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ARTÍCULOS

Enhancing Educational Growth Through Social Neuroscience: E-Learning as a Safe Platform for ASD Students

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EN **Abstract.** The outbreak of the COVID-19 pandemic caused significant disruptions to conventional educational methodologies, resulting in a swift transition towards online and remote learning. This shift presented notable obstacles, especially for students with specific requirements like autism spectrum disorder (ASD). This current theoretical analysis explores the potential of electronic learning as a tool to facilitate the academic advancement of ASD students from the perspective of social neuroscience. Studies in social neuroscience emphasize the profound consequences of social seclusion on mental well-being and emotional health. Prolonged periods of social distancing and the absence of in-person interactions may have adverse effects on cognitive growth and academic achievement. Nonetheless, the digital realm could provide distinct benefits for ASD students, who frequently encounter difficulties in social interaction and emotional management within traditional class settings. The assessment delves into the social-cognitive deficiencies linked with ASD and how online learning could supplement the educational requirements of these students. Despite conflicting findings on the effectiveness of online education for ASD, this review proposes that an adaptable and personalized approach tailored to individual needs could improve learning prospects. Ultimately, the infusion of social neuroscience principles into educational methodologies could facilitate the establishment of a more comprehensive and supportive learning atmosphere for all students, including those with specific needs.
Keywords: social neuroscience; social isolation; mental health; emotional well-being; e-learning; special needs education; academic performance

ES Potenciar el crecimiento educativo a través de la neurociencia social: El e-learning como plataforma segura para los alumnos con TEA

ES **Resumen.** El estallido de la pandemia de COVID-19 provocó importantes trastornos en las metodologías educativas convencionales, lo que dio lugar a una rápida transición hacia el aprendizaje en línea y a distancia. Este cambio presentó notables obstáculos, especialmente para los alumnos con necesidades específicas como el trastorno del espectro autista (TEA). El presente análisis teórico explora el potencial del aprendizaje electrónico como herramienta para facilitar el progreso académico de los alumnos con TEA desde la perspectiva de la neurociencia social. Los estudios en neurociencia social destacan las profundas consecuencias del aislamiento social en el bienestar mental y la salud emocional. Los periodos prolongados de distanciamiento social y la ausencia de interacciones en persona pueden tener efectos adversos sobre el crecimiento cognitivo y el rendimiento académico. No obstante, el ámbito digital podría aportar ventajas claras a los alumnos con TEA, que con frecuencia encuentran dificultades en la interacción social y la gestión emocional dentro de los entornos de clase tradicionales. La evaluación profundiza en las deficiencias sociocognitivas vinculadas al TEA y en cómo el aprendizaje en línea podría complementar las necesidades educativas de estos alumnos. A pesar de los resultados contradictorios sobre la eficacia de la educación en línea para el TEA, esta revisión propone que un enfoque adaptable y personalizado adaptado a las necesidades individuales podría mejorar las perspectivas de aprendizaje. En última instancia, la incorporación de los principios de la neurociencia social en las metodologías educativas podría facilitar el establecimiento de una atmósfera de aprendizaje más integral y de apoyo para todos los estudiantes, incluidos aquellos con necesidades específicas.
Palabras clave: neurociencia social; aislamiento social; salud mental; bienestar emocional; E-learning; educación especial; rendimiento académico

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1. Introduction

The past few years have been marked by stringent adherence to social distancing, extensive efforts to contain diseases, and a variety of quarantines enforced by governments. These measures necessitated citizens to remain at home and minimize direct contact with friends and relatives as much as possible (Loades et al., 2020; Unicef, 2021 a). With the onset of the novel COVID-19 pandemic, policymakers, governors, and all relevant parties had to make unexpected adjustments to adapt to the new circumstances. These unwelcome changes significantly altered societal infrastructures at various levels, impacting the educational, mental, and personal aspects of individuals' lives. Understandably, these abrupt changes were not well-received by the majority of communities across different domains. This was particularly evident in the rapid transition to online education and the dominance of distance learning within a very short timeframe. The online mode of education was relatively new to a large number of educational systems, instructors, and learners in many countries. This led to the emergence of additional issues, such as difficulties in engaging students in classroom discussions, adapting to the usual classroom procedures, and, ultimately, the decline in students' academic performance. These unresolved issues, which are closely linked to mental health troubles, can be explained based on psychological guidelines. It goes without saying that the sudden loss of social connections with peers, colleagues, and even students has a profound impact on both students and teachers. School closures and the extended period of social isolation have put the psychological well-being of children and adults alike at risk (Alamiri et al., 2024; Brooks et al., 2020; Hossain et al., 2020; Mazrekaj & De Witte, 2024).

The global outbreak of the virus has imposed a state of loneliness and social isolation on people worldwide. The concept of social isolation has been a topic of intense debate for many years. However, in the context of the coronavirus, addressing this issue has become a mandatory task for researchers (Wang, 2017). Humans, by nature, are social beings who construct ideas and beliefs within societies through a mutual exchange of thoughts. Like all social species, humans are predisposed to form social networks that extend beyond individual members (Cacioppo & Decety, 2011). The biological essence of humans is profoundly influenced by social interactions and the convergence of cultural and social ideas over centuries (Bell et al., 2009; Gazzaniga, 2008, as cited by Cacioppo & Decety, 2011). Indeed, maintaining healthy social relationships with others is vital for human survival (Calsyn & Winter, 2002; Giles et al., 2005; Uchino, 2009). One plausible explanation for humans' essential need to connect with others can be best illustrated through the cognitive window towards the brain. Essentially, the mammalian brain is highly evolved to nurture social connections with other community members. Consequently, it instinctively perceives isolation, rejection, or loneliness as threats to its survival.

It is widely understood that the risks associated with loneliness could outweigh the benefits of remaining safe. The lack of social connections can trigger physiological responses and inevitably lead to psychological distress, such as anxiety, depression, stress, and even mortality (Cacioppo et al., 2006; Eisenberger, 2013; Luanaigh & Lawlor, 2008). Eisenberger et al. (2003) found that certain regions of the brain are involved in both the perception of physical pain and the pain caused by social isolation or rejection. Receiving positive social support and establishing a broad network of social connections can help individuals combat these stressors. This is because positive social feedback enhances the release of the "Oxytocin" hormone in the brain. Oxytocin, in turn, encourages the brain to form additional social bonds (Carter et al., 2008; Insel & Young, 2001; Rodrigues et al., 2009; Stevenson et al., 2019; Uvna¨s-Moberg, 1998). As a result of forming more social relationships and receiving positive social support and feedback, individuals can be shielded from harmful behavioral influences (Grippo et al., 2009). A socially healthy brain opens new communication channels and establishes new connections with other brains. In contrast, brains affected by neurodegenerative disorders, such as Alzheimer's, often struggle to maintain social communication or exhibit normal social behaviors (Gregory et al., 2002). Therefore, it is clear that there is a bidirectional link between the brain and the development of social behavior. Social behavior can influence brain structures, but the fundamental structures of the brain can also significantly influence social behaviors (Cacioppo et al., 2007).

Social isolation can ultimately impact students' academic performance and jeopardize their psychological well-being, a situation that must be avoided at all costs. However, this perspective leaves several questions unanswered. For instance, to what extent do we prioritize the education of children with mental disabilities or those with specific needs? Have children with autism exhibited any signs of improvement in relation to isolation? How are students and teachers navigating the mental and environmental challenges posed by the pandemic? The present study seeks to address these questions from the perspective of social neuroscience. The objective of this article is to establish a multidimensional framework for understanding social isolation and related concepts.

2. Social neuroscience

Cognitive Neuroscience is currently a leading field of global inquiry, probing into the mysteries of the human brain, the social ties that shape human communities, and the construction of emotionality. The significant contributions of this field have given rise to newer disciplines. Humans, no longer living in isolation, have their general responses shaped by their gregarious nature. The human brain is specifically developed to comprehend other minds, categorizing humans as a highly socialized species. The interconnections among humans are understood in relation to other societal connections; thus, humans are no longer studied in isolation. The social nature of humans has gained traction among various scholars, making the reflection on social relationships and their impending impacts on neural networks an important area of study.

Social neuroscience during the pandemic period gained popularity more than before as some dimensions of healthy social life were omitted, and social isolation and loneliness were regarded as chronic and burdensome (Gronewold & Engles, 2022; Mertens et al., 2020). During the last two decades, the main focus of research has been on the effects of loneliness on the social brain of humans. Actually, social neuroscience entered the scene to address new perspectives in the social and biological world of humans using genetic studies, fMRI Techniques, EEG, and ERP (Cacioppo & Cacioppo, 2013). Social neuroscience, an emerging cross-disciplinary platform, bridges the gap between the internal aspects of human nature and the external elements of the surrounding world. This field aims to establish connections between the subtle biological mechanisms occurring within the body and overt/covert social behaviors, in addition to analyzing neural pattern activations associated with social performance (Cacioppo & Decety, 2011). In fact, Social neuroscience represents the brain as a complicated device comprising several underlying computing systems, all operating simultaneously to manifest a goal. According to Cacioppo and Cacioppo (2013), the brain is a cell phone instead of a desktop merely plugged into an electricity source. To elaborate more, researchers suggested that from a social neuroscience perspective, language is considered a system dedicated to exchanging information between brains. However, merely a transference of data is not intended, but other supplementary information, such as communication attachment, social recognition, empathetical reactions, cultural norms, emotional contagion, etc, are also recorded (Cacioppo & Cacioppo, 2013). Evidently, multiple sources of conceptual data and comparative information analysis are integrated sequentially until a consistent understanding emerges. As the title suggests, this subsection focuses on the social dimension of the concepts, primarily understanding behavioral and emotional responses that could significantly influence societal parameters. Indeed, social neuroscience has placed a strong emphasis on the communicative interaction of individuals and their bidirectional social impacts. Singer (2012) identifies three salient characteristics of the field: a) social neuroscience investigates the innate capacity of humans for mutual understanding, empathizing, and applying pragmatic knowledge to extract connotative intentions and beliefs, b) it shapes our interpretative capabilities, and c) it distinguishes the reciprocal sharing of feelings with other community members.

Social neuroscience is a rapidly expanding discipline that encompasses several developmental movements, each studying different aspects related to the broader picture. The primary contribution of the social neuroscience perspective in the current study pertains to the field of education. Ever since the onset of the pandemic crisis, which has posed significant challenges to educational systems worldwide, ministries of education, universities, and schools have primarily sought to redefine educational procedures for students. Educating students globally in the face of the Covid-19 crisis has proven to be a formidable challenge. Both teachers and students are grappling with psychological and mental issues at a time when they are deprived of traditional classrooms and the ability to establish direct rapport with each other. Evidently, face-to-face social interactions have plummeted to their lowest levels ever, making online education the most prevalent form of teaching, regardless of whether students appreciate it. Researchers and educational policymakers tried to accommodate the need for designing new pedagogical concepts to cater to the connectivity needs of students. In this line of discussion, Dreamson (2020) attempted to redefine pedagogical needs in the era of social isolation and loneliness and termed their pedagogy as “metacognitive pedagogy,” focusing primarily on the need for communication. According to Dreamson (2020), the suggested pedagogy takes a holistic, systematic approach toward the need for interconnectivity in times when digital education is highly appreciated. The widespread COVID-19 pandemic raised serious pedagogical issues, which required teachers to adopt new teaching strategies and students to adapt to the new environment. The salient point is attending to the various needs of learners and instructors in times of crisis. Researchers demonstrate that between 2020 and 2022 learning and performance of students were affected due to loneliness, mental health isuues, lack of communication with peers and school closure (Dewitte & Francois, 2023; Di Pietro, 2023). Studies show there is a link between the duration of school closure and learning déficits in younger children specifically in primary and secondry education (Mazrekaj et al., 2024).

Social neuroscience addresses both the health and educational dimensions of the scenario, investigating the negative and positive outcomes of the situation. However, the present study attempts to reconsider the educational dilemmas and emotional setbacks in the case of children with disabilities and their instructors through the lens of social neuroscience. Generally speaking, both learners and educators have faced a challenging time in online learning environments, but the effects on children with specific needs, their families, and their teachers might be more significant. Such critical issues involve not only academic aspects but also mental health concerns, and psychological and socioeconomic burdens are part of the framework as well.

2.1. Mental health and social neuroscience

The coronavirus, recognized as one of the most potent viruses in recent decades, has necessitated large-scale containment measures due to its rapid spread and high contamination rate. Governments worldwide were compelled to implement these measures, which included school closures, social distancing, home quarantines, and social isolation (Loades et al., 2020). In response to the swift proliferation of the virus, various organizations promptly enacted stringent regulations. These required employees, staff, and students to adapt to new conditions, such as working from home. This shift in lifestyle, while necessary, prevented individuals from engaging in face-to-face interactions with friends, colleagues, and instructors. The quarantine regulations, while crucial for disease containment, were associated with psychological stress, increased disease risk, loneliness, and mortality (Cohen et al., 2007; Hawkley & Cacioppo, 2010; Muscatell & Eisenberger, 2012). Inflammatory responses are a critical component of the immune system's reaction to diseases or bodily damage. However, the prolonged presence of inflammation contributors in the body could potentially pave the way for the emergence of other disorders (McEwen, 1998).

2.2. Mental health and social isolation

A wealth of data accumulated over recent decades illustrates the profound impact of stress on mental health and various psychological aspects of life (Christiansen et al., 2021; Vasan et al., 2023). Research has established robust links between major stressors experienced during strict quarantine periods, loneliness, mental health, and the neural pathways of the brain (Gianaros et al., 2007; Martins et al., 2024; Mushtaq & Khan, 2024). The widespread implementation of home quarantines has significantly intensified social isolation. Mental health issues could stem from regulations and restrictions on social gatherings. Social isolation is defined as "the inadequate quality or quantity of social relations with other people at the individual, group, community, and larger social environment levels where human interactions take place" (Zavaletes et al., 2014). Wang et al. (2017) propose a comprehensive model that encompasses several perspectives on the theme of social isolation. This model is constructed in five stages, each viewing social isolation from a unique angle. The principles of this conceptual model encapsulate five domains: quantity, structure, quality, emotions, and resources. These domains are typically discussed in relation to social networks, but they can also shed light on the nature of social isolation, loneliness, social support, and social networks. Network quantity refers to the number of contacts, frequency of meetings with friends over a specific period, and the number of people constituting the social network. Network quality measures the quality of significant social relations, be they partnerships or friendships. It also assesses which network members can be trusted, who are considered friends, and who would be most missed in their absence. "Appraisals of relationships; emotional and resources" aim to determine the influence of certain relationships and the accessibility of individuals to sources of social support. According to the model, during times of social isolation, the five elements of quantity, quality, emotion, and resources are disrupted across individuals, leading to devastating effects. During the pandemic marked mental health issues were left on younger generations from different classes of scociety. In a study held by da Cruz and colleagues (2024) seventy six plrofessional soccer players were studied to better understand the effects social isolation could have on their sleep quality, and anxiety. Researchers reported that nationwide lockdown had resulted in drastic rise in the leve lof anxtiousness, but the effects on sleep quality were obscure. They believe that in order to elaborate further on the posible impacts of social confinement on sleep higiene longitudinal studies should be conducted. In another similar study, reserachers revealed that social distancing and imposed lockdown were weighing heavily on young females, arguing that their mental health were severely threatened due to lack of contact with friends, and increased verbal arguments with family members. 650 participants took part in this online study which demonstrated the regression of moderate to extreme depression, stress and traumas (Liozidou et al., 2024; Vasan et al., 2023). According to the reserachers, pandemic not only forced people into physical distancing, but also imposed them into psychological confinments (Liozidou et al., 2024; Loades et al., 2020). The same results were reported with regard to Young children whose learning performance was significantly affected due to school closure, and being deprived of being in touch with peers (di Pietro, 2023). Other scholars have suggested additional components to address the issues of social isolation and loneliness (for further reading, Dunn et al., 1990; Hays & DiMattio, 1987; de Jong-Gierveld, & Kamphuis, 1985; Webber & Huxley, 2007).

2.3. Social neuroscience, emotion and resilience

Sentiments or general emotions constitute a crucial component of daily conversational interactions. During these interactions, individuals exchange emotional messages, such as fear, pride, embarrassment, and happiness. These emotions can be realized both interpersonally and intrapersonally, serving as catalysts for social interactions and the formation of social ties (Tangney et al., 2007). Humans, akin to other mammals, are inherently social. The need to maintain and expand their social networks compels them to frequently interact with other members of their community. However, when this need is suppressed by external factors, leading to social isolation or exclusion, other mental elements, including emotions, are adversely affected. The pain of social rejection extends beyond conventional boundaries, impacting neural networks and cognition (Eisenberg et al., 2003). The neural signals perceived during social exclusion are primarily analyzed by the anterior insula and dorsal anterior cingulate cortex, regions also involved in processing physical and affective pain (Cacioppo et al., 2013; Eisenberger, 2012). In more severe cases of social exclusion, cortical areas and posterior regions of the insula also become engaged (Kross et al., 2011). Cacioppo et al. (2000) examined executive functions in individuals experiencing social isolation. They found that these individuals had difficulty

controlling attentional tasks. In a dichotic listening examination, participants were asked to recognize pairs of sounds presented simultaneously to the left and right ear. The task required significant attentional regulation, and participants experiencing loneliness performed weaker compared to their socially connected counterparts. Prolonged social isolation can trigger severe negative emotional reactions. The sources of these negative emotions can vary across individuals and circumstances. For instance, news headlines about the coronavirus pandemic have been identified as strong triggers of negative feelings (Aslam et al., 2020). Thus, it is evident that emotional well-being can be significantly disrupted by social isolation and the negative emotions it engenders, such as fear, anticipation, and doubt.

Resilience and wellbeing have emerged as prominent topics of discussion within psychological domains (Jeste et al., 2015). As defined by Luthar et al. (2000, p. 543), resilience is a "dynamic process of positive adaptation or development in the context of significant adversity." It is viewed as a safeguard against succumbing to stressors that could potentially compromise mental immunity (Davydov et al., 2010; Jin et al., 2009). Rutter (2013) posits that there exists a bidirectional relationship between resilience and environmental/contextual factors, indicating their interdependence. Resilience is significantly influenced by environmental causal elements (Zynchincki & Polo, 2012). However, Schultze-Lutter et al. (2016) argue that the scarcity of research projects concerning the concept of resilience has led to a proliferation of definitions for this term. Despite this, their overarching idea is predicated on the notion that resilience serves as a defensive mechanism, a mental barrier safeguarding mental health. Consequently, mental health is a crucial component of the comprehensive definition of resilience (Schultze-Lutter et al., 2016). Resilience is preserved when mental health remains intact. Resilience is thus defined both as a process and as an outcome of coping strategies, resulting in enhanced capabilities for managing adversities (Machielse, 2018; Masten, 2001; Gloria & Steinharted, 2014; Rutter, 2013). Emotional resilience echoes this idea, emphasizing the ability to recover from the detrimental effects of negative factors and reflect positive emotions in return (Zhang et al., 2020).

The development of emotional resilience is crucial for enhancing problem-solving capabilities and coping strategies in challenging times. Essential coping skills aid individuals in internalizing qualities that foster mental resilience, enabling them to manage mental issues and behavioral difficulties. In the current era of education, it is vitally important for students to be equipped with these coping strategies. Emotional wellbeing, a fundamental principle contributing to improved lifestyle and academic performance, is significantly influenced by environmental factors such as family and school (Chadwick, 2014, pp. 31 and 33). The age of students is also a strong determinant in this context (Zhang et al., 2020). Managing emotional disturbances is notably more challenging in younger children compared to their adult counterparts. Academic failure during the pandemic has emerged as a major source of negative feelings such as anticipation and anxiety among students, leading to a heightened vulnerability to reduced mental resilience. Therefore, acquiring emotional management skills is essential for students, as effective emotional management strategies can significantly improve academic performance and alleviate psychological distress (Berenson et al., 2008; Zhang et al., 2020).

Emotional wellbeing assists us in better addressing social and mental difficulties (Chadwick, 2014, pp. 31 and 33; Gross et al., 1995). Wellbeing is achieved when a healthy balance is struck between resilience across various elements (physical, academic, economic, etc.) and risk factors of different kinds (social, psychological, mental, etc.) (Dodge et al., 2012). Given the prolonged closure of schools, emotional wellbeing has likely been dramatically affected. Factors such as alienation and social isolation can significantly influence emotional wellbeing and the level of psychological resilience (Franke & Elliott, 2021). The isolation caused by the spread of the virus has forced students to remain separated from each other, leading to a reluctance to participate in classroom activities (Schachter, 1959). This separation hinders the interactive exchange of ideas among students, a critical process in the classroom.

3. Social neuroscience and autism

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that is widely recognized for impairing social skills and mentalizing abilities in individuals (Lord et al., 2000). As suggested by its name, the disorder is not defined by a single dysfunction, but rather encompasses a range of behavioral and psychological disturbances (Jam et al., 2017). Children with autism often demonstrate commendable intellectual and executive functioning. However, their inability to maintain effective social communication or to engage in social contexts forms the primary characteristics of the disorder (Lanter & Watson, 2008; McPartland & Pelphrey, 2012; Ozuna et al., 2015). These children typically avoid establishing direct eye contact and tend to look elsewhere while speaking. They exhibit less interest in social interactions compared to their neurotypical peers, and their use of gestures to enhance their conversations is often limited (Wong & Kasari, 2012). The multimodal nature of conversations requires speakers to utilize various modes, such as bodily gestures and eye contact, to maintain effective social communications. However, children with autism often struggle to integrate all these elements, leading to occasional social rejection by their peers (Watkins et al., 2015).

Oral disabilities in children with autism are more profound than initially anticipated. These children may exhibit prolonged pauses before formulating a response, or they may struggle to fully comprehend the linguistic input of other speakers. A common characteristic among these children is the repetitive use of certain words or phrases in their conversations (Tager-Flusberg, 2000). Parental communication with children with autism naturally requires a different approach. Research has indicated that the emotional resilience measured in mothers of children with autism tends to exceed that of mothers with neurotypical children (Manicacci et

al., 2019). Consequently, parents often adapt their behavior to align with the needs and preferences of their children. It has been observed that mothers are more likely to communicate with their children with autism primarily through nonverbal means (Doussard-Roosevelt et al., 2003).

Children with autism are often reported to struggle with understanding the mental states of others, including emotions, intentions, and beliefs. This difficulty can sometimes lead to misconceptions about the intentions of others, making them vulnerable to deception. Their social impairments are not confined solely to oral communication but can also extend to written modes. This can further exacerbate their communication challenges (Asaro-Saddler, 2014; Baron-Cohen, 2002; Baron-Cohen et al., 1985; Zajic et al., 2016).

Social neuroscience, the scientific study of the mind, places significant emphasis on the interactional processes that occur between humans in a social context. The complex interplay between the human brain and social communication has long been a subject of interest for many scientists. Autism, in particular, has been at the center of this attention. The study of children with autism has sparked interest and has become a favored topic in cognitive studies within this field. Social communication, a crucial aspect of human nature, involves several neural circuits in the brain that process various dimensions of interactions. This complexity is what characterizes humans as social beings. Over time, scholars have identified specific regions of the brain that are responsible for comprehending different aspects of social communication. These regions have been observed to show decreased activation patterns in individuals with Autism Spectrum Disorder (ASD) compared to their neurotypical peers (Kaiser et al., 2010; Maestro et al., 2002). The Superior Temporal Sulcus (STS) and the Fusiform Gyrus (F.G.) are among the most studied areas in the brain. These regions assist individuals in understanding physical gestures or communicative movements (such as eye contact and hand motions) and in recognizing faces, respectively.

The Superior Temporal Sulcus (STS) plays a crucial role in interpreting intentions based on observed biological motions, while the Fusiform Gyrus (F.G.) is responsible for distinguishing familiar faces from unfamiliar ones (Hirari & Hiraki, 2005; Pelphrey et al., 2005; Puce et al., 1996; Simion et al., 2008). In fact, it is suggested that the detective role of the STS in the human brain serves as the fundamental basis for the emergence of more sophisticated social behaviors (Johnson, 2006).

4. The interplay between the Neuroscience and education

Social neuroscience has firmly established its presence in the field of education, leading to the emergence of educational neuroscience as a widely debated topic in contemporary times. The integration of neuroscience and educational principles has opened up new avenues for teachers, policy makers, and students to envision novel approaches for academia and to incorporate fresh perspectives into educational frameworks (Thomas et al., 2019). Known as mind, brain, and education, educational neuroscience is an interdisciplinary research field that bridges three major cognitive domains. It leverages a range of practical and theoretical findings to create a nexus between education and brain science (Arman et al., 2019). In essence, educational neuroscientists strive to understand new concepts and adapt them to meet the requirements of contemporary education. There is a growing optimism among researchers that neuroscience can play a pivotal role in enhancing the quality of learning and teaching practices (Thomas et al., 2018). Educational neuroscience encompasses a broad spectrum of studies that explore the potential impact of neuroscience research on learning processes and teaching methodologies. With the increasing interest in understanding the functions of the brain and its anatomical structures, there has been a surge in efforts to apply these findings across various contexts (Howard-Jones, 2014a; Thomas et al., 2018). Numerous research initiatives have been undertaken to explore the relationship between the mind, brain, and education. This has led to the coining of new terms such as Neuroeducation, brain-based learning, and neuroscience of education (Ansari et al., 2012; Caine et al., 2005; Zanida, 2015).

The assumption of a bidirectional relationship between neuroscientific insights and educational practices posits that education could effectuate significant changes in the brain. This has led to attempts to apply the principles of social neuroscience across various levels of education. Recent findings suggest that researchers have explored the benefits of integrating neuroscience into educational settings to enhance learning opportunities (Gabrieli, 2016). This idea has spurred extensive empirical and theoretical research in the neuroscience of education and learning. As the intersection between these areas garnered attention from academicians, neuroscientists, and psychologists, there emerged a strong need to form new groups and scholarly parties to either advocate for or argue against the translation of neuroscientific findings into education.

Studies suggest that before neuroscience can be widely applied in educational settings, a solid foundation in basic sciences must be established (Howard-Jones, 2010; Howard-Jones et al., 2009; Sparks, 2012). The author argues that transferring knowledge to classrooms without providing the necessary foundations could be extremely time-consuming or even impossible. Willetts (2018) echoes this concern, stating that without taking proper measures before applying neuroscience to education, the desired outcomes may not be achieved.

The risks may intensify as educators show an excessive enthusiasm for the direct application of neuroscience in education (Ansari & Coch, 2006; Howard-Jones & Fenton, 2012). A survey study by Ching et al. (2020) involving 968 pre-service teachers revealed that while the majority lacked sufficient knowledge of brain science, they expressed positive attitudes towards implementing neuroscientific findings in teacher training sessions or educational settings. Despite criticisms against the use of neuroscience in classrooms (Dougherty & Robey, 2018; Willis, 2008; Mayor, 1998), the general consensus has been welcoming towards

bringing neuroscience findings into the classroom (Gabrielli, 2016; Howard-Jones et al., 2016). The prevailing idea is that neuroscience can aid instructors in improving their instructional practices and help students enhance their learning and gain a clearer understanding of their learning processes (Tommerdahl, 2010).

Sinclaire-Harding et al. (2018) studied the integration of neuroscience into child education and argued that adopting a neuroscientific, brain-based learning approach could optimize effective learning and promote healthy growth. Researchers believe that increased dialogue between different fields can yield rewarding outcomes, as they can reflect on the potential contributions of neuroscience to other disciplines (Arman et al., 2019).

5. Discussion

Recently, neuroscience has been incorporated into the realm of online education, a mode of learning and teaching that has gained popularity, especially during pandemics when social distancing became mandatory for promoting physical well-being. As Doukakis et al., (2020) suggest, neuroscience can effectively enhance teacher training skills, reduce pedagogical issues, and ensure better cognitive preparedness, thereby potentially boosting learning opportunities.

Hodges et al. (2020) support the notion that online language teaching requires full awareness and differs significantly from emergency remote teaching implemented under strenuous circumstances, such as during the Covid-19 pandemic. Neuroscience research indicates that the brain's plasticity allows it to adapt to various circumstances. However, this requires individuals to engage in different activities to strengthen specific neural pathways. Such large-scale changes can mold the brain's structure to accommodate various conditions, resulting in improved learning (Darling-Hammond et al., 2020).

Teachers are advised to contribute to memory consolidation in learners by implementing effective assessment techniques and providing feedback. Both teachers and learners can benefit from formal and informal ways of evaluating students' knowledge, as teachers can adopt new methods and students can deepen their knowledge (Hwang & Chang, 2011). According to Nottingham (2017), online learning can be beneficial for students. The researcher posits that the online environment can be resourceful, enabling students to work creatively in collaboration, contribute to classroom discussions, and actively challenge themselves with new learning activities. However, this may not hold true for autistic children who may find it difficult to use technology, especially if they have motor skill difficulties (Faraj et al., 2020). In such cases, constant parental involvement may be required, which could be burdensome for other family members. Nevertheless, researchers suggest that user-friendly online learning platforms could be beneficial for autistic students (Faraj et al., 2020).

The incorporation of technological tools in pedagogical practices has been a priority for years, aiming to enhance students' achievements. Devices such as iPods and tablets have been suggested to have a positive impact on autistic children, as they can easily use them and adjust their behavioral representations based on the learnings acquired through online education (Ayres et al., 2013; Schmidt, 2014; Southall, 2013).

Aspiranti et al. (2020) highlighted the positive outcomes of learning through iPad Technologies. While they encouraged educators to promote the use of this technology, they also emphasized the need to consider various underlying factors. The online learning environment, with its flexible timing and learning opportunities, could be advantageous for autistic students, as it does not require physical presence in classrooms. However, it should be understood that online learning does not necessarily lead to effective learning; it depends on how well both the teacher and the student engage with their teaching and learning experiences (Ellis & Good year, 2019). According to Kauffman (2015), students undertaking online education must demonstrate a range of skills, including time management, self-evaluation, and self-studying, sometimes even before classes. It has been reported that demonstrating such skills can often be challenging for autistic students (Fabri & Andrews, 2016). Therefore, from this perspective, online education may not be efficient for autistic children.

Contrarily, a study conducted by Moore and Calvert (2000) showed that students with Autism Spectrum Disorder (ASD) tended to learn more effectively from educational material presented through computers or similar devices. Chu et al., (2020) tested this hypothesis by assisting autistic students to improve their mathematical learning and emotion regulation. They concluded that online learning significantly influenced their academic achievements. However, students exhibited varied emotional behaviors, and learning was not necessarily successful in mastering emotion regulation. In fact, the results in this line of research have been contradictory, and very little is known in this regard. Further research is required to highlight the advantages and disadvantages of online learning for ASD children.

6. Conclusion

The advent of the online learning environment has brought new hopes for enhancing learning and teaching experiences. Despite the contradictions in the results of employing online education for students with special needs, it is still suggested to implement a model that is adaptable to their needs and reinforces their strengths in educational settings. Adaptive education could potentially enhance learning opportunities (Chu et al., 2020).

Some studies suggest that e-learning could be beneficial as students could apply their skills to the same virtual conditions. Emotion regulation, which is crucial in any kind of learning, has been found to be mostly impaired or abnormal in ASD children, who may express more anger, sadness, anxiety, etc., across various occasions. Likewise, ASD children often demonstrate excessive frustration towards time-limited contexts

due to difficulties in adapting to new situations (Kriete & Noelle, 2015). Thus, e-learning holds an advantage for these students (Roskam, 1997).

Other studies have argued that the inability to regulate emotions in ASD children is one of the main reasons for underachievements in the ASD community (Ashburner et al., 2010). E-learning, by offering a safe location for learning free of probable stressors, could be regarded as an efficient learning platform for ASD students.

However, this does not suggest completely limiting these individuals to self-study education and eliminating their presence from the public. On the contrary, it is suggested that e-learning could complement the educational growth of ASD students, just like their healthy peers. All students, regardless of their academic and family backgrounds, have the right to a decent education. Perhaps, online learning and the use of technological advancements could pave the way for the rise of a new generation of competent students.

The global pandemic of COVID-19 has exerted a substantial influence on the educational encounters of students, notably those diagnosed with autism spectrum disorder (ASD). The abrupt transition to remote and online instruction has introduced a variety of challenges and possibilities for this particular group of individuals. An essential difficulty encountered by ASD students within the realm of online learning pertains to the struggle in adjusting to the novel instructional format. The disruption of customary routines and frameworks, which are vital for many ASD students, can be a consequence of the shift to virtual classrooms. Furthermore, the absence of face-to-face social engagements and the heightened dependence on technology can prove to be especially demanding for individuals grappling with social communication impediments, a fundamental trait of ASD (Fabri & Andrews, 2016). Nevertheless, the online learning model has also displayed potential advantages for ASD students. Research indicates that certain individuals with ASD might exhibit enhanced learning outcomes when educational material is delivered through computers or digital gadgets (Chu et al., 2020; Moore & Calvert, 2000). The capacity to regulate the pace of learning, reduce sensory disturbances, and interact with content in a more personalized manner can be beneficial for ASD students. Moreover, the online setting may offer a more secure and comfortable space for social interaction, enabling ASD students to engage in conversations and cooperate with peers in a less overwhelming environment. The assimilation of social neuroscience principles into the development and execution of online learning platforms for ASD students can further enrich their educational encounters. By comprehending the neural mechanisms that underlie social cognition and communication, educators and researchers can design more precise interventions and support systems to cater to the distinctive requirements of this demographic (Muscatell & Eisenberger, 2012; McPartland & Pelphrey, 2012). To ensure the effective deployment of online learning for ASD students, it is imperative to supply comprehensive assistance and guidance for both students and their families. This might encompass techniques for managing emotional regulation, nurturing social interactions, and cultivating self-regulation skills essential for proficient online learning (Hodges et al., 2020). Additionally, sustained collaboration among educators, neuroscientists, and ASD experts can help bridge the disconnect between theory and application, ultimately resulting in more empirically-grounded and customized educational methodologies. On the whole, the COVID-19 crisis has underscored the necessity for innovative and inclusive educational remedies for individuals with ASD. By capitalizing on the potential of online learning and integrating insights from social neuroscience, educators can endeavor to establish more supportive and enriching learning environments that address the diverse needs of this demographic.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

Alamiri, B., Alkhamis, M. A., Naguy, A., Alenezi, H. F., & Al Shekaili, M. (2024). Anxiety disorders among children and adolescents during COVID-19 lockdowns and school closures: a cross-sectional study in Kuwait. *Frontiers in Psychiatry*, *15*, 1322745.

Ansari, D., & Coch, D. (2006). Bridges over troubled waters: Education and cognitive neuroscience. *Trends in cognitive sciences, 10*(4), 146–51. doi:10.1016/j.tics.2006.02.007

Ansari, D., De Smedt, B., & Grabner, R. (2011). Neuroeducation: A Critical Overview of an Emerging Field. *Neuroethics, 5*, 1-13.

Arman, M. S., Rahman, S., Surat, S., & Bakar, A. Y. A. (2019). Connecting neuroscience and education: Insight from neuroscience findings for better instructional learning. *Journal for the education of gifted young scientists, 7*(2), 341-352.

Asaro-Saddler, K. (2016). Using Evidence-Based Practices to Teach Writing To Children with Autism Spectrum Disorders. *Preventing School Failure: Alternative Education for Children and Youth, 60* (1), 79-85. https://doi.org/10.1080/1045988X.2014.981793

Aslam, F., Awan, T. M., Syed, J. H., Kashif, A., & Parveen, M. (2020). Sentiments and emotions evoked by news headlines of coronavirus disease (COVID-19) outbreak. *Humanities and Social Sciences Communications, 7*(1), 1-9.

Aspiranti, K. B., Larwin, K. H., & Schade, B. P. (2020). iPads/tablets and students with autism: A meta-analysis of academic effects. *Assistive Technology, 32*(1), 23-30.
Ayres, K. M., Mechling, L., & Sansosti, F. J. (2013). The use of mobile technologies to assist with life skills/independence of students with moderate/severe intellectual disability and/or autism spectrum disorders: Considerations for the future of school psychology. *Psychology in the Schools, 50*(3), 259-271.
Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in Cognitive Sciences, 6*(6), 248-254.
Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*(1), 37-46.
Bell, A.V., Richerson, P.J., & McElreath, R. (2009). Culture rather than genes provides greater scope for the evolution of large-scale human prosociality. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 106*(42), 17671-17674. https://doi.org/10.1073/pnas.090323210
Berenson, R., Boyles, G., & Weaver, A. (2008). Emotional intelligence as a predictor of success in online learning. *The International Review of Research in Open and Distributed Learning, 9*(2), 1-17. https://doi.org/10.19173/irrodl.v9i2.385
Brooks, S. K., Webster, R. K., Smith L. E., Woodland, L., Wessely, S., Greenberg, N., & Rubin, G. J. (2020). The psychological impact of quarantine and how to reduce it: a rapid review of the evidence. *Lancet, 395*, 912-920.
Cacioppo, J. T., & Decety, J. (2011). Social neuroscience: challenges and opportunities in the study of complex behavior. *Annals of the New York Academy of Sciences, 1224*(1), 162-173.
Cacioppo, J. T., Amaral, D. G., Blanchard, J. J., Cameron, J. L., Carter, C. S., Crews, D., ... & Quinn, K. J. (2007). Social neuroscience: Progress and implications for mental health. *Perspectives on Psychological Science, 2*(2), 99-123.
Cacioppo J. T., Hughes, M. E., Waite, L. J., Hawkley, L. C., & Thisted, R. A. (2006). Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses. *Psychol Aging, 21*(1), 140-151. doi:10.1037/0882-7974.21.1.140
Cacioppo J. T., & Cacioppo, S. (2013). Social Neuroscience. *Perspect Psychol Sci, 8*(6), 667-9. https://doi.org/10.1177/17456916135074
Cacioppo, S., Frum, C., Asp, E., Weiss, R. M., Lewis, J. W., & Cacioppo, J. T. (2013). A quantitative meta-analysis of functional imaging studies of social rejection. *Sci. Rep., 3*(2027).1-3. https://doi.org/10.1038/srep02027
Cacioppo, J.T., Ernst, J. M., Burleson, M. H., McClintock, M. K., Malarkey, W. B., Hawkley, L. C., Kowalewski, R. B., Paulsen, A., Hobson, J. A., Hugdahl, K., Spiegel, D., & Berntson, G. G. (2000). Lonely traits and concomitant physiological processes: the MacArthur social neuroscience studies. *Int. J. Psychophysiol. 35*, 143–154.
Caine, R. N., Caine, G., McClintic, C., & Klimek, K. (2005). *12 brain/mind learning principles in action: The fieldbook for making connections, teaching, and the human brain.* Corwin Press.
Calsyn, R. J., & Winter, J. P. (2002). Social support, psychiatric symptoms, and housing: a causal analysis. *Journal of Community Psychology, 30*(3), 247-259. https://doi.org/10.1002/jcop.10004
Carter, C. S., Grippo, A. J., Pournajafi-Nazarloo, H., Ruscio, M. G., & Porges, S. W. (2008). Oxytocin, vasopressin, and sociality. *Prog Brain Res, 170*, 331-336. https://doi.org/10.1016/S0079-6123(08)00427-5
Chadwick, S. (2014). Social and emotional resilience. In *Impacts of cyberbullying, building social and emotional resilience in schools* (pp. 31–55). Springer, Cham.
Ching, F. N. Y., So, W. W. M., Lo, S. K., & Wong, S. W. H. (2020). Preservice Teachers' Neuroscience Literacy and Perceptions of Neuroscience in Education: Implications for Teacher Education. *Trends in Neuroscience and Education*. https://doi.org/10.1016/j.tine.2020.100144
Christiansen, J., Qualter, P., Friis, K., Pedersen, S. S., Lund, R., Andersen, C. M., ... & Lasgaard, M. (2021). Associations of loneliness and social isolation with physical and mental health among adolescents and young adults. *Perspectives in public health*, *141*(4), 226-236.
Chu, H.-C., Tsai, W. W.-J., Liao, M.-J., Chen, Y.-M., & Chen, J.-Y. (2020). Supporting E-Learning with Emotion Regulation for Students with Autism Spectrum Disorder. *Educational Technology & Society, 23* (4), 124-146.
Cohen, S., Janicki-Adverts, D., & Miller, G. E. (2007). Psychological stress and disease. *Journal of the American Medical Association, 298*, 1685-1687.
da Cruz, W. M., Coimbra, D. R., Vilarino, G. T., Dos Santos, A. M. C., da Silva, V. F., Mancone, S., ... & Andrade, A. (2024). Did social isolation affect anxiety and sleep quality of elite soccer players during the COVID-19 lockdown? Comparisons to training before distancing in the pandemic and outlook for mental health. *Frontiers in Psychology*, *15*, 1490862.
Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), pp. 97-140
Davydov, D. M., Stewart, R., Ritchie, K., & Chaudieu, I. (2010). Resilience and mental health. *Clinical psychology review, 30*(5), 479-495.
de Jong-Gierveld, J., & Kamphuis, F. (1985). The development of a Rasch-type loneliness scale. *Appl Psychol Meas, 9*(3), 289-299. doi:10.1177/014662168500900307.
De Witte, K., & François, M. (2023). *COVID-19 Learning Deficits in Europe: Analysis and Practical Recommendations. Analytical Report*. European Commission. Available from: EU Bookshop.
Di Pietro, G. (2023). The impact of Covid-19 on student achievement: Evidence from a recent meta-analysis. *Educational Research Review*, *39*, 100530.

Dodge, R., Daly, A., Huyton, J., & Sanders, L. (2012). The challenge of defining wellbeing. *Int J Wellbeing, 2*(3), 222-235. doi:10.5502/in.v2i3.4.
Dougherty, M. R., & Robey, A. (2018). Neuroscience and education: A bridge astray?. *Current Directions in Psychological Science, 27*(6), 401-406.
Doussard-Roosevelt, J. A., Joe, C. M., Bazhenova, O. V., & Porges, S. W. (2003). Mother-child interaction in autistic and nonautistic children: Characteristics of maternal approach behaviors and child social responses. *Development and Psychopathology, 15*(2), 277-295.
Dreamson, N. (2020). Online Design Education: Meta-Connective Pedagogy. *International Journal of Art & Design Education, 39*(3), 483-497. https://doi.org/10.1111/jade.12314
Dunn, M., Odriscoll, C., Dayson, D., Wills, W., & Leff, J. (1990). The taps project.4 An observational study of the social life of long-stay patients. *Br J Psychiatry, 157*, 842-848.
Eisenberger, N.I. (2012). Broken hearts and broken bones: a neural perspective on the similarities between social and physical pain. *Current Directions in Psychological Science, 21*, 42-47. https://doi.org/10.1177/0963721411429455
Eisenberger, N. I. (2013). Social ties and health: a social neuroscience perspective. *Current opinion in neurobiology, 23*(3), 407-413. https://doi.org/10.1016/j.conb.2013.01.006
Ellis, R., & Goodyear, P. (2019). *The education ecology of universities: Integrating learning, strategy and the academy*. Routledge.
Fabri, M., & Andrews, P. C. (2016). Hurdles and drivers affecting autistic students' higher education experience: Lessons learnt from the multinational Autism&Uni research study. In L.
Faraj, A., Alzahrani, S., Almumtin, R., Alrajhi, D., Alshyban, S., Alshabanah, M., ... & Almarashdeh, I. (2020). Developing and implementing an online learning platform for children with autism. *International Journal of Scientific Research in Science and Technology*.
Franke, V. C., & Elliott, C. N. (2021). Optimism and social resilience: Social isolation, meaninglessness, trust, and empathy in times of covid-19. *Societies, 11*(2), 35.
Gabrieli, J.D.E. (2016). The promise of educational neuroscience: Comment on Bowers (2016). *Psychological Review, 123*, 613-619.
Gazzaniga, M. (2008). Human: The Science Behind what Makes Us Unique. Ecco. New York. Available at http://www.worldcat.org/title/human-the-science-behind-whatmakes-us-unique/OCLC/179807190&referer=brief results.
Gianaros, P. J., Jennings, J. R., Sheu, L. K., Derbyshire, S. W. G., & Matthews, K. A. (2007). Heightened functional neural activation to psychological stress covaries with exaggerated blood pressure reactivity. *Hypertension, 49*, 134-140.
Giles, L. C., Glonek, G. F., Luszcz, M. A., & Andrews, G. R. (2005). Effect of social networks on ten-year survival in very old Australians: the Australian longitudinal study of aging. *Journal of Epidemiology & Community Health, 59*(7), 574-579.
Gloria, C. T., & Steinhardt, M. A. (2016). Relationships among positive emotions, coping, resilience and mental health. *Stress and Health, 32*(2), 145-156.
Gomez, A. Lopez Martinez, & Candel Torres, J. (Eds.), *Proceedings of the 10th Annual International Teaching, Education and Development Conference* (pp. 7-9). Valencia, Spain: IATED Academy.
Hwang, G. J., & Chang, H. F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56*(4), 1023-1031.
Gregory, C., Lough, S., Stone, V., Erzinclioglu, S., Martin, L., Baron-Cohen, S., & Hodges, J. R. (2002). Theory of mind in patients with frontal variant frontotemporal dementia and Alzheimer's disease: theoretical and practical implications. *Brain, 125*(4), 752-764.
Grippo, A. J., Trahanas, D. M., Zimmerman II, R. R., Porges, S. W., & Carter, C. S. (2009). Oxytocin protects against negative behavioral and autonomic consequences of long-term social isolation. *Psychoneuroendocrinology, 34*(10), 1542-1553.
Gronewold, J., & Engels, M. (2022). The lonely brain–associations between social isolation and (cerebro-) vascular disease from the perspective of social neuroscience. *Frontiers in integrative neuroscience*, *16*, 729621.
Gross, J. J., & Muñoz, R. F. (1995). Emotion regulation and mental health. *Clinical psychology: Science and practice, 2*(2), 151-164.
Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness matters a theoretical and empirical review of consequences and mechanisms. *Ann Behav Med, 40*, 218–227. https://doi.org/10.1007/s12160-010-9210-8
Hays, R. D., & DiMatteo, M. R. (1987). A short-form measure of loneliness. *J Pers Assess, 51*(1), 69-81. doi:10.1207/s15327752jpa5101_6.
Hirai, M., & Hiraki, K. (2005). An event-related potentials study of biological motion perception in human infants. *Brain Res Cogn Brain Res, 22*(2), 301-304.
Hodges, C., Moore, S., Lockee, T., Trust, T., & Bond, A. (2020). The Difference Between Emergency Remote Teaching and Online Learning. Retrieved from https://er.educause.edu/articles/2020/3/the-difference-betweenemergency-remote-teaching-and-online-learning on March 27, 2020.
Hossain, M. M., Sultana, A., & Purohit, N. (2020). Mental health outcomes of quarantine and isolation for infection prevention: a systematic umbrella review of the global evidence. Available at: psyarxiv.com/dz5v2/ Published 2020 Accessed April 10, 2020.
Howard-Jones, P. A., & Fenton, K. D. (2012). The need for interdisciplinary dialogue in developing ethical approaches to neuroeducational research. *Neuroethics, 5*(2), 119-134. doi:10.1007/s12152-011-9101-0.

Howard-Jones, P. (2014). *Neuroscience and education: A review of educational interventions and approaches informed by neuroscience*. Education Endowment Foundation.
Howard-Jones, P. A., Franey, L., Mashmoushi, R., & Liao, Y. C. (2009). The neuroscience literacy of trainee teachers. EDUCTATION-LINE.
Howard-Jones, P. A., Varma, S., Ansari, D., Butterworth, B., De Smedt, B., Goswami, U., Laurillard, D., & Thomas, M. S. C. (2016). The principles and practices of educational neuroscience: Comment on Bowers (2016). *Psychological Review, 123*(5), 620-627. doi:10.1037/rev0000036.
Jeste, D. V., Palmer, B. W., Rettew, D. C., & Boardman, S. (2015). Positive psychiatry: its time has come. *J Clin Psychiatry, 76*, 675-683. doi:10.4088/JCP.14nr09599.
Jin, J., Tang, Y.-Y., Ma, Y., Lv, S., Bai, Y., & Zhang, H. (2009). A structural equation model of depression and the defense system factors: A survey among Chinese college students. *Psychiatry Research, 165*, 288-296.
Johnson, M. H. (2006). Biological motion: a perceptual life detector. *Curr Biol, 16*(10), 376-377.
Kaiser, M. D., Hudac, C. M., Shultz, S., Lee, S. M., Cheung, C., Berken, A. M., Deen, B., Pitskel, B. P., Sugrue, D. R., Voos, A. C., Saulnier, C. A., Ventola, P., Wolf, J. M., Klin, A., Vander, B. C., & Pelphrey, K. A. (2010). Neural signatures of autism. *Proceedings of the National Academy of Sciences of the United States of America, 107*(49), 21223-21228.
Kauffman, H. (2015). A review of predictive factors of student success in and satisfaction with online learning. *Research in Learning Technology, 23*, 1-13. https://doi.org/10.3402/rlt.v23.26507
Kriete, T., & Noelle, D. C. (2015). Dopamine and the development of executive dysfunction in autism spectrum disorders. *PloS one, 10*(3), e0121605. doi:10.1371/journal.pone.0121605
Kross, E., Berman, M. G., Mischel, W., Smith, E. E., &Wager, T.D. (2011). Social rejection shares somatosensory representations with physical pain. *Proceedings of the National Academy of Sciences, 108*, 6270-6275. https://doi.org/10.1073/pnas.1102693108
Liozidou, A., Varela, V., Vlastos, D. D., Giogkaraki, E., Alzueta, E., Perrin, P. B., ... &
Arango-Lasprilla, J. C. (2024). Forced social isolation and lockdown during the COVID-19 pandemic: Depression, anxiety, trauma-distress and coping mechanisms of a Greek sample. *Journal of Public Health*, *32*(7), 1261-1270.
Loades, M. E., Chatburn, E., Higson-Sweeney, N., Reynolds, S., Shafran, R., Brigden, A., ... & Crawley, E. (2020). Rapid systematic review: the impact of social isolation and loneliness on the mental health of children and adolescents in the context of COVID-19. *Journal of the American Academy of Child & Adolescent Psychiatry, 59*(11), 1218-1239.
Lord, C., Cook, E. H., Leventhal, B. L., & Amaral, D. G. (2000). Autism spectrum disorders. *Neuron, 28*(2), 355-363.
Luanaigh, C.O., & Lawlor, B. A. (2008). Loneliness and the health of older people. *International Journal of Geriatric Psychiatry, 23*(12), 1213-1221.
Luthar, S. S., Cicchetti, D., & Becker, B. (2000). The construct of Resilience: A critical evaluation and guidelines for future work. *Child Development, 71*, 543-562.
Maestro, S., Muratori, F., Cavallaro, M. C., Pei, F., Stern, D., Golse, B., & Palacio-Espasa, F. (2002). Attentional skills during the first six months of age in autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 41*(10), 1239-1245
Manicacci, M., Bouteyre, E., Despax, J., & Bréjard, V. (2019). Involvement of emotional intelligence in Resilience and coping in mothers of autistic children. *Journal of autism and developmental disorders, 49*(11), 4646-4657.
Martins, T. B., Branco, J. H. L., Martins, T. B., Santos, G. M., & Andrade, A. (2024). Impact of social isolation during the COVID-19 pandemic on the mental health of university students and recommendations for the post-pandemic period: A systematic review. *Brain, Behavior, & Immunity-Health*, 100941.
Masten, A. S. (2001). Ordinary magic: resilience processes in development. *American Psychologist, 56*, 227-238.
Mayer, R. E. (1998). Does the brain have a place in educational psychology? *Educational Psychology Review, 10*(4), 389-396. doi:10.1023/A:1022837300988
Mazrekaj, D., & De Witte, K. (2024). The impact of school closures on learning and mental health of children: Lessons from the COVID-19 pandemic. *Perspectives on Psychological Science*, *19*(4), 686-693.
McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. Annals of the New York Academy of Sciences, 840, 33-44.
McPartland, J. C., & Pelphrey, K. A. (2012). The implications of social neuroscience for social disability. *Journal of Autism and Developmental Disorders, 42*(6), 1256-1262.
Mertens, G., Gerritsen, L., Duijndam, S., Salemink, E., & Engelhard, I. M. (2020). Fear of the coronavirus (COVID-19): Predictors in an online study conducted in March 2020. *Journal of anxiety disorders*, *74*, 102258.
Moore, M., & Calvert, S. (2000). Vocabulary acquisition for children with autism: Teacher or computer instruction. *Journal of Autism and Developmental Disorders, 30*(4), 359-362. doi:10.1023/A:1005535602064
Muscatell, K. A., & Eisenberger, N. I. (2012). A social neuroscience perspective on stress and health. *Social and personality psychology compass, 6*(12), 890-904.
Mushtaq, A., & Khan, M. A. (2024). Social isolation, loneliness, and mental health among older adults during COVID-19: A scoping review. *Journal of Gerontological Social Work*, *67*(2), 143-156.
Nottingham, J. (2017). *The learning challenge: How to guide your students through the learning pit to achieve deeper understanding*. Sage Publications.

Ozuna, J., Mavridis, A., & Hott, B. L. (2015). Interventions to Support Social Interaction in Children with Autism Spectrum Disorders: A Systematic Review of Single Case Studies. *Exceptionality Education International, 25*(2), 107-125.
Pelphrey, K. A., Morris, J. P., Michelich, C. R., Allison, T., & McCarthy, G. (2005). Functional anatomy of biological motion perception in posterior temporal cortex: an FMRI study of eye, mouth and hand movements. *Cerebral Cortex, 15*(12), 1866-1876.
Puce, A., Allison, T., Asgari, M., Gore, J. C., & McCarthy, G. (1996). Differential sensitivity of human visual cortex to faces, letter strings, and textures: A functional magnetic resonance imaging study. *Journal of Neuroscience, 16*(16), 5205-5215.
Roberts, C. A., Smith, K. C., & Sherman, A. K. (2019). Comparison of online and face-to-face parent education for children with autism and sleep problems. *Journal of Autism and Developmental Disorders, 49*(4), 1410-1422.
Rodrigues, S.M., Saslow, L. R., García, N., John, O. P., & Keltner, D. (2009). Oxytocin receptor genetic variation relates to empathy and stress reactivity in humans. *Proceedings of the National Academy of Sciences, 106*, 21437-21441.
Roskam, E. E. (1997). Models for speed and time-limit tests. In W. J. van der Linden & R. K. Hambleton (Eds.), *Handbook of Modern Item Response Theory* (pp. 187-208). Springer.
Rutter, M. (2013). Annual research review: Resilience–clinical implications. *J Child Psychol Psychiatry, 54*(4), 474-487. doi:10.1111/j.1469-7610.2012.02615.x.
Schachter, S. (1959). *The Psychology of Affiliation: Experimental Studies of the Sources of Gregariousness*. Stanford University Press.
Schultze-Lutter, F., Schimmelmann, B. G., & Schmidt, S. J. (2016). Resilience, risk, mental health, and wellbeing: Associations and conceptual differences. *European Child & Adolescent Psychiatry, 25*(5), 459-466.
Singer, T. (2012). The past, present, and future of social neuroscience: a European perspective. *Neuroimage, 61*(2), 437-449.
Sinclaire-Harding, L., Vuillier, L., & Whitebread, D. (2018). Neuroscience and early childhood education. *International handbook of early childhood education*, 335-361.
Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proc Natl Acad Sci U S A, 105*(2), 809-813.
Southall, C. (2013). Use of technology to accommodate differences associated with autism spectrum disorder in the general curriculum and environment. *Journal of Special Education Technology, 28*(1), 23-34.
Sparks, S. D. (2012, June 6). Teachers Need Lessons in Neuroscience, Experts Say. *Education Week,* 16-17.
Stevenson, J. R., McMahon, E. K., Boner, W., & Haussmann, M. F. (2019). Oxytocin administration prevents cellular aging caused by social isolation. *Psychoneuroendocrinology, 103*, 52-60.
Stone, B. G., Mills, K. A., & Saggers, B. (2019). Online multiplayer games for the social interactions of children with autism spectrum disorder: A resource for inclusive education. *International Journal of Inclusive Education, 23*(2), 209-228.
Tager-Flusberg, H. (2000). Language development in children with autism. In L. Menn & N. Bernstein Ratner (Eds.), Methods for studying language production (pp. 313-332). Lawrence Erlbaum.
Tangney, J. P., Stuewig, J., & Mashek, D. J. (2007). Moral emotions and moral behavior. *Annu Rev Psychol, 58*, 345-372. doi:10.1146/annurev.psych.56.091103.070145.
Thomas, M. S., Ansari, D., & Knowland, V. C. (2019). Annual research review: Educational neuroscience: Progress and prospects. *Journal of Child Psychology and Psychiatry, 60*(4), 477-492.
Thomas, M., & Ansari, D., & Knowland, V. (2018). Annual Research Review Educational neuroscience: progress and prospects: Education neuroscience. *Journal of Child Psychology & Psychiatry, 60*(4), 477-492. https://doi.org/10.1111/jcpp.12973
Tommerdahl, J. (2010). A model for bridging the gap between neuroscience and education. *Oxford Review of Education, 36*, 97-109.
Uchino, B.N. (2009). Understanding the Links Between Social Support and Physical Health: A Life-Span Perspective With Emphasis on the Separability of Perceived and Received Support. *Perspectives on Psychological Science, 4*, 236–255. https://doi.org/10.1111/j.1745-6924.2009.01122.x.
Unicef (2021). *What's Next? Lessons on Education Recovery*. World Bank Publications-Books.
Uvna¨s-Moberg, K. (1998). Oxytocin may mediate the benefits of positive social interactions and emotions. *Psychoneuroendocrinology, 23*, 819-835.
Vasan, S., Eikelis, N., Lim, M. H., & Lambert, E. (2023). Evaluating the impact of loneliness and social isolation on health literacy and health-related factors in young adults. *Frontiers in Psychology*, *14*, 996611.
Wang, J., Lloyd-Evans, B., Giacco, D., Forsyth, R., Nebo, C., Mann, F., & Johnson, S. (2017). Social isolation in mental health: a conceptual and methodological review. *Social psychiatry and psychiatric epidemiology, 52*(12), 1451-1461.
Watkins, L., O'Reilly, M., Kuhn, M., Gevarter, C., Lancioni, G. E., Sigafoos, J., & Lang, R. (2015). A Review of Peer-Mediated Social Interaction Interventions for Students with Autism in Inclusive Settings. *Journal of Autism and Developmental Disorders, 45*(4), 1070-1083. doi: 10.1007/s10803-014-2264-x.
Webber, M. P., & Huxley, P. J. (2007). Measuring access to social capital: the validity and reliability of the resource generator-UK and its association with common mental disorder. *Social Science & Medicine, 65*(3), 481-492.
Weller, C. (2018). Novel approaches to creating economic security at older ages amid growing economic volatility. *Innovation in Aging, 2*(Suppl 1), 25.

Willis, J. (2008). Building a bridge from neuroscience to the classroom. *Phi Delta Kappan, 89*(6), 424-427. doi:10.1177/003172170808900608

Wong, C., & Kasari, C. (2012). Play and Joint Attention of Children with Autism in the Preschool Special Education Classroom. *Journal of Autism and Developmental Disorders, 42*(10), 2152-2161. doi:10.1007/s10803-012-1467-2.

Zadina, J. N. (2015). The emerging role of educational neuroscience in education reform. *Psicologia Educativa, 21*, 71-77.

Zajic, M. C., McIntyre, N., Swain-Lerro, L., Novotny, T., Oswald, T., & Mundy, P. (2016). Attention and Written Expression in School-age, High-functioning Children with Autism Spectrum Disorders. *Autism, 22*(3), 245-258. https://doi.org/10.1177/1362361316675121

Zamani Jam, A., Talab, R. H., Sheikh, M., Torabi, F., & Rafie, F. (2018). The effect of 16 weeks gymnastic training on social skills and neuropsychiatric functions of autistic children. *Sport Sciences for Health, 14*(1), 209-214.

Zavaleta, D., Samuel, K., & Mills, C. (2014). Social isolation: a conceptual and measurement proposal. *Working Paper: 67*. Oxford Poverty & Human Development Initiative (OPHI), Oxford.

Zhang, Q., Zhou, L., & Xia, J. (2020). Impact of COVID-19 on emotional resilience and learning management of middle school students. Medical science monitor: *international medical journal of experimental and clinical research, 26*, e924994-1.

Zychinski, K. E., & Polo, A. J. (2012). Academic achievement and depressive symptoms in low-income Latino youth. *J Child Fam Studies, 21*(4), 565-77.