level. This point is critical as it suggests that intelligence and development contribute differentially to ability and thus are not variations on the same dimension.

To our knowledge, Merrill's findings have not since been replicated. However, there are several advantages in replicating that design. Firstly, using modern tests of intelligence, it should be possible to obtain more accurate ability profiles of the younger and older groups of children. Secondly, by reducing the range of chronological ages in our groups, we may be more confident that any differences we observe, relate to differences between children who fall within the normal range of abilities (as opposed to differences between typically developing and atypically developing children). This point is especially relevant when studying lower ability children because, as the gap between their chronological age and mental age increases, so too does the likelihood that some form of learning, or developmental disorder, underlies their poorer performance. Given that the younger and older groups in Merrill's study

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