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The proxy-measurement of intelligence quotients using a relational skills abilities index☆

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ABSTRACT

Relational Frame Theory proposes that levels of sophistication with relational concepts may underlie intellectual performance. In order to further elucidate this relationship, the current study examined correlations between scores on a novel Relational Abilities Index (RAI) and a range of widely-used cognitive ability measures, including Full Scale IQ. In Study 1, 35 adult participants completed a battery of cognitive assessments, comprising of the National Adult Reading Test, the Rey Auditory Verbal Learning Test, the Trail Making Test, the Cognitive Failures Questionnaire and a RAI assessment at two time periods. In Study 2, a full WAIS-III assessment and RAI was administered to 25 college students. Results indicate that performance on the RAI displayed impressive degrees of correlation with the three main IQ indices, three of the four IQ subindices, and three of the four cognitive ability measures, suggesting that the RAI assessment may represent a promising potential proxy measure of Full Scale IQ.

Intelligence is commonly believed to lie beyond the remit and descriptive powers of behavior analysis (Abramson, 2013; Block, 1981; Putnam, 1975; Schlinger, 2003). Theoretical objections to hypothetical constructs (Skinner, 1974), a preference for functional (i.e., in terms of environment-behavior relationships) accounts, as well as an apparent difficulty in accounting for the generativity of language and cognition (Hayes, Barnes-Holmes, & Roche, 2001), are often employed to support the argument that a behavioristic account of intelligence is not only difficult technically, but inappropriate conceptually. However, recent advances in a behavior-analytic account of language and cognition, known as Relational Frame Theory (RFT; Hayes et al., 2001; see also Dymond & Roche, 2013) have led to new insights into how we might conceive intellectual behavior in a non-mentalistic manner (e.g., Hayes, 1994; O'Hora, Pelaez, & Barnes-Holmes, 2005; O'Toole, Barnes-Holmes, Murphy, O'Connor, & Barnes-Holmes, 2009; Smith, Smith, Taylor, & Hobby, 2005) as well as the development of intervention protocols that have shown early promise in increasing intelligence quotients (Cassidy, Roche, Colbert, Stewart, & Grey, 2016; Cassidy, Roche, & Hayes, 2011; Dixon, Whiting, Rowsey, & Belisly, 2014; Moran, Stewart, McElwee, & Ming, 2010). As such, RFT-inspired measures are increasingly being looked upon within the behavior-analytic community as conceptually-sound proxies for IQ with acceptable construct validity.

Behavior analysts have proposed theoretical objections to essentialistic conceptualization of intelligence, suggesting such accounts commit the logical errors of reification (Gottfredson, 1998; Gould, 1981; Howe, 1990) and circular reasoning (Schlinger, 2003). While a behavior-analytic perspective may propose theoretical objections to the concept of *g*, the practical utility of IQ tests in providing an index of *intellectual performance* for a given individual in a given assessment, is increasingly being recognised. Indeed, psychometricians have long posited that the term intelligence merely refers to the collection of behaviors that cannot be separated from their context (Schlinger, 2003) and this is an acceptable position for most behavioral researchers concerned about reification. In any case, IQ remains the benchmark for indexing intelligence, and provides the comparative litmus test for any new potential measure of intellectual performance, even where the model of intelligence differs radically from those on which IQ testing is based, as does the current model.

RFT represents the convergence of several decades of research focused on a key skills repertoire known as derived relational responding or *relational framing*, referred to as a verb rather than a noun, to draw attention to framing as a behavioral skill rather than to frames as mental entities. Relational responding refers to the process of responding to one stimulus in terms of its contextually controlled arbitrary relationship to another. For example, responding to the word "cat" in terms of its relationship to images of cats represents a form of relational responding in terms of stimulus equivalence or coordination. On the other hand, responding to a 5c coin as worth less than a 10c coin

☆ Declaration of interests: The assessment protocol described in this paper has been developed by Dr. Bryan Roche as part of a commercially available treatment intervention available at RaiseYourIQ.com.

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represents a form of relational responding in terms of a relation of comparison (i.e., more/less). It is the presence of contextual cues (e.g., the spoken word "more"), that controls the relational response to any given stimulus.

Relational responding comes in a variety of other forms or 'frames', such as coordination ("cat is the same as kitty"), opposition ("big is opposite to small"), hierarchy ("an apple is a type of fruit"), analogy ("foot is to sock, as hand is to glove"), deixis ("I am here and you are there") and temporality ("morning comes before afternoon"). Importantly, when an individual acquires an understanding of several such relationships, a network of relations between numerous stimuli can be understood, allowing the individual to derive relations between stimuli in the network that have not been explicitly taught. For example, if a child is taught that Jamie is taller than Joanne and Joanne is taller than Aoife, the child can derive that Jamie is therefore taller than Aoife, but only given appropriate training to do so. Hayes et al. (2001) proposed that this learned behavior of deriving relations between and among stimuli is a behavioral process that gives rise to much of human cognition.

RFT suggests that a relatively small variety of relational frames may yield the full array of cognitive skills, like deductive reasoning, problem solving, analogies and language (Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001; Cassidy et al., 2011, 2016; Hayes & Stewart, 2016). As such, intelligence is not treated as something one "has", but rather as a generalized set of relational skills (i.e., applicable to any set of stimuli) that are learned, and that therefore could be improved.

1. The relationship between relational responding and measures of IQ

Many standard IQ tests contain items that can be understood in terms of relational frames and as tests of derived relational responding (DRR), potentially indicating a degree of overlap between intellectual performance and relational responding proficiency. For example, the Wechsler Vocabulary subtest assesses simple relations of sameness between objects and words, by asking such questions as; "What does simple mean?" or by showing a picture of a carrot and asking; "What is this?". Comparison-based tasks are also commonly assessed by questions such as: "Michelle is 2 years younger than Peter and 5 years older than Sam. If Sam is 6 how old is Michelle?". Relations among relations (analogies) are also widely assessed on standardized IQ tests due to their conceptual relevance to intelligence (Esher, Raven, & Earl, 1942; Sternberg, 1977; see Cassidy, Roche, & O'Hora, 2010 for a full conceptual unpacking of IQ test items in terms of relational concepts).

Various correlational analyses have identified the close relationship between relational responding proficiency and performance on a number of IQ indices, subindices and subtests (Dixon et al., 2014; Gore, Barnes-Holmes, & Murphy, 2010; Moran et al., 2010; O'Hora et al., 2005, 2008; O'Toole et al., 2009). O'Hora et al. (2005) found that performance on a complex relational task involving the derivation of temporal relations, predicted performance on two of the three subtests of the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997) included in the analysis (Vocabulary & Arithmetic). In a subsequent study, O'Hora et al. (2008) reported that successful completion of a similar task was associated with higher Full Scale and Verbal IQ. Furthermore, O'Toole et al. (2009) reported that performance on a relational task involving temporal and distinction relations predicted scores on the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 2004). These results were complimented by a later study by Gore et al. (2010) who identified strong correlations between perspective-based relational responding and scores for Full Scale, Verbal and Performance IQ scales of the Wechsler Abbreviated Scale of Intelligence (WASi; Wechsler, 1999) in a sample of adults with intellectual disabilities (see also Dixon et al., 2014). While these correlational analyses alone are not sufficient to support the RFT claim that DRR is foundational to intellectual behavior, they do suggest a degree of functional overlap between the fluency of relational responding and intellectual performance. This functional overlap may allow a relational skills measure to provide an estimate of IQ in certain research contexts in which an estimate is all that is required or in which the researcher or clinician wishes to assess intellectual capacity in purely functional terms.

Cassidy et al. (2011) demonstrated the efficacy of two relational frame multiple exemplar training (MET) interventions in increasing intelligence quotients in samples of children. The MET protocol refers to a technique in which children are posed with a large number of relational "problems" to solve, involving nonsense words and relational cues (e.g., CUG is Opposite to BEH, BEH is Opposite to VEK, Is CUG Opposite to VEK?), all of which take the same form but each of which involves different stimuli. Completion of MET over many sessions and months was correlated with significant rises in Full Scale IQ in both Experiment 1 ($M = 27$ points) and Experiment 2 ($M = 13$ points). In order to assess pre- and post-intervention relational responding proficiency, a preliminary Relational Abilities Index (RAI) was also devised, consisting of 60 relational tasks, such as those outlined above, assessing the relational frames of Same, Opposite, More than and Less than. Significant rises in RAI scores were observed following intervention. Correlations between the RAI score and baseline IQ were not assessed as the RAI was employed only to ensure that relational skills were being increased due to the intervention.

In a follow-up study, Cassidy et al. (2016) reported clinically significant IQ gains following the implementation of a modified version of the MET intervention across two experiments with larger samples and more rigorous controls. In both experiments, a revised RAI consisting of 55 questions was presented pre- and post-intervention. In Experiment 1 ($n = 15$), RAI scores failed to correlate with baseline IQ scores ($r = 0.13$). However, in Experiment 2, which employed a larger sample ($n = 30$), RAI scores at baseline did correlate significantly with baseline levels of Verbal Reasoning ($r = 0.67$), Numerical Reasoning ($r = 0.43$) and overall Educational Aptitude ($r = 0.66$), supporting the RFT-inspired hypothesis that relational skills are closely related to intelligence, with some suggesting that these repertoires are possibly even synonymous (e.g., Hayes & Stewart, 2016).

1.1. The current study

The aim of the current study is to conduct a preliminary assessment of the utility of the Relational Abilities Index (RAI) as a proxy measure of Full Scale IQ and a range of widely used cognitive ability measures. The purpose of using a range of measures that assess different cognitive domains is precisely to begin investigating which aspects of cognitive functioning relational skills best correspond to and to allow for the assessment of both convergent and divergent validity. That said, as the traditional litmus test for assessing the validity of a potential proxy measure of intelligence is an investigation into the strength of its relationship to general intellectual performance, the correlation between Full Scale IQ and RAI score represents the focal point of our analysis.

In Study 1, adult participants completed the National Adult Reading Test (NART; Nelson, 1982), the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1958; English version: Taylor, 1959), the Trail Making Test (TMT; Lezak, 1995) and the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982), as well as a RAI assessment at two separate time periods for the purpose of assessing test-retest reliability. Due to the level of correlation between IQ and the NART (Nelson, 1982), RAVLT (Mitrushina, Boone, Razani, & D'Elia, 2005) and TMT (Ardila, Pineda, & Rosselli, 2000), we anticipated significant correlations between performance on these measures and the RAI. Conversely, as the CFQ has not been found to show a strong relationship with IQ (Broadbent et al., 1982), we predicted that the RAI would not correlate with this metric, thereby providing some divergent validity for the RAI. Study 2 focused on the degree of correlation between the RAI and scores on the WAIS-III. It was expected that performance on

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