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The effect on Intelligence Quotient of Training Fluency in Relational Frames of Coordination

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Abstract

Relational training protocols based on Relational Frame Theory (RFT) are showing promising results as regards increased intelligence quotient. This study aimed to analyze the effect on intelligence quotient of a fluency and flexibility training protocol based on relations of coordination. Two students from the same school were the study participants. They were randomly assigned the roles of experimental participant (a boy aged 4 years, 1 month) and control participant (a girl aged 3 years, 11 months). The McCarthy´s Aptitudes and Psychomotricity Scale (MSCA) was used to evaluate cognitive and psychomotor development. The 8-hour training protocol was implemented over a 2-month period. The experimental participant showed an increase of more than 1.5 SD in the General Cognitive Index (GCI) of the MSCA (from 106 to 132) whereas the control participant showed a 10-point increase. The experimental participant partly maintained the improvements at the 6-month follow-up. This study provides further empirical evidence of the potential of RFT training for improving cognitive abilities and intelligence.
Key words: RFT, intelligence, multiple-exemplar-training, derived relational responding.

Novelty and Significance

What is already known about the topic?

- Relational frame theory (RFT) provides a functional-contextual account of human language and cognition.
- Trainings based on RFT are beginning to be successfully applied to improve IQ.

What this paper adds?

- An analysis of the effect on intelligence quotient of training fluency in relational frames of coordination in a 4-year-old child, compared with a control participant.
- The IQ of the experimental participant significantly improved after the training whereas the control participant merely showed a minor improvement. The experimental participant's improvement was maintained at the 6-month follow-up.

Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001) is a functional-contextual approach to complex human behavior that suggests that fluency and flexibility in different patterns of arbitrarily applicable relational responding -or relational framing- underlie linguistic and cognitive abilities. In simpler terms, relational framing means responding to one event in terms of another event, where the relation between both events is not based on nonarbitrary features, but rather on arbitrary relational cues (e.g., same as). For instance, consider the case of a boy who very much likes cakes and is told that tarta is the Spanish word for cake (i.e., cake is the same as tarta). Later, he feels like eating cake when hearing his grandmother say "I have bought a tarta", given the arbitrary relationships between tarta, cake, and an actual cake.

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The simplest form of relational framing is relating stimuli through coordination (is, same as). However, there are other types of relational framing such as distinction (is different from), opposition (is opposite to), comparison (more than, less than), hierarchy (is part of, includes), etc. Each type of relational framing is defined according to three properties: mutual entailment, combinatorial entailment, and transformation of functions. Mutual entailment involves the bidirectionality of stimulus relations: if A is related to stimulus B, then B is related to A (e.g., if tarta is the same as cake, then cake is the same as tarta). Combinatorial entailment means that two or more relations that have acquired the property of mutual entailment can be combined. For example, if A is related to B, and B is related to C, then C and A are related (e.g., if tarta is the same as cake, and cake is the same as an actual cake, then tarta is the same as the actual cake, and vice versa). Transformation of functions means that the function of a stimulus can change the functions of other mutually or combinatorially related stimuli. In the previous example, if C acquires an appetitive function, then B and A will have the same appetitive function due to the mutual and combinatorial relations of coordination, respectively (e.g., the boy feels like eating a cake when hearing the words tarta and cake).

Recent empirical evidence has shown that relational framing abilities correlate with performance on standardized intelligence tests (for a review, see Cassidy, Roche, & O'Hora, 2010) and with specific cognitive skills such as analogical reasoning (e.g., Ruiz & Luciano, 2011). Indeed, psychometric measures of intelligence can be deconstructed into the specific relational responses required to solve their items (Cassidy *et al*., 2010).

An important premise of RFT is that all relational framing patterns are generalized operant behaviors learned through multiple exemplar trainings (MET). MET consists of a process providing multiple examples of mutual and combinatorial relations and transformations of functions with a specific relational framing pattern, through multiple sets of stimuli. Empirical evidence supports that relational frames of coordination, opposition, or comparison can be trained through MET (e.g., Barnes-Holmes, Barnes-Holmes, & Smeets, 2004; Berens & Hayes, 2007; Luciano, Gómez Becerra, & Rodríguez Valverde, 2007; Vizcaíno Torres *et al*., 2015).

The previous main tenets of RFT defend that linguistic and cognitive abilities might be established and improved through MET in different relational framing patterns. Indeed, preliminary evidence shows that RFT-based trainings can produce significant increases in intelligence both in normally and developmentally delayed individuals (Cassidy, Roche, & Hayes, 2011; Ruiz, Suárez, & López, 2012; Vizcaíno Torres *et al*., 2015). In Cassidy *et al*.'s study, four normally developing children, aged 8 to 12 years, were matched against a non-treatment control group and received automated METs over two years (15 hours in total) to promote fluency in stimulus equivalence and relational frames of opposition and comparison. The study comprised two different stages. In the first stage, experimental participants only received a MET of stimulus equivalence, which showed limited efficacy in increasing IQ. Approximately 18 months later, the experimental participants were exposed to opposition and comparison METs, and subsequently showed significant improvements in IQ (M= 27.25 points), whereas control participants remained roughly the same. In a second study, an improved training protocol was implemented over nine months (approximately two 90-minute

sessions per week) with eight schoolchildren, aged 11 to 12 years, with educational and behavioral difficulties. All but one participant improved their IQ scores more than 1 standard deviation (*M*= 13 points), with statistically significant pre-post differences. Ruiz *et al*. (2012) presented a case study with a 4-year-old autistic child who showed an improvement of 35 IQ points after six months of treatment of 2-3 hours per week, basically using MET to establish fluency and flexibility with the most basic relational frames. Lastly, Vizcaíno Torres *et al*. (2015) analyzed the effect of a training protocol in fluency and flexibility in relational frames of coordination, opposition, and comparison in a 4-year-old child. The training was effective in establishing relational responding based on opposition and comparison frames and in promoting fluency and flexibility in all three types of trained relations. After this training, the child's IQ increased more than 1.5 standard deviations (from 106 to 131 points).

The goal of the current study was to contribute additional evidence of the improvement on intelligence measures derived of training fluency and flexibility in relational frames of coordination in a normally developing 4-year-old child as compared to a control participant. At the start of the study, both children completed the *Fluency in Naming Test* and *McCarthy's Aptitudes and Psychomotricity Scale*. Subsequently, one child was trained in three different types of relations of coordination (visual-auditory, visual-visual, and auditory-auditory relations) during approximately two months (eight 1-hour sessions). The child's mother was also given some guidelines to promote fluency in coordinate relational framing. Afterwards, both children completed the same tests administered at the beginning of the intervention. Lastly, the experimental participant underwent a follow-up assessment 6 months later.

Method

Participants, experimenter, and experimental context

Two children participated in this study: SV, a boy aged 4 years and 1 month, and DN, a girl aged 3 years and 11 months. According to their teachers' reports, both SV and DN were at an age-appropriate stage of social development and grade level, though without excelling in any particular subject. They were enrolled in the same school in Valencia (Spain) during the study period. Their parents described them as healthy, happy children. SV was occasionally shy and DN was quite extroverted.

The first author, a final-year university student pursuing studies in Teaching, administered all tests and relational trainings. She was trained in RFT by the second author. All tests and trainings were conducted in a quiet room at the children's homes.

Design

The study design was *N*= 1 with a control participant. SV was randomly assigned as experimental participant and DN as control participant. The main dependent variables were the children's scores on the *Fluency in Naming Test* and the *McCarthy's Aptitudes and Psychomotricity Scale* (details of these tests follow). These instruments were applied before and after the administration of the independent variable: a training

protocol in relational frames of coordination. Figure 1 shows the three phases of the training protocol. Phases 1 to 3 were dedicated to training fluency with visual-auditory, visual-visual, and auditory-auditory relations of coordination, respectively. Lastly, only SV underwent an assessment 6 months later. DN moved to another city and therefore, did not complete said assessment.

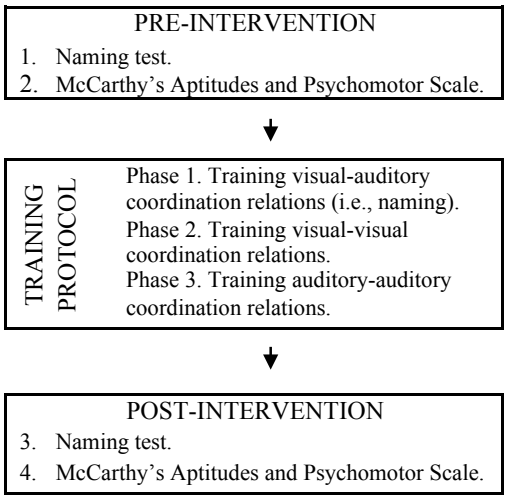

Figure 1. Design sequence.

Instruments

- *Fluency in Naming Test* (FNT). This test, designed for this study, comprised three subtests: (a) receptive naming without delay, (b) productive naming without delay, and (c) delayed receptive and productive naming. No feedback was given during the test. In each subtest, four pictures of unknown stimuli were presented (Table 1). The first subtest consisted of 16 trials. In the first trial, stimulus A was presented by picking it up and saying "This is an X (e.g., thimble). What is this?" and waiting until the child responded with the name of the object (i.e., thimble) to ensure that the child had paid attention to the experimenter. Then, the experimenter put stimulus A with stimulus B, mixed them, and asked: "Give me the X (i.e., thimble)." If the child gave the experimenter the correct stimulus, the trial was considered correct; otherwise, the trial was considered incorrect. The second trial was the same as the first but with stimulus B (e.g., blade). Next, the two previous trials were repeated but without presenting stimuli to the child (i.e., only saying "give me the X"). The same process conducted with stimuli A and B was also performed with stimuli C (e.g., mascara) and D (e.g., hairpin) between the fifth and eighth trials. Finally, two mixed 4-trial blocks were conducted with all stimuli of the set available as response options. The mastery criterion to pass this subtest was responding correctly to at least 15 trials. The productive naming subtest followed the same rationale and mastery criterion as the receptive subtest, but with a novel set of stimuli (i.e., Set 2) and, instead of having to give the stimuli, the child was asked to name it after the question "What is this?"

Lastly, the delayed receptive and productive naming test consisted of 8 trials and was conducted with Set 3. The experimenter first presented the child the four stimuli of the set, similarly to the previous subtests. After a 15-min delay, a mixed 8-trial block was conducted with four receptive and four productive trials (one trial per stimulus of each trial type). The mastery criterion was responding correctly to at least 7 of the 8 trials.

Table 1. Set of stimuli employed in FNT administrations and Phase 1 training

Phase	Set number	Stimuli
FNT pre-intervention	Set 1	Thimble, blade, mascara, hairpin.
	Set 2	Lime, grapefruit, nail clippers, clothespin.
	Set 3	Grater, calculator, mp3, loupe.
Training receptive naming	Set 4	Flamingo, walrus, lynx, orca.
	Set 5	Compass, abacus, canteen, deodorant.
	Set 6	Apricot, blueberry, mushroom, can opener.
Training productive naming	Set 7	Chard, date, thermos, papaya.
	Set 8	Hazelnut, speaker, broccoli, custard apple.
	Set 9	Almond, leek, match, mango.
	Set 10	Mask, keyboard, diamond, seal.
	Set 11	Megaphone, tulip, easel, mouse.
	Set 12	Anchor, jellyfish, padlock, bridle.
	Set 13	Iguana, lemur, caiman, squid.
	Set 14	Corkscrew, emerald, harmonica, carabineer.
	Set 15	Satellite, rhombus, Málaga, sprite.
	Set 16	Salmon, Toledo, scale, pentagon.
Training delayed naming	Set 17	Hexagon, hair remover, barbecue, Úbeda.
	Set 18	Oval, battery, raincoat, whisky.
	Set 19	Trapezium, tapper, oven glove, detergent.
	Set 20	Fan, drill, cauliflower, gin.
FNT post-intervention	Set 21	Rattan, mattress base, screen, paving stone.
	Set 22	Furnace, grouper, soybean, shoemaker.
	Set 23	Gravel, bell, vacuum, canapé.

- *McCarthy's Aptitudes and Psychomotricity Scale* (MSCA; McCarthy, 1988). The MSCA is a widely used psychological test that provides normative T-scores (i.e., *M*= 50 and *SD*= 10) in several developmental areas for children aged 2 to 8.5 years: verbal, perceptual-manipulative, numerical, motor skills, and memory. A general index, the *General Cognitive Index* (GCI), with a mean of 100 and a standard deviation of 16, is also obtained by adding the verbal, perceptual-manipulative, and numerical subscales. This index is considered an intelligence quotient. The MSCA provides 90% confidence intervals for the scores on every scale and for the GCI. The GCI has very good psychometric properties and there is evidence of its factorial and predictive validity (Kaplan & Sacurzzo, 2012). Very strong correlations have been found between the GCI and the *Wechsler Preschool and Primary Scale of Intelligence and the Stanford-Binet Intelligence Scales*. This study used the Spanish adaptation by TEA Ediciones.

Materials

The sessions and child's responses were recorded using the webcam of an *Inspiron 15 Intel Core* laptop.

Procedure

The study lasted approximately 2 months during which 13 sessions were held: 5 to administer the above-mentioned instruments and 8 to apply the training protocol. The study began when SV was 4 years and 1 month old and DN 3 years and 11 months old.

- *Pre-intervention assessment*. The FNT and the MSCA were administered during three sessions in the first two weeks of the study. Sets 1 to 3 were employed in the FNT. The MSCA was applied according to the guidelines provided by the test developer.
- *Training protocol*. The protocol was based on the guidelines presented in Luciano et al. (2009). During all phases, SV's correct responses were followed by positive social feedback. Incorrect responses were followed by the experimenter saying: "No, SV, that is not right" or "No, that is not correct." Some guidelines were provided to SV's mother, as the person in greatest contact with SV, for her to offer daily interactions similar to the training protocol to support and maximize its effects. Specifically, she was instructed to: (a) not respond for SV when someone asked him questions or not finish his sentences when he wanted to say something, and (b) she had to show SV five novel objects every day and ask about them at the end of the day; if SV responded correctly, he was given a candy.
- *Phase 1. Training fluency with visual-auditory coordinate relations*. This training phase was conducted following the same rationale as the FNT but providing feedback in every trial (except for sets used for testing). Sets 4 to 20 were presented over four 1-hour sessions (Table 1). SV was first trained in receptive naming until meeting the criterion, then in productive naming, and finally in delayed receptive and productive naming. The mastery criteria to pass the receptive and productive naming entailed responding correctly to at least 15 out of 16 trials in two consecutive sets, the first one with feedback and the last one without feedback (test set). Regarding delayed receptive and productive naming, the mastery criterion entailed responding correctly to at least 7 out of 8 trials in two consecutive sets. Sets 4 to 6 were used in receptive training, Sets 7 to 16 in productive naming, and Sets 17 to 20 in delayed receptive and productive naming.
- *Phase 2. Training fluency with visual-visual coordinate relations*. This phase was designed to determine whether SV was able to derive mutual and combinatorial visual-visual relations. Figure 2 shows the abstract shapes used in this phase. Alphanumeric labels (e.g., A1, B1, C1, etc.) identified the stimuli, though these labels were not presented to SV. Four conditional discriminations (B1-A1, C1-A1, B2-A2, and C2-A2) were trained in a *many-to-one* matching to sample procedure. Afterwards, mutual (A1-B1, A1-C1, A2-B2, and A2-C2) and combinatorial relations (B1-C1, C1-B1, B2-C2, and C2-B2) were evaluated. The trials were presented on sheets covered with a cardboard. The sample stimuli were presented in the center of the upper third of the sheet and the comparisons appeared in a line on the lower third of the sheet. The comparison stimuli were positioned randomly. In a typical trial the experimenter presented the sample by sliding the cardboard off the top of the sheet. Then, while revealing the lower third of the sheet, the experimenter pointed to the sample and said: "SV, what goes with this?" or "Tell me what goes with this."

  The training sequence commenced with the presentation of a respondent trial with the B1-A1 relation by saying: "This (B1) goes with this (A1). What goes with this (pointing to B1)"? After emitting a correct response, trials with the B1-A1 relation with two comparisons (i.e., A1 and A2) were conducted. When SV responded correctly to

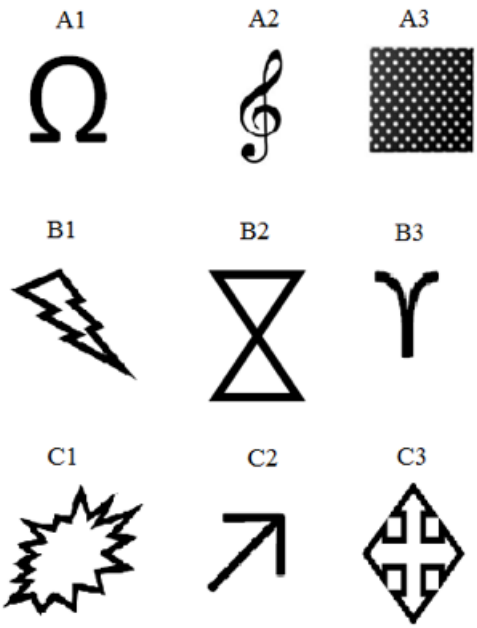

Figure 2. Abstract shapes used in Phase 2.

two consecutive trials, the same relation was presented with three comparison stimuli (i.e., A1, A2, and A3) and SV had to emit two consecutive correct responses. Then, the relation B2-A2 was trained in the same manner as the B1-A1 relation. Afterwards, mixed 4-trial blocks with the B1-A1 and B2-A2 relations (two trials per relation) were presented until SV responded correctly to all trials of a block. C-A relations were trained in the same manner as the B-A relations, but beginning with C2-A2 and following with C1-A1. Subsequently, mixed 4-trial blocks with B-A and C-A relations (one trial per relation) were presented until SV responded correctly to all trials of a block. Lastly, SV was told that no feedback would be provided during the next trials and the same mixed block was presented until he responded to it correctly. When SV passed the previous training, an 8-trial mutual relations test was conducted with two trials per relation. The mastery criterion entailed responding correctly to at least 7 trials. After passing the latter test, SV was exposed to an 8-trial combinatorial test (2 trials per relation) with the same mastery criterion. SV responded correctly to all trials of the mutual and combinatorial tests. Accordingly, SV proceeded to the next phase (a MET with novel sets would have been conducted in case of failing some of the tests).

- *Phase 3. Training fluency with auditory-auditory coordinate relations*. Similar to Vizcaíno-Torres *et al*. (2015), 25 short stories were used to train fluency with auditory-auditory coordinate relations. Each story or set contained four trials: 2 mutual and 2 combinatorial trials. There were two types of sets: (a) eight short stories of children and toys, and (b) seventeen sets of synonyms. An example of a short story is: *There was a teacher who played with his students in the following way: When the teacher drew a square (A) on the blackboard, the children raised their hands (B). What did the teacher draw on the board so that the children would raise their hands?* (B⇒A

mutual trial) *When the children raised their hands (B), a violin sounded (C). What did the children do to make the violin sound?* (C⇒B mutual trial) *What did the teacher draw on the board in order to make a violin sound? (C⇒A combinatorial trial) If the teacher drew a square on the board, what could be heard?* (A⇒C combinatorial trial). An example of a set of synonyms is: *A sacapuntas (pencil sharpener) is the same as an afilador (B). What is the same as an afilador?* (B⇒A mutual trial). *An afilador (B) is the same as a cortalápices (C). What is the same as a cortalápices?* (C⇒B mutual trial). *What is the same as a sacapuntas?* (A⇒C combinatorial trial; if the child said stimulus B, he was asked "And what else?" to instigate stimulus C). *What was the same as cortalápices?* (C⇒A combinatorial trial; if the child said stimulus B, he was asked "And what else?" to instigate stimulus A). This Phase ended when SV responded correctly to all trials of seven consecutive sets.

- *Post-intervention assessment*. This evaluation was conducted in two sessions at the end of the study. Sets 21 to 23 of the FNT were used.
- *Follow-up assessment*. Approximately six months after the post-intervention assessment, the MSCA was administered again to SV. It was not possible to evaluate DN because she moved to another province with her parents.

Data analysis

SV and DN's direct scores on the MSCA at pre- and post-intervention were interpreted according to the scales for ages 3 years and 10 months to 4 years and 3 months. At the 6-month follow-up, SV's scores on the MSCA were interpreted according to the scales for ages 4 years and 4 months to 4 years and 9 months. Ninety percent confidence intervals were obtained from the MSCA manual.

The integrity of the protocol administration was measured by means of inter-observer agreement (agreement between two independent observers divided by the sum of agreement and disagreement, multiplied by 100). Both observers claimed 100% agreement in evaluation, training, and tests regarding the correct presentation of the trials, identification of SV's responses, and adequate feedback provision.

RESULTS

Figure 3 shows that both participants displayed a similar performance level in the FNT at pre-intervention. Neither child passed the FNT. SV improved his scores on a task similar to the FNT with feedback (Phase 1 of the training protocol). He needed three, ten, and four sets to meet the mastery criterion on receptive, productive, and mixed delayed training, respectively. At post-intervention, SV passed the FNT, but DN failed to pass any of the subtests.

SV passed Phase 2 on his first attempt. Figure 4 shows the evolution of SV in the percentage of correct responses in Phase 3 (auditory-auditory trials). Twenty-five stories were used. At the beginning, SV achieved about 50-75% of correct responses. He met the mastery criterion at story 25 (i.e., correct responses to 7 consecutive stories).

Figure 5 presents both participants' scores in the MSCA (Table 2 displays the direct scores). SV improved in all MSCA subscales from pre- to post-intervention, with

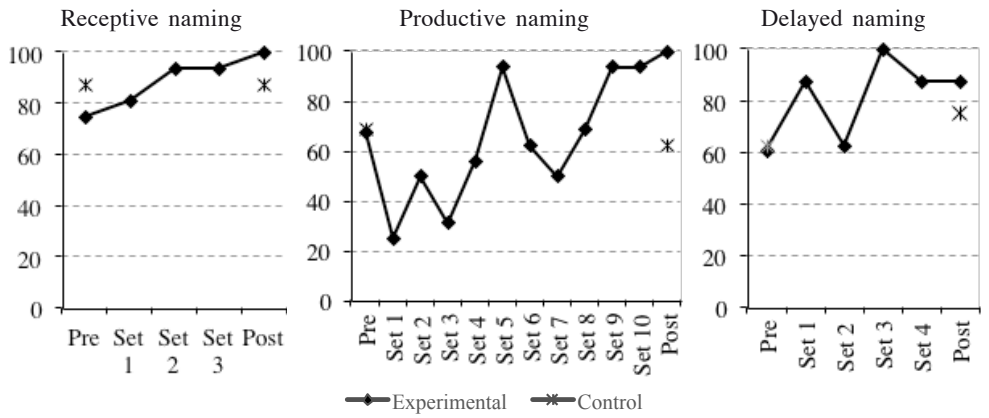

Figure 3. Evolution of the percentage of correct responses in the FNT and training in Phase 1.

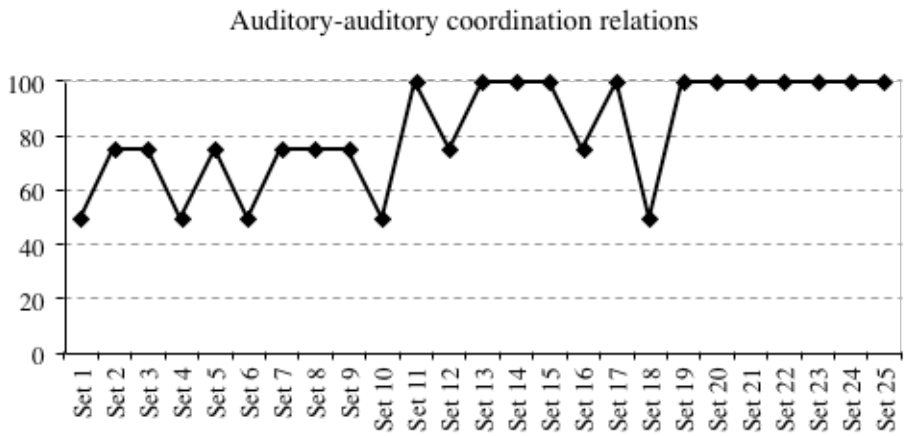

Figure 4. Evolution of the percentage of correct responses in the training of auditory-auditory coordination relations (Phase 3).

notable increases in *T*-scores in verbal (13), perceptive-manipulative (18), memory (17), and motor (19) subscales. In general, DN showed slight increases in the subscales, except for memory, where she obtained a 16-point increase. With respect to the GCI, SV showed a 26-point increase from pre- to post-intervention, representing an increase of 1.625 standard deviations, from 106 (90% CI [99, 113], direct score of 103.5) to 132 points (90% CI [125, 139], direct score of 141.5). DN showed a 10-point increase in the GCI, from 105 (90% CI [98, 112], direct score of 102.5) to 115 (90% CI [108, 122], direct score of 113), representing an increase of .625 standard deviations.

SV partially maintained the improvements at the 6-month follow-up. He scored 127 (90% CI [121, 135], direct score of 146.5) on the GCI. Though his MSCA T-scores slightly decreased, all scores were higher than those obtained at pre-intervention.

Table 2. Evolution of the direct scores in the McCarthy's Scales.

	Experimental participant			Control participant	
	Pre	Post	F-Up	Pre	Post
Verbal	42	59	56.5	34.5	44.5
Perceptive-manipulative	42.5	59.5	64	52.5	53.5
Numeric	19	23	26	15	15
Memory	20	35	37.5	11.5	23.5
Motor	27	44	47	39	44
General Cognitive Index	103.5	141.5	146.5	102.5	113

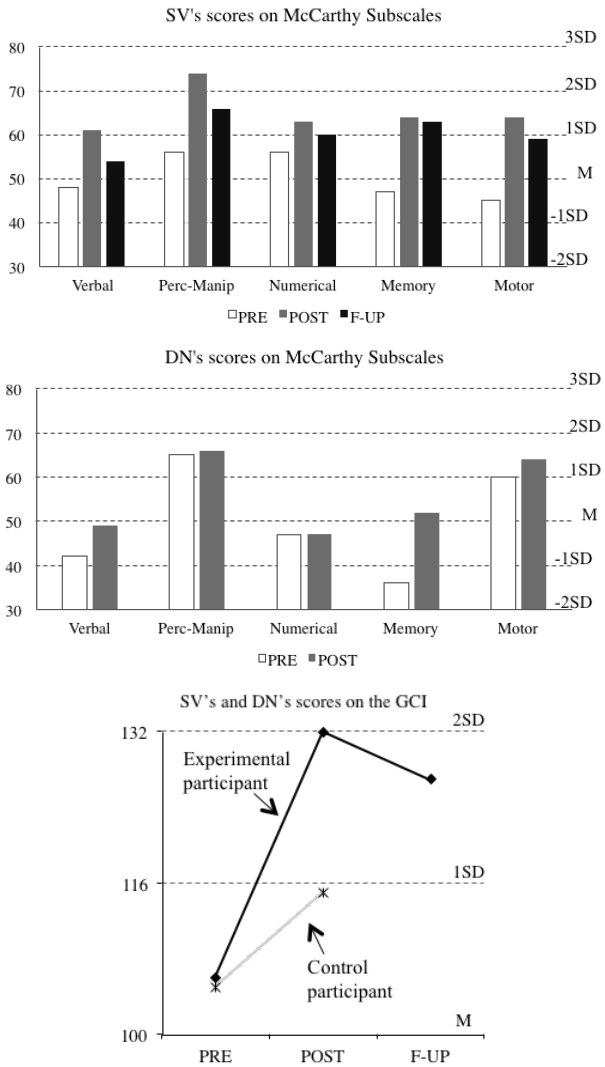

Figure 5. Evolution of the scores in McCarthy's Scales with M referring to normative mean scores and SD to the standard deviations.

Discussion

SV and DN entered the study performing at average levels in the MSCA and failing to meet the mastery criteria of the FNT subtests. They were then randomly assigned as experimental (SV) and control (DN) participants. After the training protocol was implemented with SV, he improved in all areas of the MSCA, with increases greater than 10 for *T*-scores in the verbal, perceptive-manipulative, memory, and motor subscales. SV also improved his CGI by 26 points from pre-intervention (106) to post-intervention (132), and passed all FNT subtests. DN slightly increased her scores in the MSCA subscales, except for the memory subscale, and slightly improved her CGI by 10 points, from 105 to 115. Like at pre-intervention, she did not pass any of the FNT subtests at post-intervention. Anecdotal reports by SV's teacher and family were consistent with the improvement found in the MSCA. For instance, SV's teacher expressed her surprise with SV's school performance during the months of the training and asked the parents whether they were taking action with the child in this regard. Similar anecdotal reports were also collected during the 6-month follow-up.

In summary, this study contributes empirical information on the efficacy of RFT-based trainings to improve IQ in normally developing children. Like in Vizcaíno Torres *et al*. (2015), the current study also incorporated daily natural interactions to promote fluency and flexibility in coordinate relational framing by providing SV's mother with some related guidelines. Anecdotal reports inform that SV's mother followed the guidelines and was very satisfied with her son's progress.

Although the current study makes progress in a relatively unexplored topic, it is not exempt of important limitations. First, only two children participated in the study, and the effect of the training protocol was only observed in one child. As regards this issue, our initial idea was to replicate the effect observed in SV with DN, but this was not possible because DN and her parents moved to another province in Spain right after the post-intervention assessment. Second, all evaluations and trainings were conducted by the first author. Thus, the IQ assessor was not blind to treatment assignment. This entails a limitation because the experimenter could have inadvertently provided some cues that would have facilitated SV's responses in the FNT and MSCA, though we must mention that this event was not observed in the recordings. Third, the training protocol applied included only frames of coordination. Further studies should study the effect of a protocol training with relational framing including relations of opposition, comparison, distinction, hierarchy, spatial, causality, and deictic relations. Lastly, although this study included a control subject, participants could be more closely matched (e.g., same sex and age).

In conclusion, the current case study provides promising evidence of the effect of an RFT-based training on improving linguistic and cognitive abilities categorized within the construct of intelligence. However, further studies with improved controls are required to analyze the potential of these RFT-based trainings.

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