Behavior Analysis in Practice (2020) 13:684–697
https://doi.org/10.1007/s40617-020-00415-0

DISCUSSION AND REVIEW PAPER

The Potential of a Relational Training Intervention to Improve Older Adults' Cognition

Michelle E. Kelly [1]

Published online: 1 July 2020

Abstract
Behavioral gerontology rarely focuses on improving older adults' cognitive function. This gap in the literature should be addressed, as our aging population means that greater numbers of older adults are experiencing cognitive decline and reduced functional independence. If cognitive training interventions are to be socially significant, they should target improvements in core executive functions (EFs) that are critical for everyday cognition and functioning independence. Evidence from the cognitive sciences suggests that a cognitive training intervention targeting "relational knowledge" and "cognitive flexibility," which are core EFs, could translate to improvements in cognition and functioning for older adults. Behavioral researchers, interested in the effects of relational training on cognition, have shown a relationship between complex and flexible arbitrarily applicable relational responding (AARRing) and improved performance on measures of intelligence in children and young adults. However, data examining the impact of AARRing on the cognition of older adults are lacking. This article suggests that complex and flexible AARRing may be synonymous with the aforementioned EFs of relational knowledge and cognitive flexibility, and that a behaviorally oriented relational training intervention might improve cognition and functioning for healthy older adults or those experiencing cognitive decline. The article initially presents a brief overview of research in behavioral gerontology and older adult cognition, followed by a detailed explanation of how training complexity and flexibility in AARRing could result in improvements in core EFs. Specific suggestions for designing a relational training intervention and assessing relevant outcomes are provided.

Keywords Aging · Behavioral gerontology · Healthy cognition · Derived relational responding · Relational training

Behavioral Gerontology

In 1986, Burgio and Burgio published a seminal article titled "Behavioral Gerontology: Application of Behavioral Methods to the Problems of Older Adults" in a special section of the *Journal of Applied Behavior Analysis* (JABA). Here, the authors described the potential of the field of behavioral gerontology to improve behavioral and everyday outcomes for older adults. Subsequently, three special issues on aging were published in *Behavior Therapy* in 1988, 1997, and 2011, and a recent special issue was published of *Behavior Analysis: Research and Practice* in 2018. The dominant theme emerging from the commentary of each was that behavior analysis can be, and often is, effectively implemented to address difficulties related to older adulthood (Beck, 1997; J. A. Buchanan, 2018; Burgio & Burgio, 1986; Houlihan & Buchanan, 2011; Rosenthal & Carstensen, 1988). Nonetheless, the prevalence of gerontology publications in behavioral journals is low compared to the large volume of research with children and individuals with intellectual disabilities (IDs; LeBlanc, Raetz, & Feliciano, 2011). One review of eight behavior analysis journals identified 109 aging articles published between 1980 and 2008 (Buchanan, Husfeldt, Berg, & Houlihan, 2008), and a subsequent review of JABA identified 21 aging articles published between 1986 and 2011 (Trahan, Kahng, Fisher, & Hausman, 2011). In both cases, the authors reported that the research was often limited to addressing behavioral excesses and deficits associated with dementia (Buchanan, 2018; Trahan et al., 2011).

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s40617-020-00415-0) contains supplementary material, which is available to authorized users.

✉ Michelle E. Kelly
michelle.kelly@ncirl.ie

[1] National College of Ireland, Mayor Street Lower, IFSC, Dublin, Ireland

These review findings might suggest that the field of behavioral gerontology is not advancing as expected, but they might also suggest that behavioral gerontologists are branching out and applying their skills in other domains or publishing outside of the core behavioral journals. Behavior analysts often publish research with older adults in mainstream aging or psychology journals (Burgio & Kowalkowski, 2011; Lucock et al., 2018). In addition, non-behavior analysts publish research with older adults that is behavior analytic in nature without sharing a similar language. For example, strategies used in cognitive rehabilitation (Clare, 2008; Kelly, Lawlor, Coen, Robertson, & Brennan, 2017), increasing adherence to interventions (Room, Hannink, Dawes, & Barker, 2017), and behavioral relaxation training (Chung, Poppen, & Lundervold, 1995) each have strong behavioral elements but are not considered behavior analytic. As a field, it is important to recognize and foster confidence in the applicability of our skill set to populations outside of those with IDs and autism (Baker, Fairchild, & Seefeldt, 2015). Branching out presents certain challenges (LeBlanc, Heinicke, & Baker, 2012), but detailed discussions of how we can transfer our knowledge to understudied areas is an important introductory step.

With the aforementioned in mind, it has been noted that behavior-analytic research that focuses on older adult cognition is especially rare (Buchanan et al., 2008; LeBlanc et al., 2011). Cognition incorporates all mental processes that allow us to think and organize our thoughts, communicate, recall information, and perceive and understand the world around us. A person with healthy cognition would be able to think clearly, formulate logical conversations, and plan out and execute daily tasks effectively. Healthy cognition is therefore vital for everyday functional independence (the ability to function and carry out daily tasks without relying on others for support). As functional independence decreases, people may become more reliant on carers to carry out daily tasks for them, resulting in a reduced ability to live independently. The aim of this article is to consider an approach based on relational frame theory (RFT) to improving older adults' cognition—specifically, to explain how relational training might promote healthy cognition, which may, in turn, influence functional independence. The article discusses older adults' cognition; outlines current evidence on cognitive training, including gaps in the literature; and considers the potential for an innovative behaviorally oriented intervention that may advance efforts to improve cognition and functional independence for healthy older adults or those experiencing cognitive decline.

Cognitive Decline in the Aging Population

The increase in our aging population has resulted in rising numbers of older adults experiencing cognitive decline (Harada, Natelson Love, & Triebel, 2013; Lipnicki et al., 2013). Cognitive decline can include problems with memory, language, planning, and thinking and can reduce a person's ability to complete everyday tasks. For example, an older adult experiencing cognitive decline may enter a supermarket having forgotten their wallet or have difficulty describing an item to a clerk because they cannot "think" of the word. Cognitive decline is a major risk factor for dementia (Fratiglioni & Qiu, 2011) and can often result in a reduced ability to live independently (Millan-Calenti et al., 2012). In 2015, an estimated 46.8 million people were living with dementia worldwide, with this figure set to double every 20 years to approximately 131.5 million by 2050 (Prince et al., 2015). This will present a significant challenge to our health care systems and a serious economic burden, with the projected cost of dementia care set to double from an estimated US$1 trillion in 2018 to US$2 trillion by 2030 (Prince et al., 2015). A number of reviews have cited evidence to suggest that the risk of cognitive decline (and progression to dementia) can be reduced by targeting protective factors such as social engagement, physical activity, and mental stimulation (Barnes & Yaffe, 2011; Fratiglioni & Qiu, 2011; Mangialasche, Kivipelto, Solomon, & Fratiglioni, 2012). Evidence from epidemiological studies and randomized controlled trials (RCTs) suggests that mental stimulation in the form of cognitive training can improve older adults' cognition and that this may contribute to a reduced risk of cognitive decline (Kelly et al., 2014; Mangialasche et al., 2012). Cognitive training interventions might also improve cognition for those already experiencing decline, including individuals with mild cognitive impairment (MCI; Gates et al., 2019) and mild to moderate dementia (Bahar-Fuchs, Martyr, Goh, Sabates, & Clare, 2019; Gates & Sachdev, 2014). This article will therefore consider the development of an RFT-based cognitive training intervention aimed at improving cognition and functional independence for cognitively healthy older adults and/or those experiencing cognitive decline. Before describing how RFT could be used to design cognitive training interventions, the article will outline the benefits of cognitive training, and the requirements for socially significant outcomes to be achieved.

The Benefits of Cognitive Training

Cognitive training interventions are specifically designed training programs that provide guided practice on a standard set of learning tasks, aimed at improving performance and cognition (Martin, Clare, Altgassen, Cameron, & Zehnder, 2011). Cognitive training has been shown to benefit memory and some executive functions (EFs; Kelly et al., 2014; Lampit, Hallock, & Valenzuela, 2014). EFs refer to the brain's ability to plan and organize, problem solve, and engage in flexible thinking (Najdowski, Persicke, & Kung, 2014) and are important for performing tasks such as scheduling, organizing daily activities, adapting to unexpected circumstances, planning ahead, and meeting novel challenges (Diamond, 2013). These EFs are critical for maintaining functional independence (Gross, Rebok, Unverzagt, Willis, & Brandt, 2011; Karbach & Kray, 2009; Kelly et al., 2014; Royall et al., 2007). Although cognitive training can improve EFs for healthy older adults (Kelly et al., 2014; Lampit et al., 2014) and for those already experiencing decline (Sitzer, Twamley, & Jeste, 2006), there is limited research showing generalization of intervention effects to everyday living tasks (Bahar-Fuchs et al., 2019; Reijnders, van Heugten, & van Boxtel, 2013) or functional independence (Burch, 2014; Kelly et al., 2014; Lampit et al., 2014; Simons et al., 2016). If cognitive training interventions are to have a socially significant impact on the lives of older adults, they should target improvements in everyday or "real-life" cognition and functional independence (Van de Ven, Schmand, Groet, Veltman, & Murre, 2015), as opposed to simply targeting performance on lab-based tasks. Interventions should therefore program for generalization of intervention effects to improve performance on measures of everyday cognition and functional independence (Kelly et al., 2014).

To devise cognitive training interventions that focus on generalization as described previously, it is necessary to consider the key components that are likely to promote generalization to everyday cognition and functional outcomes. With this in mind, further consideration should be given to what are deemed *core* EFs. Core EFs are the foundational EFs from which more complex, higher order EFs of thinking, problem-solving, reasoning, revising, and planning (Diamond, 2013; García-Madruga, Gómez-Veiga, & Vila, 2016). are built (Fig. 1). These higher order EFs are critical for everyday living and maintaining functional independence (Collins & Koechlin, 2012; Diamond, 2013). Core EFs, including relational knowledge, working memory, cognitive flexibility, and inhibition and interference control (Diamond, 2013), refer to the abilities to shift flexibly between competing activities/trains of thought, to work automatically and efficiently, to inhibit impulsive responses, to process novel stimuli, and to generalize learning to new situations (Chan, Shum, Toulopoulou, & Chen, 2008). Interventions that directly target core EFs may therefore be of greater benefit to real-life cognition and functional independence for older adults (Van de Ven et al., 2015), as they would target foundational skills upon which more complex skills are built (see Supplemental Table 1 for further explanation of cognitive terms). Upon comparing the literature across behavioral and cognitive science, it seems that relational complexity and flexibility, as explained by RFT, are comparable to cognitive descriptions of core EFs. If this is the case, this would further support the RFT argument that derived relational responding is at the core of human cognition. This would also present an interesting opportunity for behavior analysts, as existing RFT technology could be integrated into a cognitive training intervention designed to improve EF ability. Before explaining how relational complexity and flexibility can be considered as core EFs, the article will explain relational complexity and flexibility in more detail.

Relational Frame Theory: Complex and Flexible Relational Responding

Despite some controversy over the fit of RFT in behavior analysis (Gross & Fox, 2009), many explanations (D. Barnes-Holmes, Barnes-Holmes, & Cullinan, 2000; Hayes & Barnes-Holmes, 2004; Hayes, Barnes-Holmes, & Roche, 2003) and years of empirical research (Dymond, May, Munnelly, & Hoon, 2010; Montoya-Rodríguez, Molina, & McHugh, 2017; M. O'Connor, Farrell, Munnelly, & McHugh, 2017) have well established RFT within this field. Even critics of RFT agree on the importance of a more thorough behavioral approach to understanding the complexities of language and cognition (Galizio, 2003; Gross & Fox, 2009; McIlvane, 2003). In short, RFT is a behavioral account of human language and cognition that postulates that complex relational responding is at the foundation of linguistic and cognitive processes (Hayes et al., 2003; Hayes, Barnes-Holmes, & Roche, 2001). *Relational responding* refers to a person's ability to respond to a stimulus or event based on its relationship to another stimulus or event (Kilroe, Murphy, Barnes-Holmes, & Barnes-Holmes, 2014). Patterns of relational responding are learned at an early age through a person's interactions with the verbal community and with an appropriate history of multiple-exemplar training (Barnes, 1994). Thus, RFT considers relational responding as a generalized operant (Y. Barnes-Holmes, Barnes-Holmes, & Smeets, 2004b). Researchers have investigated relational responding in terms of relational frames, including frames of coordination (e.g., the spoken word "computer" corresponds with an actual computer; J. O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009), opposition (e.g., *old* is the opposite of *young*; Y. Barnes-Holmes, Barnes-Holmes, & Smeets, 2004b), distinction (e.g., EFs are different from memory; Roche & Barnes, 1996), comparison (e.g., "this" training program is better than "that" one; Y. Barnes-Holmes, Barnes-Holmes, Smeets, Strand, & Friman, 2004c), hierarchy (e.g., working memory is a type of EF; Y. Barnes-Holmes & Rehfeldt, 2009), perspective taking or deixis (e.g., I vs. you, here vs. there, and now vs. then; Y. Barnes-Holmes, McHugh, & Barnes-Holmes, 2004d), and causality (e.g., practicing a skill causes an improvement; Blackledge, 2003). Complexity in relational responding begins to increase when responses become *derived* and *arbitrarily applicable* (Y.

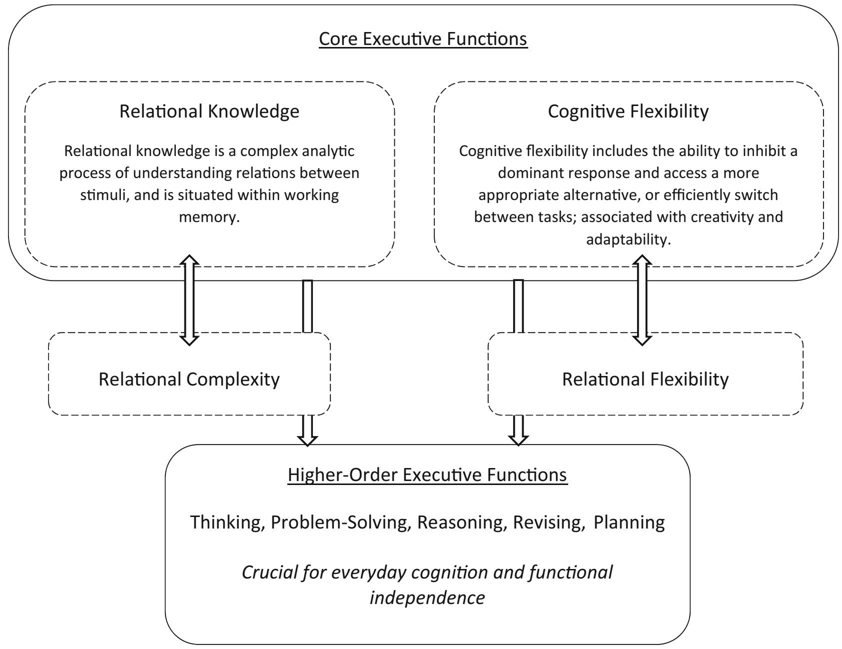

Fig. 1 A representation of executive functions (EFs) as described in-text; including core EFs of relational knowledge and cognitive flexibility. The figure depicts that these core EFs are necessary for higher order EFs, which in turn are important for everyday cognition and functional independence. The figure also suggests that relational complexity and relational flexibility, as described by RFT, are interrelated with relational knowledge and cognitive flexibility. Note that this figure does not depict all executive functions, only those relevant to this paper

Barnes-Holmes, Barnes-Holmes, & Murphy, 2004a; Hayes et al., 2001).

A relational response is *derived* when the response to stimulus relations has not been explicitly taught or has no history of direct reinforcement (Gorham, Barnes-Holmes, Barnes-Holmes, & Berens, 2009). For example, if you learn that A = B and B = C, you are likely to derive without further instruction that B = A and C = B (termed *mutual entailment*) and A = C and C = A (termed *combinatorial entailment*). This example deals with stimuli that are considered equivalent and thus refers to a simple relational frame of coordination. Exposure to multiple exemplars of different relational frames, as described previously, allows for the emergence of the operant response class of derived relational responding (D. Barnes-Holmes et al., 2000). Levels of derivation can range from high to low, depending on how well practiced a pattern of relational responding has become (see Supplemental Figure 1). For example, the first time an individual derives C = A when exposed to A = B = C, derivation is high, but as this relationship becomes more practiced and less novel, the level of derivation decreases (D. Barnes-Holmes, Barnes-Holmes, Hussey, & Luciano, 2016). A relational response is *arbitrary* when the response is not based on any physical properties of the stimuli in question. In the operant behavior of arbitrarily applicable relational responding (AARRing), the type of relation that is derived is specified by contextual cues (e.g., more than, less than), rather than just by the physical properties of the stimuli (Hayes et al., 2001). For example, someone may be deemed "the bigger person" after walking away from an argument with another, but we understand that this comparison is not related to physical size; it is a relational response that is arbitrarily applied.

Relational responding may be established in verbally able individuals, but relational repertoires typically vary in terms of *complexity* and *flexibility* (D. Barnes-Holmes, Barnes-Holmes, Luciano, & McEnteggart, 2017; see Supplemental Figure 1). *Complexity* refers to "the intricacy or density of a pattern of relational responding" (D. Barnes-Holmes et al., 2017, p. 438) and takes into account the number of relations, stimuli, transformation of functions, and varieties of contextual control (D. Barnes-Holmes et al., 2016; Hughes & Barnes-Holmes, 2016). For example, a combinatorially entailed relation (i.e., A = B; B = C ➔ C = A) is more complex than a mutually entailed relation (A = B ➔ B = A), a combinatorially entailed relation involving four stimuli (A = B; B = C; C = D ➔ D = A) is more complex than one involving three (A = B; B = C ➔ C = A), and relating relations (A1 = B1; B1 = C1 ➔ C1 = A1: A2 = B2; B2 = C2 ➔ C2 = A2) is more complex than mutually entailing them (A = B ➔ B = A; D. Barnes-Holmes et al., 2016; D. Barnes-Holmes et al., 2017). The following example shows the differences in relational complexity between mutually entailing and relating relational networks: A girl is showing her grandmother how to look up information online. The girl says, "This is a laptop," and shows her grandmother her portable computer. Now the word *laptop* enters into a frame of coordination with the portable computer, and later, upon seeing the portable computer, the grandmother can tact the object "laptop." This level of relational responding (mutually entailing) is low in complexity. Now consider that the grandmother tells her friend that her granddaughter has taught her to "surf the net." This metaphor, as explained by Hughes and Barnes-Holmes (2016, p. 192), involves two events that participate in separate relational networks that are entered into a frame of coordination with one another (i.e., surfing waves in the ocean is similar to looking up information on the Internet). The two relational networks have a variety of psychological functions, and the relating of these two networks leads to the functions of one (surfing in the ocean) transforming the functions of the other (surfing the Internet). The friend might now derive that the grandmother was delving in and out of "waves" of information on the Internet, which was challenging but enjoyable, similar to surfing in the ocean (see Hughes & Barnes-Holmes, 2016). This level of relational responding (relating relational networks) is high in complexity. Complexity therefore increases as responses change from nonarbitrary to arbitrary, as the number and type of relations increase, and as one moves from basic to more complex frames, taking also into account the transformation of functions and variations of contextual control.

Numerous RFT studies have provided empirical evidence of complex relational responding (AARRing) across all relational frames (Dymond et al., 2010; M. O'Connor et al., 2017). Studies suggest that relational-responding ability might be related to IQ (Dixon, Carman, et al., 2014a; Dixon, Whiting, Rowsey, & Belisly, 2014b) and that those with IDs have difficulty responding to relationally complex tasks (J. O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009b). In one study, participants who were better able to complete relational-responding tasks performed significantly better on vocabulary and arithmetic IQ subtests than others who failed to do so (O'Hora, Pelaez, & Barnes-Holmes, 2005). Two later studies reported significant between-group differences on standard IQ measures between participants who were exposed to relational-responding training and those who were not (Cassidy, Roche, & Hayes, 2011; Thirus, Starbrink, & Jansson, 2016). Correlational studies have also shown a relationship between relational-responding ability and improved performance on IQ measures (Cassidy, Roche, & O'Hora, 2010) for college students (Colbert, Dobutowitsch, Roche, & Brophy, 2017; O'Hora et al., 2005; O'Hora et al., 2008), typically developing children (Cassidy et al., 2011; Cassidy, Roche, Colbert, Stewart, & Grey, 2016; Vizcaino-Torres et al., 2015) and teenagers (Cassidy et al., 2016), children with autism (Kent, Galvin, Barnes-Holmes, Murphy, & Barnes-Holmes, 2017), and adults with IDs (Gore, Barnes-Holmes, & Murphy, 2010). Although some conflicting evidence exists for individual participants (Lyons & Murphy, 2013), the aforementioned results appear promising in that training in complex relational responding (AARRing) tends to result in improvements in tests of IQ. That said, it is unclear whether these results can be generalized to an older adult population, or whether higher IQ scores might translate to improvements in specific cognitive domains.

To date, there is only one known published study that implemented a relational training intervention with older adults with Alzheimer's disease (Presti, Salvatore, Migliore, Roche, & Cumbo, 2017). Twenty-six participants were randomized into two groups and either received medication alone (cholinesterase inhibitors, ChEIs) or medication plus 1 hr of multiple-exemplar relational training (ChEIs + RFT) once per week for 3 months. Relational training was presented using the Strengthening Mental Abilities with Relational Training (SMART; Cassidy et al., 2011) program, which includes training in stimulus equivalence and in same/opposite and more-than/less-than relations. The results showed significant pre- to postintervention improvements for the ChEIs + RFT group on measures of global cognition (Milan Overall Dementia Assessment; Brazzelli, Capitani, Della Sala, Spinnler, & Zuffi, 1994) and nonverbal intelligence (Coloured Progressive Matrices; Muniz, Gomes, & Pasian, 2016), as well as significant postintervention difference scores between groups (i.e., ChEIs + RFT vs. ChEIs) in favor of the RFT group. Although the results are preliminary, they are encouraging and support further investigation into the effects of relational training on older adults' cognition. It is unclear what the exact nature of the training entailed for each participant, but the SMART program typically trains relational responses that increase in complexity. If this was the case for participants with Alzheimer's disease, the data lend further support to the suggestion that complex relational responding might be related to cognition.

Relational flexibility refers to "the extent to which a particular pattern of AARRing may be modified by a contextual variable" (D. Barnes-Holmes et al. 2017, p. 438), or one's ability to respond rapidly to changing contingencies in a way that coheres with or contradicts previously established verbal relations (D. Barnes-Holmes, Barnes-Holmes, & Stewart, 2010; O'Toole, Barnes-Holmes, Murphy, O'Connor, & Barnes-Holmes, 2009). For example, in a standard Implicit Relational Assessment Procedure (IRAP; D. Barnes-Holmes et al., 2010; Finn, Barnes-Holmes, & McEnteggart, 2018; Hussey, Barnes-Holmes, & Barnes-Holmes, 2015), two patterns of responding are required: one consistent and the other inconsistent with previously established relations. Participants who can alternate their response patterns to respond quickly and accurately on both consistent and inconsistent trials demonstrate relational flexibility. For example, during consistent trials in one IRAP study, participants were required to select "True" when presented with the words "Table," "Cat" ➔ "Different" and "False" when presented with "Table," "Cat" ➔ "Similar." On inconsistent trials, participants were required to select "False" for "Table," "Cat" ➔ "Different" and "True" for "Table," "Cat" ➔ "Similar" (O'Toole & Barnes-Holmes, 2009). Relational flexibility was shown when participants could readily switch back and forth (i.e., maintaining speed and accuracy) between the opposing patterns of AARRing (see also Barbero-Rubio, López-López, Luciano, & Eisenbeck, 2016).

Although fewer studies tend to focus on the relationship between relational *flexibility* and IQ or cognition (compared to complexity), RFT researchers have argued that relational flexibility is central to the development of increasingly superior cognitive performances and that those with higher IQ scores demonstrate a greater degree of relational flexibility (O'Toole & Barnes-Holmes, 2009; O'Toole et al., 2009). A recent single-subject design study provided some preliminary supportive data that relational flexibility might improve IQ (Murphy, Lyons, Kelly, Barnes-Holmes, & Barnes-Holmes, 2018). The researchers used the Teaching-IRAP, or T-IRAP, to teach same/different relational skills with arbitrary and nonarbitrary stimuli and included contingency reversals to promote flexibility. In the contingency reversals, previously taught coordination and distinction relations were taught in reverse (e.g., contingencies of reinforcement and corrective feedback were reversed so that "different" was reinforced in the presence of two similar stimuli, and "like" was reinforced in the presence of two different stimuli). In the double reversal, presented after the initial reversal, the original correct relations were taught again. Murphy et al. (2018) reported an improvement of 12–14 points from pre- to post-relational training in scores on standardized measures of IQ and verbal ability for only one participant, the participant who successfully completed arbitrary relational training with double contingency reversals. This research supports the suggestion that both complexity and flexibility in terms of AARRing may be important for increasing IQ scores, although more research is required to determine the individual or combined effects of each.

The evidence outlined previously suggests that a cognitive training intervention targeting complex and flexible relational responding might improve IQ. Although fluid IQ is strongly related to the core EF of working memory (Kane, Hambrick, & Conway, 2005; Shipstead, Harrison, & Engle, 2016), this alone does not present a strong enough argument to suggest that the aforementioned interventions would directly improve core EFs and generalize to older adults' everyday cognition and functional outcomes. In the next section, therefore, evidence from cognitive literature is presented to suggest that a cognitive training intervention aimed at improving complex and flexible relational responding could target core EFs. Specifically, the argument will be made that relational complexity (AARRing) and relational flexibility, as described by RFT, are synonymous with relational knowledge (in working memory) and cognitive flexibility, which are identified as core EFs in the cognitive science literature (Braver, Paxton, Locke, & Barch, 2009; Deak, 2003; Halford, Wilson, & Phillips, 2010). If relational complexity and flexibility can be compared to the core EFs of relational knowledge and cognitive flexibility, then cognitive training interventions focusing on relational complexity and flexibility might improve core EFs for older adults.

Relational Knowledge and Relational Complexity

Descriptions of relational knowledge in the cognitive literature share similarities with RFT's descriptions of complex relational responding. Recall that relational responding begins to increase in complexity when it becomes derived (e.g., in instances of combinatorial entailment) and arbitrarily applicable (e.g., not based on simple physical associations). Relational knowledge has been described as

> relational representations that can be conceptualized as a binding between a relation symbol and a set of ordered . . . elements. The symbol specifies which relation is intended (e.g. larger than) and the ordered sets (e.g. horse, dog) represent an extension of the relation. The representations can be knowledge learned by experience . . . and can provide statistical knowledge of the world. (Halford et al., 2010, p. 497)

The symbol as described above is referred to as a contextual cue in RFT terms, and the example of "horse larger than dog" is explained in RFT as the relational frame of comparison. Halford et al. (2010) go on to describe and visually depict a "transitive inference" (p. 498) and explain what is known in RFT terms as combinatorial entailment. Finally, the authors distinguish relational knowledge from other forms of cognition, such as association or more automatic processes that are nonanalytic (Halford et al., 2010). These nonanalytic associations are synonymous with nonarbitrary associations, whereas relational knowledge is thought to require more complex analytic processes based on arbitrary "symbols," as in complex relational responding or AARRing.

Based on these observations, it is argued that relational knowledge is either equivalent to or at least very closely related to complex relational responding. Relational knowledge, as described in the cognitive sciences literature, is constructed within and dependent on the core EF process of working memory (Andrews, Birney, & Halford, 2006; Halford, Wilson, & Phillips, 1998; Oberauer, 2009). Evidence from empirical research and computational modeling indicates that relational knowledge plays a crucial role in higher order EFs (Halford et al., 2010; Halford, Andrews, & Wilson, 2015). This is supported by neuroscientific evidence that shows that brain areas known to be involved in higher order EFs are activated by processing relations (Golde, von Cramon, & Schubotz, 2010; Halford et al., 2010). If relational knowledge is constructed within core EF processes and plays a crucial role in higher order EFs, and complex relational responding is synonymous with relational knowledge, then a cognitive training intervention that targets relational complexity might be useful in improving older adults' EFs, which in turn may improve everyday cognition and functional independence.

Cognitive Flexibility and Relational Flexibility

Cognitive flexibility is another core EF and is deemed the "hallmark" of human intelligence (Diamond, 2013). *Cognitive flexibility* refers to the ability to inhibit a dominant response preference when that response is inappropriate and access more remote alternatives that may be more effective (Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007). *Relational flexibility* also refers to this ability but specifically in terms of relational responses under the control of contextual variables. For example, the faster an individual can respond to relations that contradict previously well-established verbal relations, the more flexible their behavior of relational responding (Barnes-Holmes, Barnes-Holmes, Hussey, & Luciano, 2016; O'Toole & Barnes-Holmes, 2009). Cognitive flexibility and relational flexibility have each been considered useful for creative thinking, perspective taking and theory of mind, flexibly adjusting to new rules, and adapting to changing situations (Y. Barnes-Holmes & McEnteggart, 2015; Y. Barnes-Holmes, McHugh, & Barnes-Holmes, 2004d; Diamond, 2013; Jacques & Zelazo, 2005), and the terms have even been used interchangeably (O'Toole & Barnes-Holmes, 2009; O'Toole et al., 2009). As with relational flexibility, Deak (2003) states that language enhances and permits the expression of cognitive flexibility (p. 272), and cognitive flexibility (Checa & Fernández-Berrocal, 2015; Dresler et al., 2013) and relational flexibility (Murphy et al., 2018; O'Toole et al., 2009) are both related to IQ.

Cognitive rigidity, on the other hand, refers to difficulty in mentally adapting to new demands, situations, or information (Cohen, 2017) and is converse to cognitive flexibility. Cognitive rigidity can interfere with learning and is associated with IDs, and with behavioral excesses and deficits in individuals with diagnosed autism (Poljac, Hoofs, Princen, & Poljac, 2017), attention-deficit/hyperactivity disorder (Capilla Gonzalez et al., 2004), and schizophrenia (Mosiołek, Gierus, Koweszko, & Szulc, 2016). Interestingly, those with rigid cognitive repertoires also tend to have deficient relational flexibility skills; evidence from populations including typically developing children, children with autism (Jackson, Mendoza, & Adams, 2014; Murphy & Barnes-Holmes, 2009a, 2009b, 2010; Murphy, Barnes-Holmes, & Barnes-Holmes, 2005; J. O'Connor, Barnes-Holmes, & Barnes-Holmes, 2011; Rehfeldt & Barnes-Holmes, 2009), and individuals with schizophrenia (O'Neill & Weil, 2014) shows that where relational flexibility is deficient or absent, training using computerized behavioral methodologies such as the IRAP can significantly improve relational flexibility and complexity (Kilroe et al., 2014; Murphy et al., 2018). Taken together, the evidence presented previously suggests that relational and cognitive flexibility are comparable, or perhaps relational flexibility is a type of cognitive flexibility.

In summary, evidence from the cognitive literature supports the idea that training in complex and flexible relational responding might improve older adults' cognition in a socially significant way. Specifically, if we can compare relational complexity and relational flexibility to the core EF processes of relational knowledge and cognitive flexibility (Braver et al., 2009), which are known to provide a basis for higher order EFs (Collins & Koechlin, 2012), and higher order EFs are required for healthy cognition and functional independence (Diamond, 2013), then training complex and flexible relational repertoires might improve cognitive and functional outcomes for older adults.

A Research Opportunity for Behavior Analysts

Over 350 empirical (and 345 nonempirical) RFT-based research papers have been published between 1991 and 2016 (Dymond et al., 2010; M. O'Connor et al., 2017), but none of these have examined the relationship between complex and flexible relational responding and older adults' cognition. Since then, only one known published study has implemented relational training with older adults with Alzheimer's disease (Presti et al., 2017). Further research is required to replicate the findings of Presti et al. (2017) and to provide empirical data to support the theoretical connection linking the concepts of relational complexity and flexibility to relational knowledge and cognitive flexibility. These gaps in the RFT literature present a pertinent research opportunity, as findings could have implications for a behavioral approach to promoting improved cognition and functional outcomes for healthy older adults and those experiencing cognitive decline.

There are a number of options available for the format that a relational training intervention might take, including tabletop training, the SMART program (Cassidy et al., 2016), the T-IRAP (Kilroe et al., 2014), or the more advanced and recently adapted Ghent-Odysseus IRAP (GO-IRAP; Murphy & Barnes-Holmes, 2017). Take for example the GO-IRAP, which was designed to train and assess AARRing; this computerized program can facilitate the presentation of sample stimuli (words or pictures), target words or pictures, and relational terms all on-screen at once (Fig. 2), and the complexity of trials can be adapted as the program proceeds. The participant can respond at his or her own pace throughout the procedure and can compete with his or her own scores using fluency data. The GO-IRAP can therefore train and test flexibility and complexity of patterns of AARRing (D. Barnes-Holmes et al., 2017). The benefit of this approach over others is that it is more efficient than the tabletop method (Kilroe et al., 2014; Murphy et al., 2018), it is freely available (at https://go-rft.com/go-irap/), and the selection and presentation of stimuli can be adapted based on participants' individual requirements (Murphy & Barnes-Holmes, 2017).

Into the GO-IRAP, one could incorporate the recently developed multidimensional multilevel (MDML) theoretical

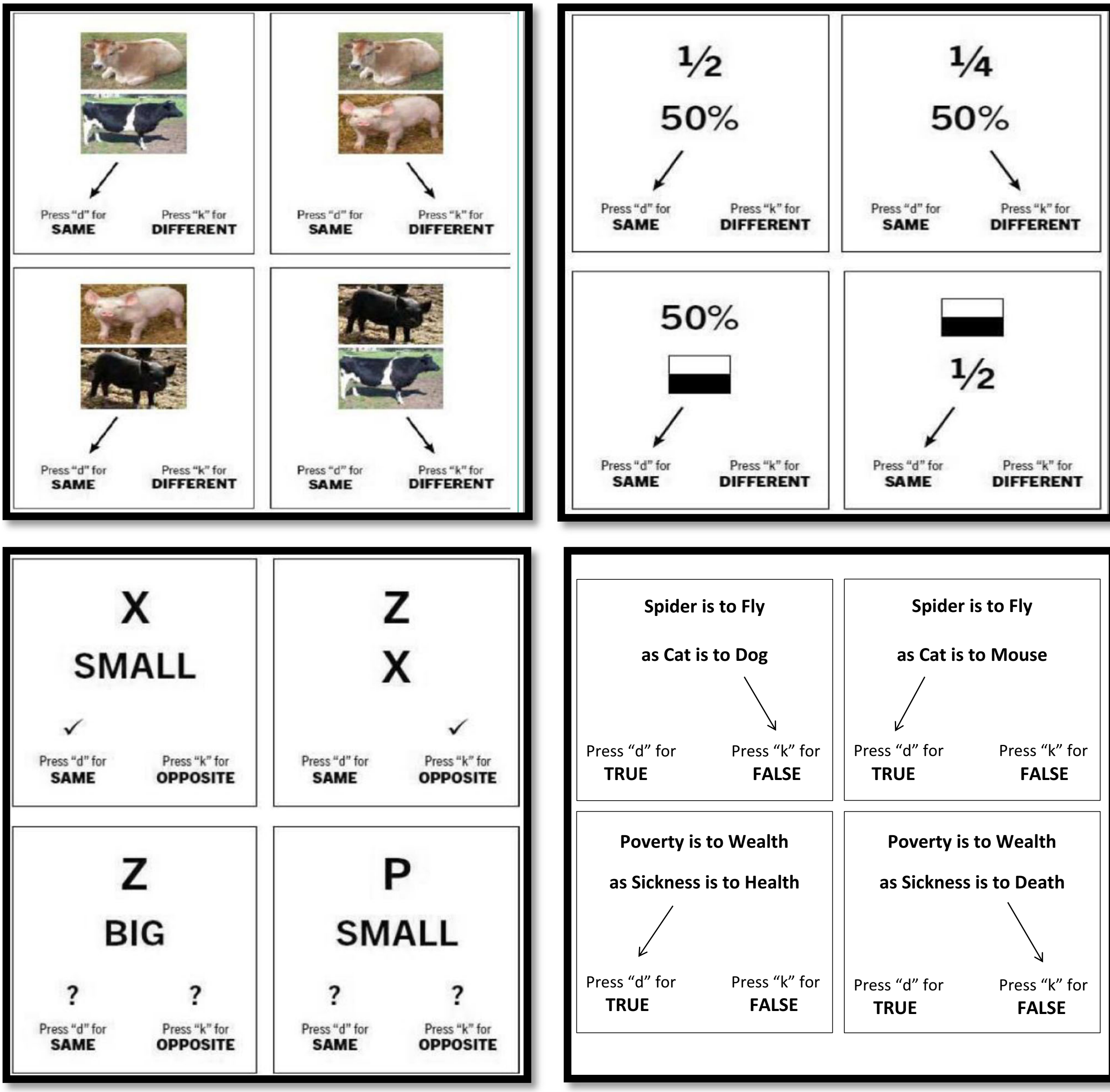

Fig. 2 Possible Ghent-Odysseus Implicit Relational Assessment Procedure (GO-IRAP) trials in a relational training intervention. Each screen shows increasing levels of relational complexity, from nonarbitrary coordination relations (top left), to arbitrary coordination relations (top right), relational framing with derived arbitrary comparative relations (bottom left), and relating relations/analogical reasoning (bottom right). Contingency reversals can be built in to promote flexibility (e.g., require correct responding first, then require incorrect responding). The first three panels are reprinted from "Teaching Important Relational Skills for Children With Autism Spectrum Disorder and Intellectual Disability Using Freely Available (GO-IRAP) Software," by C. Murphy and D. Barnes-Holmes, 2017, *Austin Journal of Autism and Related Disabilities*, *3*, 1041–1047. Copyright 2017 by Murphy et al. Reprinted with permission.; Top left: "Nonarbitrary coordination relations (e.g., select SAME when trial presents 2 pigs; select DIFFERENT when trial presents a pig and a cow)" (p. 1042); top right: "Arbitrary coordination relations (e.g., select SAME when trial presents 50% with the symbol indicating half, and select DIFFERENT when trial presents 50% with ¼)" (p. 1043); bottom left: "Derived arbitrary comparative relations (DRR) based on SAME-OPPOSITE relations: Participants were taught relations: X same-as SMALL, Z same-as P, Z opposite to X. Test trial for DRR depicted in graphic: Z same or opposite to BIG? P same or opposite to SMALL? DRR response based on taught relations is Z and P are both same-as BIG" (p. 1044). The bottom-right panel (newly devised) requires relating relations (e.g., select TRUE when the analogy is correct and FALSE when the analogy is incorrect)

framework for analyzing AARRing (D. Barnes-Holmes et al., 2017; D. Barnes-Holmes, Finn, McEnteggart, & Barnes-Holmes, 2018). The MDML framework provides a description of the dimensions and levels of relational responding (D.

Barnes-Holmes et al., 2017). According to the MDML framework, the dimensions of relational responding include coherence, complexity, derivation, and flexibility. D. Barnes-Holmes et al. (2018) explain that *coherence* is the extent to which the elements of the derived relation are consistent with what has previously been learned. As described previously, complexity refers to the intricacy or density of the pattern of AARRing (e.g., low complexity: A = B; B = C ➔ A = C, whereas higher complexity: A = B; B = C; C = D ➔ A = D, and higher again: A opposite of B; B same as C; C opposite of D ➔ A same as D), derivation refers to how well practiced AARRing has become, and relational flexibility refers to the extent to which a pattern of AARRing can be modified by a contextual variable. The complexity of a relational task increases as one moves down the five levels of relational responding (see Supplemental Table 2) from mutually entailing to relating relational networks (see D. Barnes-Holmes et al., 2017, for an explanation of each). A cognitive training intervention aimed at improving responses to relationally complex tasks, therefore, might initially train increasingly dense patterns of AARRing within the first level of "mutually entailing," and then repeat this process for each of the subsequent levels of relational responding, down to relating relational networks. To target relational flexibility, participants could be required to fluently switch back and forth between opposing patterns of AARRing in the GO-IRAP. The MDML model therefore presents a template for training relational complexity and flexibility that could be incorporated into the GO-IRAP and presented as a cognitive training intervention to target improvement in core EFs. In order to assess intervention effects, one might consider conducting an assessment of relational complexity and flexibility and then comparing the results to outcomes on standardized measures of relational knowledge, cognitive flexibility, and global cognition and everyday functioning.

To further describe how the intervention and assessment might work, consider the following example: A female participant, aged 65, has a formal diagnosis of MCI and scores 24 on the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975). She reports difficulty with planning and organizing, such as weekly scheduling and preparing family meals. Baseline and postintervention assessments might consist of (a) a standard IRAP task with contingency reversals to measure relational flexibility, in which the presentation of stimuli could vary in complexity, with the percentage accuracy score used to determine relational complexity (this requires further investigation); (b) standardized measures of global cognition (e.g., the Montreal Cognitive Assessment; Nasreddine et al., 2005), cognitive flexibility (e.g., the Wisconsin Card Sorting Test; Berg, 1948), and relational knowledge (e.g., the Latin square task; Birney, Halford, & Andrews, 2006); (c) a subjective measure of daily functioning (e.g., instrumental activities of daily living; Graf, 2008); and (d) a practical measure of behavior such as event recording of the number of instances of planning/organizing errors (to be operationally defined). For the intervention, training in the participant's home may increase adherence and reduce the risk of attrition. A GO-IRAP relational training task could be presented on the researcher's laptop, for 1 hr per week for 3 months (as per Presti et al., 2017). The intervention should incorporate contingency reversals and present increasingly complex relations (see sample in Fig. 2). For example, training might initially require nonarbitrary followed by arbitrary relational responding, and then derived relational responding (presenting various examples of coordination, opposition, distinction, hierarchy, etc., at each stage). Using the MDML model, then, training might require mutually entailed AARRing initially, followed by relational framing (bottom-left panel, Fig. 2), relational networking, relating relations (bottom-right panel, Fig. 2; see also Dennehy, Murphy, Barnes-Holmes, & Kelly, 2017), and relating relational networks. Data generated from the GO-IRAP would include percentage accuracy and response latency scores.

When contemplating methodological approaches to assessing the efficacy of relational training interventions, behavior analysts should consider high-quality designs, standards of reporting, and advancing analytic techniques. Single-case experimental design (SCED) is a commonly used design within behavior analysis and in neurorehabilitation literature and is particularly useful when examining intricacies regarding important or novel features of an intervention and/or target population. If SCED is to be employed, researchers should utilize resources aimed at improving both methodological quality (e.g., the SCED Scale; Tate, Mcdonald, Perdices, Togher, Schultz, & Savage, 2008) and standards of reporting (e.g., the Single-Case Reporting Guidelines in Behavioral Interventions; Tate, Perdices M, Rosenkoetter, Shadish, Vohra, Barlow, Horner, Kazdin, Kratochwill, McDonald, Sampson, Shamseer, Togher, Albin, Backman, Douglas, Evans, Gast, Manolov, Mitchell & Wilson, 2017; see also Horner, Carr, Halle, McGee, Odom, & Wolery, (2005); Kratochwill, Hitchcock, Horner, Levin, Odom, Rindskopf, & Shadish, 2013). In terms of analysis, options for analyzing SCED data have been growing steadily over the past few years (Manolov & Moeyaert, 2017b). Techniques now extend beyond visual analysis to permit statistical analysis and synthesis of data in meta-analyses (Manolov & Moeyaert, 2017b). An article published in *Behavior Modification* presented a tutorial on recent approaches and software developments for quantitative analysis of SCED data (Manolov & Moeyaert, 2017a) and illustrated "how visual and quantitative analyses can be used jointly, giving complementary information and helping the researcher decide whether there is an intervention effect, how large it is, and whether it is practically significant" (p. 179). If this kind of approach were implemented, it could hugely benefit our understanding of the impact of a relational training intervention on older adults' cognition and functional independence. If SCED data show an intervention effect, and important aspects of the intervention are clarified, similar rigor should be applied to large-*N* within- and between-groups designs to build an epidemiological and RCT evidence base. Sample sizes that are large enough to permit reliable results with greater precision and power are also an important consideration for RFT intervention studies (Biau, Kernéis, & Porcher, 2008).

Conclusion

Cognitive training research recommends that if training is to have any meaningful impact on older adults' everyday cognition and functional independence, interventions should target core EFs that play a crucial role in higher order EFs, such as relational knowledge in working memory and cognitive flexibility. Simultaneously, RFT research suggests that relational training can facilitate greater complexity and flexibility in relational responding, which may result in increasingly adaptive cognitive abilities. This article argues that the core EFs of relational knowledge and cognitive flexibility are synonymous with, or at least related to, relational complexity and relational flexibility. Because the former abilities have been shown to be core EFs, and the latter are suggested to be at the core of human language and cognition, a cognitive training intervention that employs RFT technology to train complex and flexible AARRing might improve everyday cognition and functional independence for healthy older adults or those experiencing cognitive decline. Currently, the specific nature of the relationship between relational responding and older adults' cognition is unclear, and requires further investigation. There are many possible avenues for future studies, including an examination of the nature and content of training, the outcomes that may be improved, and the population for whom the intervention may be most beneficial (i.e., older adults who are cognitively healthy or those with MCI or dementia). An investigation of these factors presents a novel and innovative opportunity for behavioral gerontology research. Behavioral methodologies and theoretical models already exist to guide the development of intervention strategies, as do guidelines to improve the quality of conducting, analyzing, and reporting SCED and group-design studies. The next step is to combine this knowledge into high-quality and informative studies to determine if an RFT-based intervention can improve cognitive and functional outcomes for older adults.

Acknowledgements Sincere thanks go to Dr. Amanda D. Kelly for her support in formulating the ideas that eventually led to this manuscript, to Profs. Dermot and Yvonne Barnes-Holmes for their assistance in discussing the design and feasibility of the intervention plans, and to the anonymous reviewers whose comments have served to greatly improve the revised manuscript.

Funding The author received no funding from any source for the writing of this manuscript.

Compliance with Ethical Standards

Conflict of Interest The author declares no conflict of interest.

References

Alexander, J. K., Hillier, A., Smith, R. M., Tivarus, M. E., & Beversdorf, D. Q. (2007). Beta-adrenergic modulation of cognitive flexibility during stress. *Journal of Cognitive Neuroscience, 19*(3), 468–478. https://doi.org/10.1162/jocn.2007.19.3.468.

Andrews, G., Birney, D., & Halford, G. S. (2006). Relational processing and working memory capacity in comprehension of relative clause sentences. *Memory & Cognition, 34*(6), 1325–1340. https://doi.org/10.3758/BF03193275.

Bahar-Fuchs, A., Martyr, A., Goh, A. M. Y., Sabates, J., & Clare, L. (2019). Cognitive training for people with mild to moderate dementia. *Cochrane Database of Systematic Reviews*, (3). https://doi.org/10.1002/14651858.CD013069.pub2.

Baker, J. C., Fairchild, K. M., & Seefeldt, D. A. (2015). Behavioral gerontology: Research and clinical considerations. In H. S. Roane, J. E. Ringdahl, & T. S. Falcomata (Eds.), *Clinical and organizational applications of applied behavior analysis* (pp. 425–450). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-420249-8.00017-4.

Barbero-Rubio, A., López-López, J. C., Luciano, C., & Eisenbeck, N. (2016). Perspective-taking measured by Implicit Relational Assessment Procedure (IRAP). *The Psychological Record, 66*(2), 243–252. https://doi.org/10.1007/s40732-016-0166-3.

Barnes, D. (1994). Stimulus equivalence and relational frame theory. *The Psychological Record, 44*(1), 91–124.

Barnes, D. E., & Yaffe, K. (2011). The projected effect of risk factor reduction on Alzheimer's disease prevalence. *Lancet Neurology, 10*(9), 819–828. https://doi.org/10.1016/s1474-4422(11)70072-2.

Barnes-Holmes, D., Barnes-Holmes, Y., & Cullinan, V. (2000). Relational frame theory and Skinner's *Verbal behavior*: A possible synthesis. *Behavior Analyst, 23*(1), 69–84. https://doi.org/10.1007/BF03392000.

Barnes-Holmes, D., Barnes-Holmes, Y., & Stewart, I. (2010). A sketch of the Implicit Relational Assessment Procedure (IRAP) and the relational elaboration coherence (REC) model. *The Psychological Record, 60*, 527–542. https://doi.org/10.1007/BF03395726.

Barnes-Holmes, P. M. D., Barnes-Holmes, Y., Hussey, I., & Luciano, C. (2016). Relational frame theory: Finding its historical and philosophical roots and reflecting upon its future development: an introduction to part II. In R. D. Zettle, S. C. Hayes, P. M. D. Barnes-Holmes, & A. Biglan (Eds.), *The Wiley handbook of contextual behavioral science* (pp. 115–128). West-Sussex: Wiley-Blackwell.

Barnes-Holmes, D., Barnes-Holmes, Y., Luciano, C., & McEnteggart, C. (2017). From the IRAP and REC model to a multi-dimensional multi-level framework for analyzing the dynamics of arbitrarily applicable relational responding. *Journal of Contextual Behavioral Science, 6*(4), 434–445. https://doi.org/10.1016/j.jcbs.2017.08.001.

Barnes-Holmes, D., Finn, M., McEnteggart, C., & Barnes-Holmes, Y. (2018). Derived stimulus relations and their role in a behavior-analytic account of human language and cognition. *Perspectives on Behavior Science, 41*(1), 155–173. https://doi.org/10.1007/s40614-017-0124-7.

Barnes-Holmes, Y., & McEnteggart, C. (2015). Behavior analysis and the treatment of human psychological suffering. In H. S. Roane, J. L. Ringdahl, & T. S. Falcomata (Eds.), *Clinical and organizational applications of applied behavior analysis* (pp. 451–475). San Diego, CA: Academic Press.

Barnes-Holmes, Y., & Rehfeldt, R. A. (2009). *Derived relational responding: Application for learners with autism and other developmental disabilities*. Oakland, CA: New Harbinger.

Barnes-Holmes, Y., Barnes-Holmes, D., & Murphy, C. (2004a). Teaching the generic skills of language and cognition: Contributions from relational frame theory. In D. Moran & R. W. Malott (Eds.), *Evidence-based educational methods* (pp. 277–293). San Diego, CA: Academic Press.

Barnes-Holmes, Y., Barnes-Holmes, D., & Smeets, P. M. (2004b). Establishing relational responding in accordance with opposite as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*(3), 559–586.

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, P. M., Strand, P., & Friman, P. (2004c). Establishing relational responding in accordance with more-than and less-than as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*(3), 531–558.

Barnes-Holmes, Y., McHugh, L., & Barnes-Holmes, D. (2004d). Perspective-taking and theory of mind: A relational frame account. *The Behavior Analyst Today, 5*(1), 15–25. https://doi.org/10.1037/h0100133.

Beck, J. G. (1997). Miniseries. [Special issue]. *Behavior Therapy, 28*, 1.

Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *The Journal of General Psychology, 39*, 15–22. https://doi.org/10.1080/00221309.1948.9918159.

Biau, D. J., Kernéis, S., & Porcher, R. (2008). Statistics in brief: The importance of sample size in the planning and interpretation of medical research. *Clinical Orthopaedics and Related Research, 466*(9), 2282–2288. https://doi.org/10.1007/s11999-008-0346-9.

Birney, D. P., Halford, G. S., & Andrews, G. (2006). Measuring the influence of complexity on relational reasoning: The development of the Latin square task. *Educational and Psychological Measurement, 66*(1), 146–171. https://doi.org/10.1177/0013164405278570.

Blackledge, J. T. (2003). An introduction to relational frame theory: Basics and applications. *The Behavior Analyst Today, 3*(4), 421–433. https://doi.org/10.1037/h0099997.

Braver, T. S., Paxton, J. L., Locke, H. S., & Barch, D. M. (2009). Flexible neural mechanisms of cognitive control within human prefrontal cortex. *Proceedings of the National Academy of Sciences, 106*(18), 7351–7356. https://doi.org/10.1073/pnas.0808187106.

Brazzelli, M., Capitani, E., Della Sala, S., Spinnler, H., & Zuffi, M. (1994). A neuropsychological instrument adding to the description of patients with suspected cortical dementia: The Milan Overall Dementia Assessment. *Journal of Neurology, Neurosurgery, and Psychiatry, 57*(12), 1510–1517. https://doi.org/10.1136/jnnp.57.12.1510.

Buchanan, J. A., Husfeldt, J., Berg, T., & Houlihan, D. (2008). Publication trends in behavioral gerontology in the past 25 years: Are the elderly still an understudied population in behavioral research? *Behavioral Interventions, 23*(1), 65–74. https://doi.org/10.1002/bin.254.

Buchanan, J. A. (2018). Introduction to the special issue on behavior analysis and aging. *Behavior Analysis: Research and Practice, 18*(1), 1–3. https://doi.org/10.1037/bar0000120.

Burch, D. (2014). What could computerized brain training learn from evidence-based medicine? *PLoS Medicine, 11*(11), e1001758. https://doi.org/10.1371/journal.pmed.1001758.

Burgio, L. D., & Burgio, K. L. (1986). Behavioral gerontology: Application of behavioral methods to the problems of older adults. *Journal of Applied Behavior Analysis, 19*, 321–328. https://doi.org/10.1901/jaba.1986.19-321.

Burgio, L., & Kowalkowski, J. D. (2011). Alive and well: The state of behavioral gerontology in 2011. *Behavior Therapy, 42*(1), 3–8. https://doi.org/10.1016/j.beth.2010.08.003.

Capilla Gonzalez, A., Etchepareborda, M. C., Fernandez Gonzalez, S., Mulas, F., Campo, P., Maestu, F., et al. (2004). The neurofunctional foundation of cognitive rigidity in attention deficit hyperactivity disorder: Some preliminary findings. *Revista de Neurologia, 38*(Suppl. 1), S145–S148.

Cassidy, S., Roche, B., & O'Hora, D. (2010). Relational frame theory and human intelligence. *European Journal of Behavior Analysis, 11*(1), 37–51. https://doi.org/10.1080/15021149.2010.11434333.

Cassidy, S., Roche, B., & Hayes, S. C. (2011). A relational frame training intervention to raise intelligence quotients: A pilot study. *The Psychological Record, 61*(2), 173–198. https://doi.org/10.1007/BF03395755.

Cassidy, S., Roche, B., Colbert, D., Stewart, I., & Grey, I. M. (2016). A relational frame skills training intervention to increase general intelligence and scholastic aptitude. *Learning and Individual Differences, 47*, 222–235. https://doi.org/10.1016/j.lindif.2016.03.001.

Chan, R. C. K., Shum, D., Toulopoulou, T., & Chen, E. Y. H. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology, 23*(2), 201–216. https://doi.org/10.1016/j.acn.2007.08.010.

Checa, P., & Fernández-Berrocal, P. (2015). The role of intelligence quotient and emotional intelligence in cognitive control processes. *Frontiers in Psychology, 6*, 1853. https://doi.org/10.3389/fpsyg.2015.01853.

Chung, W., Poppen, R., & Lundervold, D. A. (1995). Behavioral relaxation training for tremor disorders in older adults. *Biofeedback and Self-Regulation, 20*(2), 123–135. https://doi.org/10.1007/BF01720969.

Clare, L. (2008). *Neuropsychological Rehabilitation: A Modular Handbook*. New York: Psychology Press.

Cohen, S. J. (2017). Cognitive rigidity, overgeneralization and fanaticism. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 1–7). Cham, Switzerland: Springer International Publishing.

Colbert, D., Dobutowitsch, M., Roche, B., & Brophy, C. (2017). The proxy-measurement of intelligence quotients using a relational skills abilities index. *Learning and Individual Differences, 57*, 114–122. https://doi.org/10.1016/j.lindif.2017.03.010.

Collins, A., & Koechlin, E. (2012). Reasoning, learning, and creativity: Frontal lobe function and human decision-making. *PLoS Biology, 10*(3), e1001293. https://doi.org/10.1371/journal.pbio.1001293.

Deak, G. O. (2003). The development of cognitive flexibility and language abilities. *Advances in Child Development and Behavior, 31*, 271–327. https://doi.org/10.1016/s0065-2407(03)31007-9.

Dennehy, J., Murphy, C., Barnes-Holmes, D., & Kelly, M. (2017). *Combining modern behavioural applications (RFT/ PEAK/ T-IRAP/ ABA) to teach relational responding to children with autism.* (Unpublished doctoral dissertation). Maynooth University, Kildare, Ireland.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750.

Dixon, M. R., Carman, J., Tyler, P. A., Whiting, S. W., Enoch, M. R., & Daar, J. H. (2014a). PEAK Relational Training System for children with autism and developmental disabilities: Correlations with Peabody Picture Vocabulary Test and assessment reliability. *Journal of Developmental and Physical Disabilities, 26*(5), 603–614. https://doi.org/10.1007/s10882-014-9384-2.

Dixon, M. R., Whiting, S. W., Rowsey, K., & Belisly, J. (2014b). Assessing the relationship between intelligence and the PEAK Relational Training System. *Research in Autism Spectrum Disorders, 8*(9), 1208–1213. https://doi.org/10.1016/j.rasd.2014.05.005.

Dresler, M., Sandberg, A., Ohla, K., Bublitz, C., Trenado, C., Mroczko-Wasowicz, A., et al. (2013). Non-pharmacological cognitive enhancement. *Neuropharmacology, 64*, 529–543. https://doi.org/10.1016/j.neuropharm.2012.07.002.

Dymond, S., May, R. J., Munnelly, A., & Hoon, A. E. (2010). Evaluating the evidence base for relational frame theory: A citation analysis. *The Behavior Analyst, 33*(1), 97–117. https://doi.org/10.1007/BF03392206.

Finn, M., Barnes-Holmes, P. M. D., & McEnteggart, C. (2018). Exploring the single-trial-type-dominance-effect in the IRAP : developing a differential arbitrarily applicable relational responding effects (DAARRE) model. *Psychological Record, 68*(1), 11–25. https://doi.org/10.1007/s40732-017-0262-z.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189–198. https://doi.org/10.1016/0022-3956(75)90026-6.

Fratiglioni, L., & Qiu, C. (2011). Prevention of cognitive decline in ageing: Dementia as the target, delayed onset as the goal. *Lancet Neurology, 10*(9), 778–779. https://doi.org/10.1016/s1474-4422(11)70145-4.

Galizio, M. (2003). The abstracted operant: A review of *Relational frame theory: A post-Skinnerian account of human language and cognition*. *The Behavior Analyst, 26*(1), 159–169. https://doi.org/10.1007/BF03392074.

García-Madruga, J. A., Gómez-Veiga, I., & Vila, J. Ó. (2016). Executive Functions and the Improvement of Thinking Abilities: The Intervention in Reading Comprehension. *Frontiers in Psychology, 7*(58), 1–15. https://doi.org/10.3389/fpsyg.2016.00058.

Gates, N. J., & Sachdev, P. (2014). Is cognitive training an effective treatment for preclinical and early Alzheimer's disease? *Journal of Alzheimer's Disease, 42*, S551–S559. https://doi.org/10.3233/JAD-141302.

Gates, N. J., Vernooij, R. W. M., Di Nisio, M., Karim, S., March, E., Martínez, G., & Rutjes, A. W. S. (2019). Computerised cognitive training for preventing dementia in people with mild cognitive impairment. *Cochrane Database of Systematic Reviews, 3*. https://doi.org/10.1002/14651858.CD012279.pub2.

Golde, M., von Cramon, D. Y., & Schubotz, R. I. (2010). Differential role of anterior prefrontal and premotor cortex in the processing of relational information. *Neuroimage, 49*(3), 2890–2900. https://doi.org/10.1016/j.neuroimage.2009.09.009.

Gore, N. J., Barnes-Holmes, Y., & Murphy, G. (2010). The relationship between intellectual functioning and relational perspective-taking. *International Journal of Psychology and Psychological Therapy, 10*(1), 1–17.

Gorham, M., Barnes-Holmes, Y., Barnes-Holmes, D., & Berens, N. (2009). Derived comparative and transitive relations in young children with and without autism. *The Psychological Record, 59*(2), 221–246. https://doi.org/10.1007/BF03395660.

Graf, C. (2008). The Lawton Instrumental Activities of Daily Living Scale. *AJN: The American Journal of Nursing, 108*(4), 52–62. https://doi.org/10.1097/01.NAJ.0000314810.46029.74.

Gross, A. C., & Fox, E. J. (2009). Relational frame theory: An overview of the controversy. *The Analysis of Verbal Behavior, 25*(1), 87–98. https://doi.org/10.1007/bf03393073.

Gross, A. L., Rebok, G. W., Unverzagt, F. W., Willis, S. L., & Brandt, J. (2011). Word list memory predicts everyday function and problem-solving in the elderly: results from the ACTIVE cognitive intervention trial. N*europsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition, 18*(2), 129–146. https://doi.org/10.1080/13825585.2010.516814.

Halford, G. S., Wilson, W. H., & Phillips, S. (1998). Processing capacity defined by relational complexity: Implications for comparative, developmental, and cognitive psychology. *The Behavioral and Brain Sciences, 21*(6), 803–864. https://doi.org/10.1017/s0140525x98001769.

Halford, G. S., Wilson, W. H., & Phillips, S. (2010). Relational knowledge: The foundation of higher cognition. *Trends in Cognitive Science, 14*(11), 497–505. https://doi.org/10.1016/j.tics.2010.08.005.

Halford, G. S., Andrews, G., & Wilson, W. H. (2015). Relational processing in reasoning: The role of working memory. In A. Feeney & V. A. Thompson (Eds.), *Current issues in thinking and reasoning. Reasoning as memory* (pp. 34–52). New York: Psychology Press.

Harada, C. N., Natelson Love, M. C., & Triebel, K. (2013). Normal cognitive aging. *Clinics in Geriatric Medicine, 29*(4), 737–752. https://doi.org/10.1016/j.cger.2013.07.002.

Hayes, S. C., & Barnes-Holmes, D. (2004). Relational operants: Processes and implications: A response to Palmer's review of relational frame theory. *Journal of the Experimental Analysis of Behavior, 82*(2), 213–234. https://doi.org/10.1901/jeab.2004.82-213.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. E. (2001). *Relational frame theory: A post-Skinnerian account of Human Language and Cognition*. New York, NY: Plenum Press.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2003). Behavior analysis, relational frame theory, and the challenge of human language and cognition: A reply to the commentaries on *Relational frame theory: A post-Skinnerian account of human language and cognition*. *Analysis of Verbal Behavior, 19*, 39–54. https://doi.org/10.1007/BF03392981.

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children, 71*(2), 165–179. https://doi.org/10.1177/001440290507100203.

Houlihan, D., & Buchanan, J. (2011). Geriatric behavior therapy: The challenges of a changing environment. [Special issue]. *Behavior Therapy, 42*, 1.

Hussey, I., Barnes-Holmes, D., & Barnes-Holmes, Y. (2015). From Relational Frame Theory to implicit attitudes and back again: clarifying the link between RFT and IRAP research. *Current Opinion in Psychology, 2*, 11–15. https://doi.org/10.1016/j.copsyc.2014.12.009.

Hughes, S., & Barnes-Holmes, D. (2016). Relational frame theory: The basic account. In S. Hayes, D. Barnes-Holmes, R. Zettle, & T. Biglan (Eds.), *Handbook of contextual behavior science*. Wiley-Blackwell: New York, NY.

Jackson, M. L., Mendoza, D. R., & Adams, A. N. (2014). Teaching a deictic relational repertoire to children with autism. *The Psychological Record, 64*(4), 791–802. https://doi.org/10.1007/s40732-014-0078-z.

Jacques, S., & Zelazo, P. D. (2005). Language and the Development of Cognitive Flexibility: Implications for Theory of Mind. In J. W. Astington & J. A. Baird (Eds.), *Why language matters for theory of mind* (pp. 144–162). UK: Oxford University Press.

Kane, M. J., Hambrick, D. Z., & Conway, A. R. A. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*(1), 66–71. https://doi.org/10.1037/0033-2909.131.1.66.

Karbach, J., & Kray, J. (2009). How useful is executive control training? Age differences in near and far transfer of task-switching training. *Developmental Science, 12*, 978–990. https://doi.org/10.1111/j.1467-7687.2009.00846.x.

Kelly, M. E., Loughrey, D., Lawlor, B. A., Robertson, I. H., Walsh, C., & Brennan, S. (2014). The impact of cognitive training and mental stimulation on cognitive and everyday functioning of healthy older adults: A systematic review and meta-analysis. *Ageing Research Reviews, 15*, 28–43. https://doi.org/10.1016/j.arr.2014.02.004.

Kelly, M. E., Lawlor, B. A., Coen, R. F., Robertson, I. H., & Brennan, S. (2017). Cognitive rehabilitation for early stage Alzheimer's disease: A pilot study with an Irish population. *Irish Journal of*

Psychological Medicine, 36, 105–119. https://doi.org/10.1017/ipm.2017.23.

Kent, G., Galvin, E., Barnes-Holmes, Y., Murphy, C., & Barnes-Holmes, D. (2017). Relational responding: Testing, training, and sequencing effects among children with autism and typically developing children. *Behavioral Development Bulletin, 22*(1), 94–110. https://doi.org/10.1037/bdb0000041.

Kilroe, H., Murphy, C., Barnes-Holmes, D., & Barnes-Holmes, Y. (2014). Using the T-IRAP interactive computer program and applied behavior analysis to teach relational responding in children with autism. *Behavioral Development Bulletin, 19*(2), 60–80. https://doi.org/10.1037/h0100578.

Kratochwill, T. R., Hitchcock, J. H., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2013). Single-case intervention research design standards. *Remedial and Special Education, 34*(1), 26–38. https://doi.org/10.1177/0741932512452794.

Lampit, A., Hallock, H., & Valenzuela, M. (2014). Computerized cognitive training in cognitively healthy older adults: A systematic review and meta-analysis of effect modifiers. *PLoS Medicine, 11*(11), e1001756. https://doi.org/10.1371/journal.pmed.1001756.

LeBlanc, L. A., Raetz, P. B., & Feliciano, L. (2011). Behavioral gerontology. In W. W. Fisher, C. C. Piazza, & H. S. Roane (Eds.), *Handbook of applied behavior analysis* (pp. 472–486). New York: The Guilford Press.

LeBlanc, L. A., Heinicke, M. R., & Baker, J. C. (2012). Expanding the consumer base for behavior-analytic services: Meeting the needs of consumers in the 21st century. *Behavior Analysis in Practice, 5*(1), 4–14. https://doi.org/10.1007/BF03391813.

Lipnicki, D. M., Sachdev, P. S., Crawford, J., Reppermund, S., Kochan, N. A., Trollor, J. N., et al. (2013). Risk factors for late-life cognitive decline and variation with age and sex in the Sydney Memory and Ageing Study. *PLoS One, 8*(6), e65841. https://doi.org/10.1371/journal.pone.0065841.

Lucock, Z. R., Sharp, R. A., & Jones, R. (2018). Behavior-analytic approaches to working with people with intellectual and developmental disabilities who develop dementia: a review of the literature. *Behavior Analysis in Practice, 12*(1), 255–264. https://doi.org/10.1007/s40617-018-0270-8.

Lyons, K., & Murphy, C. (2013). *Can teaching flexible relational responding result in improved ability scores in children with diagnosed autism?* (Unpublished doctoral dissertation). Maynooth University, Kildare, Ireland.

Mangialasche, F., Kivipelto, M., Solomon, A., & Fratiglioni, L. (2012). Dementia prevention: Current epidemiological evidence and future perspective. *Alzheimer's Research & Therapy, 4*(1), 6. https://doi.org/10.1186/alzrt104.

Manolov, R., & Moeyaert, M. (2017a). How can single-case data be analyzed? Software resources, tutorial, and reflections on analysis. *Behavior Modification, 41*(2), 179–228. https://doi.org/10.1177/0145445516664307.

Manolov, R., & Moeyaert, M. (2017b). Recommendations for choosing single-case data analytical techniques. *Behavior Therapy, 48*(1), 97–114. https://doi.org/10.1016/j.beth.2016.04.008.

Martin, M., Clare, L., Altgassen, A. M., Cameron, M. H., & Zehnder, F. (2011). Cognition-based interventions for healthy older people and people with mild cognitive impairment. *Cochrane Database of Systematic Reviews*, (1), Cd006220. https://doi.org/10.1002/14651858.CD006220.pub2

McIlvane, W. J. (2003). A stimulus in need of a response: A review of *Relational frame theory: A post-Skinnerian account of human language and cognition. The Analysis of Verbal Behavior, 19*(1), 29–37. https://doi.org/10.1007/BF03392980.

Millan-Calenti, J. C., Tubio, J., Pita-Fernandez, S., Rochette, S., Lorenzo, T., & Maseda, A. (2012). Cognitive impairment as predictor of functional dependence in an elderly sample. *Archives of Gerontology and Geriatrics, 54*(1), 197–201. https://doi.org/10.1016/j.archger.2011.02.010.

Montoya-Rodríguez, M. M., Molina, F. J., & McHugh, L. (2017). A review of relational frame theory research into deictic relational responding. *The Psychological Record, 67*(4), 569–579. https://doi.org/10.1007/s40732-016-0216-x.

Mosiołek, A., Gierus, J., Koweszko, T., & Szulc, A. (2016). Cognitive impairment in schizophrenia across age groups: A case-control study. *BMC Psychiatry, 16*(1), 37. https://doi.org/10.1186/s12888-016-0749-1.

Muniz, M., Gomes, C. M. A., & Pasian, S. R. (2016). Factor structure of Raven's Coloured Progressive Matrices. *Psico-USF, 21*, 259–272.

Murphy, C., & Barnes-Holmes, D. (2009a). Derived more-less relational mands in children diagnosed with autism. *Journal of Applied Behavior Analysis, 42*(2), 253–268. https://doi.org/10.1901/jaba.2009.42-253.

Murphy, C., & Barnes-Holmes, D. (2009b). Establishing derived manding for specific amounts with three children: An attempt at synthesizing Skinner's verbal behavior with relational frame theory. *The Psychological Record, 59*(1), 75–91. https://doi.org/10.1007/BF03395650.

Murphy, C., & Barnes-Holmes, D. (2010). Establishing complex derived manding with children with and without a diagnosis of autism. *The Psychological Record, 60*(3), 489–503. https://doi.org/10.1007/BF03395723.

Murphy, C., & Barnes-Holmes, D. (2017). Teaching important relational skills for children with autism spectrum disorder and intellectual disability using freely available (GO-IRAP) software. *Austin Journal of Autism and Related Disabilities, 3*, 1041–1047.

Murphy, C., Barnes-Holmes, D., & Barnes-Holmes, Y. (2005). Derived manding in children with autism: Synthesizing Skinner's verbal behavior with relational frame theory. *Journal of Applied Behavior Analysis, 38*(4), 445–462. https://doi.org/10.1901/jaba.2005.97-04.

Murphy, C., Lyons, K., Kelly, M., Barnes-Holmes, Y., & Barnes-Holmes, D. (2018). Using the Teacher IRAP (T-IRAP) interactive computerized programme to teach complex flexible relational responding with children with diagnosed autism spectrum disorder. *Behavior Analysis in Practice, 12*(1), 52–65. https://doi.org/10.1007/s40617-018-00302-9.

Najdowski, A. C., Persicke, A., & Kung, E. (2014). Executive functions. In D. Granpeesheh, J. Tarbox, A. C. Najdowski, & J. Kornack (Eds.), *Evidence-based treatment for children with autism* (pp. 355–387). San Diego, CA: Academic Press.

Nasreddine, Z. S., Phillips, N. A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., et al. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*(4), 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x.

O'Connor, J., Rafferty, A., Barnes-Holmes, D., & Barnes-Holmes, Y. (2009). The role of verbal behavior, stimulus nameability, and familiarity on the equivalence performances of autistic and normally developing children. *The Psychological Record, 59*(1), 53–74. https://doi.org/10.1007/BF03395649.

O'Connor, J., Barnes-Holmes, Y., & Barnes-Holmes, D. (2011). Establishing contextual control over symmetry and asymmetry performances in typically developing children and children with autism. *The Psychological Record, 61*(2), 287–312. https://doi.org/10.1007/BF03395761.

O'Connor, M., Farrell, L., Munnelly, A., & McHugh, L. (2017). Citation analysis of relational frame theory: 2009–2016. *Journal of Contextual Behavioral Science*, *6*(2), 152–158. https://doi.org/10.1016/j.jcbs.2017.04.009.

O'Hora, D., Pelaez, M., & Barnes-Holmes, D. (2005). Derived relational responding and performance on verbal subtests of the WAIS-III. *The Psychological Record, 55*(1), 155–175. https://doi.org/10.1007/BF03395504.

O'Hora, D., Peláez, M., Barnes-Holmes, D., Rae, G., Robinson, K., & Chaudhary, T. (2008). Temporal relations and intelligence: Correlating relational performance with performance on the WAIS-III. *The Psychological Record, 58*(4), 569–584. https://doi.org/10.1007/BF03395638.

O'Neill, J., & Weil, T. M. (2014). Training deictic relational responding in people diagnosed with schizophrenia. *The Psychological Record, 64*(2), 301–310. https://doi.org/10.1007/s40732-014-0005-3.

O'Toole, C., & Barnes-Holmes, D. (2009). Three chronometric indices of relational responding as predictors of performance on a brief intelligence test: The importance of relational flexibility. *The Psychological Record, 59*(1), 119–132. https://doi.org/10.1007/BF03395652.

O'Toole, C., Barnes-Holmes, D., Murphy, C., O'Connor, J., & Barnes-Holmes, Y. (2009). Relational flexibility and human intelligence: Extending the remit of Skinner's *Verbal behavior*. *International Journal of Psychology and Psychological Therapy, 9*(1), 1–17.

Oberauer, K. (2009). Design for a working memory. In *The psychology of learning and motivation* (Vol. 51, pp. 45–100). San Diego, CA: Elsevier.

Poljac, E., Hoofs, V., Princen, M. M., & Poljac, E. (2017). Understanding behavioural rigidity in autism spectrum conditions: The role of intentional control. *Journal of Autism and Developmental Disorders, 47*(3), 714–727. https://doi.org/10.1007/s10803-016-3010-3.

Presti, G., Salvatore, T., Migliore, D., Roche, B., & Cumbo, E. (2017). Relational training intervention as add-on therapy to current specific treatments in patients with mild-to-moderate Alzheimer's disease. *International Journal of Psychology and Neuroscience, 3*(2), 88–97.

Prince, M., Wimo, A., Guerchet, M., Ali, G. C., Wu, Y. T., & Prina, M. (2015). The global impact of dementia: An analysis of prevalence, incidence, cost and trends. *World Alzheimer Report*, 1–82.

Rehfeldt, R. A., & Barnes-Holmes, Y. (2009). *Derived relational responding: Applications for learners with autism and other developmental disabilities*. Oakland, CA: New Harbinger Publications.

Reijnders, J., van Heugten, C., & van Boxtel, M. (2013). Cognitive interventions in healthy older adults and people with mild cognitive impairment: A systematic review. *Ageing Research Reviews, 12*(1), 263–275. https://doi.org/10.1016/j.arr.2012.07.003.

Roche, B., & Barnes, D. (1996). Arbitrarily applicable relational responding and sexual categorization: A critical test of the derived difference relation. *The Psychological Record, 46*, 451–475. https://doi.org/10.1007/BF03395177.

Room, J., Hannink, E., Dawes, H., & Barker, K. (2017). What interventions are used to improve exercise adherence in older people and what behavioural techniques are they based on? A systematic review. *BMJ Open, 7*(12), e019221. https://doi.org/10.1136/bmjopen-2017-019221.

Rosenthal, T. L., & Carstensen, L. L. (1988). Mini-series on aging: Clinical needs and research opportunity. [Special issue]. *Behavior Therapy, 19*, 3.

Royall, D. R., Lauterbach, E. C., Kaufer, D., Malloy, P., Coburn, K. L., & Black, K. J. (2007). The cognitive correlates of functional status: A review from the Committee on Research of the American Neuropsychiatric Association. *The Journal of Neuropsychiatry and Clinical Neurosciences, 19*(3), 249–265. https://doi.org/10.1176/jnp.2007.19.3.249.

Shipstead, Z., Harrison, T. L., & Engle, R. W. (2016). Working memory capacity and fluid intelligence: Maintenance and disengagement. *Perspectives on Psychological Science, 11*(6), 771–799. https://doi.org/10.1177/1745691616650647.

Simons, D. J., Boot, W. R., Charness, N., Gathercole, S. E., Chabris, C. F., Hambrick, D. Z., & Stine-Morrow, E. A. L. (2016). Do "brain-training" programs work? *Psychological Science in the Public Interest, 17*(3), 103–186. https://doi.org/10.1177/1529100616661983.

Sitzer, D. I., Twamley, E. W., & Jeste, D. V. (2006). Cognitive training in Alzheimer's disease: A meta-analysis of the literature. *Acta Psychiatrica Scandinavica, 114*(2), 75–90. https://doi.org/10.1111/j.1600-0447.2006.00789.x.

Tate, R. L., Mcdonald, S., Perdices, M., Togher, L., Schultz, R., & Savage, S. (2008). Rating the methodological quality of single-subject designs and n-of-1 trials: Introducing the Single-Case Experimental Design (SCED) Scale. *Neuropsychological Rehabilitation, 18*(4), 385–401. https://doi.org/10.1080/09602010802009201.

Tate, R. L., Perdices, M., Rosenkoetter, U., Shadish, W., Vohra, S., Barlow, D. H., Horner, R., Kazdin, A., Kratochwill, T., McDonald, S., Sampson, M., Shamseer, L., Togher, L., Albin, R., Backman, C., Douglas, J., Evans, J. J., Gast, D., Manolov, R., Mitchell, G., et al. (2017). The single-case reporting guideline in behavioural interventions (SCRIBE) 2016 Statement. *Neuropsychological Rehabilitation, 27*(1), 1–15. https://doi.org/10.1080/09602011.2016.1190533.

Thirus, J., Starbrink, M., & Jansson, B. (2016). Relational frame theory, mathematical and logical Skills: A multiple exemplar training intervention to enhance intellectual performance. *International Journal of Psychology and Psychological Therapy, 16*(2), 141–155.

Trahan, M. A., Kahng, S., Fisher, A. B., & Hausman, N. L. (2011). Behavior-analytic research on dementia in older adults. *Journal of Applied Behavior Analysis, 44*(3), 687–691. https://doi.org/10.1901/jaba.2011.44-687.

van de Ven, R. M., Schmand, B., Groet, E., Veltman, D. J., & Murre, J. M. (2015). The effect of computer-based cognitive flexibility training on recovery of executive function after stroke: rationale, design and methods of the TAPASS study. *BMC Neurology, 15*, 144–156. https://doi.org/10.1186/s12883-015-0397-y.

Vizcaino-Torres, R. M., Ruiz, F. J., Luciano, C., Lopez-Lopez, J. C., Barbero-Rubio, A., & Gil, E. (2015). The effect of relational training on intelligence quotient: A case study. *Psicothema, 27*(2), 120–127. https://doi.org/10.7334/psicothema2014.149.