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ORIGINAL ARTICLE

# Post-Stroke Cognitive Rehabilitation: A Single Case Research

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**Abstract** Cognitive rehabilitation is of utmost importance to restore the well-being of stroke patients. The case study research allows an in-depth exploration of complex symptomatology. In this pre-post intervention study of a case with cerebrovascular insults, core cognitive deficits were identified following the idiographic approach. A multimodal approach has been adopted to address the diverse deficit conditions. PD, a 52-year-old male, suffering from two cerebrovascular insults within two years, reported with a complex presentation of cognitive and behavioural symptoms, to get relief of his problems. To develop an intervention programme, baseline assessment of cognitive symptoms was done with Addenbrooke Cognitive Examination, and selected sub-tests from Wechsler Adult Intelligence Scale, Montreal Cognitive Assessment and West Bengal Aphasia Battery. Post-stroke depression and anxiety were assessed using Beck Depression Inventory and Beck Anxiety Inventory. The intervention programme was designed to address the problems in the domains of attention, working memory, naming, retrieval and verbal fluency. One-hour weekly session was conducted for 6 months. Home-based practice was continued even during follow-up period. Gradual post-intervention improvement has been evident in all the aforesaid cognitive functions on trend analysis at three different time points over a period of 5 years. A significant progression has been observed in daily functioning, in quality of life, including, restoration of his creative and professional career. The study-outcome authenticates the efficacy of the current intervention model in bringing about a holistic, persistent improvement in the client's overall level of functioning.

**Keywords** Stroke · Case study · Cognitive rehabilitation · Intervention model · Home-based practice

## Introduction

Stroke has been the second leading cause of death worldwide (WHO, 2020) and the third leading cause of disability (Prathima and Hegde, 2022). It is debilitating when it disrupts physical, psychological and social progressions. The most common impact of cerebrovascular insult is paresis which hinders synergistic movements and the abolition of touch or proprioception (Salles et.al. 2015). However, its impact is not restricted to movement but it extends up to the impairment in spatial perception and recognition of object location and global cognitive impairment

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across the domains of attention, memory, language, problem-solving, decision making and divergent thinking, thereby, culminates in all-pervasive decline in adaptive functions.

A meta-summary of qualitative studies exploring stroke survivors' experiences of rehabilitation emphasized the rehabilitation of physical deficits over nonphysical needs (cited in O'Donoghue et al. 2023). Mazmanian et al, (1993), however, report from their review that impairment of cognitive functions are significant sequela of traumatic brain injury and stroke, and 95% of rehabilitation programmes incorporate some form of cognitive rehabilitation.

Cognitive rehabilitation is often defined as "a systematic functionally orientated intervention of therapeutic cognitive activities based on the assessment and understanding of the patient's brain-behaviour deficits" (O'Donoghue et al. 2023). Post-stroke rehabilitation is of utmost importance to restore the well-being of the patient and the associated lives (Evans, 2019), as cognitive impairment is often not responsive to pharmacotherapy alone.

Cognitive rehabilitation for brain insult, with its multidisciplinary approach, draws upon neuropsychology, occupational therapy, speech and language therapy and special education as modes to ameliorate cognitive deficits. Cognitive rehabilitation and cognitive retraining or remediation though often used interchangeably, technically cognitive remediation and retraining are a part of the rehabilitation process, which is an umbrella term (Hegde, 2014).

For functional recovery of the impaired neural networks, the efficacy of specific intervention techniques for reinforcing, strengthening, or re-establishing the learnt patterns of behaviour and establishing new patterns of cognitive activity, is well-documented (Wilson, 2009). New patterns can be developed through compensatory cognitive mechanisms for impaired neurologic systems. Cognitive rehabilitation has been successfully implemented in ameliorating cognitive impairment in cases of attentional deficits (Tiersky et al 2005), working memory (Vallat et al 2005) and executive function deficits (Goverover et al., 2005)), language impairment and visuospatial deficits (Cicerone et al., 2011). Randomized controlled trial (RCT), a better means to evaluate treatment efficacy with reference to the control condition, does not always apply in the clinical set up for multiple factors. Patient with comparable profiles of brain injury with identical sequelae is scarce. Though RCT designs are accepted as robust one for maximising internal validity, there are increasing calls for methodological pluralism with the recognition that within a typical clinical setting, the best available treatment may be the combined application of standardized treatment protocols and individualized treatments based on clinical judgement. At present, the controlled multiple-baseline designs across subjects or single-subject research designs are more preferred mode of studying an intervention approach (Paparini et al., 2020).

Case study research, currently under-utilised, can offer considerable potential for strengthening faith in both external and internal validity. The overall approach of case study research is based on the in-depth exploration of complex phenomena in their natural, or 'real-life' settings. The physical, emotional and behavioural sequel of the brain pathology needs to be addressed and intervention to be tailor-made to ensure functional recovery of the patient. The case itself leads to frame a therapeutic model (Evans, 2019).

A history of multiple cerebral strokes in different strategic areas of the brain at different time points followed by surgeries with a complex presentation, prompted us to take up the present case as a single case study. In the present case, the major challenge was to isolate the core cognitive deficits from the complex symptom presentation. Hence it was thought to be judicious not to restrict to a single module of cognitive training rather multi-modal and tailor-made approach would be the best choice for the client. Finally, a holistic approach was adopted following the theoretical standpoint of Seligman's PERMA model to bring a wholesome adaptation of the patient to improve independence, employability and quality of life (QOL).

## Methods

### Participant

The client P.D., 52-year-old Bengalee right-handed individual. He was married and was living with his wife and son. He was professionally a psychiatrist. He first visited the clinic in 2019, after 24 months from his last stroke. He suffered from the first

cerebrovascular stroke in 2015 which was followed by a second cerebral stroke in 2017.

## Background

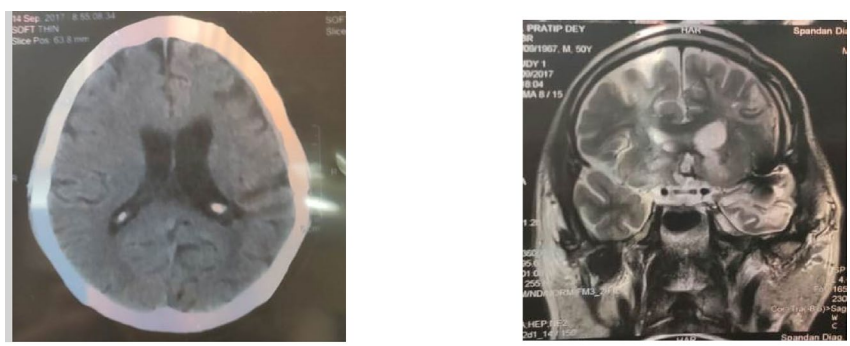
PD had suffered from two cerebrovascular insults within a span of two years. In the acute stage after the first haemorrhagic stroke in the left temporal lobe and in the left capsulo-ganglionic region, he presented with right sided hemiplegia and loss of speech. His condition improved progressively with physiotherapy and speech therapy for six months. The second episode of infarct, ischemic in nature, occurred two years later. The MRI after his last stroke in 2017 confirmed ischemic gliosis in deep white matter of both hemispheres with encephalomalacia in the fronto-parieto temporal region. Both the medial frontal lobes and the head of the caudate nuclei (Fig. 1) were affected by multiple small acute infarcts. Client was under pharmacological intervention required as the immediate post-stroke treatment plan. He was on anti-epileptic drugs like levetiracetum and mood stabilizer like bupropion, combining it with the SSRIs like escitalopram and sertraline for the treatment of persistent low mood occurred as an ancillary symptom after the cerebrovascular insult. Furthermore, rosuvastatin was used to control the cholesterol of the patient alongside Olmesartan as the antihypertensive drug. However, the functional recovery of the client was not in progress after the last stroke.

## Initial Behavioural Observation

At 24 months after the second stroke, when he first reported in the clinic, initial observation revealed stooped posture, uncoordinated gait, and he looked significantly older than his age. His movement was very slow. He maintained minimal eye contact and mostly looked down even while answering. The client did not initiate conversation and only responded in few words. He showed difficulty in finding words. His speech was slurred with occasional stuttering. He spoke in a very soft voice and appeared to be in a low mood. The client presented with complaints of persistent difficulty in recalling names of objects and people. He was unable to organize his thoughts while talking and often his speech became non-goal-directed, which made it difficult for him to hold conversations with people. He had difficulty in both reading and listening comprehension, although his reading skill was intact. It was also difficult for him to do shopping because he tended to forget some of the items he was supposed to buy and made mistakes in evaluating the total cost of his purchases (Fig. 2). The severity of the cognitive impairments following the stroke had prevented him from resuming his work as a psychiatrist. His case history revealed that before the stroke he used to enjoy listening to music and singing and watching theatres but had lost all interest in these activities.

## Design

A single case research design was followed in the present research (Fig. 3). It was considered to test the effectiveness of the intervention provided to a single



Infarct in caudate nuclei

Infarct in Middle Frontal Lobes

**Fig. 1** Neuroradiological findings of the client

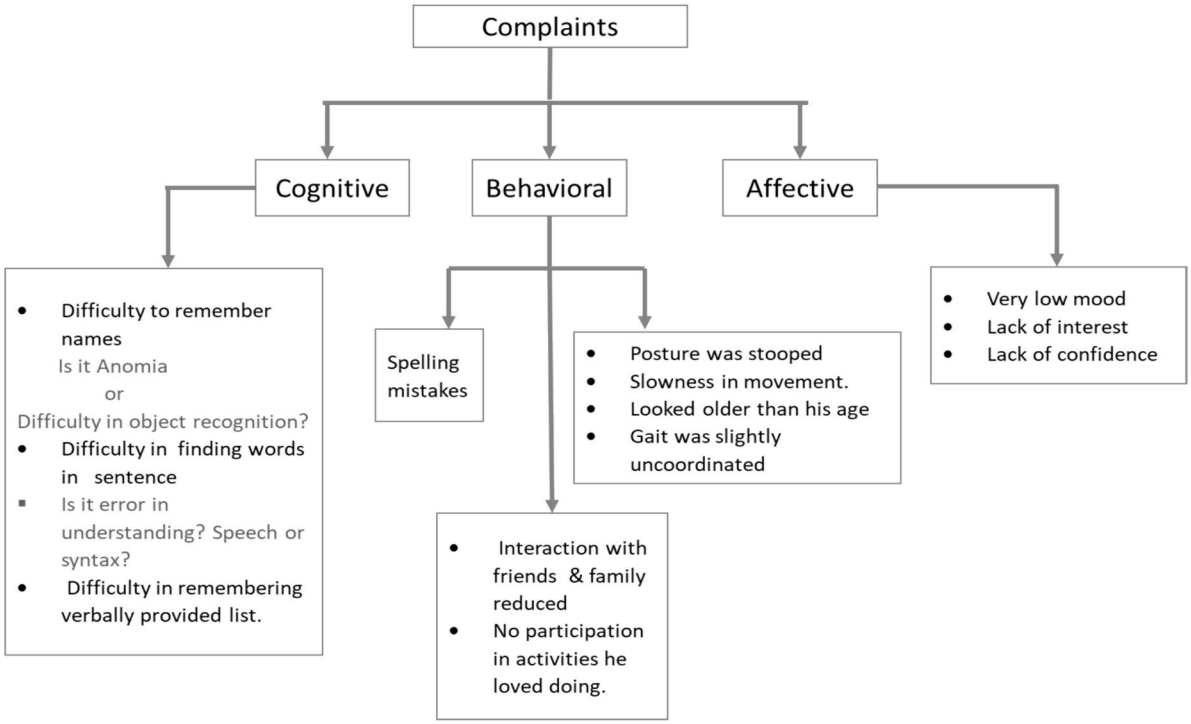



**Fig. 2** Schematic representation of the complaints in cognitive, behavioural and affective domains

case in an ABA design by comparing baseline or pre-intervention phase (A), during intervention (B) and after removal of the intervention with multiple follow-ups (A). Ethical clearance was obtained from the Institutional Ethical Committee of University of Calcutta for the purpose of the study. As previously stated, the therapy was started 24 months post-stroke, when further, spontaneous recovery was unlikely. Moreover, the deficits as identified from the assessments had not improved during the previous months, despite conventional speech therapy and pharmacotherapy. After initial screening for cognitive impairment, pre-intervention measures were obtained using standardized measures. A need-based intervention was planned on the basis of the difficulties identified from the assessments. Recall scores for each task were obtained at the end of each training session. During the intervention programme, a total of 56 recall scores were obtained. Post-intervention measures were obtained at the end of 3 months, 6 months and 12 months. Then again at the end of 3 years and 5 years follow-up scores were obtained (Fig. 3).

## Initial Screening Measures

The findings from Addenbrooke Cognitive Examination (ACE-III) (Hodges & Larner, 2017) revealed that the client was oriented to person, and the time of the day but had a poor orientation of date and month and partial orientation to place [5/10]. He performed at the ceiling in the task of attention, his score [3/3] indicating an ability to register at least three units of information free from distraction. To fulfil the test demand of ACE-III serial subtraction as an attention task of 100–7 was administered. As expected, client PD could not perform [0/5] in it. However, he could repeat up to 3 sequences when given a simpler operation [40–3]. The discrepancy in performance suggests his difficulty in maintenance of neural record with higher cognitive demand. An impaired performance in the memory subdomains of immediate recall

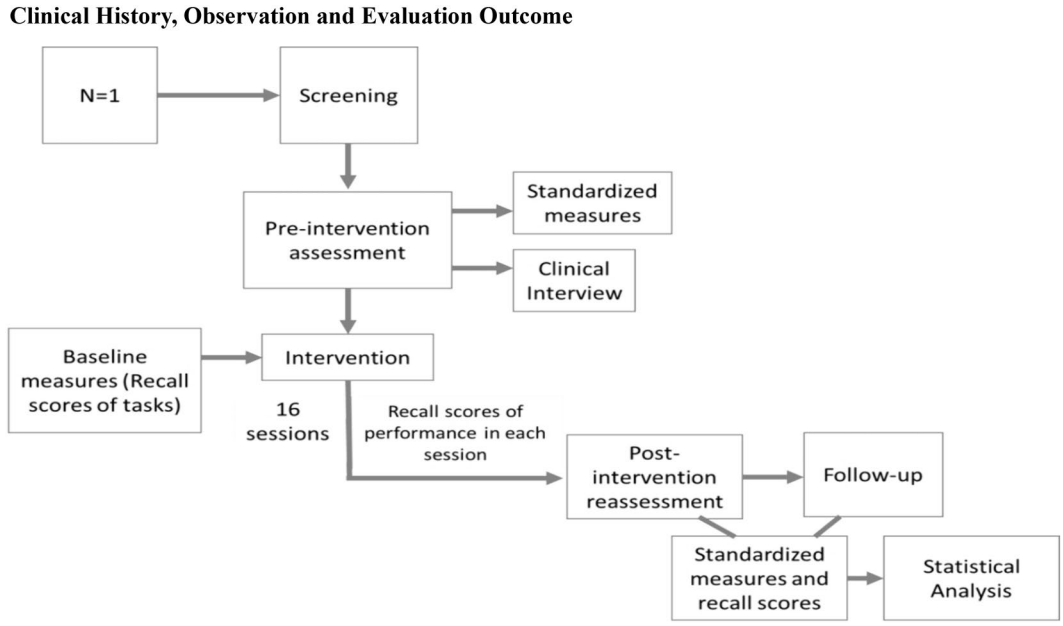



**Fig. 3** The schematic representation of the design of the study

[2/7] and delayed recall [0/3] was observed. The client showed difficulty in answering factual questions [0/4]. To specify whether the deficit was limited to the retrieval process or in the process of retention too, cues were provided in terms of multiple options to the questions. The patient's intact recognition of options, despite the difficulty in generating the answers verbally, substantiates his difficulty in recalling. However, in the case of new learning, his recognition difficulty [2/5] indicated a deficit in the acquisition of new information.

His impaired performance in both the tasks of verbal letter fluency [2/7] and category fluency [2/7] denoted a word-generation deficit. In the language domain, though he was efficient in the repetition of single words (3/4) but could not repeat sentences [0/2]. He had impairment in the naming task [1/12] but could correctly point [4/4] at all the objects given for its functional use.

He showed impaired visuospatial ability but no hemineglect was detected. An overall score of 32 on ACE III, which was much below the criterion score of 88, indicated a definite cognitive impairment.

The cognitive profile presented difficulty in sustained attention, memory, verbal fluency, naming and visuospatial ability (Fig. 3).

## Pre-Intervention Assessment

Rationale of Assessment

In the present study, initially, PD was in a pervasive low mood and was not very communicable, so an extensive neuropsychological assessment was not possible. Hence the assessment was done in two phases.

1. In the first phase, the possible cognitive dysfunctions related to affected brain regions in PD were identified based on existing literature. Since the origin of the same expressed cognitive dysfunction could result from different brain sites with diverse treatment implications and varied prospective outcomes, identification and relating the function to the identified regions was deemed an important requisite.
2. In the second step, as he started communicating, a clinical interview was conducted based on his complaints and neuropsychological tests were administered to identify the affected cognitive functions and their corresponding affected and the spared regions of the brain.

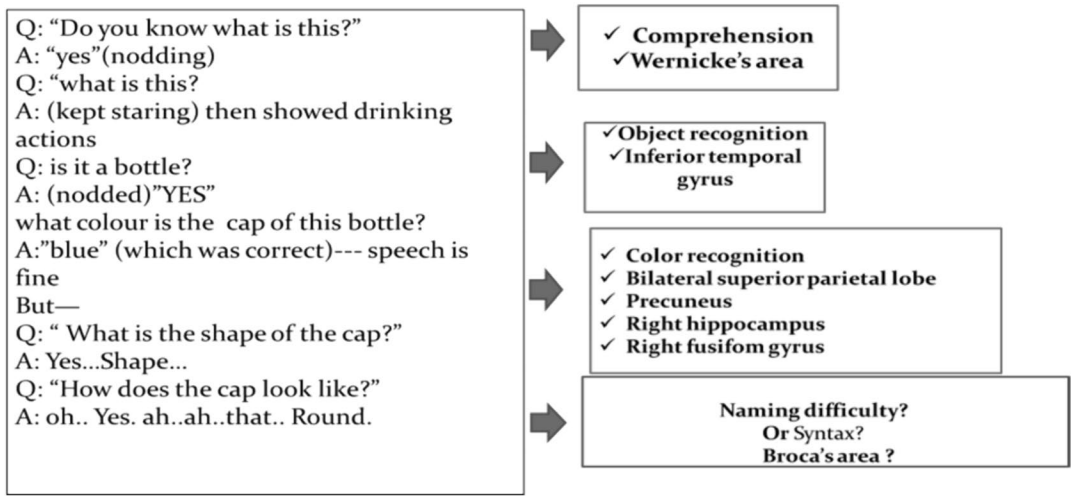



**Fig. 4** An excerpt from one clinical interview to identify the core cognitive deficit and corresponding probable associated brain regions

## Neuropsychological Evaluation

### Clinical Interview

An excerpt from the systematic interview, is depicted in Fig. 4. Here the naming function has been probed in a conversational mode with the active participation of the client that helped him to be engaged in the therapeutic situation. To isolate the core deficit, precise questioning was done with a caution of not overtaxing the patient and maintaining his volition, a prerequisite for therapeutic engagement.

This is an example of how using one common object, "bottle" we could rule out the difficulty in comprehension, as PD's clear understanding of the questions suggests intactness of the Wernicke's area. PD had accurate object recognition, reflected through his response of functional use of the bottle indicating the intactness of the object recognition area of the right inferotemporal cortex. His intact colour

**Table 1** Identified Lesion sites in the client and probable cognitive dysfunctions

| Lesion Site | Dysfunction relating to specific complaints |
|---|---|
| Left temporo parietal region | Attentional processes, Lexical processing, Spatial relations and spatial attention difficulty, two-way naming deficits (can neither retrieve nor point), comprehension deficit (Doricchi, 2022) |
| Left capsulo-ganglionic region | Flaccid muscle tone, motor impairment (Miyai et.al (1997), Pantano et al. (1995) |
| Left sylvian fissure | Speech production deficits, pain and temperature sensation with visceral sensation (Toledo, 2023) |
| Left frontoparietal region | Cognitive control abilities, selective and sustained attention (Marek, 2018) |
| Left temporal region | Impaired memory for verbal material (Cutsuridis, 2017) |
| Right superior parietal region | Difficulty in proprioception, working memory (Alahmadi, 2021) |
| Left fronto-temporo parietal region | Cognitive control (Marek, 2018) |
| Head of caudate nuclei | Executive control of motor function, response selection and goal-directed behaviour (Graff-Radford et al., 2017; Redgrave et al., 2010) |
| Bilateral medial frontal lobe | Decision making, retrieval of remote memory and consolidation on time scales and associative learning (Euston et al., 2012) |
| Deep white matter of both cerebral hemispheres | Cognitive impairment, loss of balance or coordination, vision loss, and dizziness, processing speed (Sharma et al., 2024) |

**Table 2** The subtests used to assess the cognitive domains

| Domain | Subtests |
|---|---|
| Attention and working Memory | Random "A" letter Test (Montreal cognitive assessment (MOCA) Nasreddine et al, 2005) |
| | Digit span task (Wechsler adult intelligence scale, fourth ed., Wechsler, 2008) |
| | Serial Subtraction (Montreal Cognitive Assessment (MOCA) Nasreddine et al, 2005) |
| Visuospatial perception | Block design Task (Wechsler Adult Intelligence Scale, fourth ed., Wechsler, 2008) |
| Language | Sentence completion (West Bengal aphasia battery, Keshree, et.al., 2013) |
| | Responsive speech (West Bengal aphasia battery, Keshree, et.al., 2013) |

recognition reveals the intact connectivity between the brain regions including the bilateral superior parietal, precuneus, right hippocampus, right fusiform gyrus and posterior occipital region (Bramão, 2010). His difficulties in naming the object and speaking in grammatically intact sentences denotes a dysfunction in significant part of the temporal gyrus involving the anterior, medial and superior regions of the temporal lobe (Lau et al 2015, Sakai, 2004) and in left inferior frontal gyrus (Broca's Area) respectively corroborating the MRI findings (Fig. 1; Table 1). Further assessment was done using standardised neuropsychological tests.

Standardised Measures

Neuropsychological tests (Table 2) were administered to confirm the level of functioning in the identified domains of cognitive deficits.

The standardised tests of Beck Depression Inventory (BDI) and Beck Anxiety Inventory (BAI) to assess the mood and the anxiety symptoms as an adjunctive difficulty of the cerebrovascular stroke has been administered in the pre-intervention phase.

*Test Findings*

1. **Digit span task** The patient could repeat only up to 3 digits indicating an impairment in registration of information free from distraction. The difficulty in sustaining attention hindered the registration of more than three units of information. On the other hand, his impairment in digit backward task indicates his difficulty in spatial reorganization too. Overall, the findings indicate his impaired efficiency in sustained attention and working memory which could be explained by the affected left fronto-parietal region in the client.
2. **Sentence completion** This task demands the ability to generate an appropriate response to complete the sentence. He could respond to simpler sentences but it was delayed. An impaired performance might indicate his difficulty in response generation due to poor lexical access that corroborates with the finding of difficulty in verbal fluency in the client as evident in ACE III, which is often the result of slow lexical access speed, poor updating and response inhibition (Bose et al., 2022). The poor lexical access indicates an affected connectivity between the left fusiform and left inferior frontal gyrus, and middle temporal gyrus (Roos et al 2023) while impaired information-updating and response inhibition indicate an affected fronto-striatal loop. The neuroradiological findings (Table 1) indicated impairment in the fronto-temporo-parietal junction and bilateral caudate head in striatum and deep white matter regions which could explain the impaired neural networks of lexical access, information updating and response inhibition involving the frontal, temporal and striatal regions and its white matter connectivity.
3. **Responsive speech** This task demands the ability to generate appropriate responses retrieved from the semantic storage. For example in response to 'what do you use to write?', the client responded correctly to the first two items but could not recall responses to the next three items, which can be explained by his difficulty in retrieval process possibly associated with middle temporal lesion (Table 1) (Sakai, 2004).
4. **Block design task** In the subsequent assessment of visuospatial ability with block design, the patient could perform well on the block design

task but with compromised processing speed. This indicates that the client had intact visuospatial concept attainment despite right superior parietal lesion, indicating a dissociation between areas involved in attentional function and visuoperceptual functions in the superior parietal lobule. Further, the poor processing speed could be traced to the affected deep white matter areas in both the cerebral hemispheres.

5. **BDI and BAI** Both the test measures indicated severe mood and anxiety symptoms in the patient. He was having persistent low mood with a sense of helplessness and hopelessness resulting from the functional impairment restricting his daily activities. He was extremely anxious with the anticipation of the future that resulted in his inability to completely engage in the initial sessions of assessment.

*Identified Areas of Difficulty*

From the neuropsychological testing, clinical interview and observation, following specific areas of deficit could be identified for Intervention.

1. Sustained attention and working memory functions
2. Retrieval
3. Temporal organization of Information
4. Naming Objects and Face
5. Verbal fluency

*Identified Strengths*

1. Intact motor abilities
2. Registration and Retention of information (up to 3 units)
3. Intact reading skill
4. Writing on prompting (not spontaneous)

## Intervention

### Rehabilitation Design

The intervention tasks aimed at restoring the affected cognitive functions by activating pathways in the affected neural networks. Each task was arranged in a difficulty hierarchy. The difficulty level was set in accordance with the modality of the stimulus presentation (visual to auditory), span of attention and capability of conceptualization (concreteness to abstraction) of the patient. The spared functions such as reading, writing, object recognition and colour recognition; the daily home-based tasks on which he was well-versed- all were retained as the intervention tasks in the therapeutic programme and were utilized to restore the compromised functions. It was designed to connect the networks of the impaired functions with those of the intact ones to enhance the potency of the summated neural activation to strengthen the inter-neural circuits connectivity. It was planned not only to enhance the cognitive efficiency but to get him back his sense of mastery that would be helpful to alleviate depression.

One-hour weekly sessions were conducted for 6 months. Tasks from different domains were practised in the same sessions and the same order of task presentation was maintained. The task for attention and working memory was followed by the task for naming which was followed by tasks of serial retrieval in one session. The training was continued till the performance level in each task was 100% following intervention.

Based on probing and rehabilitation design, the following tasks were developed for each domain.

### Attention and Working Memory

As the mechanisms for attention and working memory overlap functionally (Corbetta and Shulman, 2002), tasks of working memory including selective, sustained and alternating attention (Solhberg and Mateer, 2001) were administered. This intervention was deemed essential as PD was a practising psychiatrist but was unable to provide a diagnosis and advice to the patients, due to his difficulty in holding the complaints required for understanding of the case. This difficulty was attributed to simultaneous processing difficulty and impaired verbal

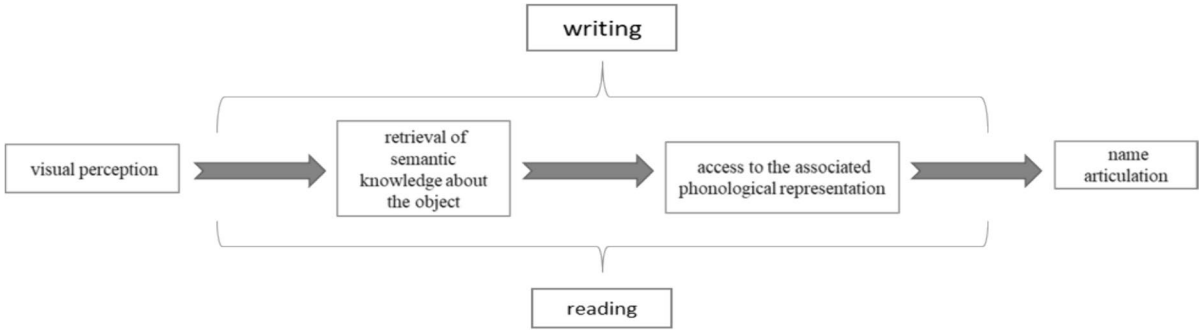
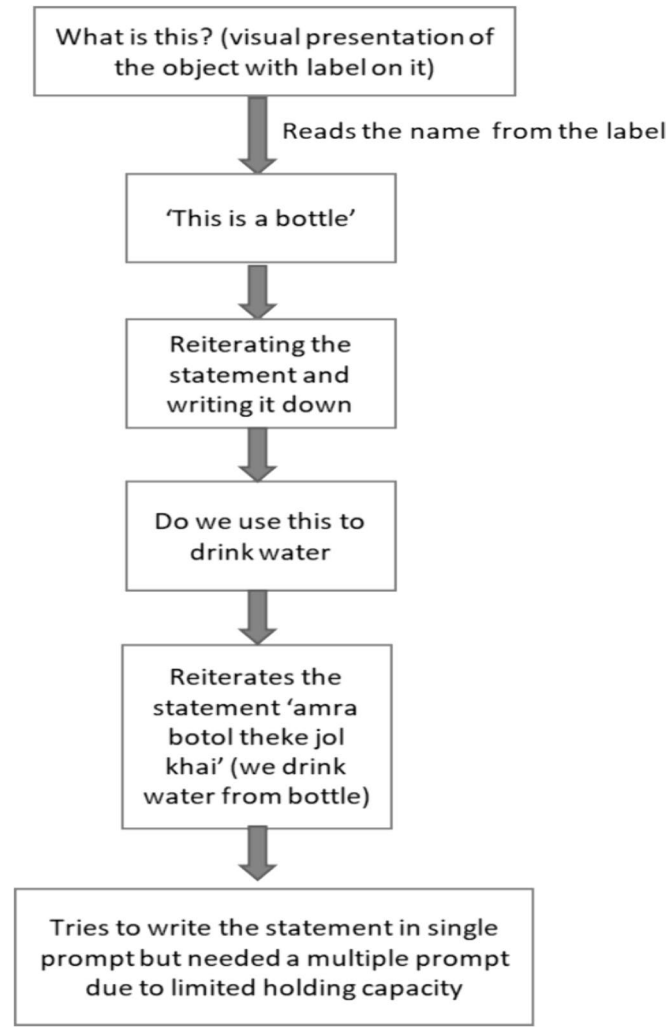



**Fig. 5** Modified training process for naming based on the model of Lau, et.al. (2015)

**Fig. 6** A schematic representation of the training procedure for object naming



working memory functions as revealed in digit span task.

The content of the task items was taken from the area of psychiatry and was designed for the cognitive retraining of the central executive, phonological loop involving both the phonological store and sub-vocal rehearsal processes. It aimed to restore PD's ability to maintain and simultaneously organize more amount of verbal information.

Task Procedure

*First Eight Sessions*

For the target of increasing the attention span and ability to sustain attention, sentence repetition was used as a task. During the training, PD progressed from repeating and processing shorter 3-word simple referential sentences (related to objects such as bottle, pen) to longer 6 words expressive sentences (For example, He is proud of his son). This practice was continued for the first 8 sessions.

*Next Eight Sessions*

For the next 8 sessions, in addition to the continuation of the attention training, the focus was on the enhancement of his ability to organize information. For this purpose, different psychological symptoms were framed as sentences to use in role-playing where the trainer would play the role of a patient and PD played the psychiatrist. Gradually the complexity of the symptoms was increased and different psychiatric symptoms were presented by the trainer. After 16 sessions the client was able to retain six to seven-word sentences, could comprehend the symptoms and advise medicines for complex psychological symptoms.

*Naming*

The task involved training the names of common objects and close relatives. Actual objects, pictures of objects and photographs of relatives were used to teach the object-name and face–name associations, which was done using an errorless method using lexical-semantic mapping, i.e., linking concepts to verbal and written output, incorporating visual imagery, vanishing cues and repeated practice (Fig. 5). The training was imparted for 14 sessions during which the recall scores of 14 trained object names and relative names increased from baseline 21% (3/14) and 7% (1/14) respectively to 100% post-intervention.

Task Procedure

*3rd Session to 16.$^{th}$ Session (14 sessions)*

- Reading the names of common objects and relatives written on the labels struck on the object or the picture,
- Framing and writing sentences about the name, shape and function of the object and framing sentence about the relation with the person.
- Finally framing sentences based on an abstract understanding of the object (Fig. 6).

*Task 2 Recognition Task*

Here recognition method was employed to choose the appropriate target words amongst multiple closely related non-targets, presented visually, using flash cards when the function was presented verbally, he was supposed to choose the right response from the given options. This required recognition of accurate information to strengthen his association between the term and its function, like the term hallucination and its concept. Therefore, retrieval through the establishment of a lexical-semantic connection was targeted.

*Retrieval Process*

Tasks were designed to focus on the difficulty of retrieval of information which affected his ability to follow auditory instructions, which impacted his daily activities like grocery shopping.

Task1: Learning Items on a Shopping List

*Task Procedure*

*3rd Session to 16.$^{th}$ Session (14 sessions)* Based on his word span of 3, the word list of shopping materials

was prepared which was gradually increased in subsequent sessions.

Gradually visual presentation in initial sessions was replaced by the auditory mode of presentation in later sessions. Prompting was provided to maximize the efficacy of the training, and maintain the motivation.

Temporal Sequencing of Information

His difficulty in retrieving and temporal sequencing of the information affected his ability to hold conversations and organizing daily activities in sequence.

*Task 1: Journaling-*

The client was asked to write down his daily activities in a temporal sequence. This practice was expected to facilitate the process of seriation of information and chronological retrieval. The repeated practice of retaining and recalling information serially improved the process of neural recording, which is the ability of the brain to sequentially record information that gives the information a temporal dimension (Large & Jones, 1999).

*Verbal Fluency*

Since PD had impairment in verbal fluency, music that necessitates an inter hemispheric function, was chosen as a mode of intervention for enhancement for verbal fluency. Moreover, the client's fondness for music enhanced his volition for participation in this programme.

Task 1 Music Based Intervention

*Task Procedure*

*3rd Session-16th Session* During the session, the client was asked to sing his favourite song. The song lines were initiated by the trainer and he had to complete the line with appropriate lyrics. The transfer of this training facilitated his verbal fluency in regular speech production.

All the tasks were conducted in a congenial, non-challenging and supportive environment both in the training sessions and during home-based practice.

The client was advised to continue regular home-based practice to maintain the level of improvement.

Supportive Therapy

To maximise the efficacy of the cognitive training, a family-time consisting of conversations and games were suggested. The client's son who was preparing for medical entrances was asked to discuss his studies with PD. Playing music at home, inviting friends over for conversations and visiting different programmes such as seminars, plays, music concerts were also prescribed.

## Results

Improvement was observed in the client in almost all the domains of functionality after the six-month intervention programme and also in the subsequent follow-ups as observed from Table 3. The line graph indicates positive progress in cognitive functioning. A slight decline is observed 6 months post-intervention that was followed by a gradual progression in the subsequent follow-ups.

Out of 56 recall scores, 2 scores from each of the 4 tasks (total 8 scores) were selected where the scores from the initial baseline phase of the session and the score from the mid-point of the session or intervention phase and post intervention phase were considered. This selection of scores from three distant point of the sessions help in understanding the curve of learning reflected in different tasks of intervention. Further, it helps to maintain the parity in assessments between the three time points.

The recall scores were submitted to trend analysis on IBM SPSS Statistics for Windows, Version 25.0. Table 4 shows the mean SD and the result of repeated measure ANOVA with trend analysis for three time points of intervention for recall scores of object naming, face naming, syllables of meaningful sentences and word list recall. The repeated between-group measure to determine mean differences amongst different time points of intervention is found to be significant with large effect size for different tests of recall (Table 4). This indicates that there is a significant difference amongst three different time points

**Table 3** Neuropsychological test scores for pre- post-intervention and follow-ups

| Cognitive domains | Initial | Interim | | | | | Final |
|---|---|---|---|---|---|---|---|
| Subtest | Pre-intervention | Post-intervention | 3-month post-intervention | 6-month post-intervention | 12 months post-intervention | 3-year post intervention | 5-year post intervention |
| *Attention* | | | | | | | |
| Digit Span forward (WAIS IV) | 03 digits<br>Impaired | 06 digits<br>Average | 06 digits<br>Average | 04 digits<br>Deficit | 05 digits<br>Average | 06 digits<br>Average | 06 digits<br>Average |
| Random 'A' letter test (MOCA) | 00/11<br>Impaired | 5/11 | 7/11 | 3/11 | 6/11 | 8/11 | 9/11 |
| *Visuospatial ability* | | | | | | | |
| Block Design (WAIS IV) | 16 (without time limit) | 28 (without time limit) | 32 (without time limit) | 24 (without time limit) | 28 (without time limit) | 32 (without time limit) | 32 (without time limit) |
| *Working memory* | | | | | | | |
| Digit span Backwards (WAIS-IV) | 02 digits<br>Impaired | 5 digits<br>Average | 5 digits<br>Average | 02 digits<br>Impaired | 03 digits<br>Deficit | 5 digits<br>Average | 5 digits<br>Average |
| Serial subtraction (100–7) | 00<br>Impaired | 02<br>Deficit | 02<br>Deficit | 01<br>Impaired | 02<br>Deficit | 03<br>Average | 03<br>Average |
| *Language* | | | | | | | |
| Sentence completion | 02<br>Impaired | 08<br>Average | 08<br>Average | 04<br>Impaired | 08<br>Average | 10<br>Average | 10<br>Average |
| Responsive speech | 04<br>Impaired | 08<br>Average | 10<br>Average | 04<br>Impaired | 08<br>Average | 10<br>Average | 10<br>Average |

of interventions in terms of the changes observed in performance.

Further, a significant linear and quadratic trend of changes in performance across the three different time points of intervention (Table 5; Fig. 8) is also evident from trend analysis with large effect size (Table 4). This indicates that with the progress of each phase of intervention, the individual has been able to maintain the therapeutic gain. Therefore, a linear increase in trend of performance subsequently and gradually from the time of intervention to post-intervention and follow up sessions is observed. Moreover, there is a slight bend in the mean of post intervention session performances while moving towards the follow up sessions signifying a quadratic trend (Fig. 8). It indicates a slight decrease in performance probably due

**Table 4** Mean, SD and repeated measure ANOVA with Trend Analysis for recall scores across different time points

| Stages of intervention | Mean/SD | F (Repeated measure) | ηp2 (Repeated measure) | F (Linear, quadratic) | ηp2 (Quadratic) | df |
|---|---|---|---|---|---|---|
| Intervention | 6.00/4.30 | 58.92** | .894 | 8.12*, 6.81* | .537, .493 | 1,7 |
| Post-intervention | 9.12/3.22 | | | | | |
| Follow up | 10.37/3.24 | | | | | |

$^{**}p < 0.01$, $^{*}p < 0.05$

*Index* F (Repeated Measure)- Repeated Measure ANOVA between group differences, F (Quadratic)- Trend Analysis, ηp2- Partial Eta squared (Effect size), df- degrees of freedom

**Table 5** Table depicting the recall scores after each intervention session

| | 3rd session | 4th session | 5th session | 6th session | 7th session | 8th session | 9th session | 10th session | 11th session | 12th session | 13th session | 14th session | 15th session | 16th session | After 3 months post intervention | After 6 months post intervention | After 12 months post intervention | After 3 years post intervention | After 6 years post intervention |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Naming* | | | | | | | | | | | | | | | | | | | |
| Object naming | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 14 | 14 | 13 | 8 | 11 | 12 | 14 |
| Face naming | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 14 | 10 | 11 | 13 | 12 |
| *Word recall* | | | | | | | | | | | | | | | | | | | |
| Syllabus recalled in meaning full sentences | 3 | 3 | 4 | 4 | 6 | 6 | 8 | 8 | 8 | 8 | 10 | 10 | 12 | 12 | 11 | 8 | 9 | 10 | 11 |
| Word list recall | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 4 | 5 | 5 | 6 |

to lack of maintenance in the practice of the therapeutic tasks that have been assigned during the intervention phase. However, the decrease is very negligible since the linear increase in value (Table 4) is more than quadratic value which indicates that the patient was able to overcome the decline and performed better in follow up sessions in comparison to the former intervention sessions.

Interestingly, the post-intervention neuroimaging did not reveal any structural change as seen from images (Fig. 11A and 11B), but improvement in the neuropsychological test performance (Table 3) was clearly evident. The schematic illustration (Fig. 10) below summarises the functional outcomes of the intervention that had significantly improved his QOL.

## Discussion

The present findings obtained from a patient with cerebrovascular insults will be discussed to understand the symptom severity in the domains of mood and cognitive functioning impacting his professional life and quality of life in general. Further the efficacy of the idiographic approach in multi-modal cognitive rehabilitation programme has been evaluated in ameliorating the post-stroke cognitive deficits with reference to the base line measures and time series analysis across the sessions and follow-ups. Hence consequent improvement in his daily functioning and occupational re-engagement with his existing limits of neuroplasticity, was a major concern of this programme. The client PD had a history of strong professional and co-curricular engagements which revealed his high cognitive reserve. Although initially the client was in a state of low mood, he was motivated to address the difficulties.

In the present study, the utilization of the identified spared functions had both psychological and neurological consequences. The difficulty of the client in naming objects and people was addressed using intact reading and writing skills as modes of practice. The repeated pairing of the intact functions helped to restore the function of naming. Neurologically, object naming is a left temporal function, while object recognition is a right temporal function and writing and reading involve the frontal, parietal, and occipitotemporal regions. The simultaneous functional activation

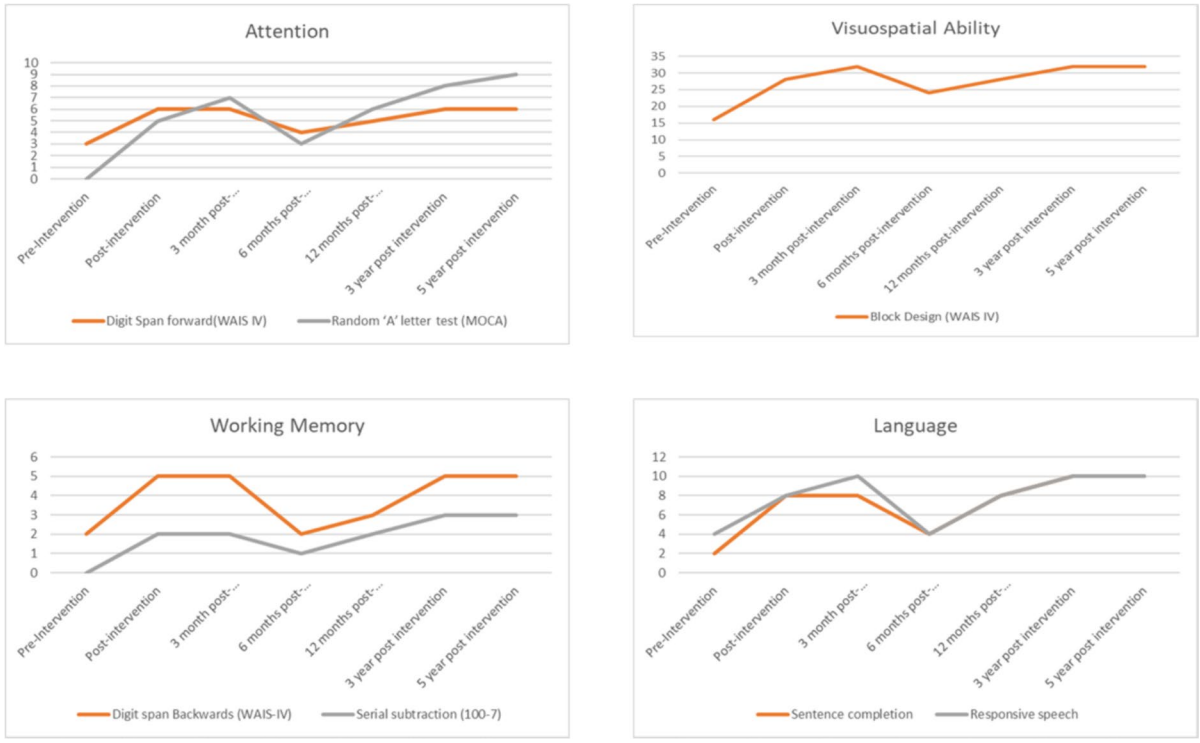



**Fig. 7** Line graph depicting the scores in different cognitive domains post-intervention, for 5 years

and pairing of these functions with the weak activation of left temporal object naming increased the synaptic strength due to spatial summation. This could explain the improvement in the naming function. A spontaneous transfer of training to other untrained names of objects was also observed.

An important aspect of our programme was the training of all the cognitive domains in each session instead of focussing on one at a time. It was decided considering the potential impact of training on the affected cognitive functions. The significant gains in working memory and attentional control enabled him to overcome automatic responses, suppress distraction, remain on task and increase his concentration span (Miller, 2000) which helped PD in retrieval of information in serial order and recalling names of objects and people. The functional activation of fronto-striatal network and the medial temporal regions resulted in a cumulative activation of a larger brain area. This activation of larger brain areas could increase the retrieval potential of information thus stimulating a general improvement of cognitive functions.

Music was used as a mode of training as it was an integral part of the client's life before stroke. The intact tune and rhythmic ability of the client facilitated retrieval and verbal fluency. Each of the musical components engages different brain sites: melody engages the left inferior temporal and frontal areas, rhythm engages the left temporal lobe and the basal ganglia, and harmony engages the inferior frontal areas (frontal operculum) bilaterally. These shared neural networks with cognition and language helped in modulating both cognitive and language networks (Koelsch, 2002; Kunert et al., 2015).Our study corroborates with earlier research that has highlighted the intriguing links between music and a variety of cognitive functions, including temporal order learning (Hitch et al. 1996), spatiotemporal reasoning (Sarntheim et al., 1997), attention (Drake et al., 2000), and auditory verbal memory (e.g., Glassman, 1999; Kilgour et al., 2000; Thaut et al., 2005; Chan et al., 1998; Ho et al., 2003).

Post-training, music listening and practice was prescribed as reinforcement that aided transfer in different social domains improving adaptivity and QOL.

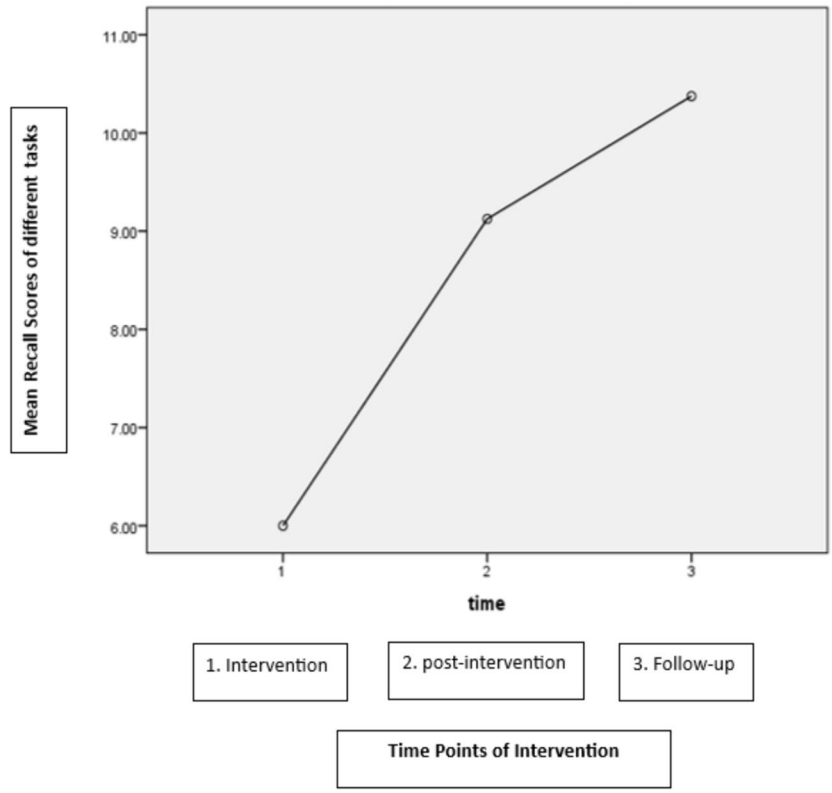



**Fig. 8** Linear and Quadratic trend of mean of recall scores across different time points of intervention

The intervention therefore met its target of being directly relevant to PD's daily life, and this relevance remained important at the end of the present study.

A naturalistic follow-up showed long-term maintenance of the effects of the cognitive rehabilitation intervention over 5 years (Fig. 7, Fig. 8). The trend analysis of the recall scores (Fig. 8, Table 5) also revealed a directly proportional trend of successful intervention which results in an enhancement of the performance in follow up sessions of the patient.

PD's performance in cognitive task showed an initial improvement at 3 months followed by a slight decline at 6 months (Fig. 7). According to PD and his wife, there was decrease in the daily home-based practice of the tasks due to other engagements during this phase. This decline in performance with the stopping of practice provides evidence for the fact that regular home-based practice is an effective way of maintaining performance as it incorporates constant feedback. The neurological impact of sustained activation of the weakened synapses with practice might result in restrengthening the activity. It is clearly evident from the graphical representation (Fig. 9) that shows the pattern of variation of mood and cognition at different time points, where a decline in cognitive performance at 6 months post-intervention aligned with a lowered mood and increased level of anxiety (Table 6; Fig. 9), and subsequently followed by an improvement in cognition that showed an elevation in mood, thus denoting its covariation.

At 12 month follow up, the client showed improvement in functioning that has been reflected in the test scores. After this the client visited the clinic for multiple follow ups and also continued with online follow-ups during the lockdown period. Repeated testing was not done for every visit to avoid making the client feel humiliated by putting his efforts to test. Post lockdown, 3 years after the initial intervention, a reassessment was done that showed improvement of gains in all the cognitive domains. A similar trend was observed at the end of 5 years.

At the pre-intervention stage the cognitive deficits were accompanied by severe depression and anxiety (Table 6; Fig. 9) reflected in slowness in movement, stooped posture, an uncoordinated gait and a limited social and professional involvement. Through the

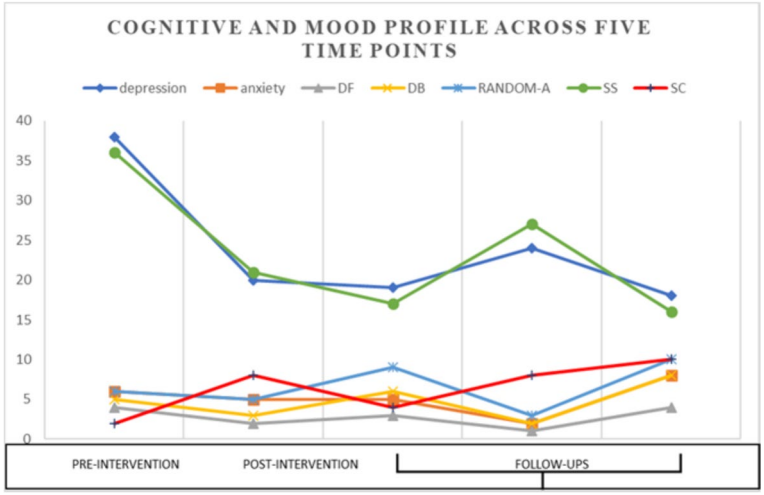



**Fig. 9** The graphical representation of cognitive and mood profile of the patient across five time points of preintervention baseline, intervention and follow-ups

**Table 6** Depicts the depression and anxiety scores of PD across different time points

| Scales used | Pre-intervention | Immediately after intervention | 6 months post intervention | 12 months post intervention | 5 years follow-up |
|---|---|---|---|---|---|
| Beck Depression Inventory | 36 (severe depression) | 21 (Moderate depression) | 17 (Borderline clinical depression) | 27 (Moderate depression) | 16 (Mild mood disturbance) |
| Beck Anxiety Inventory | 38 (Potentially concerning levels of anxiety) | 20 (Low anxiety) | 19 (Low anxiety) | 24 (Moderate anxiety) | 18 (Low anxiety) |

process of intervention, with gradual improvement in his ability to recall names of friends and relative, there was an increased sense of social connectedness, resulting in elevation of mood and a spontaneous change in his posture and gait. An initiation of professional engagement such as attending medical seminars further gave him a sense of agency. This improvement in his mood and sense of control reciprocally improved his cognitive performance (Figs. 10, 11).

This evidence stands contrary to the views that cognitive retraining appears to achieve modest, short-term improvement in cognitive function but does not persist beyond the training session (Rabin, 1996).

The finding corroborates with the earlier reports of the effectiveness of interventions which place a strong emphasis on effective encoding that demonstrates successful learning should have the capacity to permit long-term maintenance. From the clinical perspective, it can be stated that when intervention targets are of direct relevance to the person's daily life, and where the participant is aware of his difficulties and motivated to put new learning into practice, then long-term maintenance is possible (Clare et al., 2000).

This is the reason an idiographic approach was adopted to focus on the amelioration of symptoms and improvement in adaptability, functionality and QOL in the context of the client's own life circumstances. Since qualitative-idiographic approach focuses on the interpretation of the clinician's observation of a person's behaviour (Freeman & Chen, 2019), it was adopted to study the changes of the patient's behaviour over the course of intervention and outside the clinical setting, along with the objective assessment. In the present study, the trend analysis of the time series data of attention, working memory, naming and retrieval tasks, at different intervals starting from intervention to post-intervention and follow-up extending up to 5 years, has been conducted to maximise the effectiveness of the idiographic research (Ottenbacher, 1992). In spite of difficulties in collecting data at different time points over a long period of time, in this study attempt has been taken to gather time-series data to give an understanding of the maintenance of gains.

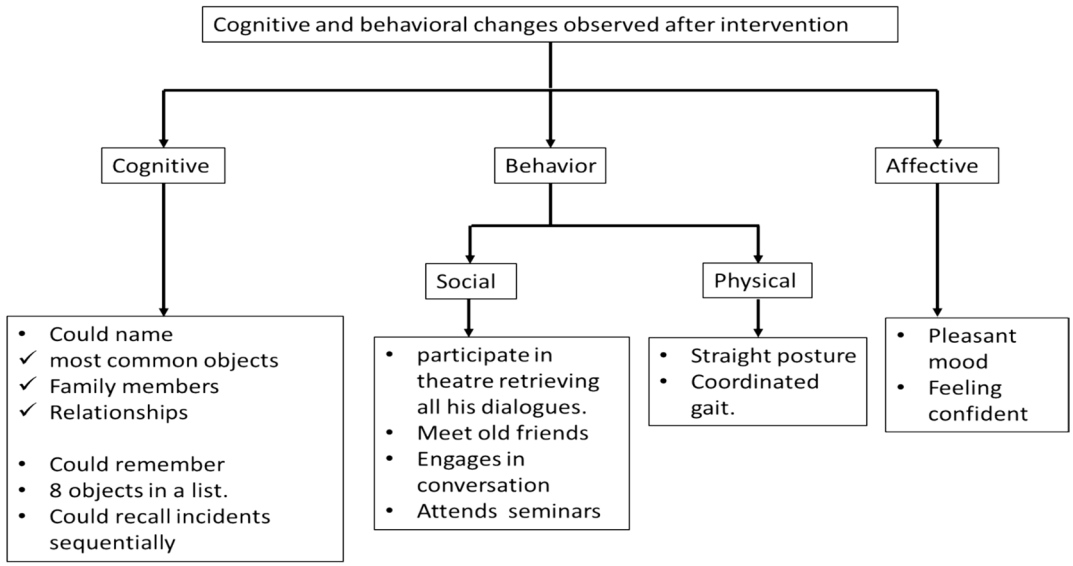



**Fig. 10** Schematic representation of the cognitive behavioural and affective changes observed post-intervention

The outcome of this pre-post intervention study is a clear indication of the efficacy of the current model of intervention (Fig. 12).

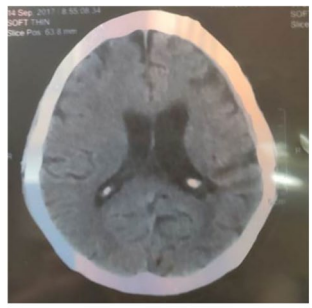
The idiographic research attempts to explain the variability based on intraindividual and temporal differences. However, as it falls short of consideration of the inter-individual variation, like the nomothetic research that provides generalizability, the present study is not beyond this criticism.

Though longitudinal, individual-level research in the study of psychopathology and psychotherapy is well recognized and the results from nomothetic research do not necessarily translate to the individual-level (Piccirillo & Rodebaugh, 2019), but it is to mention that the idiographic approach has the limited research base. The efficacy of this approach as compared to other approaches still needs verification (Riccio & Reynolds, 1998), thereby, generalisation from the results of the present study is warranted, particularly, considering the idiosyncrasies of symptoms of a complex disorder, like, stroke. The difficulty in collecting time-series data in idiographic approach is also a matter of concern. In the present study too, if time analysis could be done at more proximal time points, the pattern of rise and fall in the client's progression could be better depicted.

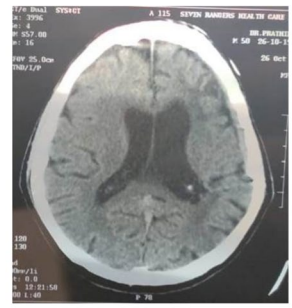
Although the validated test were used for the assessment, affectively tuned tasks were chosen for the intervention, which were optimally challenging in congruence to the varying functional level of the patient at different time- points of therapy. Since the tasks were created extracting the elements from the creative and professional fields that he used to remain engaged in the premorbid condition, the patient could remain absorbed in those emotionally engrossing tasks, attaining a flow state. The tailor-made tasks were designed to facilitate maximum engagement in the task, instead of considering the tasks in existing intervention protocols.

## Conclusion

This study denotes the importance of adoption of idiographic approach in understanding and intervention of clinical cases and effectiveness of multimodal approach to address the diverse deficit conditions in a client. The therapeutic model developed (Fig. 12) in this study can be adapted in similar cases with a comparable pattern of dysfunction and oddities. A detailed in -depth analysis of the symptoms and development of need-based model of intervention is perhaps possible only with idiographic approach. However, clinician's knowledge, judgment and acumen is required for identifying the deficits, in selecting appropriate tasks and adopting



A. The neuroimaging before intervention



B. The neuroimaging after intervention

**Fig. 11** A comparative neuro-radiological finding pre and post intervention

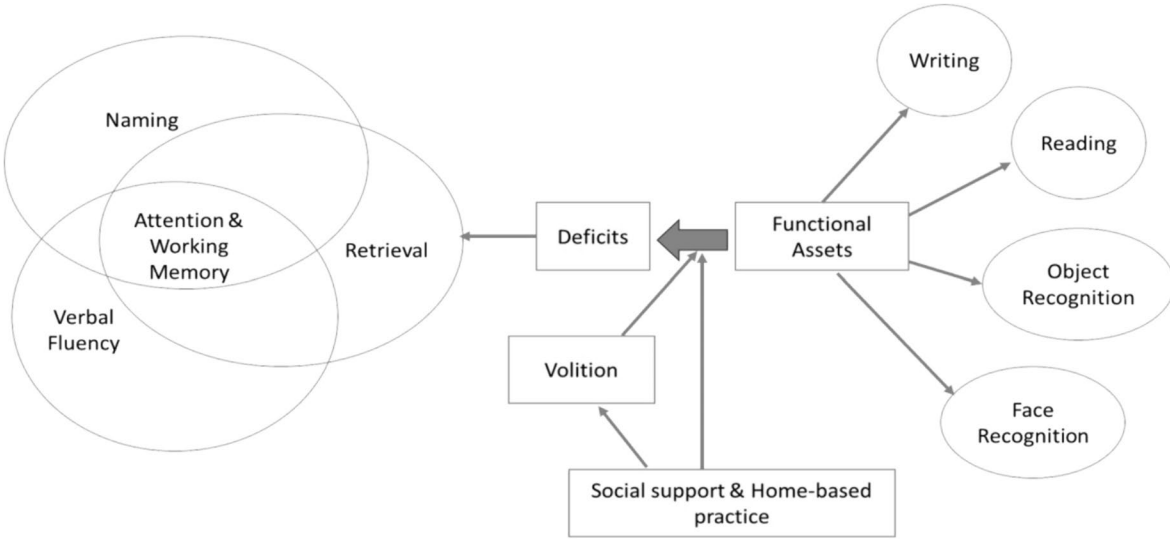



**Fig. 12** An illustration of the cognitive-rehabilitation model followed in the present study

treatment strategy tailor- made to the need of the patient.

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**Data availability** All the data of this study is available within the article.

**Declarations**

**Conflict of interest** The authors report there are no competing interests to declare.

**Ethical approval** Ethical clearance was obtained from the Institutional Ethical Committee of University of Calcutta for the purpose of the study.

**Informed consent** Written informed consent was obtained from the patient and his caregiver for participating in the study and for publishing the details of the case.

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