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Neuropsychological Perspective on Autism Spectrum Disorder Individuals with Savant Syndrome

Muchamad Salamun Abdul Rahman[1]
[1]Faculty of Psychology,
University of Gadjah Mada, Indonesia
[1] muchamadsalamunabdulrahman@mail.ugm.ac.id

Nadia Riwu Kaho[2]
[2]Faculty of Psychology,
University of Gadjah Mada, Indonesia
[2] tengaaramintanadiariwukaho@mail.ugm.ac.id

Nadief Fikri Jatmiko[3]
[3] Faculty of Psychology,
University of Gadjah Mada, Indonesia
[3] nadief.fj@mail.ugm.ac.id

Gian Baringin Noach[4]
[4]Faculty of Psychology,
University of Gadjah Mada, Indonesia
[4] gianbaringinrolinonoach@mail.ugm.ac.id

Supra Wimbarti[5]
[5]Faculty of Psychology,
University of Gadjah Mada, Indonesia
[5] supra@ugm.ac.id

Zulfikri Khakim[6]
[6] Faculty of Psychology,
University of Gadjah Mada, Indonesia
[6] zulfikri.khakim@ugm.ac.id

Correspondence:

Nadia Riwu Kaho
Faculty of Psychology, University of Gadjah Mada, Indonesia
Email: tengaaramintanadiariwukaho@mail.ugm.ac.id

Abstract

The high prevalence of individuals with ASD has shifted the focus of research toward exploring strengths rather than weaknesses, one of which is the phenomenon of savant syndrome, which is most commonly observed in individuals with ASD. However, studies specifically examining the neuropsychological basis of individuals with ASD and savant syndrome remain limited. Therefore, this study aims to explore the characteristics of brain structure and cognitive function in individuals with ASD and savant syndrome using the narrative literature review method. The literature review findings indicate that individuals with ASD and savant syndrome exhibit distinct brain structures and specific cognitive functions that differentiate them from both individuals with ASD without savant syndrome and the general population. These findings provide new insights into the relationship between neuropsychological aspects and the extraordinary abilities possessed by individuals with savant syndrome. The implications of this study serve as a scientific foundation for developing intervention strategies and educational approaches that are better suited to the unique needs and potential of individuals with ASD and savant syndrome.

Keyword *: Autism Spectrum Disorder* (ASD), *savant syndrome, neuropsychology, brain structure, cognitive function*

Abstrak

Prevalensi individu dengan ASD yang tinggi telah menggeser arah penelitian untuk lebih menitikberatkan pada kekuatan daripada kelemahan, salah satunya adalah fenomena savant syndrome yang paling banyak dialami oleh individu dengan ASD. Meskipun demikian, penelitian yang secara spesifik mengkaji dasar neuropsikologis individu ASD dengan savant syndrome masih tergolong terbatas. Oleh karena itu, penelitian ini bertujuan untuk mengungkap karakteristik struktur otak dan fungsi kognitif individu ASD dengan savant syndrome melalui metode narrative literature review. Hasil dari tinjauan literatur menunjukkan bahwa individu ASD dengan savant syndrome memiliki pola struktur otak yang khas serta fungsi kognitif tertentu yang membedakan mereka dari individu ASD tanpa savant syndrome maupun populasi umum. Temuan ini memberikan wawasan baru mengenai keterkaitan antara aspek neuropsikologis dan kemampuan luar biasa yang dimiliki oleh individu dengan savant syndrome. Implikasi dari penelitian ini adalah memberikan landasan ilmiah yang dapat digunakan dalam pengembangan strategi intervensi dan pendekatan edukatif yang lebih sesuai dengan kebutuhan serta potensi unik individu ASD dengan savant syndrome.

Kata Kunci *: Gangguan Spektrum Autis (ASD), sindrom savant, neuropsikologi, struktur otak, fungsi kognitif*

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BACKGROUND

Autism is a developmental disorder related to biological functions, but appears in a series of impaired behaviors, especially in social interaction, communication, and individual flexibility (Basa Dewangga Yuda et al., 2023). Recent research states that autism is a condition that occurs within a spectrum of, so this disorder is called *Autism Spectrum Disorders* (ASD). Autism is also a pervasive developmental disorder, namely a set of severe neuropsychological deficits that appear in early childhood, and have a poor prognosis for achieving "normal" conditions. (Rodrigues et al., 2020) ASD has been studied in various scientific literature for 79 years. The term autism was first introduced in a scientific forum in 1943 by Kanner with the term " *infantile autism* ". Since then, the concept of ASD has evolved and has symptoms related to neurodevelopmental disorders , characterized by (1) impairment in the quality of reciprocal social relationships, (2) communication barriers and limited interests, and (3) repetitive or repetitive behaviors or movements, which appear in childhood and limit and hinder the individual in daily activities (Daulay, 2017).

Previous research has shown that over-focusing on deficits in individuals with autism can be detrimental to their well-being, but to date, little research has focused on the strengths and positive qualities of individuals with autism. Some studies have explored " *savant skills* "—or "extraordinary talents (ET)," abilities that stand out compared to the general population (Eunice Meng Yin Tan, 2024) . The term *savant* is derived from the French word for *scholar* , or *sage* , which is derived from the French verb *savoir* , meaning " *to know* ". *Savant syndrome* is a rare but remarkable condition in which individuals with developmental disabilities, brain injury, or brain disease have exceptional areas, skills, or abilities in one or more specific areas—in stark contrast to their overall impairments (Eunice Meng Yin Tan, 2024). This condition cannot be learned and can appear from early birth or in early childhood (*congenital*) appear unexpectedly after a head injury, *stroke* , dementia, or central nervous system disorder; or appear later in life due to brain lesions or degenerative processes of the central nervous system (CNS) especially in the temporal lobe and frontotemporal dementia especially if related to the left hemisphere (Park, 2023).

The special skills of individuals with *savant syndrome* generally appear in the form of musical, artistic, rapid arithmetic, or spatial/mechanical abilities and are accompanied by extraordinary memory abilities in certain are. The *Autism Diagnostic Interview-Revised* , a diagnostic tool that evaluates children with autism, groups special ASD performance into six areas, namely *visuospatial ability* , *memory* , *musical ability* , *drawing ability* , *reading ability* , and *computational ability*. These six areas have been shown to be above average functioning in population norms (Praptomojati, 2019). People with *savant syndrome* are often associated with mnemonic and mathematical skills. This is consistent with previous studies on Autism *traits* characterized by certain interests related to *high-systematizing patterns* (the tendency to understand non-social, mechanistic, and rule-based systems), stereotypical behavior (even obsessions), and the presence of limited emotional intelligence (Praptomojati, 2019).

Although the condition is quite rare, study reported that at least one in ten individuals with ASD have at least one *savant skill* , with the condition being rarer in females than males (6:1). ASD is also reported to be the most common comorbid disorder with *savant syndrome,* which is 75% of the population (Bölte & Poustka, 2004). Several studies have stated that 50% of individuals with *savant syndrome* also have ASD and 10-30% of individuals with ASD have *Extraordinary Talen*. Another study by Treffert stated that *savant syndrome* occurs in males 4-6 times more than in females. Several studies summarizing reports from parents state that as many as 10% to 63% of Autism individuals have *Extraordinary Talent,* and as many as 45% of them display more than one talent (Meilia, 2021).

The link between ASD and *savant syndrome* began with the investigation of the phenomenon of individuals who have intellectual disabilities but display extraordinary talent in one area, or at that time termed *idiot* (Khakim & Kusrohmaniah, 2021). The findings regarding *savants developed and it was discovered that savant* talent actually emerged in individuals with neurological or developmental disorders such as autism (Eunice Meng Yin Tan, 2024). However, individuals with *savant syndrome* have various characteristics similar to individuals with autism, including obsessive behavior, preoccupation with activities that are fun for them, and having limited and specific interests (Daulay, 2017).

A diagnosis of autism can be made if repetitive behavior or limited interests can interfere with daily life functions, but in cases of autism with *savant syndrome* , this behavior often becomes a source of motivation for the emergence of extraordinary talent in certain areas (Pratiwi et al., 2022). Research shows that repetitive behavior and limited interests are found more in individuals with *savant syndrome* than in *non-savants*. The available evidence suggests that the phenomenon of *savant syndrome* in Autism individuals can be explained by the individual's hard training (in certain areas) and/or weak central coherence *(*WCC). This is empirical evidence that *savant syndrome* is strongly associated with ASD or ASD *traits* , and both share the same etiological basis (Daulay, 2017).

Another empirical evidence that associates ASD and *savant syndrome* is the *Enhanced Perceptual Functioning model* which states that the over-functioning of one area of the brain related to perceptual function among ASD individuals is also responsible for the high prevalence of spatial abilities in a person (Nurzakiah et al., 2021). The *Empathizing-Systemizing model* also states that the attention to detail possessed by ASD individuals makes it likely that they also have superior specific skills. However, currently, there is still little research from the neuropsychological side that discusses individuals with ASD who have *savant syndrome.* In fact, by understanding the brain and cognitive functions of ASD individuals with *savant syndrome* , we can better understand their condition and understand the right

interventions or methods in optimizing their potential. Therefore, this study was conducted with the aim of providing a neuropsychological perspective of ASD individuals with *savant symptoms* (Ngwu et al., 2023).

RESEARCH METHODS

In this study, the narrative review method was chosen to summarize various research findings related to children with autism spectrum disorder (ASD) who also have savant syndrome (Ilmiah & Sandi, 2022). This approach allows for the compilation of data based on measured results from previous studies, providing a comprehensive overview of the focus areas being examined. The articles collected came from various sources, such as Google Scholar, ScienceDirect, and PubMed, with publication dates limited to 2008 through 2024. This time frame was chosen to capture the most current developments in research on the topic.

However, the question arises whether the narrative review method is sufficient to provide the clarity and structure needed, or if the Systematic Literature Review (SLR) method with the PRISMA model would be more suitable (Sugiyono, 2021). SLR has the advantage of filtering, evaluating, and synthesizing research in a more structured manner with clear inclusion and exclusion criteria. With PRISMA, mapping out the research conducted becomes more transparent, including identifying limitations in previous studies and discovering gaps that can be addressed in future research (Rukminingsih, 2020).

Had this study used SLR, the article selection process would have been more systematic, and the analysis would have been more focused. SLR helps classify research based on methods, key findings, and contributions to the development of studies on ASD and savant syndrome. This approach also makes it easier to identify patterns in findings and evaluate how thoroughly previous research has covered the aspects being examined. Furthermore, the limitations of past research would be clearer, providing a foundation for advancing the field in the future (Djajasaputra & Halim, 2019).

Nevertheless, the choice of method ultimately depends on the research objectives. If the goal is to explore different perspectives in a more flexible and in-depth manner without following strict selection protocols, then the narrative review remains a relevant option. However, if the aim is to obtain results that are more systematic, objective, and reproducible in future studies, then the SLR with PRISMA approach would be a better alternative (Sugiyono, 2021).

RESEARCH RESULTS

The results of the literature review through a neuropsychological perspective show that individuals with *Autism Spectrum Disorder* (ASD) who have *savant syndrome* tend to have differences in the structural and functional aspects of the brain. This is likely the result of the interaction between genetic factors, neurological disorders, and adaptation which gives rise to extraordinary skills despite other cognitive limitations. By understanding how brain structure and cognitive function change in these individuals, this literature review provides in-depth insight into the underlying causes of savant abilities. The two main aspects discussed in this section are brain structure and cognitive function in individuals with savant abilities, where these two aspects complement each other and provide a comprehensive picture of the *savant phenomenon* from a neuropsychological perspective (Park, 2023).

Brain Structure and Nervous System

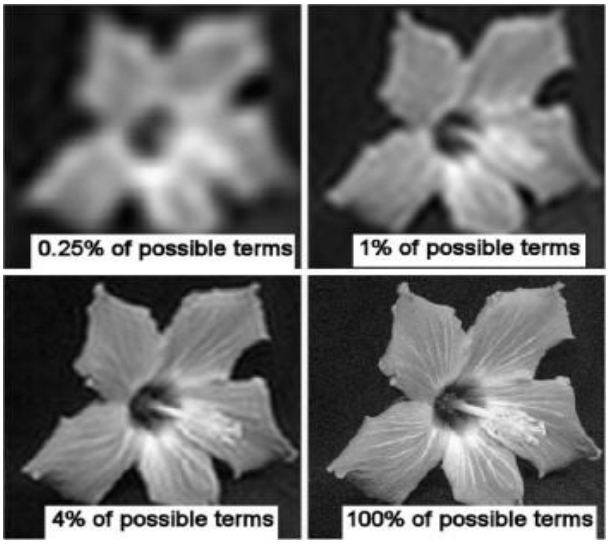
Through a neuropsychological review of *Autism savants in the literature, it is known that brain structure plays an important role in the development of savant abilities. According* (Park, 2023) , *savant* abilities can emerge through transcranial magnetic stimulation and *top-down cortical inhibition* in the left *frontotemporal lobe savant* syndrome is mostly inherited from birth, some cases of *savantism* that appear after birth have also been reported. Most of these cases involve damage to the left parietal lobe. This finding is supported by (Eunice Meng Yin Tan, 2024) who stated that injury to the left brain can result in the emergence of savant skills due to increased function of the *posterior neocortex,* which is the part related to visual, auditory, and spatial processing. This is in accordance with the hypothesis of (Rodrigues et al., 2020) that damage to the left brain is the cause of the development of savant skills.

Meanwhile, (Tryanan Asmaradhani, 2024) suggested that the ability to remember which tends to be high in *savants* could be related to increased activation in the perceptual areas of the brain, namely in the visual cortex, auditory cortex, and parietal lobe. This then supports processing that is carried out locally. Meanwhile, according to (Park, 2023) , the combination of high sensory sensitivity, obsessive tendencies, *hyper systemizing* , and cognitive styles that tend to be local in individuals with ASD, especially *savants,* indicates a structural adaptation in the brain that underlies the emergence of their extraordinary abilities (Fakhriya, 2022).

Stated that if the growth of one part of the hemisphere is delayed, then the other area will be larger than usual. With the difference in size in certain parts of the brain, it will affect the development of talent in that part. In accordance with research conducted shows that lateralization of the left brain which is injured or problematic, can cause compensation by the right brain (Muhammad Aldwin Priyatama et al., 2023). This compensation explains the emergence of the *savant phenomenon* . This theory is based on findings from cases of the *savant phenomenon* studied (Islamiyah & Inayah, 2023). Cases like this are caused by traumatic brain injury to the left hemisphere or *frontotemporal dementia* with disorders on the left side of the brain. These findings support the hypothesis that savant skills may be dormant in all individuals and can be awakened by suppression of the dominant hemisphere control mechanism .(Meilia, 2021)

In his research tried to explain *signal processing theory* with the *savant phenomenon* . In individuals with ASD and *savants* , there is a deficit in the level of sensory compression by *inhibitory neurons.* Therefore, individuals with *savant*

syndrome process all neural signals due to the deficit, so that in the image below, individuals with *savants* process 100% information which gives them access to detail. Unlike non-savants, they only use representations of part of the sensor, the information processed is closer to 1% (Hastjarjo, 2020).



Ficture 1. Illustration of the differences in sensory information between savants and non-savants (Fabricius, 2010).

However, presents four pieces of evidence that challenge Fabricius' hypothesis. First, the filtering of sensory signals by *inhibitory neurons* does not explain *savant artistic abilities* . There is no evidence that brain changes can underlie all *savant abilities* . Second, there is evidence that extraordinary abilities can also appear in children and adults with normal cognitive development. Third, this theory emphasizes the importance of the role of *inhibitory neurons* , but there are cases where anatomical changes are not in line with the assumed inhibitory phenomena. Fourth, the fact that perception and cognition have been shown to work together. However, argues that the theory can be improved to explain some of the *savant phenomena* (Ngwu et al., 2023).

Cognitive Function

Individuals with *Autism Spectrum Disorder* (ASD) often show significant differences in brain function that affect communication and social interaction abilities (Zhu & Yin, 2021). However, not all individuals with ASD experience brain function decline. As many as 50% of them show extraordinary abilities, known as *savant syndrome* (Park, 2023).

Neuropsychologically, individuals with *savant syndrome* show higher synaptic activity, which can lead to reorganization of neuronal networks and affect communication between neurons. This is related to increased connectivity between the cerebral cortex and the cerebellum (*cerebro-cerebellar loops*), which supports their cognitive abilities despite impairments in other aspects of brain development. For example, neuronal morphology in individuals with *savant syndrome* shows increased neuronal soma size and decreased dendritic *spine density* , which contribute to more efficient and optimal synaptic connectivity in learning and memory (Gordon-Lipkin & Lipkin, 2018). An example of an extraordinary ability often found in *savant individuals* is the ability to calculate dates accurately (*calendar calculation*), which reflects a higher memory capacity in retrieving and storing information (Dania & Novziransyah, 2021).

Further neuropsychological studies have shown that the right hemisphere of the brain in individuals with *savant syndrome* tends to be more dominant. This is believed to be a compensation for left hemisphere dysfunction. In males with *savant syndrome* , testosterone is known to slow the development of the left hemisphere, which affects neuronal function (Meilia, 2021). In addition to genetic factors, brain structure and function are also influenced by environmental experiences. For example, studies on *induced pluripotent stem cell (IPSC*)-derived neurons from individuals with ASD showed that their neuronal soma were larger than control neurons, with hypertrophy of the soma and decreased dendritic spine density (Daulay, 2017). In addition, these derived neurons showed higher electrophysiological activity, with greater synaptic release at excitatory synapses (Song et al., 2019).

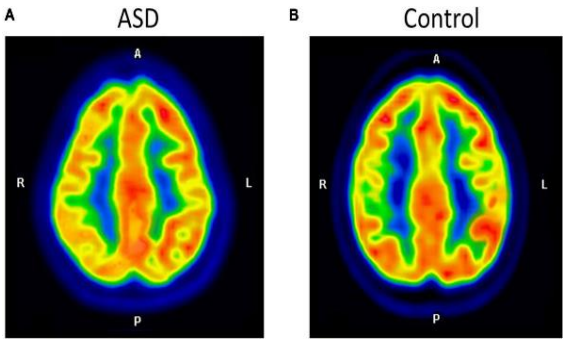


Figure 2. Brain imaging (PET or SPECT) comparing neural activity in individuals with Autism Spectrum Disorder (ASD) (A) and healthy controls (B), highlighting differences in metabolic activity. (Keeratinont et al., 2022)

CT scan results showed that individuals with ASD had lower activity in the left hemisphere compared to the control group, as indicated by lower glucose levels (Tryanan Asmaradhani, 2024). This condition is associated with an increase in savant abilities, which is believed to occur due to dysfunction in the left hemisphere. When the function of the left hemisphere decreases, the right hemisphere becomes more dominant in processing information, potentially leading to a more unique, detailed, and deep-thinking pattern in specific areas (Daulay, 2017).

Specifically, in individuals with *savant syndrome* , the left *frontotemporal lobe* is often associated with extraordinary abilities such as drawing, calculating calendars, and declarative memory (Djajasaputra & Halim, 2019). Research shows that stimulation of the left anterior temporal lobe can improve these abilities, especially in terms of the ability to calculate prime numbers accurately (Hastjarjo, 2020). The brain activity of savant individuals can also be analyzed through *biofeedback EEG* , and central nervous system stimulation, such as amphetamine use, which have

been shown to enhance their cognitive and artistic abilities (Praptomojati, 2019).

In human brain function is divided into two cognitive functions, namely cognitive functions related to empathy and systematization. explains that these cognitive functions are different and unrelated to each other (Wicaksono, 2024). Baron-Cohen divides based on the differences between the female and male brains using two tools, namely " *Systemizing Quotient* " (SQ) and " *Empathy Quotient* " (EQ) (Pratiwi et al., 2022). Baron-Cohen associates empathy with the female brain, while the male brain is programmed to understand and build systems (Systematic). The female brain (empathy) and male brain (systematization) are present in all individuals, only varying in the results for these characteristics in each individual(Latifah & Sahroni, 2020). found a recent study aimed at verifying whether the *savant syndrome profile* in ASD and the ASD profile without *savant syndrome* agree to understand the differences between individuals and Autism individuals that can affect the development of savant skills (Muhammad Aldwin Priyatama et al., 2023).

Based on neuropsychological analysis, the development of abilities in individuals with *savant syndrome* is the result of a complex interaction between genetic and environmental factors (Naji et al., 2020). Environmental experiences can affect the brain's neuroplasticity, allowing for the development of extraordinary artistic or cognitive skills.

CONCLUSION

This literature review provides a neuropsychological perspective of individuals with *Autism Spectrum Disorder* (ASD) who have *Savant Syndrome* through two parts, namely brain structure and cognitive function. The findings indicate that *Savant Syndrome* is closely related to structural changes in the brain, especially in the left hemisphere of the brain. The right hemisphere of the brain, which becomes dominant as compensation for left brain dysfunction, has an impact on the development of extraordinary abilities such as spatial memory, music, and mathematics. This article is expected to help develop scientific understanding of the neuropsychological basis behind the extraordinary abilities of individuals with Savant Syndrome. This article is also expected to enrich the neuropsychological literature and broaden the perspective related to the influence of right brain dominance in compensating for impaired cognitive functions. Further research can be done by exploring the relationship between genetic factors, environmental experiences, and skill development in individuals with Savant Syndrome.

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