

## Can Plasticity Transform Functions in Neurodegeneration in Children as Well as Adults? An Observational Study

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### ABSTRACT


**Introduction:** Creativity is a physiological need based biological function very essential for survival. However, generally in disorders of progressive cognitive dysfunction creative skills are lost. However there are situations where these potentials are temporarily enhanced. **Patients and Methods:** We did an observational study of children and adults, 5 adults and 2 children, who showed extraordinary creativity evaluated based on evidence shown by patient, peers and re produced in test situation. **Discussion:** Our observational study reveals spontaneous interest in new and useful creative activity in our patients with various disorders causing progressive cognitive dysfunction. This observation reveals creative gain of function does take place in the face of progressive cognitive dysfunction in the setting of several diseases and it serves as a treatment option in behaviour management. Whether it is due to disinhibition of creative areas in the brain or facilitated function in regenerating data linking circuits needs further study. **Conclusion:** Set goals which are survival instinct based activities are probably removed by neurodegeneration and thereby the innate creativity gets disinhibited and expressed in wonderful forms of creativity. Whether special creative circuits in the brain, which causes this extraordinary creativity also needs to be studied. These creative skills in some of our patients served as effective pharmaco sparing agents during periods of aggression and agitation by engaging them in those activities, utility of which can be considered as a therapeutic option.

**Key words:** Progressive cognitive dysfunction, creativity, therapeutic options

### INTRODUCTION

Degeneration is a situation where there is a progressive loss of function which is due to various etiological

factors. However, nature always utilizes several context-dependent repair mechanisms. Even though the neurons are not capable of replicating repair takes place

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in the brain through a phenomenon called plasticity. Plasticity is defined as the intrinsic capacity of the brain to react as a highly dynamic system as a result of change in the properties of its neural circuits.<sup>[1]</sup> The consequences of such repair mechanism can produce new circuits which try to compensate for the lost function. This may occasionally produce new and useful functions which can present as newly developed skills which are seen during illness as transient creative potentials. The word creativity means ideas which are surprising for a context, new and valuable. It needs novelty seeking efficiency, motivation, and a degree of social influence. Unexpected happenings, unfamiliar combinations of familiar ideas, exploration on the novel idea formed and transformation to a creative phenomenon are the several steps involved in creativity. Creativity is the result of interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context.<sup>[2]</sup> Creativity has been considered a higher cognitive ability requiring multitude of processes such as information processing, problem solving, making associations, unfiltered attention, ability to reason abstractly, retrieval of semantic concepts, working memory, mental manipulations, imagination for combining unique or remotely associated concepts, problem solving to arrive at various alternatives, experience, and error monitoring.

### **Creativity in Srinivasa Ramanujam**

He was not educated in a prestigious school. However, he learned by himself and by 26 years of age, he knew more than 5000 mathematical equations. He also learned to understand western mathematics. He created a large volume of new results in number theory. His old notebooks are still being evaluated by mathematicians. Worldwide people in the field of mathematics have taken years to prove his theorems. The principles are applied in blast furnace design, manufacture of plastics and telephone cables, cancer research, statistical mechanics, and computer science. According to Hardy, he had an extraordinary memory, but according to Ramanujam goddess Namagiri and Lord Narahimsa are responsible for his skills. This is exactly the way Einstein spoke about intuitions ideas come suddenly, but you do not know from where and how? He claimed the gods wrote equations on his tongue and gives him mathematical information in his dream as he was often unable to give an explanation to his creative genius and refused ownership and claimed the results came from God and never got the recognitions he richly deserved. This is a classic example depicting that neither education nor training has anything to do with creativity, but it is some special circuits which are involved.

### **Creativity and intelligence**

The cognitive models of creativity consider creativity synonymous to intelligence, as both require to make associations between concepts and an amalgamation of convergent and divergent thinking styles. Creativity may be verbal, visual, or both. However, it has been found that intelligent children are not necessarily creative.<sup>[3]</sup> Creativity is a complex cognitive ability, and varying reports on the role of brain regions such as prefrontal cortex<sup>[4]</sup> inferior parietal lobule,<sup>[5]</sup> anterior cingulate cortex, inferior and superior temporal gyri<sup>[6,7]</sup> and cerebellum with its strong cerebrocerebellar links is implicated.<sup>[8]</sup> Dopamine activity has been linked to novelty-seeking.<sup>[9]</sup> Functional networks in the brain are default mode network which is the attention control system and executive attention network or task positive network which work activating each other. Children with attention deficit hyperactivity disorder (ADHD) are not able to sustain on task positive network for the needed period due to mind wandering and oscillation between both modes. Novel but not useful activities are seen most often in patients with major mental illness although useful creative work is also seen in them. Seat of creativity is like the seat of thoughts it is probably a global brain phenomena. The right hemisphere is believed to be associated with novelty detection, negative emotions, and avoidance behavior but when the same stimuli become familiar it is processed by the left brain which is not avoiding, but curiosity seeking and pursues the phenomena. Therefore, when curiosity is added creativity manifests, and probably both hemispheres are needed for creativity. During functional magnetic resonance imaging (fMRI), studies done with creative tasks frontal, temporal, parietal, occipital as well as cerebellar areas are reported to be active in various studies which is understandable due to the complexity of the networks that are activated during creative acts and therefore over the interpretation of fMRI results needs to be avoided. There may or may not be a map for creativity.

### **Concepts on creativity in the setting of cognitive dysfunction**

Pathology in the form of hypomania, depression, openness to unusual ideas and low latent inhibition by which decreased the tendency to triage unwanted perceptions (Schizotype), Parkinson's disease, frontotemporal dementia (FTD), temporal lobe epilepsy are often seen in the setting of creativity. Novelty, seeking with reduced latent inhibition, increased neural connectivity is postulated as the cause of creativity in some of these situations as this is the overlap zone between creativity, psychopathology, and shared vulnerability.

Most neurological diseases are associated with performance deficits with neurocognitive decline.

However, there are situations where changes contrary to the conventional ones are seen both in children and adults. Children with ADHD, demonstrate higher creativity due to impaired inhibitory control that may facilitate divergent thinking.<sup>[10]</sup> Focused attention might be needed to persevere on the task, uninhibited attention and poor working memory and novel thoughts, while deactivating the default mode network might lead to creativity.<sup>[11]</sup> However, children with autism and Asperger syndrome refuse to accept available scientific information and can remain with focused attention on their own ways, analyzing things around them spending several days too.<sup>[12]</sup> Tran modal creativity converting musical forms in to visual art, has been reported in patients with progressive aphasia type of dementia at the beginning of their disease raising question on how anterior and posterior cerebral areas support creativity. The authors felt healthy dominant inferior frontal gyrus, probably inhibits nondominant posterior neocortex which becomes released with disease.<sup>[13]</sup> Probable paradoxical function facilitation due to asymmetrical parietal atrophy causing reverse diaschisis is reported in a patient with Alzhiemers disease<sup>[5,14]</sup> Patients with primary progressive aphasia type of FTD showing artistic talents is reported by Miller and Liu.<sup>[15,16]</sup> Is it neofunctional plasticity or dysfunctional plasticity, is it disinhibited function or new function remains to be proved.

## PATIENTS AND METHODS

Rationale of our study is based on casually made observations of extraordinary creative skills in some of our patients with progressive cognitive dysfunction and that it served as a pharmaco sparing agent during periods of agitation and depression. Patients who were children, young adults, and elderly who showed extraordinary and spontaneous creativity among patients with progressive cognitive dysfunction of any cause, in the past 5 years were analyzed. No questionnaire-based assessment was used. Objective evidence produced by caregivers and also demonstrated during interview was taken as suggestive. Patients who were previously artist and who had radiation, brain surgery, cerebrovascular accidents, substance dependence, or using dopaminergic drugs were not included in this study. All patients included in the series underwent all mandatory investigations and special tests based on specific indications. They also underwent MRI in 1.5 Tesla machine with T1, T2, and Flair sequences and neuropsychological evaluation using National Institute of Mental Health and Neurosciences (NIMHANS) battery in adult patients. Neuropsychological tests done are Hindi Mental Status examination, digit forward-backward, category fluency, color trials one and two, stick test, and logical memory test. The raw score obtained was evaluated with age-,

gender-, and education-matched normative data. None of the patients have prior creative skill based on four-point evaluation scale used. That was our prior exclusion criteria. The 4-point evaluation as per the table below was used as by other reports too [Table 1].

## OBSERVATIONS

Total number of consecutive patients seen with moderate cognitive dysfunction seen in the past 5 years – Total: 445 patients. Adults – 315 and children – 130. Extraordinary creative skills were seen in five adults and 2 children. Evidenced by self-reported information on their skill and supported by family, obvious evidence and reproduced in test situation. Drawing and painting were seen in four males, two adults and two children. Singing was seen in two females. One female showed features of precognition.

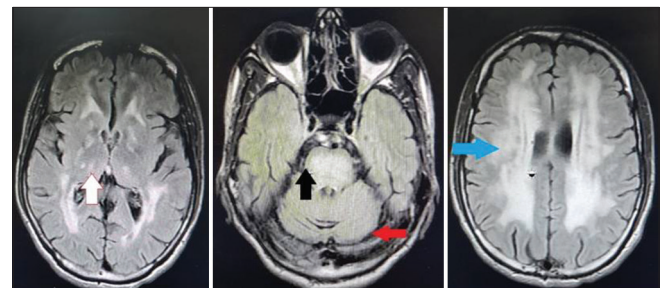
### Case descriptions

#### Patient 1

A 36-year-old very brilliant, very orthodox in religious practices engineer was put in a low functioning backseat after a very successful career of several years. His parents attributed the psychomotor withdrawal of the patient to psychological depression. However, detailed analysis of symptoms revealed that his illness started as loss of secondary sexual characters, which was later followed by cognitive dysfunction and choreiform movements. His illness was brought to the notice of his parents about 2 years after the onset of illness and investigations revealed neurosarcoidosis causing hypophysitis and leukoencephalopathy. Complete vasculitic workup, Cerebral Autosomal-Dominant Arteriopathy with Subcortical Infarcts and Leukoencephalopathy genetics, evaluation for inborn errors of metabolism was all

**Table 1: Format for creativity assessment at bedside**

Data source	Not yet evident	Emerging	Expressing	Excelling
Behaviour or performance data				
Self report data				
Rating scales				
Test				



**Figure 1:** Magnetic resonance imaging flair images showing diffuse periventricular and cerebellar white matter changes



negative. Angiotensin converting enzyme levels were very high. MRI showed diffuse white matter changes in periventricular white matter, thalamus and atrophy of cerebellum [Figure 1]. During the early course of his illness for 9 months, he developed spontaneous creativity in drawing [Figure 2]. Neuropsychological assessment revealed severe global dysfunction. Later as disease progressed, the patient lost these skills. Picture characteristics are as follows. All pictures were gods or famous persons to whom he was very much bound from childhood. Symmetrical imitative pictures reproduced with absolute accuracy. However, they lacked original, innovative content, though it was a spontaneous new skill acquired. Currently, the patient is bed bound following fall and fracture Femur.

### Patient 2

A 53-year-old bus conductor was brought to our outpatient department with abnormal behavior 3 years ago. He showed spurts of unprovoked anger with travellers in bus. He became obsessed to taking Vitamin C tablets and later developed renal stones as a complication which needed treatment. Slowly, he lost interest in personal care, wandered away from home often, showed familiarity to strangers, became over talkative. Later, he showed socially unacceptable behavior with persons of opposite gender and became furious when restrained. When psychotropic drugs were given he became excessively drowsy and incontinent. At this point of time, the patient's son found that if the patient is provided with paper and pen he became quiet for several hours. He was provided with color pens and he created wonderful colorful pictures. Most pictures he drew from picture books and some spontaneous [Figure 3]. However, slowly his skills started declining over about 1 year and patient started showing features of progressive language dysfunction. Currently 3 years into his illness he is fully mute. He understands his son and awaits his arrival from office. The patient takes the chair for the Son to be seated and asks wife to give snacks and after that starts playing with him. he does not show any signs of familiarity to any other family member. Is doubly incontinent and on diapers. His MRI shows bifrontal atrophy [Figure 4] gradual decline in quality can be appreciated [Figure 5].

### Patient 3

This is a 51-year-old illiterate homemaker. She was brought to us with the following history. Son noticed a personality change in his mother. She was euphoric, talkative and showed over familiarity. She claimed she has the capacity to predict future happenings and claimed she got that ability from Jesus. She started predicting outcome from diseases, family disputes, predicted future events in other people's life so that her house started filling with people who thought she had

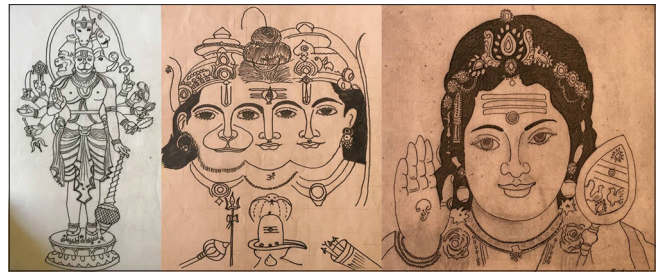


Figure 2: Images drawn by patient 1 in the beginning of illness



Figure 3: Figure drawn by patient 2 at the beginning of disease

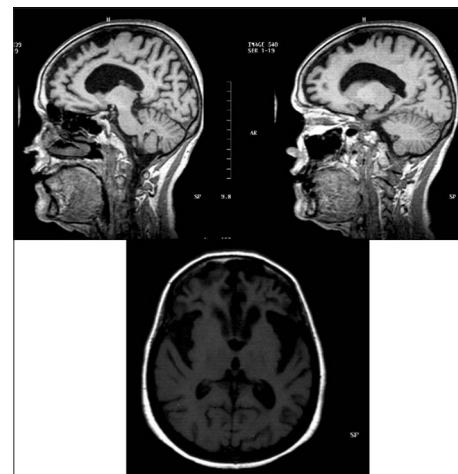


Figure 4: Magnetic resonance imaging of patient 2 showing bifrontal atrophy

become a very successful astrologer. Later, she was found to show odd social behaviors and her language remained fluent but the semantic content was lost. Investigations showed features of semantic variant FTD [Figure 6]. Currently, 2 years after her illness, her socially unacceptable behavior has made her family keep the doors of their home shut always. The phenomenology can be explained by the following facts. The human perceptive capacity through the sensory end organs is a very small percentage of the knowledge available in the universe. Having directly seen this patient number



**Figure 5:** Figure drawn by patient 2 during the course of illness showing decline in quality

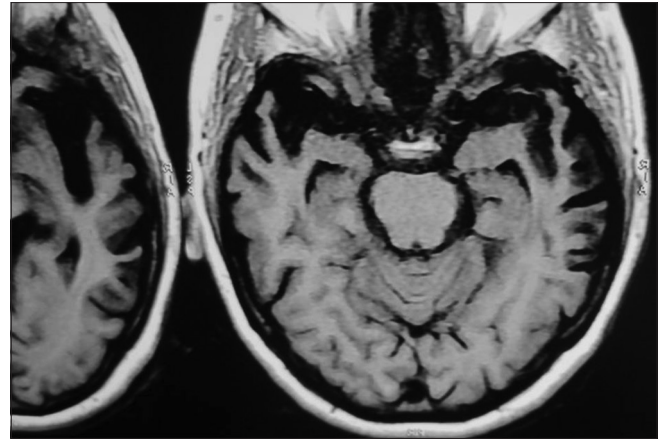
3 during her period of novel capacity, and followed up subsequently into her advanced dementia now, author feels abstract information processing is not mystical but depends on higher order processing in the brain.

#### *Patient 4*

This patient is a 50-year-old school drill teacher. Premorbidly, a person concerned about her dressing esthetics started dressing with unmatched combinations, careless in combing of hair, carelessly applying bindi. Even though this was noticed by her family, they ignored it. Later, she became interested in learning music and started learning the religious bhajans and started singing beautiful songs almost nonstop. Later typical features of behavior variant FTD became obvious. Slowly she became incontinent and mute, in the next 3 years. However, continued her wonderful songs on Lord Krishna. She later passed away due to carcinoma breast, but even a day before her end when she was wheelchair bound, not communicating with anyone and incontinent, continued to sing asking the Lords mercy. Her songs are recorded by her family; however, they were sentimental about giving a copy for our purpose.

#### *Patients 5 and 6*

Patient 5 is a 12-year-old child with complex partial seizures, with attention deficit and severely hyperactive and violent with his family members. He was unable to continue study at normal school. However, he showed Eidetic memory for drawing all that he saw without any training in drawing. When I showed him the Krishna's wallpaper in my mobile he just saw it for a fraction of a second and told me to take it away and in a second reproduced the Krishna's picture in paper. He drew several pictures of gods and also pictures from Indrajal comics from his memory [Figure 7]. Patient 6 is again a child of 10 years with refractory complex partial seizures. He was referred to us for treatment of epilepsy. He spontaneously drew pictures of landscape and anything in nature, which was very effective in controlling his distractibility [Figure 8].



**Figure 6:** Magnetic resonance imaging of patient 3 showing lateral temporal atrophy

He has not been send to school. Both these children's parents are making them quite, by giving paper and pencil [Figure 9].

## **DISCUSSION**

This observational study shows evidence of spontaneous creativity in the face of progressive cognitive dysfunction due to various disorders. These were novel and useful and therefore satisfies the criteria for creativity. Further, they do not fulfill the criteria for psychosis. Three patients suffered from FTD behavior variant in two and semantic variant in one. One patient in this group showed drawing skills, one patient new onset musical skills which persisted even when her language skills were lost, and one patient precognitive skills. All of them had these skills for periods varying from 9 months to 1 year and later lost it as the disease advanced. However, during the creative period, it served as an effective tool in behavior control. The patient with neurosarcoidosis who's drawings are exemplary, however, it was also for an year during which period patient had manifested a lot of apathy the two children with epilepsy included in this group had epilepsy with cognitive regression. They continue to have these skills though their seizures are fairly well controlled. These observations reveal creative gain of function does take place in the face of progressive cognitive dysfunction in the setting of several diseases and it serves as a treatment option in behavior management. Whether it is due to disinhibition of creative areas in the brain and facilitated function in regenerating data linking circuits needs further study. Further art therapy is used in restless patients who are not creative by themselves. However, our patients represent a group who could be made to sit unagitated and quiet when they were provide the right materials to engage themselves with their unique creative potential. In fact, we utilized this in our patients until they in their course of the disease





**Figure 7:** Image drawn by child patient 5. The first picture was drawn looking for a second at mobile wall paper and others drawn *de novo*



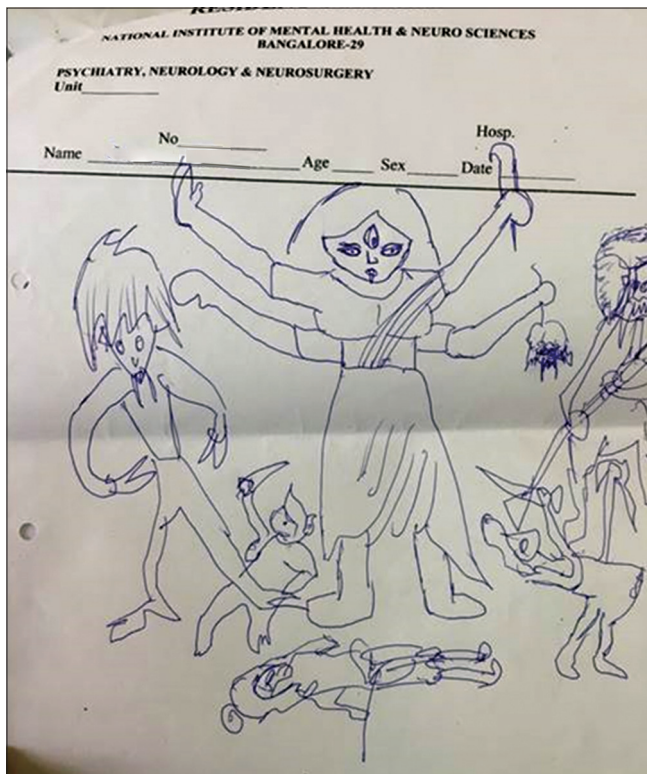
**Figure 8:** Figure drawn *de novo* by the patient child 6

## CONCLUSION

Creativity is well reported in literature in the presence of psychopathology such as bipolar affective disorders, schizophrenia, and autism spectrum disorders. There are also case reports in patients with FTDs and Alzheimer’s disease with hypothetical explanations. Probably set goals made for survival suppress innate skills which the individual probably never knew and gets released in disease state.

The possible explanations could be that when the set goals which are survival instinct-based activities are lost by neurodegeneration the innate creativity is probably disinhibited and expressed in wonderful forms of creativity irrespective of their educational status. The next possibility can be the presence of plasticity even in the degenerating brain resulting in creativity circuits generation giving the potential for exploring novel therapeutic options. Are there special creative circuits in the brain which causes this extraordinary creativity also needs to be studied. However, currently, creative skills of some of our patients serve as effective pharmaco sparing agents for a short duration in the course of illness when patients are agitated and aggressive by engaging them in activities for which attention and motivation are preserved. There is also the probability that music can be used as a mode of communication when language fails which happens in neurodegenerative disorders. Finally, an important question always arises while dealing with our patients with progressive cognitive decline who are so much pure in their thoughts and deeds. That is “Is this a disease or evolution to the next stage of enlightenment at least in some of our patients”?

The strength of our observation lies in the novelty and its utility for temporary rehabilitation of the patients. Further evaluation of these phenomena may provide



**Figure 9:** Figure of goddess drawn by child 5

lost this potential. This is entirely different from art therapy in noncreative patients.

more insight into repair mechanisms taking place in the degenerating brain. However, there are certain limitations in our study. As this an observational study, when the index case was identified, complete workup including fMRI was not done other than the mandatory work up. Moreover, it was a random occurrence in a large clinic over the duration of 5 years, and only six cases out of 445 patients showed this phenomenon. Although all these cases are under follow-up with us, at present, they neither has the creative efficiency nor are they amenable for workup currently. However, a prospective fMRI-based study has been started.

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### Conflicts of interest

There are no conflicts of interest.

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