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A relational frame skills training intervention to increase general intelligence and scholastic aptitude☆

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ABSTRACT

This study aimed to replicate and extend the pilot findings of Cassidy et al. (2011) which found that teaching children to derive various relations among stimuli leads to increases in the full scale IQ scores of both typically developing children and those with educational and learning difficulties. In Experiment 1, fifteen 11–12 year old children were exposed over several months to an intensive training intervention to improve their understanding of the relations Same, Opposite and More and Less. Significant increases in full scale IQ of around one standard deviation were recorded for each child. In Experiment 2, the same intervention was delivered to thirty 15–17 year old children. Significant increases in verbal and Numerical Reasoning were recorded for almost every child. These findings corroborate the idea that relational skills may underlie many forms of general cognitive ability.

1. Introduction

The idea that intelligence may be a malleable trait has a well-documented and contentious history. Arguably, the evidence base is shifting in favor of the idea that intelligence is not a stable trait, with leading researchers in the field arguing that an increasing role can be assigned to the environment in determining intelligence levels (e.g., Nisbett et al., 2012). Evidence for this perspective comes from educational, cognitive, neuroscientific and, most recently, behavior-analytic sources (the focus of the current study). For instance, educational studies have shown that the Intelligence Quotient (IQ) scores of children who miss a year of school drop several points and that such effects can even be measured over the summer months (see Ceci, 1991; Jencks et al., 1972). In one large-sample naturalistic and retrospective study (Brinch & Galloway, 2012), two extra years of compulsory schooling was associated with substantial IQ increases by age 19. Educational interventions for younger children, such as the Milwaukee Project (Garber, 1988), were reported as leading to an average IQ increase of 10 points over matched controls. Similarly, the Abecedarian pre-kindergarten program (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002) was reported to have had an effect on IQ scores amounting to 4.5 points over matched controls by age 21. One study involving teaching reasoning skills to seventh-grade children improved IQ scores by 0.4 SD (Herrnstein, Nickerson, Sanchez, & Swets, 1986). More recently, a partial replication of that study reported intelligence gains across a range of measures (Sanz de Acedo Lizarraga, Ugarte, Iriarte, & Sanz de Acedo Baquedano, 2003). Several other studies have shown the impact of intensive intervention on scholastic performance (e.g., Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Nisbett, 2009; Schweinhart et al., 2005; Schweinhart & Weikart, 1980).

Research within the cognitive tradition has focused to a large extent on such features as working memory training and its impact on fluid intelligence, indexed using measures such as Raven's Progressive Matrices (RPM). For instance, Klingberg, Forssberg, and Westerberg (2002) reported improvements in RPM scores for both children with attention deficit/hyperactivity disorder (ADHD) and adults who had been provided with memory training. More recently, Mackey, Hill, Stone, and Bunge (2011) reported matrix reasoning improvements equating to 10 full scale IQ points in low SES children who had been exposed to memory training across a range of modalities. Similar effects have been reported for elderly populations in studies targeting memory training (Borella, Carretti, Riboldi, & De Beni, 2010) and executive functioning (Basak, Boot, Voss, & Kramer, 2008; Stephenson & Halpern, 2012).

Perhaps no single paradigm for increasing intelligence has received as much scientific and media attention as that involving extended dual n-back training, a task designed to target working memory. While not without its critics, research reported by Susan Jaeggi and

☆ Declaration of interests: the intervention described in this paper has been developed by the first two authors into a commercially available treatment intervention available at RaiseYourIQ.com.

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colleagues indicates increases in fluid intelligence (g_f) as measured by RPM across short term and long-term (3-month) follow-up measurement periods (see Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Jaeggi et al., 2010; Jäeggi, Buschkuehl, Jonides, & Shah, 2011).

Evidence from the field of neuroscience also points to neural changes that might be expected to accompany improved brain functioning following interventions designed to enhance reasoning skills. For instance, Mackey, Miller-Singley, and Bunge (2013) reported that intensive reasoning training in the form of preparation for the Law School Admissions Test (LSAT) resulted in tighter coupling among regions in the lateral fronto-parietal network, as measured with resting-state fMRI (rs-fMRI). A demonstration of such plasticity is important because the regions affected by the training are associated with complex cognition (see also Mackey, Whittaker, & Bunge, 2012).

Psychologists in the behavior-analytic tradition have always adopted a purely functional approach to understanding intelligence and general cognitive ability (e.g., Schlinger, 2003). Instead of viewing intelligence as an invariant trait (encapsulated by the concept of "g"), they see it as a malleable skill set, while viewing IQ measures as mere indices of the fluency of the skills involved (e.g., Cassidy, Roche, & O'Hora, 2010; Cassidy, Roche, & Hayes, 2011). The late O. Ivar Lovaas (1987) reported IQ gains up to 30 points (roughly two standard deviations) following a three-year applied behavior analysis (ABA) intervention for autism. Nearly half of the autistic children in that study were not noticeably intellectually different from normally functioning children after the three-year program (Reed, Osborne, & Corness, 2005). In an independent replication of the Lovaas study, Sallows and Graupner (2005) recorded similar significant IQ rises among autistic children. In a further study, Smith, Eikeseth, Klevstrand, and Lovaas (1997) used an ABA treatment program to improve expressive speech and adaptive behavior among severely mentally retarded children with autistic features. They also measured IQs at follow-up. While behavioral problems diminished in both groups, children in the treatment condition displayed a higher mean IQ at follow-up and evinced more expressive speech than those in the comparison group.

A more recent behavioral approach to intellectual functioning is provided by Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001; Dymond & Roche, 2013) that attempts to codify a wide range of cognitive skills in terms of a smaller range of underlying, teachable skills. These are known as relational framing skills (or relational skills for short) and might be considered loosely as the functional counterpart of the more widely used concept of relational reasoning skills (e.g., Halford, Wilson, & Phillips, 2010).

RFT draws together several decades of research focused on a key repertoire referred to as *derived relational responding*, the most widely studied form of which is *stimulus equivalence*. The latter refers to the emergence of stimulus relations that are untrained but which are nevertheless predictable and controllable. A typical procedure for studying this behavioral phenomenon involves training participants to make stimulus selections from a pair (or more) of stimuli, in the presence of a sample stimulus (i.e., a conditional discrimination made in a matching-to-sample format). All stimuli are unrelated to each other along any physical continuum. For example, given sample stimulus A, selecting comparison stimulus B is reinforced (i.e., A–B). On other trials selecting comparison stimulus C given sample stimulus A is reinforced (i.e., A–C). For most verbally-able individuals, B–A, C–A (i.e., symmetry), B–C and C–B (i.e., combined symmetry and transitivity) relations emerge without further instruction or reinforcement, and if they do stimulus equivalence has been observed (Sidman, 1971).

Researchers have been fast to capitalize upon the obvious relevance of this and related phenomena to a wide range of cognitive skills, including language, reasoning, and problem solving (see Dymond & Roche, 2013). Galizio, Stewart, and Pilgrim (2001), for example, described how derived relational responding can be used as a new paradigm for understanding reasoning insofar as the emergence of stimulus equivalence classes is not unlike the process of category clustering. Galizio et al. argued that traditionally the study of categorization has been the province of cognitive psychology and psycho-linguistics (e.g., Margolis & Laurence, 1999) but that a behavior-analytic approach to categorization can complement the cognitive approach to understanding such phenomena as organizational processes in memory (e.g., Bousfield, 1953). Indeed, it is a widely held view that derived relational responding and language processes are in fact synonymous (see Dymond & Roche, 2013 for a book-length review).

RFT extends the analysis of derived relational responding to include relations other than equivalence, such as comparison (more than/less than), time (before/after), opposition and difference. All of the deriving skills relevant to these frames are thought to be learned through multiple exemplars delivered through extended social and educational interactions (see, e.g., Stewart, Tarbox, Roche, & O'Hora, 2013) and each is characterized by a pattern of derivation (mutual and combinatorial entailment and transformation of response functions of each stimulus by the others) that confirms the emergence of a particular type of frame. The important point in the current context, however, is that a relatively narrow range of taught and derived stimulus relation types (i.e., frames) can be used to describe a very wide range of intellectual processes (e.g., problem solving, and vocabulary). For instance, vocabulary test items can be viewed as tests for taught or derived frames of coordination (e.g., "What does brave mean?"). Some IQ test items require definitively derived, rather than taught relational responding in accordance with a frame of coordination. As an example, the *Picture Concepts* subtest on the Wechsler Intelligence Scale for Children fourth edition, UK (WISC-IV^{UK}), requires a child to look at several rows of images, and choose one image from each row to form a cluster of images that have a meaningful relationship to each other. The stimuli may be novel in the given arrangement, but for children who have been exposed to a typical education, the skill of deriving relations among an arbitrary array of stimuli is not itself novel. Frames of opposition are also specifically probed for in vocabulary items asking the respondent to identify a word with the opposite meaning to a sample (e.g., the AH4). The reader is referred to Cassidy et al. (2010) and Roche, Cassidy, and Stewart (2013) for an extensive analysis of popular IQ tests along these lines.

The relational frame approach to intelligence is somewhat commensurate with several mainstream cognitive approaches to understanding intellectual skills. The most obvious of these is the concept of relational reasoning or knowledge. Specifically, relational knowledge is thought to integrate heuristic and analytic cognition and to be important for symbolic processes. As it happens, the regions of the brain activated by relational reasoning are in the prefrontal cortex, which further corroborates the view that relational reasoning is central to many higher cognitive processes (see Halford et al., 2010). Indeed, behavior-analytic theorists agree with the cognitive position that mathematics can be characterized as a set of relational networks or concepts (Ninness et al., 2006, 2009, Marr, 2015).

It has not gone unnoticed by cognitive psychologists that if relational reasoning skills are teachable, that it should be possible to enhance general intelligence by enhancing relational reasoning (e.g., Mackey et al., 2013). A similar line of logic has been followed within RFT. More specifically, the development of framing appears to be correlated with the development of language, itself seen as a crucial aspect of intellectual development and ability (Smith, Smith, Taylor, & Hobby, 2005). Framing has been shown to emerge at the same time as language (Lipkens, Hayes, & Hayes, 1993) and to be absent in language disabled individuals (Barnes, McCullagh, & Keenan, 1990; Devany, Hayes, & Nelson, 1986). In addition, numerous empirical and conceptual research papers have presented evidence that the ability to derive relations is associated with, and possibly even underpins language ability (Moran, Stewart, McElwee, & Ming, 2010, 2014; O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009).

In addition, several correlational studies have concluded that there are important overlaps between the ability to derive relations and intellectual skills established in the school setting. For example, O'Hora and