Polarized Processing: A Theory of Exceptional Cognition

By Eric Brian Lacy, PhD

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Abstract

Polarized Processing is a theory of cognition outlining a dual processing system that switches modes according to functional demands. This new model reframes savant syndrome as exceptional cognitive abilities attributable to a shift from bottom-up to top-down processing. The introduction of this theory examines the internal mechanism of a prodigious music composer with rare cognitive traits. Through metacognitive analysis, he provides an introspective account of the dual cognitive system from initial input through the final expression of output. Polarized Processing Theory steers the focus away from external observation and toward internal processing, resulting in a more comprehensive understanding of exceptional cognitive systems and a pathway to a more inclusive classification scheme. Early indicators suggest that Polarized Processing may generalize to all savant types and have significant implications in adjacent disciplines.

Polarized Processing: A Theory of Exceptional Cognition

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Introduction

Savant syndrome as described by psychiatrist Darold A. Treffert is "a rare, but extraordinary, condition in which persons with serious mental disabilities, including autistic disorder, have some 'island of genius' which stands in marked, incongruous contrast to overall handicap".[1] Savant skills typically occur in music, art, calendar calculation, mathematics, and spatial skills.[2] These traits exist on a continuum ranging from splinter skills, on the milder end, to prodigious talent on the more extreme end.[3] Savant skills are generally evaluated through external observation, limiting taxonomical accuracy; and while these skills can be observed externally, there is little information available about the internal cognitive mechanism of this condition. While savant syndrome is rare, Treffert insists, "No model of brain function, including memory, will be complete until it can account for, and fully incorporate, the rare but spectacular condition of savant syndrome", later adding, "No single theory can explain all savants".[4] While it is true that understanding savant syndrome is essential to our understanding of the brain, this essay aims to challenge the notion that there can be no single generalizable theory of exceptional cognition.

Review of Current Literature

Weak Central Coherence results in the tendency to notice details before viewing it holistically. According to Francesca Happé and Uta Frith, "'Weak Central Coherence' refers to the detail-focused processing style proposed to characterize autism spectrum disorders (ASD)."[5]

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[1] Darold A. Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," Philosophical Transactions of the Royal Society B: Biological Sciences 364, no. 1522 (May 27, 2009): 1351.

[2] Ibid., 1353.

[3] Ibid.

[4] Ibid., 1354-55.

[5] Francesca Happé and Uta Frith, "The Weak Coherence Account: Detail-Focused Cognitive Style in Autism Spectrum Disorders," Journal of Autism and Developmental Disorders 36, no. 1 (2006): 1.

The result of weak central coherence is bottom-up processing and may account for cognitive input in savant syndrome. It is reasonable to theorize that savants absorb large amounts of information before it is processed internally. We could evaluate, for example, a piano performance savant, who can replicate a piece of music at the piano after hearing it once. The savant not only absorbs large amounts of detail through bottom-up processing, but also likely systemizes these details as well. While weak central coherence offers supplemental information on the savant's cognition—it explains processing during the input stage—it has not yet been extended to outline the internal processing that takes place as well as the final output stage.

Enhanced Perceptual Functioning (EPF) is a theory that frames autistic perception in terms of "enhanced low-level operations; locally oriented processing as a default setting; greater activation of perceptual areas during a range of visuospatial, language, working memory or reasonable tasks; autonomy towards higher processes; and superior involvement in intelligence."[6] EPF theory seems to imply that top-down processing is optional in autistic cognition, while mandatory in non-autistic individuals, which aligns strongly with the idea that extreme modes of cognition may be prevalent in autistic individuals. Further, research in this area indicates the savant's reduced filtering of low-level information and increased pattern recognition creates a strong pull toward detailed data synthesis, making it easier to fit new information into existing models. This, in turn, provides an easier pathway to mastering new domains without instruction and without external support.[7]

Predictive Processing Theory speaks of two processing modes: top-down and bottom-up. The theory proposes that there is a balance between these two modes; that information is perceived and maintained generally, through top-down processing, while new, bottom-up information is used predictively based on expectations from previous knowledge.[8] While predictive processing theory presents a dual processing model—the two modes of processing describe an efficient means of improving predictive outcomes—high level processing and the extreme efficiency seen in exceptional cognitive processes has not been addressed in this current model.

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[6] Mottron, Dawson, and Soulières, "Enhanced Perception in Savant Syndrome: Patterns, Structure and Creativity," Philosophical Transactions of the Royal Society B: Biological Sciences 364, no. 1522 (May 27, 2009): 1385.

[7] Ibid., 1388.

[8] R.R. Reeder, G. Sala, and T.M. van Leeuwen, "A Novel Model of Divergent Predictive Perception," Neuroscience of Consciousness 2024, no. 1 (2024): 1-2.

Compensatory Plasticity suggests that certain undeveloped or underdeveloped areas of the brain cause other areas of the brain to compensate for the deficit. As a result, "The brain will undergo extensive reorganization following sensory deprivation or damage to afferent pathways."[9] The literature is very limited on this subject. However, it addresses some critical elements that may apply to savant cognitive development. It addresses the possible cause of the condition seen in some exceptional cognitive mechanisms, but does not currently address the cognitive process itself.

While existing theoretical models address elements of exceptional cognition, no current theory explains savant cognition holistically, but instead offer explanations for segments of exceptional cognitive processes. Enhanced perceptual functioning, for example, addresses bottom-up processing, pattern recognition, and enhanced memory but does not currently integrate these traits into one comprehensive framework. Further, EPF does not, at this time, account for speed of process and narrow concentration of skill. Current proposals do not yet provide an internal model and a complete framework for savant cognition. None have been demonstrated to be generalizable, nor are they predictive. This essay proposes an alternative approach to understanding exceptional cognition, addresses these gaps, and may explain the internal cognitive processes that take place broadly in savant syndrome.

Taxonomy

The term "savant" is a clinical term with implications that are based on external observation and strict diagnostic criteria. As discussed earlier, Darold Treffert describes savant syndrome as a condition in which a person has exceptional abilities that stand in stark contrast to a notable cognitive impairment.[10] With that understanding, how would we describe someone who is using the same underlying process, but without the cognitive disability? What if the disability is not present, or if it is not in noticeable contrast to the extraordinary ability? The clinical view of savant syndrome does not seem to account for the possibility of more than one exceptional

[9] Jon H. Kaas (ed.), "Mutable Brain: Dynamic and Plastic Features of the Developing and Mature Brain," (2001)

[10] Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," 1351-52.

cognitive mechanism operating simultaneously in the same individual; that is to say, can a savant excel intellectually in areas outside the boundaries of their prodigious domain?

Treffert states that most often, "savant skills emerge in childhood", from which it may be inferred that those skills must be displayed and witnessed through third person observation during childhood as well.[11] At this time, the facts are not entirely consistent on this and it remains unclear when savant skills may or may not emerge. Nevertheless, the literature appears to be quite sparse regarding neurodivergent people with late emergent savant traits, resulting in a series of open questions. What if these traits are hidden from public view while the underlying framework is still present? What if savant traits are observable and yet go unrecognized or unnoticed? What if a musical savant is never introduced to music? What if a piano performance savant never learned to play the piano? These are substantive issues of explanation and not merely observation. The current clinical view of savant syndrome does not yet address the internal mechanism of the savant and instead maintains a narrower focus on external observation, which creates restrictive barriers and limitations on the ability to identify and understand these complex systems.

Consequently, the term *cognitive polarizer* (or *polarizer*) has been established in this context to describe an individual who displays genius level output that is typically attributed to savants, but is instead identified through the internal mechanism. In addition, the subcategories *prodigious polarizer* and *metacognitive prodigious polarizer* correspond to the hierarchical structure that is also seen in individuals with savant syndrome. Both function at a prodigious level, with the latter possessing the additional trait of metacognitive awareness. These distinctions restructure savant cognition within the framework of the internal process and away from external observation alone. This reframing also removes the connection with pathology normally associated with savant syndrome as well as the barriers to identifying otherwise unrecognized individuals due to the limitations created by current clinical criteria.

[11] Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," 1354.

The Theory of Polarized Processing

Polarized Processing is a theory of cognition outlining a dual processing system that switches modes according to functional demands. This cognitive process, which is automatic in nature and foundationally structural, is the method through which individuals with exceptional cognitive functioning rapidly produce complex output. The theory rests on two stages of cognitive processing: bottom-up and top-down.

The bottom-up, or input stage is where information is absorbed, integrated, and systemized. This stage involves the absorption of large quantities of data, usually in one narrow domain such as visual arts, music, or mathematics. Abstract or conceptual details may also be integrated and systemized during this process. As these details are absorbed, the cognitive system automatically structures the information systematically through enhanced pattern recognition and advanced associative processing, creating a large, detailed internal framework in preparation of new data integration. This internal framework of systemized data, or *the network*, is formed at a foundational level before increasing complexity. The development of the network is an entirely internal, unconscious, and automatic process.

The top-down, or output stage is where the integration and development of additional data and external expression take place. At the beginning of this stage, the input data has already been developed into an internalized system of patterns and organized into the structural network. At this point, information in the network integrates with additional information through audiation for musical savants, visual processing for visual art savants, and pattern processing for mathematical or calculator savants. This additional information, which may include external data or a derivation of existing internal data, is conceptually blended through the network for top-down processing. Because the network is optimized to isolate schematic regularities within a given framework, the cognitive system focuses on high-level information, prioritizing the essential data over ancillary information for final output. The final expression of this information may include musical and artistic works, mathematical formulas, and numerical calculations, depending on the information selection biases of the cognitive system. As a result of this top-down approach, the final output is produced rapidly, with minimal reliance on external support.

During each stage, highly advanced associative linking is an integral part of the organization process, actively making connections within the network itself. Relational bindings formed

during conceptual acquisition enhance memory and internal connections within the network as well. The systemization and structure of polarized processing results in an efficient operation, allowing for maximum speed of process within entirely automatic input and output stages.

It is important at this time to return to Treffert's statement that "no single theory can explain all savants".[12] This is only true to the extent that a diagnosis of savant syndrome is evaluated through external output alone. Doing so results in the false inclusion of certain savant types, including pure memory savants, who operate through eidetic processing and not polarized processing. While enhanced memory through advanced associative processing and pattern recognition is an essential part of exceptional cognition, polarized processing does not rely on memory as the defining characteristic of the model. The network, which is developed through the bottom-up absorption of relevant information, efficiently incorporates new data into the framework in preparation of a top-down approach to output, reducing the role memory plays in the process. As a result, pure memory savants, or the person who possesses prodigious memory, may be considered a savant, but is not necessarily operating via polarized processing.

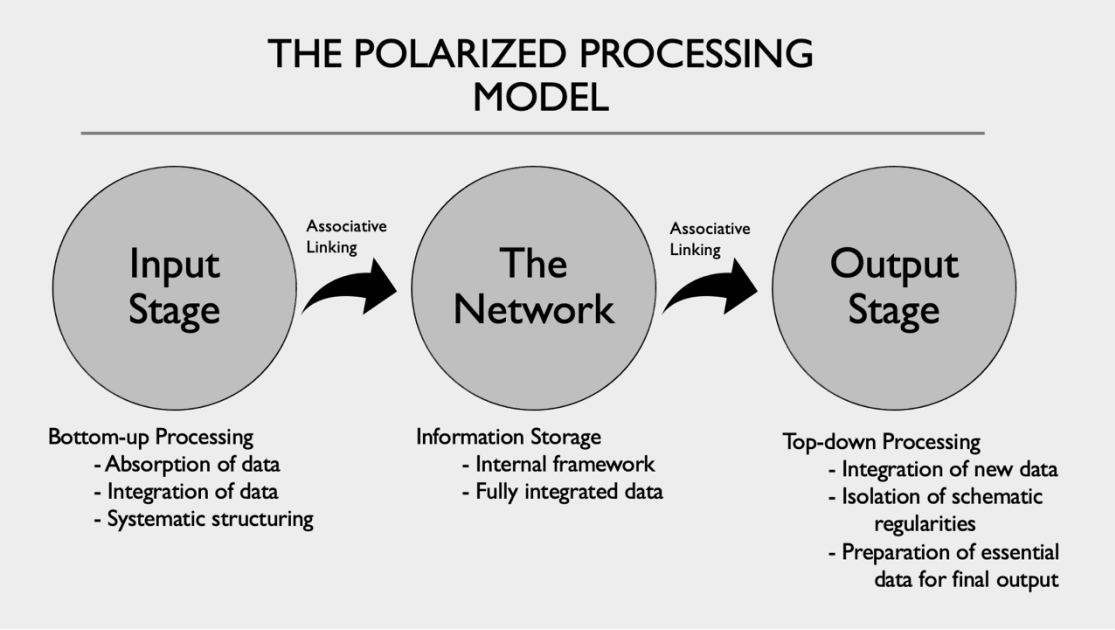

Figure 1. The Polarized Processing model

[12] Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," 1354.

Participant X: An Atypical Cognitive Profile

Participant X* is a self-taught music composer who displays a highly efficient compositional process. His profile consists of no less than the following atypical features:

- He first began composing music for orchestra in his 30s and achieved mastery apart from formal education.
- He never uses piano or external sound as a compositional tool.
- His compositional process is internal. He composes segments of music through advanced audiation.
- He perceives music ensembles, including the orchestra, as a single instrument divided into a variety of sounds, articulations, and textures, not as several instrumental families.
- When composing, he does not conceptualize blended harmonies. He perceives the *harmonic direction* of the music. This includes elements of texture, melodic and rhythmic drive, tension, and resolution.
- He exhibits unusually strong associative processing.
- By intuition, he orchestrated complete scores before taking lessons in instrumentation or orchestration.
- His process is extremely efficient. He composes large scale works at extraordinary speed. The length of time to complete a compositional work is not affected by the ensemble size.
- He composes directly to orchestral score, bypassing piano sketches and drafts.
- He demonstrates metacognitive awareness and is able to understand, reflect upon, and articulate his own cognitive process.

Under the suggested taxonomical system, Participant X is considered a metacognitive prodigious polarizer, meaning he shows evidence of the same internal processing system as individuals with prodigious savant syndrome while also being metacognitively aware of his internal process. He was diagnosed with autism spectrum disorder subsequent to compositional mastery and demonstration of the traits described in his profile. He is a bottom-up processor generally and has created an internal network of music, including sounds, textures, and sound hierarchies. As he unconsciously absorbed these details, he systemized large amounts of sound patterns and sound structures. These sound structures have been organized in a way that facilitates the integration of new data, resulting in an expedited, efficient cognitive process in the development of new, original output. As a result, Participant X, having begun his music pursuits as a composer, is able

to compose through advanced audiation directly to score with minimal external support. This is distinct from the typical process described by Treffert as progressing from "replication to improvisation to creation" in most savants.[13] In fact, Participant X is notable for having bypassed instrumental and performance mastery before mastering composition.

Polarized processing is efficient in the sense that once a data system is completely internalized, the synthesis of additional information at the beginning of the output stage produces new data expeditiously. When Participant X is creating new music, his compositional speed is the result of advanced audiation and sound manipulation through the established internal network, which includes sounds, thematic content, orchestration, and articulations. At the output stage, after the details have been organized schematically, he conceptualizes the orchestra as a single instrument divided into several instrumental families. He organizes sound holistically before balancing them instrumentally. He creates and arranges new music internally based on harmonic direction through the network. These measures function as a distinct part of a top-down approach to notating the music he perceives internally, allowing him to bypass the more conventional approach of using intermediate steps such as piano sketches and drafts.

Similarly, a music performance savant is able to reproduce music after hearing it once because the music patterns that exist in traditional Western music are internalized into a performance network—an internal system of information that can quickly absorb and integrate new data while isolating schematic regularities and recurring patterns. Subsequently through advanced associative processing and a conceptually driven approach to developing output, the performance savant is able to reproduce complex music by focusing on high-level information. As an ancillary function, schematic regularities are assimilated into the performance based on traditional or common music patterns. Consequently, if Western music is the basis for the internal network, a performance savant may struggle to accurately reproduce atonal music because atonal music strays from the traditional Western music archetype.[14] All types of savants are predicted to use the same cognitive mechanism because all savant types likely draw from some organized, patterned system of data regardless of the intricacy of the pattern.

[13] Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," 1354.
[14] Adam Ockelford, "Comparing Notes: How We Make Sense of Music," (2018): 289.

Implications

Understanding the underlying mechanism of exceptional cognition may prove beneficial in identifying more individuals with atypical cognitive functioning. Placing more focus on the internal processes of exceptional cognitive abilities and the modified taxonomical system may allow for more accurate categorization, a better understanding of how exceptional cognition functions, and the ability to create a more supportive environment for individuals who may benefit from these refinements.

The Polarized Processing model may be similar to the cognitive mechanism seen in first language acquisition. If we were to describe first language acquisition through the lens of polarized processing, the language learner would become immersed in the details of language structure, vocabulary, and syntax, forming an internal network of vocabulary and sentence structure patterns. The output stage would result in the formation of new sentences through the internal language network, demonstrating a similar automatic bottom-up input and top-down output process as described in Polarized Processing Theory. There may be a relationship between these two processes.

As specified by the model, polarizers tend to absorb large amounts of data, develop an internal network of information, attain fluency within a narrow domain most often before becoming formally educated in that domain. Language acquisition often functions analogously to that process. Typically, native language fluency is achieved before learning the formal rules that govern it.

Initial analyses demonstrate that Polarized Processing may generalize to all savant types. This includes individuals who exhibit exceptional skills in music performance, calendar calculation, and visual art. Further analyses have demonstrated the Polarized Processing model to have explanatory power in interdisciplinary fields and for the cognition of mathematician Srinivasa Ramanujan. If validated empirically, Polarized Processing may emerge as a unified theory of exceptional cognition.

Because an estimated 10% of autistic people display some savant traits, our understanding of autism, autism cognition, and neurodiversity may be directly impacted by Polarized Processing Theory.[15]

In the Polarized Processing model, memory is enhanced by advanced associative processing. This may have implications on how we understand memory and how cognitive systems retain information.

Because cognitive science is an interdisciplinary field, Polarized Processing Theory has potential implications in philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology, among other scientific fields.[16]

Polarized processing requires the absorption and integration of details before extracting high level information. If polarizers are evaluated through the scope of more traditional processing methods, those individuals may be mistakenly perceived as requiring remedial support.

Limitations and Future Research

While Polarized Processing Theory explains exceptional cognition, empirical evidence is required to verify its generalizability and how broadly it can be applied across disciplines.

Further research is necessary to determine the extent to which the internal development of the polarized processing mechanism is random and the reason for its apparent narrow domain distribution.

While Polarized Processing Theory may have broad explanatory power, it does not yet fully explore its interdisciplinary scope. Further research is suggested in adjacent fields such as neuroscience, psychology, and philosophy.

Initial analyses demonstrate a potential relationship between polarized processing and first language acquisition, including their possible association with nonspeaking autistic individuals.

[15] Treffert, "The Savant Syndrome: An Extraordinary Condition. A Synopsis: Past, Present, Future," 1351.

[16] Paul Thagard, "Cognitive Science," Stanford.edu, 2023, https://plato.stanford.edu/entries/cognitive-science/?utm_source=chatgpt.com.

Additional research is recommended in order to develop a more comprehensive understanding of these potential relationships. (For related discussion, see Schwartz et al., 2025)

Conclusions

The Polarized Processing Theory of exceptional cognition explains the internal process of exceptional cognitive systems, initiating a shift from external observation to internal functioning. The dual cognitive process of bottom-up input and top-down output establishes a complete framework for exceptional cognition, accounting for the speed of final expression and the absence of external support and intermediate steps. The theory has been demonstrated in its early stages to generalize to other types of savants, establishing a potential unifying framework of exceptional cognition. Polarized Processing adequately addresses gaps in the current literature, while opening new pathways to understanding how atypical cognitive processes function in interdisciplinary fields.

*In this paper, the pseudonym “Participant X” is used in order to protect the privacy of the subject and for purposes of anonymity.

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