Endocrine, Metabolic & Immune Disorders-Drug Targets, 2023, *23*, 250-253

COMMENTARY

The Savant Syndrome: a Gift or a Disability? A Deeper Look into Metabolic Correlates of Hidden Cognitive Capacity

Irem Onin[1], Lutfu Hanoglu[2] and Burak Yulug[3,4,*]

[1]*Graduate School of Health Science, Department of Cognitive Rehabilitation, Istanbul Medipol University, Istanbul 34810, Turkey;* [2]*REMER, Clinical Electrophysiology, Neuroimaging, and Neuromodulation Lab., School of Medicine, Department of Neurology, Istanbul Medipol University, Istanbul 34810, Turkey;* [3]*Department of Neurology and Neuroscience, Alanya Alaaddin Keykubat University, Antalya 07425, Turkey,* [4]*Department of Neuroscience, Istanbul Medipol University, Istanbul 34810, Turkey*

ARTICLE HISTORY

Received: December 23, 2021
Revised: January 7, 2022
Accepted: January 7, 2022

DOI:
10.2174/1871530322666220408134359

Abstract: Savant syndrome is a rare and unusual condition that occurs in the presence of severe developmental disabilities, disorders, and injuries. The syndrome can be congenital from birth to childhood or acquired as a result of a brain injury or damage to the central nervous system. There are several findings that indicate that savant syndrome usually occurs with significant brain metabolism alterations resulting in critical brain network changes. These types of changes in the brain are usually explained by the "tyranny of the left hemisphere" theory, which indicates the inhibition of the left hemisphere to allow the right hemisphere to develop savant abilities. Another way to temporarily simulate these types of changes in the brain can be through different neuromodulation techniques such as transcranial magnetic stimulation and transcranial direct current stimulation. Such neuromodulation techniques might help us discover the "hidden talent" potential through modulating the brain network metabolism. We herein discussed the types of savant syndrome along with its relation to specific neurometabolic network alterations. Furthermore, we provide a perspective on how newly developed neuromodulation and cognitive rehabilitation techniques can help simulate savant syndrome in healthy individuals through modulating the brain network activity.

Keywords: Savant syndrome, autism spectrum disorder, traumatic brain injury, acquired savant syndrome, congenital Savant syndrome, epilepsy.

1. INTRODUCTION

Savant syndrome is a rare but remarkable disorder in which individuals with diverse developmental disabilities exhibit extraordinary abilities [1]. Savant syndrome can occur as congenital or as acquired. Also, there is a new type of savant syndrome that appears without any genetic background and a traumatic head injury called sudden savant syndrome. Unfortunately, there are no published research articles about the syndrome yet. The savant abilities usually appear under five common groups; calendar calculating, art, mathematics,-visual-spatial talent, and music [2]. Individuals with savant syndrome usually tend to have a single exclusive skill. Yet, in some rare cases, several special skills occur concurrently, for example, synaesthesia and ploy-glot [3]. Multiple savant syndrome abilities usually appear in individuals with ASD in comparison to other developmental disabilities [4]. Even though there is a diverse range of abilities, extraordinary memory capacity is the only consistent feature observed in all savants [5]. This phenomenon affects the male population commonly in comparison to the female population [6]. There is a spectrum of savant skills, which can be divided into the following three categories: talented, splinter skills, and prodigious savants. Savant skills do not improve by practice, and it usually appears at an early age [7]. One of the examples of this theory came from the research team of O'Connor and Hermelin [8]. The study compared the calculating speed performance of a 10-year-old savant with an adult savant. The results showed that the performance results were similar in both savants. The pattern for both musical and artistic savant's ability usually starts with an impressive imitation of what they have heard or seen, followed by improvisation, and lastly, they begin to compose their song or design their scene [6].

2. NEUROMETABOLIC BASIS OF SAVANT SYNDROME

Despite a diverse range of clinical features of individuals with savant skills, there are limited reports that investigated

*Address correspondence to this author at the Department of Neurology and Neuroscience, Alanya Alaaddin Keykubat University, Antalya 07425, Turkey and Department of Neuroscience, Istanbul Medipol University, Istanbul 34810, Turkey;
E-mail: burakyulug@gmail.com

2212-3873/23 $65.00+.00

brain metabolic activity in such individuals. Although these have largely been case studies, they provide an attractive look into the neurometabolic basis of savant talents and reveal useful information for enhancing cognitive performances in healthy persons.

A positron emission tomography study from 2005 displayed that an autistic 22-year-old right-handed prodigious savant male with calendar calculation ability activated frontotemporal network glucose metabolism, including the hippocampus, during the task [9]. In the same manner, in some ASD individuals, certain brain circuits may be overdeveloped in comparison to normal individuals, which might lead to superior calculation and memory skills. For instance, a recent neuroimaging study on visual-spatial savant abilities and Asperger syndrome showed increased volumes of left cerebral white matter, left cingulate gyrus, and bilateral amygdala and entorhinal areas, suggesting an overcompensated brain metabolic activity [10]. For instance, during the visual language task, the functional activity of bilateral parietal cortices was increased, while for the music task, the functional activation of the medial prefrontal cortex was increased. Shortly, the common findings in neuroimaging studies of individuals with congenital savant syndrome were decreased activity in the left anterior temporal lobe and increased functional activity in the posterior neocortex with an aberrant activation in the right cerebral hemisphere [3, 5, 11].

Based on the neurometabolic dysregulations mentioned above, the main question is, "should we eliminate the defects of the disorder, or should we train the talent?" According to the savant studies, by training the talent, we might eliminate some defects/disabilities as well [6]. Individuals with special savant talents (both congenital and acquired) may be able to attain improved language learning, socialising, and independence by utilising their special savant abilities without sacrificing any specific abilities. Even though being a savant does not eliminate the symptoms of ASD, the new skills might be a new channel for autistic individuals to express themselves by creating a new social network [4]. For traumatic brain injury patients, for instance, savant abilities might be a new motivation factor for them to continue their cognitive rehabilitation to develop new abilities. To the best of our knowledge, there is still no neuromodulation study on people with savant syndrome; however, the majority of the present tDCS studies report reduced ASD symptoms after DLPFC stimulation [12].

3. NEUROMODULATION AS A NEUROMETABOLIC TOOL FOR UNLOCKING THE HIDDEN RESERVE IN NORMAL INDIVIDUALS?

The human brain is a complex functional structure that experiences continuous activity variations, and its dynamic range is related to the capacity to process information [13]. For instance, creativity is a complicated and broad construct that requires a metabolic synergy of multiple networks and brain regions [13]. Therefore, it is implied that a healthy brain would be complex. We are just not yet capable of bringing out the special capabilities that everyone possesses. To activate and produce an ability, there should be some sort of "disability or accident" [14].

The reason why neuromodulation temporarily creates savant ability in healthy individuals is mentioned in the literature; this technique targets a more creative, more rational, more effective, and more harmonious brain. The question "Can we acquire savant-like skills temporarily as healthy individuals utilising neuromodulation techniques?" is still being investigated today. Neuromodulation techniques allow the targeted areas of the body to change neural metabolic activity by chemical or electrical stimulation. Some of the most used non-invasive techniques for neurological disorders are transcranial magnetic stimulation, transcranial direct current stimulation, and transcranial alternant current stimulation. Human wiring is not identical in every individual [15]. The effects of neuromodulation applications vary from person to person, and the results would not be the same in every individual. This is the main reason for the development of different savant abilities.

There have been numerous studies that investigated the "left hemisphere tyranny" by stimulating the left frontotemporal area with repetitive transcranial magnetic pulses. As stated in the TMS study with healthy individuals, 11 male right-handed participants' drawing and proof-reading abilities were evaluated pre and post 1 Hz TMS application to the left frontotemporal lobe. 2 out of the 11 participants' drawing skills improved temporarily after the application of TMS [16]. The main reason for its application to the left frontotemporal is to simulate savant syndrome abilities observed in frontotemporal lobe patients and ASD [17]. As reported in another neuromodulation study simulating savant skills, 5 out of the 17 right-hand dominant healthy participants developed savant types of abilities, such as drawing, calendar calculating, mathematics, and declarative memory concurrently with the stimulation [18]. The 0.9 Hz repetitive TMS application was applied to the participants' left frontotemporal area. Another stimulation study replicating the savant abilities reported that 8 of the 12 right-hand dominant neurotypical subjects improved their accurately guessing prime number abilities under low-frequency (1 Hz) TMS to the left anterior temporal lobe, which inhibited the neural activity, thereby creating a "virtual lesion" [19]. Another published virtual lesion study showed that 13 out of the 28 right-hand dominant participants solved the 9 figure test right after the application of transcranial direct current stimulation (the cathodal electrode was placed on the left anterior temporal lobe, and the anodal electrode was placed on the right anterior temporal lobe) [20].

Prior research suggests that many of us may acquire savant type of abilities under certain circumstances [4, 21]. In the literature, besides the traumatic brain injuries and magnetic stimulation techniques, savant abilities may be developed by EEG biofeedback and central nervous system stimulant amphetamine. In addition, after the usage of amphetamine, an individual developed artistic savant-like abilities [22]. He could draw every detail as if it were a photograph. Also, in ancient cave drawings, it was observed that the perception abilities of humans were affected by mescaline usage, and their sk*etc*hes were similar to the individuals with savant syndrome [23].

According to the literature, there are several theories to explain this savant syndrome phenomenon. One of the theories for the savant syndrome proposed that savants use their pre-

conscious mind by reallocating social functioning into perceptual pattern recognition, resulting in poor performance on social cognition tasks and superior performance on perceptual pattern recognition tasks [24]. As stated in the "Paradoxical Functional Facilitation" paper, the loss of some abilities enables other skills to appear [25]. For example, a 68-year-old man with frontotemporal dementia acquired the same artistic savant skills after his diagnosis. This FTD case indicates that by the inhibition of the left anterior temporal lobe, the right posterior parietal lobe starts to support more artistic skills [21]. Savants tend to rely on lower-level (cortico-striatal circuit) procedural memory since the higher-level semantic memory (corticolimbic circuitry) is damaged [1]. These theories support the idea of "recruiting" an ability to compensate for the lost skill. Contrarily to those theories, some scientists argue that instead of the "recruiting" ability, the brain actually "releases" already "existing" but inactive skills [6]. The weak central coherence theory was proposed earlier in the literature to possibly explain symptoms of ASD. The same theory was mentioned to explain calendar calculation in savants [26]. According to this theory, savants pay more attention to and remember more details (by reducing global processing, local connectivity increases). The dynamics of the resting-state networks are the key to the array of cognitive architectures available to the brain, rather than embodying particular cognitive or behavioral operations [27]. The ASD studies with functional connectivity and entropy studies results showed that the reduced entropy may explain the loss of behavioral and cognitive functions, which are associated with specific brain regions (emotional memory, visual sensory processing, and motor functions) [28].

CONCLUSION AND FUTURE DIRECTIONS

Savant syndrome challenges our capabilities and helps us change our perspective on traditional therapy by evaluating metabolic shifts between specific brain regions. The published savant literature recommends the evaluation of not only the neuron and synapse dimension but also specific metabolic correlates, which could provide further rationale for the use of neuromodulation techniques in both healthy persons and also in people with savant's syndrome in contrast to many alternative agents [29, 30].

LIST OF ABBREVIATIONS

ASD	=	Autism Spectrum Disorder
EEG	=	Electroencephalography
FTD	=	Frontotemporal Dementia
MRI	=	Magnetic Resonance Imaging
OCD	=	Obsessive-Compulsive Disorder
TMS	=	Transcranial Magnetic Stimulation

CONSENT FOR PUBLICATION

Declared none.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

FUNDING

Declared none.

ACKNOWLEDGEMENTS

Declared none.

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