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NOISE LEVELS IN AUTISM SPECTRUM DISORDER: THEIR ROLE IN SCHOOL AND SOCIAL SETTINGS, INFORMATION NOISE ON THE INTERNET AND SOCIAL MEDIA, AND THE CONTRIBUTION OF ICT

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ABSTRACT

Autism Spectrum Disorder (ASD) is characterised by cognitive and social deficits, repetitive stereotyped behaviours and difficulties in sensory perception. Individuals with ASD exhibit hypersensitivity to environmental auditory stimuli, which is associated with the triggering of intense reactions, the onset of anxiety and, more generally, a deterioration in their quality of life. This article sought to investigate, through a literature review, the effects of noise on individuals with ASD, whether occurring in school settings or in the wider environment. The impact of information noise originating from the internet and social media was also examined. Finally, the review concluded that the use of Information and Communication Technologies (ICT), such as remote microphone (RM) technology, noise-cancelling headphones and assistive listening technology, can alleviate auditory difficulties and auditory discomfort experienced by individuals with ASD.

Keywords: Autism Spectrum Disorder (ASD), Noise, Social Media, Remote Microphone Technology, Noise-Cancelling Headphones

1 INTRODUCTION

Neurodevelopmental disorders are characterised by difficulties in acquiring cognitive and social skills [1]. They emerge during the early stages of an individual's life and persist throughout their lifetime. For this reason, intervention programmes should aim to continuously improve individuals' daily lives rather than merely provide temporary relief from symptoms [30]. Autism Spectrum Disorder (ASD) affects the perception and processing of information, social interaction and cognitive behaviour [4]. Individuals with ASD are characterised by deficits in social interaction skills, stereotyped behaviours and difficulties in sensory perception. One of the key characteristics of individuals with ASD is their hypersensitivity to auditory stimuli [8]. The heightened sensitivity of individuals with ASD to environmental sounds and their inability to tolerate loud noises may contribute to difficulties in language comprehension and an inability to distinguish sounds from background noise [36]. Situations that cause anxiety among pupils with ASD arise more frequently in mainstream classrooms than in special education classrooms. For this reason, specific measures are required, such as ensuring good classroom acoustics, providing opportunities for noise management and developing a behaviour management plan, particularly for pupils with additional educational needs [28].

Social media constitute an important means of disseminating information and raising awareness of social issues. At the same time, however, they also facilitate the spread of both misinformation and hate speech [27]. Fake news serves as a means of spreading misinformation and distorting people's views, thereby exacerbating social inequalities and insecurity [17]. The algorithms used by social media platforms to encourage user engagement often prioritise sensationalist and misleading content, thus contributing to the spread of misinformation [16].

The use of technology can support individuals with Autism Spectrum Disorder (ASD) and contribute to their independence and safety [45]. Information and Communication Technologies (ICT) can be employed to develop the skills of individuals with ASD. Easy access to these technologies within a structured learning environment can be beneficial for children with ASD [5]. Autism is a neurodevelopmental condition characterised by deficits in social interaction and repetitive stereotyped behaviours or activities. Individuals with autism experience difficulties in processing audiovisual information and understanding speech in noisy environments. Therefore, the use of specific technologies that improve speech perception in noise can be particularly beneficial for individuals with ASD [9].

2 DECIBEL LEVELS IN AUTISM SPECTRUM DISORDER: THE ROLE OF NOISE IN SCHOOL AND SOCIAL ENVIRONMENTS

Sensory difficulties associated with autism, which had already been identified by Asperger, have now been included in the DSM-5. Although it has not been established whether sensory difficulties constitute a core characteristic of ASD or of co-occurring conditions, such as anxiety, they nevertheless share a similar aetiology with ASD and contribute to broader behavioural and developmental difficulties. Consequently, individuals with ASD tend to respond to environmental sensory stimuli more intensely and atypically than their typically developing peers [24]. Noise is an environmental stimulus that causes distress in individuals with ASD, Down syndrome, hearing impairments and, in some cases, even gifted individuals. The intense reactions to noise observed in individuals with ASD are primarily attributed to Sensory Processing Disorder (SPD). This is a condition in which an individual is unable to process information received through the senses, resulting in ineffective neurological processing. At the same time, individuals with ASD experience sensory overstimulation, which causes them to react to light touch, certain clothing textures, the noise of crowds and loud noises in general. In order to assess the intensity of a noise, its characteristics are examined. For example, the sound of a whistle can be particularly disturbing, depending on its intensity. Similarly, a dog's barking may not significantly increase environmental noise levels, yet it may be extremely irritating to the general population. For individuals with ASD, a dog's barking, the sound of thunder or rain falling on a roof may trigger an intense behavioural response. Thus, even when the sound intensity is not particularly high, considerable discomfort may nevertheless be experienced [28]. Misophonia and phonophobia are conditions associated with reactions to specific sounds, such as those produced by breathing in or chewing. In contrast, hyperacusis is related to sound intensity rather than its source. In hyperacusis, everyday sounds are perceived as loud, unpleasant or even frightening, causing discomfort and difficulties in an individual's daily life [15]. Hyperacusis, which is frequently observed in children with autism, involves an intense reaction to environmental auditory stimuli. Individuals with hyperacusis perceive noise as excessively loud. This is attributed to difficulties in processing incoming information. More specifically, the central nervous system is unable to distinguish the intensity, duration and frequency of stimuli and, consequently, to differentiate between significant and insignificant sounds. As a result, the volume of incoming information causes sensory overload, leading to intense reactions. According to researchers, hyperacusis in children with ASD is attributed to delayed auditory responses in the brain and the existence of connections between the central nervous system and the amygdala. Both noise-induced anxiety and sensory overload may cause respiratory arrhythmia and an increased heart rate. More generally, heightened anxiety about noise leads to reduced social interactions, which negatively affects an individual's quality of life. Furthermore, the World Health Organization (WHO) has highlighted the effects of environmental noise on the general population, including psychological stress, sleep disturbances and tinnitus. In addition, in classrooms where noise levels considerably exceed WHO guidelines, both pupils with ASD and typically developing pupils demonstrated reduced performance due to noise [32]. The study conducted by Landon et al. (2016) aimed to investigate noise sensitivity among individuals with ASD. The sample consisted of 10 adults (six men and four women) aged between 20 and 68 years. Semi-structured interviews were used as the research instrument. According to the findings, anxiety was identified as the primary cause of noise sensitivity among adults with ASD [24].

Individuals with ASD may experience difficulties in distinguishing signals from noise [42]. According to a study, young people with ASD experience greater difficulty in simultaneously attending to social and non-social stimuli than their typically developing peers. The findings revealed that young people with ASD were able to encode social information despite the presence of background noise by increasing activity in the neural networks involved in speech and language processing [13]. The study conducted by Kuiper et al. (2019) aimed to determine whether auditory stimuli and auditory detection thresholds were directly related to the auditory sensitivities frequently reported by individuals with ASD. The participants were divided into two groups: one comprising 33 adults with ASD and the other comprising 31 typically developing adults. According to the findings, adults with ASD exhibit greater sensitivity to sound, as they perceive certain auditory stimuli more intensely. However, neither auditory stimuli nor auditory detection thresholds were

found to account for the auditory sensitivity of adults with ASD. In conclusion, investigating the responses of individuals with ASD to auditory stimuli is essential for understanding their auditory sensitivities [20]. Difficulties in auditory processing are associated with poor academic performance among children with ASD, as communication in the classroom primarily takes place through speaking and listening. Children with ASD experience difficulties in processing speech in noisy environments and perceive classroom noise as an unpleasant sensory experience [43]. Studies have reported that factors such as classroom acoustics, lighting and temperature affect children with ASD [10]. Improving classroom acoustics, particularly by improving the signal-to-noise ratio between the signal level (such as the teacher's voice) and the level of background noise, may provide a solution to this problem. According to research, typically developing individuals without hearing impairments can perform effectively in the classroom provided that the signal they receive is at least 6 decibels (dB) louder than the existing background noise. There are various ways of insulating classrooms against noise originating from both external and internal environments. More specifically, acoustically soft surfaces are installed in classrooms to absorb external sounds, while acoustically hard surfaces are used to reflect sounds generated within the classroom. Implementing these measures can significantly improve pupils' academic performance, as they make it easier for them to follow lessons and gain a better understanding of the material being taught. These findings are supported by studies conducted among both typically developing children and children with disabilities or disorders, including learning difficulties, intellectual disabilities, Down syndrome, language disorders and hearing impairments. Consequently, such interventions could also prove beneficial for children with ASD [43]. A similar study highlighted the importance of noise control for pupils with autism. The sample consisted of 95 teachers from three schools for children with moderate- to high-functioning autism in Houston, Texas. According to the findings, the teachers emphasised the importance of wall insulation and carpeting in classrooms for children with autism [19]. The gradual introduction of auditory stimuli into the environment of a child with ASD (e.g. sound-producing toys and music) helps the child become accustomed to noise. Gradual desensitisation has proved particularly effective for children with ASD who exhibited extreme behavioural reactions to sounds. During the intervention, the children were exposed to noise while barriers (e.g. closed doors) between the children and the sound sources were gradually removed. Furthermore, implementing a reward system whenever a child successfully tolerates a sound may produce positive results [41].

Individuals with Asperger syndrome may exhibit either hyposensitivity or hypersensitivity to sounds [21]. According to a study, hyperacusis and tinnitus are more common among individuals with Asperger syndrome. Furthermore, this population experiences difficulties with concentration, listening and reading in noisy environments [6]. A study investigated whether the difficulties experienced by individuals with Asperger syndrome in perceiving speech in noisy environments could be attributed to their inability to segregate auditory streams. The sample consisted of 16 children with Asperger syndrome and 14 typically developing children. According to the findings, children with Asperger syndrome experience difficulties in segregating simultaneous auditory streams, which may contribute to their inability to distinguish speech in noisy environments [25]. Sensory stimuli frequently cause anxiety and fear in children with Asperger syndrome, which may lead to extreme behavioural reactions. A relevant study identified three types of noise perceived as extremely intense by individuals with Asperger syndrome: firstly, sudden noises, such as a telephone ringing or a dog barking; secondly, continuous noises, such as the ticking of a clock or a child crying; and thirdly, noise arising from multiple simultaneous sources in crowded places, such as department stores. Classroom noise affects the behaviour of pupils with Asperger syndrome and, when it occurs unexpectedly, may lead to verbal or even physical aggression. The effects of sensory stimuli can be mitigated in various ways. Firstly, establishing a 'safe space' within the school, namely an area designated exclusively for a pupil experiencing negative emotions, may prove beneficial. Furthermore, pupils should be informed in advance of when potentially disturbing noises are likely to occur, such as the ringing of the school bell, and should know whom to approach for help or support if necessary. Additionally, the use of pictures as a means of communication may be particularly helpful when pupils with Asperger syndrome experience high levels of anxiety and are unable to comprehend spoken language [29]. Finally, according to the systematic review conducted by Llamas et al. (2026), there is a lack of sufficient data regarding sensory hypersensitivity among autistic adults aged over 50. Consequently, it remains unclear how hypersensitivity changes over time and whether age-related hearing loss contributes to alleviating or exacerbating the problem. Furthermore, the review found that studies focus disproportionately on the male population, resulting in uncertainty regarding how autistic women process sound and light [26].

3 INFORMATION NOISE ON THE INTERNET AND SOCIAL MEDIA

In today's digital age, the spread of misinformation on the internet is particularly widespread. The dissemination of fake news is a global phenomenon that has implications for social, political and public health issues. Even traditional news media now use social media platforms to publish news stories, which may further exacerbate the spread of misinformation [46]. Although social media were originally created to facilitate communication between individuals, they have evolved into channels for exchanging information and news. It has been established that the majority of people in America and Europe now obtain their news from social media [7]. Social media facilitate the rapid dissemination of information due to their low cost and ease of access. Consequently, the spread of fake news intended

to mislead is inevitable [40]. The internet enables easy access to health-related information, making individuals without medical knowledge susceptible to deception through fake news. According to UNESCO, fake news is characterised by deliberately deceptive content and spreads rapidly [3]. Fake news concerning health issues is responsible for causing psychological disorders, fatigue, fear, panic and even depression [35]. Young people and individuals with lower levels of education primarily use the internet to obtain information about health-related issues. According to a study conducted in Brazil, a high proportion of individuals (89.4%) had received fake news through Facebook and WhatsApp [49]. Social noise contributes to the unintentional dissemination of misinformation on social media, as occurred during the COVID-19 pandemic [2]. Findings from a study conducted in Vietnam revealed high levels of exposure to fake news among both adolescents and young adults. It is therefore essential to equip young people with the appropriate skills to implement preventive strategies when navigating digital media [31]. Furthermore, individuals experiencing severe symptoms of post-traumatic stress, particularly women and older adults, are more susceptible to fake news. Specifically, women use social media for communication purposes and, as they exhibit high levels of reflective thinking, demonstrate a greater tendency towards stress and anxiety. Similarly, older adults typically have limited access to news and information, making it difficult for them to recognise misinformation [11]. Mental health problems among vulnerable social groups may be exacerbated by the dissemination of fake news on social media. Therefore, collaboration among all relevant stakeholders is considered necessary to develop strategies aimed at mitigating the negative impact of social media on individuals' well-being [12].

4 THE CONTRIBUTION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) TO EDUCATION AND TO NOISE MANAGEMENT

4.1 Remote Microphone Technology

Individuals with ASD experience listening difficulties and communication deficits. More specifically, children with ASD have difficulties processing auditory stimuli, exhibit attention difficulties and struggle to adapt to noisy environments. Furthermore, individuals with ASD experience greater difficulty recognising speech against background noise than their typically developing peers. Poor acoustics, combined with the high noise levels found in classrooms and the academic challenges faced by most individuals with ASD, make it necessary to implement interventions aimed at improving their listening performance. One such intervention involves the use of remote microphone technology to address the auditory difficulties experienced by individuals with ASD. Remote microphone technology consists of a microphone connected to a transmitter worn by the primary speaker and open-ear receivers for individuals with normal hearing. This technology helps overcome the effects of external noise and poor acoustics by facilitating speech recognition in noisy environments. A relevant study conducted among children and young adults with high-functioning autism demonstrated the importance of remote microphone technology. More specifically, this technology helped participants both recognise speech in noise and tolerate background noise [38]. According to a study involving 12 children with ASD, remote microphone technology was found to provide significant benefits in auditory filtering, auditory attention and auditory memory, while also improving overall auditory abilities [39]. More specifically, remote microphone (RM) technology can improve the signal-to-noise ratio (SNR) by providing broadband audio transmission through a microphone positioned close to the speaker and an ear-level device or loudspeaker positioned near the listener [9, 15]. The benefits of using remote microphone technology both at school and at home for children with hearing impairments are well established. Similarly, pupils with autism demonstrated improvements in speech recognition in noise and reductions in stress levels through the use of remote microphone technology. Overall, a study found that the use of this technology benefits individuals with autism by improving listening accuracy in noise and reducing listening effort, provided that they possess above-average language and cognitive skills [9]. According to another study, remote microphone technology can contribute to improving auditory functioning in children with ASD. Devices such as sound-blocking, noise-cancelling or noise-reducing headphones, although affordable, have certain disadvantages, including a lack of feedback and the potential to cause fatigue among users [44]. The use of remote microphone technology can benefit children with ASD and normal hearing in several areas. More specifically, this intervention improves speech perception in noisy environments, reduces anxiety caused by complex listening situations, enhances attention and auditory memory, and reduces disruptive behaviours. However, the benefits of remote microphone technology are not guaranteed for all individuals with ASD but vary from case to case [18]. The study conducted by Schafer et al. (2024) aimed to investigate the effects of an auditory processing training programme on individuals with ASD. The programme lasted 12 weeks, and the sample consisted of 28 children and young adults with ASD. The programme included individual speech-in-noise training, computer-based dichotic listening training and the use of remote microphone technology both at home and at school. Before the start of the training programme and following its completion, participants underwent tests assessing speech recognition in noise, spatial processing, binaural integration and general auditory processing abilities. According to the findings, the auditory processing training programme contributed to improvements in spatial and phonological processing, binaural integration, auditory memory and cohesion, as well as speech recognition in noise among individuals with ASD when using a remote microphone system [37].

4.2 Noise-Cancelling Headphones

Noise is exhausting for individuals with ASD and affects their nervous system, increasing stress levels. Consequently, it causes attention difficulties, reduced performance, limited participation in activities and avoidance of social interactions, thereby diminishing their quality of life. The accumulation of sensory stimuli causes anxiety and exhaustion among pupils with ASD. In order to achieve inclusive education, the individual needs of this population must be taken into account and the educational environment must be adapted accordingly. The contribution of auditory technologies, such as noise-cancelling headphones, is particularly significant. These technologies modify auditory experiences and substantially reduce auditory discomfort among pupils with ASD [14]. Noise-cancelling headphones aim to optimise auditory experiences through the use of active noise control, which eliminates external environmental noise. The study conducted by Kwong et al. (2025) aimed to investigate auditory perception among children with ASD. The study was conducted in two phases, and the participants were divided into two groups. One group consisted of 83 children with ASD (75 boys and 8 girls), while the other comprised 50 typically developing children (38 boys and 19 girls). In the second phase, a subgroup of participants from the first phase was involved, specifically 35 children with ASD (32 boys and 3 girls). In both phases, the children were aged between 7 and 12 years. The finding that different responses occur to sounds of varying intensity levels highlighted the need for individualised noise control interventions. Accordingly, headphones incorporating a noise control system based on the auditory perception of children with autism were used as an intervention technology. According to the findings, the noise control strategy successfully alleviated unpleasant emotions. More specifically, the perception-based headphones minimised noise by reducing the amplitude of auditory evoked potentials in the central region of the brain in children with autism, resulting in less discomfort and improved auditory perception. In conclusion, noise control technology based on auditory perception can reduce hyperacusis in children with ASD [22]. According to studies, 18% of children and adolescents with autism are unable to tolerate noise at 80 dB, while another study found that children with ASD experience greater difficulty tolerating noise levels exceeding 100 dB than typically developing children. Earplugs and portable noise-cancelling headphones are intended to control noise by creating a barrier between the listener's ears and the external environment. Thus, pupils with autism who found classroom noise intolerable demonstrated improvements in their behaviour as a result of using noise-cancelling headphones [23]. A study conducted among children with ASD and auditory hypersensitivity, aged between 6 and 12 years, found that the use of noise-attenuating headphones contributed to increased participation in activities within home, school and community settings [33]. The study conducted by Zanin et al. (2024) aimed to evaluate the effectiveness of Bluetooth noise-cancelling headphones in improving speech perception and auditory attention among children with autism. The sample consisted of 13 children with ASD aged between 6 and 13 years. According to the findings, the use of noise-cancelling headphones did not contribute to improvements in speech perception in noise among children with ASD. However, improvements were observed in auditory attention and listening behaviours in the classroom. These findings suggest that Bluetooth noise-cancelling headphones could be used as an alternative to remote microphone technology to enhance auditory attention among children with ASD in classroom settings [50].

4.3 Listening Systems, Assistive Listening Technology and a Mobile Application

The use of personal frequency modulation (FM) listening systems can improve speech perception in noise and enhance both social interaction and learning outcomes among children with ASD [34]. Furthermore, a study conducted in China investigated the effectiveness of assistive listening technology in sentence recognition in noise. The sample consisted of 26 children with ASD and 19 typically developing children, aged between 6 and 12 years. According to the findings, assistive listening technology facilitated speech perception in noise among children with ASD [47]. Finally, App4Autism, a mobile application, was designed to enhance social skills and regulate emotions among individuals with ASD through listening to music and monitoring heart rate. At the same time, the App4Autism application focuses on sensitivity to noise. More specifically, when high-frequency noise is detected, music is played while the user's heart rate is simultaneously monitored using a pulse sensor. According to the findings of a study, selecting music based on users' personal preferences can have a calming effect on them in environments with high levels of background noise [48].

4.4 ICT in Education Practices

The importance of all digital technologies in the field of education is highlighted in our final point. ICTs support universal access to education, provide innovative approaches for effective teacher training, enhance learning retention, promote cooperation, increase openness, develop learner-centered approaches, and hasten the process of learning. Additionally, by using virtualization, mobilization, artificial intelligence, and new learning environments like virtual worlds, support educational activities and methodologies. More specifically, ICTs are very effective and productive in autism training, facilitating and improving the assessment, intervention, and educational procedures via mobile devices that bring educational activities everywhere [51] and through a variety of ICT applications that serve as the backbone of education [52-54]. While games turn education into a multimodal, incredibly amiable, and enjoyable interaction, the use of AI, STEM, and ROBOTICS raise educational procedures into new levers of adaptation, creativity, and performance [55-58]. Furthermore, the adoption, improvement, and fusion of ICTs with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation [59-63] place the development of mental abilities at the center of

educational procedures and policies, which accelerates and improves educational practices and outcomes, particularly in children with autism.

5 CONCLUSIONS

Autism Spectrum Disorder (ASD) is characterised by deficits in cognitive and social skills, repetitive stereotyped behaviours and difficulties in sensory perception. Consequently, individuals with ASD exhibit more intense reactions to environmental sensory stimuli than the general population. They may therefore experience discomfort from light touch, certain clothing textures and noise. The assessment of noise intensity depends on its characteristics. Individuals with Asperger syndrome describe sudden noises (e.g. a telephone ringing), continuous noises (e.g. the ticking of a clock) and noise arising from multiple simultaneous sources (e.g. crowded places) as extremely intense. Hyperacusis, which is frequently observed in children with autism, is associated with sound intensity, causing individuals with ASD to perceive all noise as excessively loud. As the central nervous system is unable to distinguish the intensity, duration and frequency of stimuli, sensory overload occurs, triggering intense reactions in individuals with ASD. Furthermore, noise-induced anxiety inevitably leads to reduced social interactions and, consequently, a deterioration in individuals' quality of life. The presence of noise in school environments is associated with poor academic performance among children with ASD. This is because this population experiences difficulties in processing speech against background noise, while classroom acoustics, lighting and temperature also play an equally crucial role. Implementing specific interventions, such as classroom soundproofing, can significantly benefit pupils with ASD. Finally, data concerning sensory hypersensitivity among autistic adults remain limited. It has not been established whether age-related hearing loss affects hypersensitivity, while studies focus disproportionately on the male population.

Undoubtedly, the internet and social media facilitate the rapid dissemination of information and news. However, information noise can sometimes contribute to the spread of misinformation. The dissemination of fake news has become a global phenomenon, with consequences affecting all aspects of life. Notably, the spread of fake news concerning health-related issues can lead to psychological disorders. Young people obtain health-related information through the internet, while individuals experiencing severe symptoms of post-traumatic stress are more susceptible to fake news. The adoption of appropriate strategies can mitigate the negative impact of social media on individuals' quality of life. More generally, noise causes exhaustion among individuals with ASD, as it affects their nervous system, increases stress levels and consequently leads to withdrawal from social activities. Therefore, the use of Information and Communication Technologies (ICT) plays a valuable role in effective noise management. More specifically, interventions such as remote microphone technology, noise-cancelling headphones and assistive listening technology can alleviate auditory difficulties and auditory discomfort experienced by individuals with ASD, while the App4Autism mobile application provides a calming effect in environments with high levels of background noise.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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The Authors proclaim no conflict of interest.

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