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Review Article

The effect of deep brain stimulation in children and adults with autism spectrum disorder: A systematic review

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ABSTRACT

Background: Autism Spectrum Disorder (ASD) is a complex neurodevelopmental and pervasive developmental disorder characterized by major impairments in social communication and interaction, stereotyped and ritualistic behavior, and deficiency in sensory activity. Children and adults with ASD show deficit in several domains such as cognition, memory, attention, emotion recognition and regulation, and social skills. The aim of this study was to investigate the effects of Deep Brain Stimulation (DBS) on children and adults with autism spectrum disorder.

Methods: This study was a systematic review. PubMed, Scopus, Cochrane library and Web of sciences were searched using terms for ASD and DBS. Eleven studies were selected for review. These studies investigated the effect of deep brain stimulation in reducing symptoms of ASD.

Results: There have been 7 published articles about patients who underwent DBS for ASD accompanied by life threatening self-injurious behavior, not alleviated by antipsychotic medication. Also, 4 studies investigated autism-like behaviors. The target included the anterior limb of the internal capsule, globus pallidus internus, and basal latera nucleus of the amygdala. The patients' age ranged between 6 and 37 years.

Conclusion: Results of this systematic review showed that DBS might be effective for severe, medically refractory symptoms in children and adults with autism spectrum disorders. Current evidence showed that the number of symptoms such as repetitive and compulsive behavior, obsessive thought, aberrant behavior, and self-injurious behaviors decreased after DBS. Further studies are suggested to be conducted on this topic.

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental and pervasive developmental disorder characterized by major impairments in social communication and interaction, deficient in sensory activity, and stereotyped and ritualistic behavior [1]. The worldwide prevalence of ASD is 1%, and the incidence was estimated in some regions as high as 1 in 57 children [2]. According to the criteria of *Diagnostic and Statistical Manual of Mental Disorders 5th edition* (DSM-5), its prevalence has grown dramatically around the world and is reported as 1% in newborn children [1]. Males are disproportionally affected, with a male to female ratio reported as high as 3 to 1 [3]. Children and adults with ASD show deficits in several domains such as memory, attention, cognition, emotion recognition and regulation, and social skills [4]. Current consensus is that the key diagnostic features of ASD include 1) persistent deficits in social communications and socio-emotional interactions across multiple contexts, such as difficulty developing, maintaining, and understanding the relationships with others, and problems in verbal and non-verbal communication; 2) limited and repetitive interests such as insistence on environmental monotony, use of restricted, repetitive phrases, and obsessive behaviors; 3) abnormal feelings and strange and odd behaviors [3,5].

The etiology and pathology of ASD are not conclusively clear. Neuroimaging studies have reported abnormalities in the patterns of brain perfusion, regional brain volumes, excitatory/inhibitory neurotransmission and synaptic plasticity, and neural biochemical characteristics of ASD [1,6]. These abnormalities are not limited to a single brain region; rather, they are the result of breakdown in integrating and functioning of long-range neural circuits [1,2]. Some neurophysiological findings that may be underlying pathological cause of the symptom associated with ASD include large volumes of the right brain structures associated with social functions and language [1]. Hypoactivation of

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specific brain region (such as amygdala) is related to social cognition and face processing, abnormal synaptic development and aberrant reduction of cortical plasticity, mirror neuron dysfunction, and decreased inhibitory function in GABAergic interneurons due to deficits in the peripheral compartment of mini columns and aberrant increase in excitation to inhibition ratio in the cortical structure [1,7].

Deep Brain Stimulation (DBS) is a type of surgery to implant a device that sends the electrical signals to the brain area responsible for body movement. Electrodes are placed deep in the brain and are connected to stimulator device [2,3]. DBS dose not damage the brain tissue; it is used to treat patients when medication is no longer effective for maintaining good quality of life [8,9].

Numerous studies have been conducted for reducing symptoms of ASD by using DBS. The results of the research conducted by *M Figee, et al.* showed that DBS often led to marked and rapid improvement in mood, anxiety, behaviors, and other psychiatric symptoms, making it a promising intervention for a variety of refractory patient groups [10]. *Paresh et al.* showed that DBS had a positive impact on obsessive thoughts and their control. Compulsive behaviors, obsessive thought, aggression, and social engagement were improved in ASD [11]. *Roger* showed benefits of DBS in self-injurious behavior in some patients with low functioning of ASD. It has potential benefits for higher functioning of ASD with disabling repetitive motor and non-motor aspects [3]. *Amber Stocco et al.* showed that stereotype behaviors in ASD were treated with DBS due to severe disability and nature of movement [12]. This systematic review evaluated DBS method that include children and adults with autism spectrum disorder.

2. Material and methods

The inclusion criteria were kept broad to capture best overall state of the current research on this topic. They were articles that had examined the effect of DBS method on children and adults with ASD, and other articles that had examined the effects of other methods were excluded.

2.1. Information source and search strategy

PubMed, Scopus, Cochrane library and Web of Sciences were searched in December 2020. The following search terms were used: (autism OR autism spectrum disorder OR autistic OR autists OR autistics OR autism spectrum OR ASD); combined with (deep brain stimulation OR deep brain stimulations OR deep brain electrical stimulation OR deep brain electrical stimulations OR DBS). The entry of search terms was adopted according to the search interface of the database. This systematic review was limited to studies that had been published after 1980 due to the introduction of autistic disorder in *Diagnostic and Statistical Manual of Mental Disorders (DSM)* that year. Also, this research was limited to articles available in English. The inclusion criteria were kept broad to capture the best overall state of the current research on this topic. Articles on the effect of DBS method in children and adults with ASD were included. Studies that showed the effects of other interventions on children or adults with ASD, editorials, abstracts, ongoing trials, and letters were excluded.

2.2. Study selection and screening

After entering the data in an endnote library, the first author performed the initial title and abstract search for articles that potentially included DBS and participants with ASD. The second author replicated this search separately with the same results. Full-text articles were independently screened by the authors. Outcomes variables were extracted from articles by one reviewer and verified by the other. Data were managed in Microsoft Excel. Quality assessment was assessed using proper NIH tool.

3. Result

The initial search yielded 36 results when the duplicate articles were removed. After title and abstract review, 26 articles were selected for full-text review. Two studies were excluded because people with ASD were not included in the outcomes, or the inclusion of people with ASD was unclear. Five articles were excluded because they were not interventional or experimental in design (e.g., book chapters). Four studies did not include DBS (i.e., neurofeedback, cognitive–behavioral therapy, emotion recognition, rTMS, tDCS, and a neuromuscular technique). Three studies were excluded because they showed the effect of DBS on animals with some symptoms of ASD. One study was excluded because it was not written in English. Finally, 11 studies were selected for final inclusion and discussion (see Fig. 1).

Eleven articles were studied in this systematic review. Four articles were about people with autism-like characteristics that underwent DBS surgery [13–16]. Seven articles were about children and adults with autism spectrum disorder that had undergone DBS surgery [2,3,8,11,12,17,18], (Table 1).

The participants' age range was 6–37 years old. Patients and their parents were interviewed to assess the outcomes. The main outcomes of interest were diverse and included behavioral, social, and psychological symptoms, as well as the subjective well-being of children and adults with ASD and their parents. A summary of the interventions and outcomes can be seen in Table 2.

4. Discussion

The goal of this systematic review was to summarize the current literature on DBS surgery interventions for children and adults with ASD. DBS has been used to send electrical impulses to specific parts of the brain [2,3,11,17]. Since it was approved by the Food and Drug Administration in 1997, the therapeutic benefit of DBS has been widely expanded from movement disorders such as essential tremor, dystonia, and Parkinson's disease, to seizure disorders and psychiatric disorders, such as depression, refractory obsessive- compulsive disorder, Tourette syndrome, anorexia nervosa, and aggressive behaviors [3,17]. There have been 7 published articles on patients who had undergone DBS for ASD accompanied by life threatening self-injurious behavior not alleviated by antipsychotic medication [2,3,8,11,12,17,18]. Target included the basal latera nucleus of the amygdala, anterior limb of the internal capsule, and globus pallidus internus. All patients obtained some benefits from DBS. These experiences suggested the possibility of DBS as an option to improve the symptoms of autism and quality of life in ASD. However, the optimal DBS target and stimulation parameters are still unclear [2,3,8,11,12,17,18].

4.1. The effects on repetitive behaviors

Repetitive and restrictive behaviors are one of the main symptoms in ASD, but the mechanisms behind repetitive behaviors in ASD are quite challenging. [3,12,13,19–21]. The results of this systematic review showed that DBS could reduce repetitive behavior in children and adults with ASD, and it can become a problem when they get in the way of ordinary activities or make it tough to get through school or work [3,12,13]. Also, the results showed that repetitive behaviors (thinking about, saying, or asking for the same thing over and over again) in children and adults who had undergone DBS surgery decreased significantly about 6–24 months after follow-up [19–21].

4.2. The effect on obsessive–compulsive thought

Another goal of this study was to investigate the effect of DBS on obsessive–compulsive though in ASD. It is an anxiety disorder characterized by persistent and distressing thoughts and behaviors used to cope with those thoughts. They often feel compelled to perform compulsive

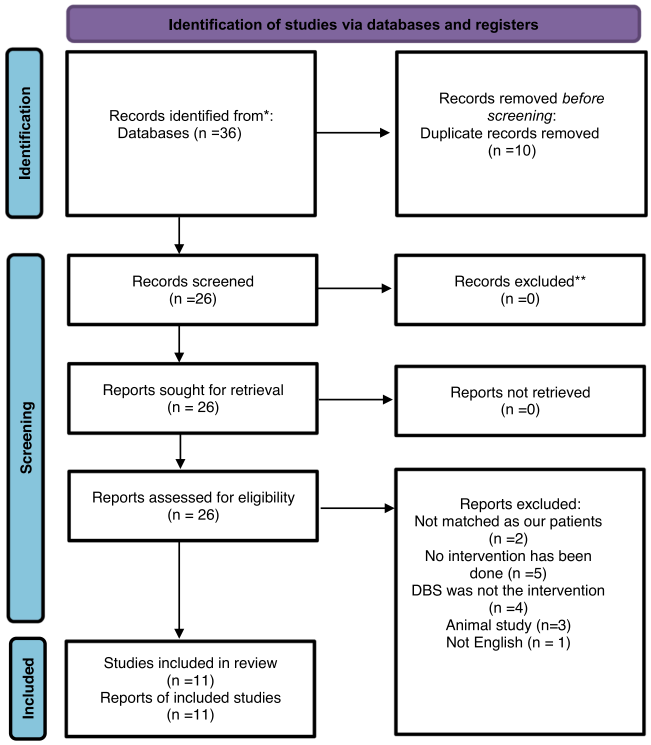

Fig. 1. PRISMA flowchart of the included studies.

Table 1
Classification of the studies by the type of patients.

DBS: Deep Brain Stimulation	
	Autism-like behaviors
	David J Segar et al. (2015), [16]
	M Figee et al. (2017), [15]
	M Figee et al. (2018), [14]
	Robert W Bina et al. (2018), [13]
	Autism spectrum disorder
	Volker Sturm et al. (2012), [8]
	Amber Stocco et al. (2014), [12]
	Saurbh Sinha et al. (2015), [2]
	Roger. (2015), [3]
	John Gaitanis. (2016), [18]
	Hye Ran Park et al. (2017), [17]
	Paresh K et al. (2017), [11]

behaviors and believe that performing these behaviors will keep bad things from happening [12,13,21–23].

Results of this study showed that after the follow-up, DBS was effective on reducing symptoms of obsessive–compulsive thought on ASD as well as obsessive behaviors, which reduced significantly [11,14–16,18]. There is an overlap between behaviors seen in people with OCD and the ritualized/repetitive behaviors commonly observed in ASD. Rather, ritualized behaviors associated with ASD may satisfy other needs, such as modifying sensory input, gaining reinforcement from the environment, or preserving sameness in their daily lives. DBS has been introduced for treatment of obsessive–compulsive symptoms in ASD [3,12,13,23,24].

4.3. The effect on self- injurious behaviors

According to the research done by psychologist and behavior management, 50% of people diagnosed with ASD engage in some form of Self Injurious Behavior (SIB) that can lead to self-injury. Our finding showed that DBS could be effective on reducing self-injurious behavior in ASD [3,8]. Most children and adults with ASD inflict harm upon themselves (e.g., hair pulling, head banging, self-biting, self-cutting, and skin scratching). It becomes a serious health risk that can impact the individual's quality of life [3,8,25–27]. After the follow-up, children and adults with autism who had undergone DBS surgery showed a significant reduction in self-injurious behaviors [3,8].

4.4. The effect on aberrant behaviors

Aberrant behaviors are irregular behaviors that deviate from what is considered normal. It is a single act of thoughtless or unplanned criminal behavior, agitation, irritability, crying, stereotypic behavior, lethargy, hyperactivity, noncompliance, and inappropriate speech [28,29]. Our findings revealed that DBS could affect the aberrant behaviors in ASD [18], but further research is required to determine the effect of DBS surgery on reducing aberrant behavior in ASD.

4.5. The effect on activity and quality of life

The main problems of autistic children and parents is dissatisfaction with their quality-of-life (human rights that allow people to interact with one another and the world on their own terms). The goal of the therapists is improving quality of life in children and adults with ASD and their parents [30,31]. Results of this study showed that using different methods in reducing symptoms of ASD could help to improve their quality of life. Researchers hope that using DBS can be effective on improving the quality of life in people with ASD [3,8].

Table 2
Study characteristics arranged by method type and author.

Study	*Design*	*Method description*	*Age*	*Result*
David j Segar et al. (2015), [16]	Case report	DBS for treatment of neuropsychiatric symptoms of psychiatric disorders	24 y/o	Gradual and progressive improvement in patient's compulsive behaviors, coprolalia, speech and social interaction Improvements in some symptoms by VC/VS DBS for Kleefstra syndrome (A rare genetic disorder characterized by childhood hypotonia, distinctive facial features, intellectual disability, multiple psychiatric symptoms,developmental delay, and ASD)
M Figee et al. (2017), [15]	Review	Effects and mechanism of DBS in patients with psychiatric disorder	–	DBS is effective for treatment of therapy- refractory OCD. Encouraging result in cases with refractory depression and Tourette syndrome Improvement in behavior, mood, anxiety, and other psychiatric symptoms as a promising intervention DBS influences brain networks of patients with psychiatric symptoms.
M Figee et al. (2018), [14]	Review	Effect of DBS in psychiatric disorder	–	DBS is an effective treatment for therapy- refractory obsessive- compulsive disorder and refractory major depressive disorder. DBS influences the brain networks of patients with psychiatric symptoms.
Robert W Bina et al. (2018), [13]	Review	Effect of DBS in psychiatric disorder	–	Peripheral signs of psychologic arousal and individual changes in central circuit patterns Activation of appropriate responses for psychiatric disorders in which there is misinterpretation of social symptoms such as ASD, PTSD and Schizophrenia Improvements in circuit-based, individual-specific, real-time adaptable modulation, forecast functional neurosurgery treatments for heretofore treatment-resistant behavioral diseases.
Volker Sturm et al. (2012), [8]	Case Report	DBS in amygdala complex as well as the supra-amygdaloid projection system	13 y/o	Stimulation of the BL part proved effective on improving self-injurious behavior (SIB) and core symptoms of autism spectrum in social, emotional, and cognitive domains over a follow up of 24 months. Amygdala may be pivotal in pathogeneses of autism and point to the special relevance of BL part.
Amber Stocco et al. (2014), [12]	Case Report	Effect of DBS on stereotypies behaviors with John's Hopkins motor stereotype rating scale (JHMRS)	–	Stereotype behaviors in ASD treated with DBS due to severe and disability nature of movement Stereotype movements were treated by DBS.
Saurabh Sinha et al. (2015), [2]	Review	DBS in basolateral nucleus of amygdala (BLA)	–	Creating environmental and genetic changes that affect nerve growth The microstructural, macrostructural, and functional abnormalities that occur during brain development form a pattern of dysfunctional neural networks involved in socio-emotional processing. BLA as a key node in pathophysiology of ASD. BLA represents logical neurosurgical target for treating severe autism.
Roger (2015), [3]	Review	DBS in patients with ASD	–	Improving self-injurious behavior in ASD DBS effects on the basal ganglia function in controlling movements, thoughts, emotions, perception and other functions in ASD. It improves motor, behavioral and emotional symptoms in these patients. DBS has potential benefits for higher functioning ASD with disabling repetitive motor and non-motor aspects
John Gaitanis (2016), [18]	Review	DBS on basolateral complex of amygdala. DBS leads were placed in the ventral capsule/ventral striatum.		DBS for patient, consisting primarily of obsessive–compulsive disorder and Tourette's syndrome as opposed to self-injurious behaviors. DBS may be effective for severe, medically refractory symptoms in ASD. The target for lead placement may need to be personalized to patient's primary symptoms Implantation of patient's DBS system took place more than 4 years ago.
Hye Ran Park et al (2017), [17]	Case report	Nucleus accumbens deep brain stimulation Bilateral nucleus NAc DBS	14 y/o	Structural and functional changes in the brain after DBS Brain metabolism in the prefrontal and frontal cortex and occipital cortex was decreased in association with decreased cortical volumes in those areas 2 years after NAc DBS. Therapeutic potential of NAc DBS is suggested for clinical improvement of ASD and SIB with functional and structural changes after DBS.
Paresh K et al. (2017), [11]	Case report	DBS of nucleus accumbens	37 Y/o	Positive impact on obsessive though. Compulsive behaviors and aggression were improved after DBS. Social engagement was improved. Obsessive thought, compulsive behaviors, and aggression were improved.

4.6. Change in physical and metabolic brain abnormalities

Children and adults with ASD often have an enlarged hippocampus (the area of the brain responsible for forming and storing memories), but it is unclear if this difference persists into adolescence and adulthood. The size of the amygdala also seems to differ in people with and without autism although researchers from different labs have turned up conflicting results [32–34]. Some findings showed that people with autism had a smaller amygdala; others have found that autistic children have enlarged amygdala early in development and difference levels fade over time. Autistic people have decreased amounts of brain tissue in parts of the cerebellum, which plays a role in social interaction and cognition as well. On a more global level, the cortex seems to have different patterns of thickness. This difference is attributed to alterations as a single type of neuron during development [2,3,17,26,32,33]. Abnormal activity in cortico-striato-thalamo-cortical circuits including the orbitofrontal cortex, anterior cingulate cortex, ventral striatum, and mediodorsal thalamus has been implicated in OCD. A number of DBS targets including the anterior limb of the internal capsule, ventral capsule/ventral striatum, ventral caudate nucleus, subthalamic nucleus, and nucleus accumbens have been investigated for treatment of OCD. [22,34]. Researchers are focusing on changes in the brain during development. They agreed with amygdala growth theory in principle but added some details. They demonstrated that different brain regions which showed these differences more profoundly than others included the cerebellum, which contributes to the execution of complex motor movements; nucleus accumbens, which are associated with motivation and reward for behaviors including social interaction; and amygdala. This might explain the specific behavioral features seen in ASD [2,3,8,17,32,33,35]. More research is needed to understand the structure of the brain in ASD.

5. Conclusion

The results of this systematic review showed that DBS might be effective for severe, medically refractory symptoms in ASD. The current evidence shows that the number of symptoms such as repetitive and compulsive behavior, obsessive thought, aberrant behavior, and self-injurious behavior have decreased after DBS in children and adults with autism spectrum disorder. Further studies are suggested to be conducted on this topic. Also, further research in DBS on ASD is warranted.

References

[1] A. Khaleghi, H. Zarafshan, S.R. Vand, M.R. Mohammadi, Effects of non-invasive neurostimulation on autism spectrum disorder: a systematic review, Clin. Psychopharmacol. Neurosci. 18 (4) (2020) 527–552.

[2] S. Sinha, R.A. McGovern, S.A. Sheth, Deep brain stimulation for severe autism: from pathophysiology to procedure, Neurosurgical Focus 38 (6) (2015) E3.

[3] Roger. Deep Brain Stimulation for Autism Spectrum Disorder: Current and Future Uses. Atlantic Neuroscience Institute, Overlook Medical Center, USA. 2015;908 (522):2089.

[4] T.-C. Lin, Y.-C. Lo, H.-C. Lin, S.-J. Li, S.-H. Lin, H.-F. Wu, M.-C. Chu, C.-W. Lee, I.-C. Lin, C.-W. Chang, Y.-C. Liu, T.-C. Chen, Y.-J. Lin, Y.-Y. Ian Shih, Y.-Y. Chen, MR imaging central thalamic deep brain stimulation restored autistic-like social deficits in the rat, Brain Stimul. 12 (6) (2019) 1410–1420.

[5] Martina A Zhukova OIT, Tatiana I. Logvinenko, Olga S. Titova, Elena L. Grigorenko Complementary and Alternative Treatments for Autism Spectrum Disorders: Areview for Parents and Clinicians. Clinical Psychology and Special Education. 2020;9(3):142-73.

[6] S.H. Ameis, D.M. Blumberger, P.E. Croarkin, D.J. Mabbott, M.-C. Lai, P. Desarkar, P. Szatmari, Z.J. Daskalakis, Treatment of Executive Function Deficits in autism spectrum disorder with repetitive transcranial magnetic stimulation: a double-blind, sham-controlled, pilot trial, Brain Stimul. 13 (3) (2020) 539–547.

[7] A. Amatachaya, N. Auvichayapat, N. Patjanasoontorn, C. Suphakunpinyo, N. Ngernyam, B. Aree-uea, K. Keeratitanont, P. Auvichayapat, Effect of anodal transcranial direct current stimulation on autism: a randomized double-blind crossover trial, Behav. Neurol. 2014 (2014) 1–7.

[8] V. Sturm, O. Fricke, C.P. Bührle, D. Lenartz, M. Maarouf, H. Treuer, et al., DBS in the basolateral amygdala improves symptoms of autism and related self-injurious behavior: a case report and hypothesis on the pathogenesis of the disorder, Front. Hum. Neurosci. 6 (2012) 341.

[9] H.-F. Wu, Y.-J. Chen, M.-C. Chu, Y.-T. Hsu, T.-Y. Lu, I.-T. Chen, P.o. Chen, H.-C. Lin, Deep brain stimulation modified autism-like deficits via the serotonin system in a valproic acid-induced rat model, Int. J. Mol. Sci. 19 (9) (2018) 2840.

[10] M. Figee, C. Bervoets, D. Denys, Deep brain stimulation in psychiatry, Tijdschrift voor psychiatrie. 59 (10) (2017) 638–642.

[11] M.ch DPKDMS. Deep Brain Stimulation Surgery helps Autistic patient control her behaviour. Functional Neurosurgery, Jakson hospital and research center. 2017.

[12] A. Stocco, J.F. Baizabal-Carvallo, Deep brain stimulation for severe secondary stereotypies, Parkinsonism Related Disord. 20 (9) (2014) 1035–1036.

[13] R.W. Bina, J.P. Langevin, Closed loop deep brain stimulation for PTSD, addiction, and disorders of affective facial interpretation: review and discussion of potential biomarkers and stimulation paradigms, Front. Neurosci. 12 (2018) 300.

[14] M. Figee, P.R. Schuurman, D. Denys, Deep brain stimulation for psychiatric disorders, Ned. Tijdschr. Geneeskd. 162 (2018) D2333.

[15] M Figee CB, D Denys Deep Brain Stimulation in Psychiatry. Article in Duch. 2017; 59(10):638-42.

[16] D.J. Segar, Y.G. Chodakiewitz, R. Torabi, G.R. Cosgrove, Deep brain stimulation for the obsessive-compulsive and Tourette-like symptoms of Kleefstra syndrome, Neurosurg. Focus 38 (6) (2015) E12.

[17] H.R. Park, I.H. Kim, H. Kang, D.S. Lee, B.-N. Kim, D.G. Kim, S.H. Paek, Nucleus accumbens deep brain stimulation for a patient with self-injurious behavior and autism spectrum disorder: functional and structural changes of the brain: report of a case and review of literature, Acta Neurochir. 159 (1) (2017) 137–143.

[18] J. Gaitanis, Deep brain stimulation for autism spectrum disorders, Neurosurg. Focus 41 (1) (2016) E12.

[19] L. Rojas-Charry, L. Nardi, A. Methner, M.J. Schmeisser, Abnormalities of synaptic mitochondria in autism spectrum disorder and related neurodevelopmental disorders, J. Mol. Med. (Berlin, Germany). 99 (2) (2021) 161–178.

[20] C. Termine, E. Grossi, V. Anelli, L. Derhemi, A.E. Cavanna, Possible tics diagnosed as stereotypies in patients with severe autism spectrum disorder: a video-based evaluation, Neurol. Sci. 42 (4) (2021) 1559–1561.

[21] A.N. Bhat, Motor Impairment Increases in Children With Autism Spectrum Disorder as a Function of Social Communication, Cognitive and Functional Impairment, Repetitive Behavior Severity, and Comorbid Diagnoses: A SPARK Study Report, Autism Res.: Offic. J. Int. Autism Res. (2020).

[22] S.K. Bourne, C.A. Eckhardt, S.A. Sheth, E.N. Eskandar, Mechanisms of deep brain stimulation for obsessive compulsive disorder: effects upon cells and circuits, Front. Integr. Neurosci. 6 (2012) 29.

[23] S.A. Bedford, M.C. Hunsche, C.M. Kerns, Co-occurrence, assessment and treatment of obsessive compulsive disorder in children and adults with autism spectrum disorder, Curr. Psychiatry Rep. 22 (10) (2020) 53.

[24] De Jesus O, Fogwe DT, Mesfin FB, J MD. Neuromodulation Surgery For Psychiatric Disorders. StatPearls. Treasure Island (FL): StatPearls Publishing. Copyright © 2020, StatPearls Publishing LLC.; 2020.

[25] G. Shkedy, D. Shkedy, A.H. Sandoval-Norton, L. Cerniglia, Treating self-injurious behaviors in autismspectrum disorder, Cognet Psychol. 6 (1) (2019).

[26] Cristina V RG, Jesus Pastor , Manuel Pedrosa, Marta Navas , Elena Ezquiage , Eduardo Garsia Camba. DBS-Deep brain stimulation and aggression, editorial and response. Unidad Neurocirugia RGS. 2020.

[27] G. Jones, A. Jassi, Modified cognitive behavior therapy for severe, treatment resistant obsessive-compulsive disorder in an adolescent with autism spectrum disorder: the importance of parental involvement, J. Cognit. Psychother. 34 (4) (2020) 319–335.

[28] S. Kat, L. Xu, Y. Guo, J. Ma, Z. Ma, X. Tang, Y. Yang, H. Wang, X. Li, J. Liu, Reliability and validity of the simplified Chinese version of the aberrant behavior checklist in Chinese Autism Population, Front. Psychiatry 11 (2020), 545445.

[29] A.N. Kildahl, H.W. Oddli, S.B. Helverschou, Potentially traumatic experiences and behavioural symptoms in adults with autism and intellectual disability referred for psychiatric assessment, Res. Dev. Disabil. 107 (2020) 103788.

[30] G. Moretto, M. Ishihara, M. Ribeiro, S.C. Caetano, J. Perissinoto, A.C. Tamanaha, Interference of the communicative profile of children with autism spectrum disorders upon their mother's quality of life, CoDAS. 32 (6) (2020), e20190170.

[31] R. Exell, K. Hilari, N. Behn, Interventions that support adults with brain injuries, learning disabilities and autistic spectrum disorders in dating or romantic relationships: a systematic review, Disabil. Rehabil. 1–14 (2020).

[32] S.A. Eisenstein, W.B. Dewispelaere, M.C. Campbell, H.M. Lugar, J.S. Perlmutter, K. J. Black, T. Hershey, Acute changes in mood induced by subthalamic deep brain stimulation in Parkinson disease are modulated by psychiatric diagnosis, Brain Stimul. 7 (5) (2014) 701–708.

[33] A.D. Haendel, A. Barrington, B. Magnus, A.A. Arias, A. McVey, S. Pleiss, A. Carson, E.M. Vogt, A.V. Van Hecke, Changes in electroencephalogram coherence in adolescents with autism spectrum disorder after a social skills intervention, Autism Res. 14 (4) (2021) 787–803.

[34] H.R. Willsey, Y. Xu, A. Everitt, J. Dea, C.R.T. Exner, A.J. Willsey, et al., The neurodevelopmental disorder risk gene DYRK1A is required for ciliogenesis and control of brain size in Xenopus embryos, Development (Cambridge, England) 147 (21) (2020).

[35] G. Deuschl, M.W.M. Schuepbach, C. Schade-Brittinger, L. Tonder, P. Krack, Author response: Quality of life predicts outcome of deep brain stimulation in early Parkinson disease, Neurology. 94 (9) (2020) 413.