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Case Study

Restoring one's language edifice: A case study of long-term effects of intensive aphasia therapy employing cognitive modifiability strategies

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Abstract.NG is an architect who suffered a left occipital-parietal hemorrhage cerebral vascular accident (CVA) in 2000, resulting in aphasia of Wernicke and conduction types. He was characterized with fluent paraphasic speech, decreased repetition, and impaired object naming. Comprehension was relatively preserved but reading and writing were severely compromised, as well as his auditory working memory. Despite a grim prognosis he underwent intensive aphasia therapy, lasting from 2001 to 2010, at the Center for Cognitive Rehabilitation of the Brain Injured at the Feuerstein Institute. The tailored-made interventions, applied in NG's therapy, were based upon the implementation of the principles of the Structural Mediated Learning Experience (MLE) and the Feuerstein Instrumental Enrichment (FIE) Program, to optimize his rehabilitation. As a result NG improved in most of his impaired linguistic capacities, attested by the results of neuropsychological and linguistic assessments performed throughout the years. More importantly, he was able to manage again his daily functions at a high level, and to resume his occupational role as an architect, a role which he holds to this day.

Keywords: Aphasia, rehabilitation, structural cognitive modifiability, mediated learning experience

1. Introduction

Aphasia is an acquired language impairment that affects comprehension and production of verbal language and is incurred by acquired brain damage, usually focused in the left cerebral hemisphere (Damasio & Damasio, 2000). The language deficits in aphasia may be multi-faceted and encompass different aspects of language, such as phonology (speech sounds), grammar (word order and word endings), lexicon (word finding) and semantics (word meanings). Other impairments such as alexia and agraphia also co-occur with aphasia, as they all depend on

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the same symbolic language mechanism used in verbal language (Hillis, 2007; Tippett, Niparko & Hillis, 2014).

Due to the complexity of the language apparatus, aphasia may be manifested in different forms. Several classification methods were proposed over the years (Benson & Ardila, 1996), but they all share the basic patterns that were described originally by Wernicke and Lichtheim in the 19th century. According to their typology aphasia can be classified into *non–fluent* and *fluent* aphasias: Anatomically, non-fluent aphasias occur as a result of lesions affecting left pre-rolandic regions, while fluent aphasias arise as a consequence of damage to left post-rolandic regions. Non-fluent, or Broca's, aphasia is characterized by deficits in spontaneous speech and sentence repetition (reduction in phrase length, diminished words per minutes). Auditory comprehension is relatively spared, although these individuals encounter difficulties with complex sentences (e.g., sentences with object relative clauses "the girl that the boy kissed ran way", Hillis, 2007). Broca's aphasia is associated with large left frontal-subcortical lesions. Other types of non-fluent aphasia include transcortical motor aphasia, global aphasia and mixed transcortical aphasia.

In fluent, or Wernicke's aphasia, verbal expression is characterized by relatively intact, yet meaningless spontaneous speech and repetitions, with relatively poor comprehension of words, sentences, and conversation. Wernicke's aphasia is associated with lesions affecting the posterior portion of the left superior temporal gyrus. Three other variants of fluent aphasia are transcortical sensory aphasia, conduction aphasia and anomic aphasia. In the latter two types, auditory asyntactic comprehension is intact while confrontation naming is severed. Repetition, which is impaired in conduction, but not in anomic aphasia, distinguishes between the two.

Recovery from aphasia varies widely between individuals, their aphasia types and its initial severity (Koenig-Bruhin et al., 2013). Some restoration of language functions following stroke typically occurs in the acute phase of recovery (DiFrancesco, 2013). In fact, speech features normalize in about one-third of patients after one month (Laska et al., 2011). However, severe chronic aphasia is not rare, and 19% of stroke patients still suffer from persistent communication disorders a year on (Dijkerman et al., 1996).

There is no universally established intervention that is valid for all aphasia patients, but usually the therapist will choose from a variety of therapeutic methods and apply an individually adapted program of treatment (Brady et al., 2012). Clinicians agree that intensive speech therapy is helpful for most aphasic patients (Barisa, Noggle, Salisbury & Boseck., 2013). Regarding the acute phase, two classes of treatment can be identified, cognitive or functional: Cognitive, or neuro-linguistic oriented, treatments concentrate on language-specific impairments, with treatments focusing on specific tasks such as naming, semantic or phonological training, sentence production, writing or reading (Koenig-Bruhin, et al., 2013). Using this approach, rehabilitation efforts are tailored to the patient's identified deficits. Although this traditional school of thought improves language skills, it has been criticized for not improving functional communication, the ability to successfully communicate a message via spoken, written and/or non-verbal modalities (Brady et al., 2012). Functional therapies, therefore, utilize compensatory strategies that rely on the individual's strengths, with the aim of enhancing their social participation and their quality of life (Schwartz & Fink, 2003). These strategies may include writing, use of symbolic gestures and facial expressions.

In treating patients with chronic aphasia, which continues beyond six months post stroke onset, interventions are individually tailored and are used in conjunction with additional group therapy (Cherney et al., 2008; Cicerone et al., 2011), or involvement of partners in community-based aphasia programs (Allen, et al., 2012). Several methods were established as effective in treating chronic aphasia. For example, in linguistic task-specific therapy, treatment-specific effects are linked to the type of impairment (Teasell et al., 2009). In constraint-induced aphasia therapy (CIAT), the use of non-verbal communication strategies is not allowed. This type of therapy may result in improved language function and everyday communication (Cherney et al., 2008; Cicerone et al., 2011).

Since speech therapy is most effective when provided intensively, it must be a mutual endeavor involving the aphasic participants, their families, and the speech therapists (Basso & Macis, 2011). This active continual collaboration will maximize functional communication (Brady et al., 2012). An example of this is family members and carers being trained to assist with additional self-managed computer treatment (Teasell et al., 2009; Basso & Macis, 2011). Another aspect of the treatment intervention, related to the exposure to FIE, is the role of face-to-face direct interactions in relation to (and supported by) using the computer for elaboration and practice.

In the current study we present the case of NG, who underwent an intensive rehabilitative treatment of his aphasia following a cerebral vascular accident (CVA), which he experienced at the age of 53. Between the years 2001–2010 NG attended the Center for Cognitive Rehabilitation of the Brain Injured (CCRBI) at the Feuerstein Institute (FI) where he received therapy, based on the principles of the *Structural Cognitive Modifiability* (SCM) and *Mediated Learning Experience* theories (MLE; Feuerstein, Rand, Hoffman, & Miller, 1980; Feuerstein, Feuerstein, Falik & Rand, 2002). The SCM theory is based on the view that an individual has a natural propensity to change, and to adapt to his environment through structural cognitive changes. The MLE theory posits that the structural cognitive modifiability is realized through a mediating agent (e.g., parent, teacher), who serves as an intermediate between the environment and the learner. Through selection, enhancement, and organization of the relevant stimuli for the learner, the mediating agent helps to maximize the functioning of the learner. Moreover, enhancing cognitive modifiability through mediated learning allows the individual to learn additional and even more complex cognitive operations and strategies than those formally taught (LeBeer, submitted).

One of the main vehicles used to achieve cognitive modifiability is through a cognitive enrichment program called *Feuerstein Instrumental Enrichment* (FIE, Feuerstein et al., 1980). The FIE program is designed to enhance the capacity of the individual to become modified as a result of mediation, using a variety of instruments. It includes 15 paper and pencil instruments, each consisting of a set of problems with increasing levels of difficulty. For each instrument, a set of teaching procedures is suggested, including, as a major component, suggestions how to generalize acquired principles to domains and contexts that are beyond the original domains presented.

Since 1996, over 120 patients, suffering from either traumatic (concussions, contusion, diffuse axonal injuries, penetrations) or acquired brain injuries (CVAs, anoxias) have been treated at the CCRBI. Most of them were suffering from multiple, mostly severe, symptoms, which include, among others, executive function deficits, memory loss, aphasia, neglect and hemiparesis. Although they received rehabilitation at hospital prior to their arrival, their severe condition required an additional rehabilitative process, focusing on the cognitive rehabilitation potential that is presumed to be available to these injured individuals. Patients were assessed upon entry, and an intensive treatment program was built for them according to their level of functioning and propensity to change. Intensity is defined as duration of treatment (over a multi-year period), and number of sessions per week (usually involving 4–6 hours). The intensity factor is deemed essential to the success of the intervention, and the eventual recovery of functions in the patient. In addition to the FIE component, the treatment program may include speech therapy, occupational therapy, reading and writing or computer skills, with FIE, imbuing all of these therapies.

In addition to the treatment NG received at the CCRBI he was assessed at several time periods following his CVA, the latest in 2014. Thus, the present case study presents a description of an extensive cognitive therapy, directed toward his aphasia and other aspects of deficient functioning, and a long-term follow-up assessment of the consequences of this therapy.

2. Method

2.1. General background information

NG is now a 68 year old male, born in an English-speaking country but currently living in a central city in Israel. He is married with three children. He is right-handed, and had no known developmental problems or learning difficulties when he was younger. He studied architecture in leading universities abroad and has an MA in both architecture and civil engineering.

NG and his family moved to Israel in the late 1970's where he started his own architectural practice, specializing in restoration and designing old houses. Prior to his CVA he was managing a medium size office and employing several architects. He was (and to some degree still is) very prominent in his field and worked on many prestigious projects. Prior to this, NG had hypertension (treated by homeopathic medication) and borderline diabetes (treated by a diet).

2.2. Incident and Neurological Background

NG suffered a left hemorrhagic CVA in the spring of 2000. He was hospitalized due to dizziness, headache, nausea, vomiting and speech disturbances. On neurological examination he was conscious, but had comprehension difficulties, executed commands only partially, his speech was unclear and included paraphasias, and he had mainly sensory dysphasia

and anomia. A CT scan showed a left occipital-parietal hemorrhage, mild edema surrounding the hemorrhage and mild shifting of the mid-line. There was also the impression of his right hand and leg dropping but towards the end of his hospitalization there was a clear improvement in his speech difficulties and in the weakness on his right side.

After two weeks NG was transferred to the rehabilitation unit in the hospital. On the day of his transfer his functional independence measure (FIM) score was 92/123. During his stay he received multidisciplinary rehabilitation therapy with emphasis on his severe apraxia, damaged visuo-motor organization, neglect to the right visual field and decreased understanding of numbers. According to a speech therapist report at the beginning of the treatment language comprehension was severely impaired. Bucofacial apraxia, anomia, alexia and agraphia (with the preservation of automatic writing) were also present. He spoke mainly Hebrew and gradually started speaking English, his native language. An audiometric examination showed a moderate to severe sensory hearing deficit in his right ear. An MRI in the summer of 2000, with and without contrast, showed a hematoma involving the left occipital and posterior aspect of the parietal lobe with a surrounding hemosiderin ring.

A neurological report concluded that NG had left brain dysfunction involving the posterior perisylvian region and at least more anterior involvement that may account for the transient motor difficulties and the conduction difficulties. There was also posterior extension involving parietal or occipital visual pathways. He was described as having both Wernicke's aphasia and conduction aphasia qualities. NG was discharged from the hospital in the autumn of 2000. His FIM score upon his discharge score had increased to 121/126. An MRI with Gadolinium (and computation of T1 and T2 before and after the injection of Gadolinium) showed a hemorrhage in an absorption phase in the left occipito-parietal area with the focus extending to the left lateral ventricle. There was still an area of increased signal in the T1 series in the center (E/12) with no evidence of relaxation after the Gadolinium.

2.3. *Rehabilitation process: Intervention/Treatment*

As part of his rehabilitation process, NG attended the CCRBI at the FI, receiving therapy intermittently between 2001 and 2010. However, the most intensive years of rehabilitation occurred between 2001 and 2003. The therapy he received at the FI included the FIE program, speech therapy, occupational therapy, computer instruction and reading/writing instructions. His treatment implemented the institute's therapeutic principles, infusing the parameters of MLE (Feuerstein, et al., 2006) into all aspects of the interventions.

Specifically, between 2001 and mid-2003, NG received therapy (conducted in English) 15 hours a week (4-5 times a week), of which speech and language therapy took up 4-5 hours weekly, with his cognitive functions mediated developmentally according to a linguistically-oriented responsive environment infused with processes of strategic thinking. This intensive program was reduced from mid-2003 to 2-3 times a week. The most detailed information on hours of treatment provided were between August 2003 and September 2004, where he received a total of nearly 200 hours of therapy. During that particular year, he received 67 hours of speech therapy, 53 hours of computer instructions and 79 hours of reading and writing instructions.

Before starting his rehabilitation at the CCRBI, NG's spontaneous speech was fluent with some agrammatism, semantic and literal paraphasias and preserved prosody and articulation. Repetition skills and word retrieval were severely impaired. Comprehension of spoken language was variable with the patient demonstrating difficulties executing commands that included prepositions. Reading was severely impaired as NG was unable to read aloud. However, he was able to derive meaning from written language to a certain extent, especially in silent reading. Writing was also severely impaired.

Speech therapy was conducted in English and focused, among other things, on auditory acoustic analysis, mechanical aspects of articulation, auditory feedback, repetition, awareness of errors, decreasing perseverations, and increasing phonological and morphological awareness. NG's speech therapists also focused on his word retrieval skills, retaining and recalling critical personal and professional information, syntax and grammar. Technology, such as text to audio software, was also used to aid him in his professional life, reading skills and conversation skills. His reading and writing therapists at the FI also used the method and workbooks of the Wilson reading system (Wilson, 2004), alongside their own therapy techniques. The computer instructions that NG received mainly focused on numerical perception and mathematical skills.

Speech and language therapy reports during this intensive period indicated general progress in language capacities. A speech-therapy report from late 2002 indicated improved speech and word-finding abilities (less paragrammatism and circumlocutions), with relatively intact comprehension, although the speaker's pace of speech has to be slower than normal to allow NG more processing time. Reading aloud of simple sentences was possible provided they followed simple sentence structures. Writing common word from visual representation was also achieved. In addition, NG was beginning to write new words from dictation via phoneme–grapheme conversion. Difficulties in self-monitoring of grammatical errors and understanding of complex speech (jokes, ambiguities) were noted. This report was further corroborated by an additional observation made in the beginning of 2003. It was noted then that NG made progress in his ability to repeat words, associate letters with their sounds in order to orally read a written word, and at times use this same strategy to retrieve a word while in conversation. Conversation skills were also found to be significantly improved. NG successfully was able to discuss different topics using substantive vocabulary to get to his point.

Between 2004 and 2008 NG received further therapy (mostly speech therapy) of approximately 353 hours in total. The therapy focused primarily on word-retrieval, sound-letter association, phonemic awareness, numbers and supplying personal information. Overall, NG received throughout the years over 1200 hours of therapy at the FI.

Throughout NG's rehabilitation, his wife was always included in the therapeutic process. Following advice, she attended every single therapy session for the first year of his rehabilitation. She reported that her presence and support boosted NG's confidence and emotional state. Her involvement continued during his rehabilitation at FI, where his speech therapists would send exercises home for practice and review.

Currently, NG continues to work in his architectural practice, but with reduced hours. His office has downsized and he now works mainly from home. He makes use of a number of different strategies to assist him with his particular difficulties. For example, he uses a program on his iPAD called "Speak-it" which reads out emails to him. He also makes lists to assist him with his short-term memory problems. He therefore manages to function on a day-to-day basis at a high level.

2.4. Neuropsychological Assessments

NG was assessed several times throughout the years. These assessments were conducted periodically during treatment to assess ongoing treatment effects and to calibrate further interventions. Three language-focused neuropsychological assessments (NA) were conducted: The first (NA1) was administered several months after his CVA, before he commenced his rehabilitation at the FI (December 2000 – January 2001). The second assessment (NA2) was administered two years later, during his rehabilitation period at the FI (February 2003). At the same period NG was also examined in the United States. These assessments are also referred to also as NA2 assessment. The third (NA3) was conducted more than ten years later (June-August 2014) as part of the current research. The first and third assessments were comprehensive, and included, in addition to language, other domains such as learning and memory processes, executive functions and attention.

Testing on all occasions was conducted in English by a native English-speaker, and all test materials were in English. NG cooperated fully with the examiners and invested considerable efforts in the tests. He made eye-contact, behaved adequately, and showed a sense of humor. He performed slowly on many of the tasks and carefully monitored his performance. During the 2014 assessment, NG sometimes expressed disappointment with his performance, particularly in the word retrieval tests. He pointed out his difficulties to the examiner, and as he understands his situation well, it bothered him to do some of the tests.

2.5. Tests Administered (in alphabetical order)

A. Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983; NA1, NA2, NA3)

The BNT is a widely used neuropsychological tool that measures word retrieval in individuals with aphasia or other language disturbances. It consists of 60 black and white drawings of items ranging in familiarity such as "house" at the beginning of the test to "sphinx" at its end. The participants have to name the items upon confrontation. If they fail they are given a semantic or phonetic cue.

B. Cookie Theft Picture (CTP; Goodglass & Kaplan, 1983b; NA1, NA2, NA3)

The CTP description task is part of the Boston Diagnostic Aphasia Examination (BDAE) and is a measure of discourse production. The picture depicts

a household kitchen scene with a boy standing on a stool, about to topple over, trying to reach a jar of cookies from a cupboard. The sister stands next to him and encourages him to take the jar. The mother, with her back to the children, is washing dishes in the sink and doesn't realize that the water is overflowing. NG was asked to look at the picture and describe what is happening in it.

C. The Diagnostic Assessments of Reading (DAR; Roswell, Chall, Curtis & Kearns, 2005, NA2)

This test assesses an individual's relative strengths and weaknesses in nine key areas of reading and language: Print awareness, phonological awareness, letters and sounds, word recognition, word analysis, oral reading accuracy and fluency, silent reading comprehension, spelling and word meaning.

D. Fuld Object Memory Evaluation (FOME, Fuld, 1980, NA1)

The FOME is a memory assessment measure designed to evaluate memory impairments in older adults. By using concrete objects it allows the examinee to encode the information with several sensory modalities. The FOME was used in NA1 due to NG's naming difficulties and was modified to assess his memory, independent of his speech deficits. He viewed a group of 10 real objects that were easily represented by gestures (e.g. cup – by miming the action of drinking). Gestures were assigned to each object before they were hidden. In each of 5 trials he was asked to recall the 10 objects, either by name or by mimicking their use. If unable to recall all the objects he was reminded of the remaining ones. In the interval between the trials short distractors tasks were introduced. In the delayed recall (approx. 5 minutes after the completion of the last trial) NG was asked to name again the objects. For any items not recalled NG was given a 3-item recognition task.

E. Phonological Awareness Test (PAT; Robertson & Salter, 1997; NA2)

The PAT is a comprehensive assessment of children's phonological awareness, phoneme-grapheme correspondences and phonetic decoding skills. Test results help educators focus on aspects of a child's oral language that may not be systematically targeted in classroom reading instruction. The test is geared to children aged 5–9 and it includes a wide variety of tasks such as rhyming, segmentation, isolation, deletion, substitution with manipulatives, blending, graphemes, decoding and invented spelling. Performance on each of these tasks has been correlated with success in early reading and spelling.

F. Raven's Colored Progressive Matrices (RCPM; Raven, 1994, 1995, 1996; NA1, NA3)

The RCPM is a simplified 36-item format of the Raven's Progressive Matrices (RPM) (Raven, 1995). This is a multiple-choice paper-and-pencil test consisting of a series of visual pattern matching and analogy problems pictured in nonrepresentational designs. It requires the participant to conceptualize spatial, design, and numerical relationships ranging from the very obvious to concrete to the very complex and abstract. The RCPM consists of sets A and B of the RPM and an intermediate set, Ab, which, like set B, contains both gestalt completion items and some simple analogies.

G. Rey Auditory Visual Test (RAVLT; Rey, 1964, NA1, NA3)

The RAVLT evaluates verbal memory and is comprised of a list of 15 words that the participant hears and is asked to recall. The list is repeated and recalled 5 times and then a second list is introduced and recall is required. After this trial participants are asked to recall again the first list. A delayed-recall and a recognition tasks (the latter consisting of 50 words, including the words from list and distractors) are also administered.

H. Rey-Osterrieth Complex Figure Test (ROCFT; Rey, 1941, Osterrieth, 1944; NA1, NA3)

This test evaluates visuo-spatial constructional abilities, visual memory and executive functions, mediated by the prefrontal lobes. The test consists of a copy task, where the participant is asked to copy a complex figure onto a sheet of paper. Following the copy stage the participant is asked to recall the complex figure either immediately (immediate recall task), on delay (delayed recall task), or both.

I. Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981, 1997; NA1 [WAIS-R], NA3 [WAIS-III])

The WAIS was administered to assess the general impact of NG's CVA on his general cognitive functioning and to track potential changes following the rehabilitation. At NA1 NG was able to perform only a few sub-tests from the general battery due to his severe aphasia (Digit Symbol-Coding, Block Design and Object Assembly). At NA3 the full battery was

administered as NG was able to perform both the verbal and performance subtests of the battery.

J. Western Aphasia Battery (WAB; Kertesz, 1982; NA1, NA2, NA3)

The WAB is an instrument for assessing language function of adults and is able to discern the presence, degree, and type of aphasia. It consists of four oral language subtests – spontaneous speech, auditory comprehension, repetition and naming – that yield five scores based on a rating scale. In addition, tests of reading, writing, arithmetic, gestural praxis, and construction, as well as Raven's Progressive Matrices are included to provide a comprehensive survey of communication abilities and related functions.

K. Wisconsin Card Sorting Test (WCST; Berg, 1948, Heaton, & PAR Staff, Psychological Assessment Resources Inc., 1993, 2008, NA1, NA3)

The WCST is used primarily to assess perseveration, abstract thinking and executive functions. As such, it allows assessing strategic planning, organized searching, ability to use feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding. The participant is presented with a total of 124 cards on the screen (64 in other versions) over a number of trials. In each trial there are four stimulus cards on the screen, where each card displays one of four symbols – triangle, star, cross, or circle – in the colors red, green, yellow, or blue, and in various numbers, ranging from 1 to 4. On each trial a response card is presented at the bottom center under the four stimulus cards. The participant is asked to match the response card to one of the stimulus cards by using a mouse or one of four selectable keys on the keyboard. Each time the participant matches a response card to the stimulus cards, the computer program provides visual (and auditory) feedback about whether the response was correct ("right") or incorrect ("wrong"). The participant must deduce what the matching rule is, however, the rule shifts after every few trials and the participant has to deduce what the current rule is.

3. Results

In this section we will describe changes in NG's functioning as a consequence of his treatment, summarizing results from the perspective of pre-, intermediate/periodic-, and post-treatment assessment:

3.1. Language assessment

A1. Language production

Spontaneous speech: Fluency (in terms of words per minute) was normal in NA1, the grammatical structure of NG's sentences was mildly incorrect and most sentences included correct conjugated verbs and pronouns (Cookie Theft, WAB: Spontaneous speech). A few sentences were missing a verbs (e.g., "..and my children happy..", see Appendix), and he tended to use plural pronouns instead of the singular when referring to himself (e.g., "and we're having difficulties speaking well"). There were semantic and literal paraphrasias. On many occasions he was aware of his mistakes and tried to correct himself. In NA2 there was some improvement in comparison to the previous evaluation, as reflected by the WAB scores (16/20 in the spontaneous speech subtest compared to 13/20, in NA1), which was due to richer sentences' content. The NA3 assessment produced similar results to NA2 (17/20, see Table 1, Fig. 1).

Repetition. Repetition was severely impaired when NG was first assessed (4/100 in WAB Repetition). Yet, in the second evaluation there was marked improvement (35/100). In NA2, there were lexical errors that preserved the meaning (e.g., *happy* instead of *elated*). This error type suggests that the word that NG heard did trigger the semantic network but could not access the correct lexical item. Noticeable improvement was also observed in NA3 (50/100, Table 1, Fig. 1).

Word retrieval. In all three assessments there were severe word finding difficulties in spontaneous speech (Cookie Theft). On confrontation naming tasks his performance was severely impaired (NA1: WAB Naming 10/100, BNT – 0). He showed some improvement in the following assessments (NA2: BNT - 2/7; NA3: WAB Naming 37/100, BNT - 1/15), but his performance remained impaired in this area. Phonemic cues (initial sounds, letters and syllables) did not improve his performance at all.

Articulation and prosody. These capacities were preserved and were not impacted by the CVA.

A2. Comprehension of auditory language

Phonemic and phonological awareness: This was tested in NA1 by same/different judgment of auditory consonant-vowel pairs (e.g. "da" vs. "ga") without lip-reading. NG performed well in this task. In NA2 a more comprehensive assessment of NG phonology was performed using the Phonological Awareness Test (Robertson & Salter, 1997, see Table 2). This

Table 1
NG's Performance in the Western Aphasia Battery

Subtest	Dec 2000/Jan 2001		Feb. 2003		Aug. 2014	
	Main Score	Subset Score	Main Score	Subset Score	Main Score	Subset Score
I. Spontaneous speech (max. 20)	**13**		**16**		**17**	
I. A. Information content (max. 10)		5		8		8
I. B. fluency, grammatical competence and paraphasias (max. 10)		8		8		9
II. Auditory verbal comprehension (max. 200)	**111**		**133**		**173**	
II. A. Yes/no questions (max. 60)		54		57		60
II. B. Auditory word recognition (max. 60)		60		56		54
II. C. Sequential commands (max. 80)		8		20		59
III. Repetition (max. 100)	**4**		**35**		**50**	
IV. Naming (max. 100)	**10**		**12**		**37**	
IV. A. Object naming (max. 60)		2		n/a		21
IV. B. Word Fluency (max. 20)		0		2		2
IV. C. Sentence completion (max. 10)		2		4		8
IV. D. Responsive speech (max. 10)		6		6		6
V. Reading (max. 100)	**52**		**62**		**78**	
V.A. Reading comprehension of sentences (max. 40)		22		32		34
V.B. Reading commands (max. 20)		5		6		8
V.C. Written word stimulus object choice matching (max. 6)		5		6		6
V.D. Written word stimulus picture choice matching (max. 6)		6		6		6
V.E. Picture stimulus written word choice matching (max. 6)		6		6		6
V.F. Spoken words, written word choice matching (max. 4)		2		4		4
V.G. Letter discrimination (max. 6)		6		n/a		6
V.H. Spelled word recognition (max. 6)		0		2		5
V.L. Spelling (max. 6)		0		0		3
VI. Writing (max. 100)	**28.5**		**27.5**		**43**	
VI.A. Writing on request (max. 6)		2		2		3.5
VI.B. Written output (max. 34)		0		0		0
VI.C. Writing to dictation (max. 10)		0		0		0
VI.D. Writing to dictation or visually presented words (max. 10)		n/a		n/a		5
VI.E. Alphabet and Numbers (max. 22.5)		14		13		18
VI.F. Dictated Letters and Numbers (max. 7.5)		2.5		2.5		7.5
VI.G. Copying of words of sentence (max. 10)		10		10		9
VII. Praxis (max. 10)	**9.5**			n/a	**10**	
VII.A. Drawing (max. 30)		19.5		n/a		29
VII.B. Block design		n/a		n/a		n/a
VII.C. Calculation (max. 24)		20		n/a		22
VII.D. Raven's Colored Progressive Matrices (max. 37)		35		n/a		35

evaluation revealed that his phonological awareness may have also been compromised. Although he was able to perform most of the rhyming, isolation (e.g., identifying first sound in a word) and deletion (e.g., saying a word without one of its parts) tasks, he encountered difficulties with tasks that required segmentation (e.g., syllables in a word) and blending (e.g., integrating separate word sounds into a word).

Semantic comprehension: NG was able to answer biographical and general knowledge yes-no questions (WAB Yes/no Questions – 54, 57, and 60/60 in NA1, NA2, NA3 respectively). He also was competent in pointing to real and drawn objects (as well as forms, numbers, colors, directions, body parts, etc.), according to a verbal command and did better on this section in the later assessments relative to the first (WAB Auditory word recognition – 49, 56, and 54/60 in NA1, NA2, NA3 respectively).

Syntactic comprehension: This function was moderately to severely impaired in NG. He had difficulty executing commands that included prepositions. However, he showed marked improvement in this function in each of his two following evaluations (WAB: Sequential commands – 8, 20 and 59 out of 80 in NA1, NA2 and NA3 respectively).

A3. Reading and writing/spelling

Reading: This capacity was severely impaired in NG. He could not read aloud words and had great difficulty pronouncing the sounds associated with most written letters. In the DAR (Roswell et al., 2005, see Table 2), conducted in NA2, his word recognition, oral reading, and spelling were at Grade 1 levels.

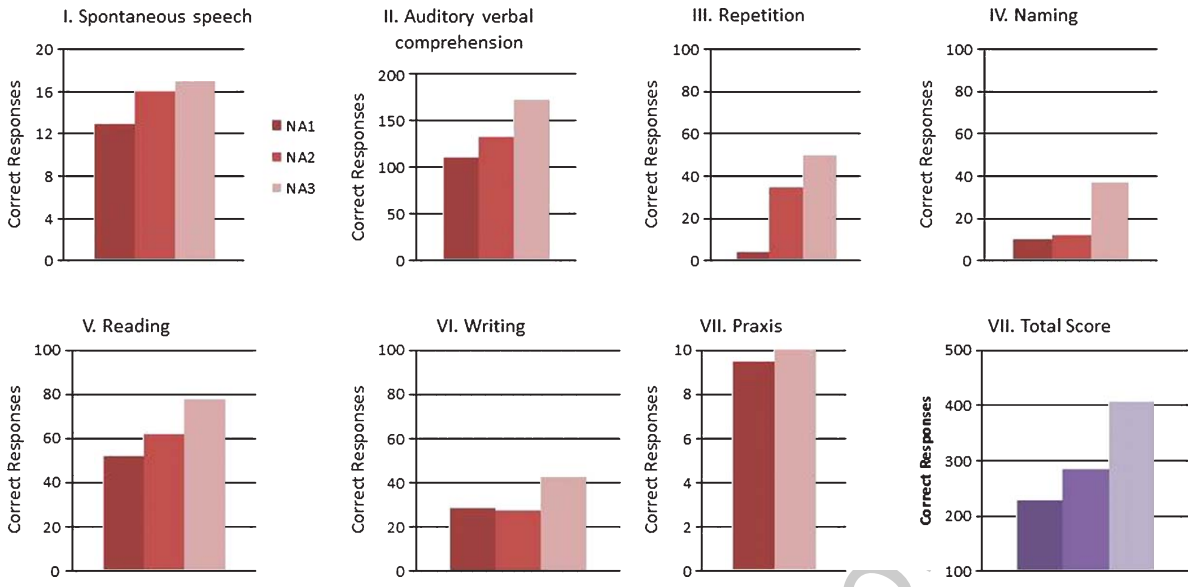

Fig. 1.

It is important to mention that he was able from the beginning of his rehabilitation to derive meaning from written language to a certain extent, and marked improvement was seen throughout the years (WAB: Reading: 52, 62, and 78/100 in NA1,NA2 and NA3, respectively). He was able to point to a written letter according to a verbal command (NA1: WAB: Auditory word recognition – 6/6 items correct). On a test that requires selecting a written word that completes a written sentence he worked slowly, but did better on each evaluation than the previous one (WAB: Reading: Reading comprehension of sentences – 22, 32, 34/40).

Complex reading comprehension is, however, limited. When asked in NA1 to perform written commands he had difficulty doing so, probably because of the language processing difficulties mentioned earlier. Despite some improvement across each evaluation the improvement was only negligible (WAB: Reading: Reading commands - 5, 6, 8/20). He was able to hear a non-word and choose the correct written non-word (e.g., GOB) from a list of written non-words with some accuracy. This suggests that he is capable of some phonological processing and that his reading does not rely completely on the combination of a relatively preserved orthographic route and extensive use of context. Comprehension of written numbers is also relatively preserved. On a simple math test he had no difficulty comprehending written two-digit numbers (WAB: Calculation –20/24 (NA1). In the 2014 evaluation, his level had further improved, receiving 22 out of 24 on the same calculation task.

Writing (letters and numbers): Writing was also originally severely impaired but improved throughout the years (WAB: Writing: 28.5, 27.5, and 43/100 in NA1, NA2 and NA3, respectively). NG is able to write his own name (WAB: Writing: Writing on request) but cannot write letters to dictation (e.g. WAB: Writing: Writing to dictation – he scored 0 on all three assessments). In his first two assessments, NG could not spell words orally or use cut-out letters to create written words (WAB: Writing: Writing of dictated or visually-presented words – 0 score), but this had improved to 5/10 in his 2014 assessment. Although this does not constitute writing, he could copy a sentence in all evaluations (WAB: Writing: Copying of words in a sentence).

Writing numbers is moderately impaired. He was able to write digits between 1 – 20, displaying his highest score in the third assessment (WAB: Writing: Alphabet and numbers – 14, 13, 18/22.5). He wrote 2-digit numbers to dictation without difficulty but made mistakes on longer numbers (WAB: Writing: Dictated letters and numbers – 2.5/7.5 on both NA1 and NA2. Part of the difficulty was with retaining the numbers in short-term memory. However, he showed marked improvement on this subtest in 2014, receiving a full score.

Table 2
Summary Report of the Phonological Awareness Test (Robertson & Salter, 1997) and the Diagnostic Assessments of Reading (Roswell, Chall, Curtis & Kearns, 2005)

Phonological Awareness Test	
Rhyming	16/20
Segmentation	9/20
Isolation	19/25
Deletion	2/2
Substitution	n/a
Blending	n/a
DAR	
	Grade equivalent level
Word recognition	<1-1
Oral reading	<1-1
Reading Comprehension	<3
Spelling	<1-1
Vocabulary	11/12

3.2. Intellectual functioning

During the initial assessment (NA1) it was impossible to compute an intelligence quotient due to NG's severe language impairments, which rendered him grossly impaired. In fact, scores were produced and calculated solely for 3 subtests, where language involvement was minimal (Block Design, Object Assembly, and Digit Symbol; see Table 3). However, in the final assessment conducted in 2014 (NA3), NG's performance was much improved and he was able to perform most of the sub-tests in the WAIS. His overall intelligence quotient was low average (FSIQ = 81, 10th percentile). He performed much better on the performance tasks (PIQ = 95, 37th percentile, average), than on the verbal tasks (VIQ = 73, 4th percentile, borderline), due to his persisting linguistic difficulties. In the RCPM his performance was almost perfect in both NA1 and NA3 (35/36).

3.3. Visuo-spatial functions

Object and line drawing identification were preserved in NA1. His performance on construction tasks was within normal limits (WAIS-R: Block design, Scaled score (SS) = 6, Object Assembly, SS = 9). It was, however, lower than expected, based on his premorbid level of functioning and profession. On the Block Design subtest he performed slowly and only got a time bonus on one of the items. He constructed all nine items but exceeded the limit on the last three. On the Object Assembly subtest he had difficulty identifying one of the items according to its scattered parts and performed slowly. In the ROCFT Copy subtest he scored 36/36 (>99 percentile). A significant improvement was observed in NA3 (WAIS-R: Block design, SS = 10, Object Assembly, SS = 12). In the ROCFT Copy subtest he scored 34/36 (>99 percentile).

3.4. Learning/memory processes

NG's ability to acquire novel information and his memory capacities were affected by his CVA. However, it should be noted that it was not possible to gauge accurately his abilities in this domain because of his linguistic difficulties. Thus, the impaired results indicating difficulties in episodic memory should be treated with caution.

Learning Processes: In both NA1 and NA3 NG's performance improved throughout trials despite the initial low number of items recalled. Due to the lack of normative data it is impossible to assess the learning curve of the FOME but in the RAVLT his performance was average (43 percentile, Table 4).

Memory: His recall performance was impaired both in NA1 and NA3. This is not surprising in light of the verbal assessment measure used in NA3 (RAVLT). Yet, his performance was compromised also in NA1 where naming was not necessary. However, when assessing his performance with a recognition task he achieved full accuracy in both NA1 and NA3. In addition, in contrast to his difficulties in verbal memory his visual memory, assessed with the ROCFT (immediate recall), was intact in both NA1 (28/36, 82–89% percentile) and NA3 (18/36, 41–59 percentile, Table 4).

3.5. Executive & Attentional Processes

Abstract thinking & response set shifting: NG completed the same number of categories in the WCST in both NA1 and NA3 ($N = 4$, Table 5). Yet, his performance in NA3 is better compared to NA1 (>16 vs. 11–16 percentiles), since the short version of the WCST (consisting of 64 cards) was administered in the NA3 assessment while the long version (124 cards) in the NA1 assessment. Improvements were also observed in other parameters of the WCST, such as the total errors (from 19 in NA1 to 58 percentiles in NA2), perseverative errors (from 19 to 58 percentiles), non-perseverative errors (from 19 to 58 percentiles) and learning to learn (from 2–5 to >16 percentiles).

Working memory (WM): This process could not have been evaluated in its usual verbal sense in NA1. Yet, there was evidence at the time that there

Table 3
WAIS Subtests and Index/IQ Scores Summary (WAIS-R in 2001, WAIS-III in 2014)

Subtest	2000/1 Age-Adjusted Scaled Score	2014 Age-Adjusted Scaled Score		
Picture Completion		10		
Vocabulary		10		
Digit Symbol-Coding	5	5		
Similarities		3		
Block Design	6	10		
Arithmetic		3		
Matrix Reasoning		14		
Picture Arrangement		8		
Comprehension		6		
Symbol Search		3		
Object Assembly	9	12		
2014	IQ/Index Scores	Percentiles	95% CI	Qualitative Description
FSIQ	81	10	77–85	Low average
PIQ	95	37	89–102	Average
VIQ	73	4	69–79	Low
Verbal Comprehension Index	82	12	77–88	Low average
Perceptual Organization Index	107	68	99–114	Average
Working Memory Index	57	0.2	53–66	Very low
Processing Speed Index	69	2	64–82	Low

Table 4
NG memory performance in the FOME (2000/1) and the AVLT (2014)

	FOME 2000/1	Percentiles	AVLT 2014	Percentiles
Trial 1	5		2	1
Trial 2	7		4	2
Trial 3	8	11*	5	<1
Trial 4	6		5	<1
Trial 5	9		6	1
Trial 6 (List B)			1	<1
Trial 7 (List A)			6	12
Delayed Recall	7		6	7
Recognition	3/3		15/15	96

Note. *Based on Ganguli et al. (2010) norms of sum of three learning trials.

Table 5
NG performance in the WCST

WCST Scores	Raw Scores 2000/1	%iles	Raw Scores 2014	%iles
Trials Administered	102*		64	
Total Correct	72		51	
Total Errors (%)	30	19	13	58
Perseverative Responses (%)	11	42	6	86
Perseverative Errors	11	37	6	79
Nonperseverative Errors (%)	19	8	7	42
Conceptual Level Responses (%)	66	25	48	63
Categories Completed	4	11–16	4	>16
Trials to Complete 1st Category	11	>16	14	>16
Failure to Maintain Set	2	>16	1	>16
Learning to Learn	–14.92	2–5	4.40	>16

*The test was terminated because of fatigue and loss of concentration.

are difficulties in this area in its broader sense. For example, in the WCST there were difficulties maintaining set (% Conceptual level responses – 25 percentile). In addition, on the FOME there was some difficulty keeping track of objects he had already recalled within the same trial (judging by the repetition errors). This may be connected to oscillations in concentration and to difficulty using short-term phonological memory as a buffer that stores information in a phonological code, thus enabling the

simultaneous manipulation of information (e.g. on the WCST: storing the name of the sorting strategy while analyzing the current sorting problem). In NA3 some improvement was observed in working memory: NG indices in the WCST showed that he was more able to maintain set (% Conceptual level responses – 68 percentile). Yet, his WM index in the WAIS-III was still very low (<1 percentile).

4. Discussion

The present study presents a long-term therapy and follow-up, extending approximately fifteen years, of NG, who suffered a left hemorrhagic cerebrovascular accident (CVA) at the age of 53. As a result of his CVA, significant language comprehension and production impairments, in addition to alexia and agraphia, were observed. He was first treated at the hospital's rehabilitative unit. He later received intensive rehabilitative treatment at the Center for Cognitive Rehabilitation of the Brain Injured at the Feuerstein Institute (FI) for several years (2001–2010).

As reflected on the range of tests administered, NG has made huge progress in his therapy. He has advanced greatly in his language capacities. His conversation skills have significantly improved and he has made much progress in his ability to repeat words. He has improved his word-finding abilities (less paragrammatism and circumlocutions) and he can successfully discuss different topics using substantive vocabulary to get to his point. He has shown marked improvement in his reading and writing. He can now associate letters with their sounds in order to orally read a written word, read aloud simple sentences and write simple words from visual representation. In addition, NG can write new words from dictation via phoneme–grapheme conversion. This amelioration is expressed in the rise of both the aphasia quotient and cortical quotient in the WAB (39.9, 54.7 and 68.9 aphasia quotient and 42.6, 43.0 and 65.3 cortical quotient in NA1, NA2, NA3).

NG's short-term memory recall remains impaired but his recognition and visual memory capabilities are intact. NG also shows high levels of abstract thinking. NG's overall improvement is most obvious when comparing his scores in general intelligence (WAIS). In the first assessment, approximately 7 months after his CVA, NG was only able to complete 3 non-verbal subtests. However, in the final assessment in 2014, not only did his scores on these 3 subtests increase, but he was able to perform most of the sub-tests.

NG still suffers from word finding difficulties and finds confrontation naming tasks a challenge; however, he is cognizant of these difficulties and tries hard to correct himself. There still remains some semantic and literal paraphasias in his spontaneous speech and he displays difficulties in self-monitoring of grammatical errors and understanding of complex speech. When conversing with others, the speaker's pace of speech has to be slower than normal to allow NG more processing time and his short term memory is still impaired.

NG has also succeeded in recovering his functionality and adaptability. He has returned to work in his architectural firm, and he functions on a high level on a day to day basis. He is generally independent, does not need accompaniment, drives by himself, makes telephone calls, corresponds with clients and continues to work on prestigious projects.

Research has revealed that therapy for chronic aphasia is more effective if sufficiently prolonged or intensive (Basso & Macis, 2011). This is a crucial aspect of the application of MLE oriented treatment, particularly as it involved the application of FIE. In one review, Bhogal, Teasell & Speechley (2003) found that significant treatment effects resulted when intensive (at least 8.8 hours per week) training was provided for a total of approximately 100 hours. This was certainly the case for the treatment of NG's chronic aphasia as he received intensive weekly therapy extending almost 15 years.

Speech therapy is the most effective form of rehabilitation for most aphasic patients (Barisa, Noggle, Salisbury & Boseck, 2015). Most patients receive conventional speech therapy targeting the particular areas of difficulty. The development and application of NG's individual speech therapy focused on his specific deficits. Efforts were made to improve his word finding difficulties, repetition and conversational skills and to link them to cognitive strategies such as finding the main ideas in the language, widening his mental field, gathering relevant information in a systematic manner, and the like. As noted above, this individual-focused therapy had a tremendous effect on his language skills. Positive effects of this type of treatment have also been documented in the literature (e.g. Brady et al., 2012).

Another method of treatment for chronic aphasia is tele-therapy. This is the use of telecommunications technologies to connect a clinician with remote clients, or use of web-based or app-based exercises

for independent work, which clients can access whenever they like (Steele et al., 2014). NG uses phone applications to assist him with his language difficulties and to improve his functioning (e.g., an app called "Speak It" helps him read). Technology, such as text to audio software, was also used in therapy to aid him with conversation skills, and in his professional life. In the early stages of the use of these applications, he was mediated to plan their use, connect them to goals and desired outcomes, and review his decisions regarding when and how to use them. In a recent review on aphasia tele-rehabilitation, it was concluded that tele-practice has demonstrated its viability as a method of service delivery to aphasic patients (Hall et al., 2013). A study by Steele et al., (2014) found marked improvement in subjects' functional communication and feelings of confidence following treatment combining tele-therapy and online language exercises. This was clearly evident in NG's use of them.

In addition, functional communication is maximized when therapy for aphasia involves the patient and the family/caregiver (Brady et al., 2012). NG's wife was highly involved in his therapeutic process; she accompanied her husband to sessions for the first year of treatment, assisted him with exercises performed at home, and provided him with emotional support throughout the whole process. Therapy that acknowledges the role of the caregiver of the patient generally has a positive impact on quality of life and communication (Sorin-Peters, 2004).

The structure and format of therapy that NG received at the FI, namely, the Mediated Learning Experience and the Feuerstein Instrumental Enrichment Program, acted as catalysts in his rehabilitation. This style of therapy improved NG's functioning by making use of his strengths and working on the areas that were damaged. Use of state of the art equipment and reference to mathematical skills specific to his field made NG feel that he was able to perform, and helped him rebuild his confidence. Tasks that proved too difficult to him were bypassed by using strategies to intellectually stimulate him in other ways. He was then able to transfer what he learned to other areas of functioning. His wife reported that the hope that NG was given alongside the effectiveness of the MLE method helped her husband bridge the gap between where he was and where he wanted to be. This created optimism in NG which ultimately led to his marked improvement in language. The contribution of intensity and prolonged therapy using IE and the MLE was therefore central to NG's improvement.

Conflict of interest

The authors have no conflict of interest to report.

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Appendix

January 2001

Ok, well there's I think two men and one girl a younger kid and there are several problems there's one of them is all kinds of water that's spilling all over the place the older woman is spilling water onto the floor and onto the dinner... area. Were the rest of it is basically normal and there's another issue....where the two girls are about to fall and the older I guess the girl, the husband the boy is trying to get girling getting food but they're falling and hurt them self's this thing what's it called (*stool) this is in the process of being falling when she's holding here food...

February 2003

Ok, there's several unusual differences which in this area that we're talking about... so the woman woman right? is water is spriding... not sprid-ing... on the floor. Um there's 2 kids the guy is about to fall um... Although he was design so that girl was to get what's it called I don't know what with it before she's about to fall and... .alright. I guess that's it.

24.06.2014

This guy is falling because he is trying to get some food from....you know what it is....it's a sweet food. This is the daughter, or the sister or something like that. This guy is falling. The mother is noticing that water is shpritzing all over the house and she didn't see it....and she's cleaning....glass... and it's pretty ridiculous that they're doing that... and she's also going to fall soon. It looks like the glass (window pane) is not here.