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Examining the stress level of autistic people using a smartwatch integrated with the internet of things technology

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Abstract

The objective of this paper is to explore the use of Internet of Things (IoT) technology, specifically through the use of a smart watch, in identifying and managing stress in individuals with autism. Autism is characterized by social anxiety, particularly in situations that require social skills. A literature review was conducted to examine the role of IoT technology in the daily lives of autistic individuals and its potential in identifying and managing stress. The significance of this research lies in highlighting the role of IoT technology in addressing the challenges faced by individuals with autism and paving the way for further studies on the use of sensor-equipped devices to improve their quality of life. The correlation of the pillars smart devices - identifying stress with the help of technology, is analyzed through the following literature review.

Keywords: Internet of Things; Autism; ASD; Stress; Sensors; Heart Rate Sensor; Smartwatch

1. Introduction

Anxiety is defined as a sensation of pressure (Mitra, 2008). Numerous studies have shown a correlation between stress and various diseases, including cardiovascular diseases, diabetes (Steptoe, A., & Kivimäki, M., 2013), and asthma (OH et al., 2013). Stress has been found to significantly impact the progression of these diseases, with lifestyle being a common contributing factor. According to the World Health Organization, stress-related disorders are the leading cause of death in Europe. Consequently, there is a need for non-intrusive and non-disruptive methods to automatically detect daily stress levels in individuals. This can be achieved through the utilization of data from various sensors. By automatically detecting stress without imposing additional stress on individuals, it can directly assist in managing stressful situations and be employed in medical intelligence applications, such as improving blood glucose predictions for diabetics under the influence of stress. Extensive research has demonstrated the efficacy of technology in reducing and managing stress. Additionally, numerous mental health apps have been developed for stress management (Carissoli, C. et al., 2015). One of the most significant technological advancements of the 20th century is Internet of Things (IoT) technology. IoT combines computing and technology with internet-connected devices that possess sensors. By integrating data collected from these sensors, IoT provides valuable insights. IoT is increasingly becoming a part of people's everyday lives, offering solutions to various needs. One area where IoT technology is particularly prevalent is in smart homes, where devices connected to the internet can control lighting, temperature, appliances, and provide security and energy savings. Furthermore, sensors can be utilized to assist elderly individuals by allowing their caregivers to monitor their well-being and intervene when necessary. Aside from smart home applications, IoT technology is also beneficial in areas such as transportation, energy, health, agriculture, and education. In the context of special education, IoT offers numerous products and services that can enhance the daily lives of students with special needs. For instance, gloves and tablets can convert sign language into verbal speech, aiding hearing-impaired students. IoT systems can also convert sound to written language and provide accessible infrastructure in schools. Research has demonstrated that

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the use of IoT applications, such as memory enhancement, attention improvement, self-regulation, and self-observation, can enhance cognitive and metacognitive functions (Moraiti, I. et al., 2022).

The present study employed quantitative research methods to investigate the efficacy of Internet of Things (IoT) technology, specifically through the use of sensors, in detecting stress levels in individuals. The research initially examines the concepts of IoT, its architectural framework, and its application in stress detection. Additionally, the study explores the impact of stress and anxiety on the human body, the hormones associated with stress, and various stress management techniques. Furthermore, the investigation focuses on how individuals with autism can utilize low-processing power sensors and processors in IoT devices to gather information about their stress levels. The research findings are directed towards researchers for further investigation, as well as autistic individuals who struggle to express their emotions. By utilizing IoT devices equipped with sensors, these individuals can benefit from technology and effectively identify and manage moments of stress.

2. The field of Internet of Things (IoT) technology and its associated architectural framework

The Internet of Things (IoT) technology refers to a system in which objects or things are equipped with sensors, actuators, and other technologies, such as Bluetooth or RFID, as well as low-frequency processors. These objects interact with each other and with their surroundings, exchanging data and collaborating to achieve common objectives. The IoT is comprised of several key visions, including the "Things Oriented Vision," which emphasizes the use of sensors and RFID technology for object localization; the "Internet Oriented Vision," which highlights the need for smart objects to connect to the internet using IP protocols; and the "Semantic-Oriented Vision," which focuses on the collection and management of data, including processing redundant information. These visions aim to establish a network connecting various things. When it comes to the architecture of IoT technology, the Three-Layer architecture is commonly used. This architecture consists of the perception layer, the network layer, and the application layer. The perception layer collects and converts information from sensors or RFID tags, transmitting it as digital signals over the internet. The transport layer processes the received data and transfers it to the application layer using various internet technologies. The application layer utilizes the processed data to present the capabilities of IoT technology to end users. The IoT heavily relies on technologies implemented in objects to meet the aforementioned specifications, including Wi-Fi, Bluetooth, 4G/5G, and Zigbee. The integrity of data is of great importance and is ensured through a specific model.

An important part of the Internet of Things is occupied by the technologies used in the objects to meet the above specifications. Some of the most common are the following:

2.1. RFID

Radio Frequency Identification (RFID) is a wireless identification system that utilizes radio waves to identify objects. Each object is assigned an electronic "tag," which can be categorized as either active or passive. Active tags have their own power supply and can communicate and emit signals regardless of distance, while passive tags rely on the energy from an electromagnetic field generated by the reader's antenna. RFID technology offers numerous benefits, such as its cost-effectiveness and reliability. It is particularly well-suited for detecting objects that are difficult to observe or locate.

2.2. Wireless sensor networks

Wireless sensor networks are comprised of nodes that gather data from the surrounding environment. These nodes are equipped with energy-constrained devices and low-power processors, making them unable to store large volumes of data. Their functionality relies on autonomous communication and the transmission of information to a central base station. The effectiveness of wireless networks is contingent upon collaborative data aggregation among nodes, rather than individual data acquisition. These networks are particularly valuable in monitoring scenarios and are a vital component of wireless Internet of Things (IoT) technology.

2.3. Cloud Computing

Cloud Computing is a technology that allows users to remotely operate their devices. It is characterized by a vast network of servers connected to a cloud service, which facilitates the storage and processing of large amounts of data collected from sensors. This technology is highly regarded in the Internet of Things (IoT) sector due to its cost-effectiveness and efficient performance. Additionally, it offers the benefit of data recovery through backup systems and seamless integration of applications into the cloud without requiring any specific actions from users. Cloud computing can be categorized into private, public, community, and hybrid clouds, each serving different purposes and accommodating various user groups. The private cloud is exclusive to a single user and does not grant access to additional users, while the public cloud is managed by a third-party service provider and supports multiple users. The

community cloud is designed for collaborative efforts among groups with shared goals, while the hybrid cloud combines two or more of the aforementioned cloud types.

3. Psychological stress is a prevalent phenomenon that affects the physiological system of the human body.

In summary, anxiety and stress differ in that anxiety is an internal emotional state, while stress is caused by external factors that exert psychological pressure, such as loss, natural phenomena, or working conditions. The brain plays a crucial role in the production and management of stress, particularly the hypothalamus, amygdala, and hippocampus, which are part of the limbic system. The limbic system controls emotions, memory, autonomic and endocrine functions, and behavioral reinforcement. The amygdala acts as the brain's alarm center and fear center, sending danger signals to other brain nuclei and the hypothalamus. The hypothalamus serves as a command center, communicating with the rest of the body through the autonomic nervous system to regulate involuntary bodily functions. The term "anxiety," as defined by the American Psychiatric Association (A.P.A.) and Parekh (2017), refers to a negative emotional state similar to sadness and anger. Anxiety is a normal response to stress and can have beneficial effects, such as alerting individuals to potential dangers and helping them focus their attention. However, chronic and excessive stress can disrupt physiological systems, such as the autonomic nervous system and endocrine system, which maintain balance in the body (Cohen et al., 2016). Prolonged exposure to psychological stress is associated with an increased risk of various diseases, including cardiovascular disease, type 2 diabetes, and mental health disorders (Kivimäki & Steptoe, 2018; Nyberg et al., 2014; Madsen et al., 2017). The reactivity of stress systems may serve as a potential marker in the prevention of negative health outcomes caused by chronic stress (Cole et al., 1999; Chrousos, 2009; de Rooij, 2013). Situations that evoke strong emotions often lead to stress, and some individuals experience chronic stress that places strain on the cardiovascular system and can even lead to depression. Symptoms of stress include loss of appetite, headache, stomach pain, difficulty concentrating, and sleep disturbances, all of which contribute to reduce quality of life (Lohaus et al., 2004; Burger et al., 2017). Chronic stress can cause long-term damage to hormonal, cardiovascular, nervous, and muscular systems due to insufficient recovery and repair. This can result in weakened immune system function, delayed healing processes, and musculoskeletal strain. It is important to note that individuals perceive and experience stress differently (Klauer et al., 2007).

Literature suggests that the severity of ASD symptoms is associated with weaker connections between the amygdala and other nodes in the emotion processing network (Pitskel, N. B, et al., 2014). These incomplete connections arise from the development of neural connections during childhood, rather than physical injury. A study revealed that infants between 6 and 12 months old who experienced a sudden increase in amygdala size were more likely to exhibit ASD symptoms at the age of 2. Furthermore, the degree of amygdala development in the second half of life was linked to ASD-related deficits at 2-3 years of age. The amygdala, a brain structure resembling an almond, is situated in the inner region of the brain. Its significance has been explored in relation to various disorders, including anxiety disorders and neurodevelopmental conditions such as autism spectrum disorder, due to its involvement in emotions. As a critical component of the "social brain," the amygdala plays a crucial role in regulating responses to everyday situations, thereby influencing an individual's ability to interact with their surroundings. In conclusion, the amygdala's importance in studies on autism spectrum disorder is a significant finding. The amygdala indirectly contributes to face recognition and the identification of others' intentions, which can influence an individual's behavior and emotions, particularly in avoiding potentially harmful individuals. Studies demonstrate that individuals with autism spectrum disorder exhibit reduced amygdala activation during face processing compared to typically developing individuals (Kleinhans, N. M., et al., 2009). Research indicates that individuals on the autism spectrum who experience anxiety tend to have a smaller amygdala. This is relevant as individuals with autism often encounter social anxiety, which is linked to concerns about being evaluated by the broader community, as well as disruptions to established routines and access to preferred objects (Andrews, D.S, et al., 2022). To summarize, individuals with ASD demonstrate a lack of heightened amygdala functioning during social interactions. However, it is important to note that the amygdala does not operate in isolation in the processing of emotions, as there are various other brain structures responsible for different aspects of emotional states. These structures include the hippocampus, which maintains emotional memories, and the prefrontal lobe, which regulates emotional responses. This discovery raises several questions, as prior studies have shown that individuals with autism tend to have reduced amygdala size and connectivity later in life. Researchers argue that the early development of the amygdala is heightened in infants who later develop ASD as a result of their difficulties in processing visual stimuli. This places additional strain on the amygdala, causing it to rapidly enlarge. Studies conducted with infants emphasize the importance of early intervention in children at an elevated risk of developing autism spectrum disorders. While intervention does not need to address all symptoms, it is crucial to target cognitive and emotional deficits.

4. The role and functionality of stress hormones

Research has shown that acute stress impairs working memory performance (Loprinzi, P.D., et al. 2019). The negative effects of acute stress on memory have been attributed, at least in part, to elevated cortisol levels and catecholamines, which can impact neuronal excitability and alter brain mechanisms involved in working memory, specifically prefrontal cortex function (Barsegyan, A. et al., 2010). Adrenaline, also known as epinephrine, has various physiological effects including increased heart rate, elevated blood glucose levels, rapid breathing, and other responses in the muscular system. Its primary role is to facilitate the body's response to stressful stimuli, with the aim of aiding in escaping dangerous situations. Adrenaline release is typically associated with experiences of fear, pressure, and intense emotions. In the global literature, there is a well-established connection between cognitive function and stress-related hormones and the nervous system. Based on this finding, strategies can be developed to effectively manage stress (Drigas & Mitsea, 2021). The stress response triggers the release of stress hormones and activates the sympathetic nervous system. Specifically, in the context of individuals with autism, research has focused on oxidative stress, which is characterized by elevated lipid peroxidation levels. Conversely, individuals with Autism Spectrum Disorder (ASD) have been found to have low levels of antioxidant proteins such as transferrin and ceruloplasmin, which are responsible for iron and copper deposition respectively (Chauhan, 2020). The following section provides a description of the functions of stress-associated hormones. Studies have investigated the differential effects of acute physical activity and psychological stress on salivary cortisol levels and working memory performance. The findings indicated that intense physical exercise and stress both increase salivary cortisol concentrations. However, exercise intensity does not appear to be associated with changes in working memory performance (Tang, A. et al., 2016). Additionally, the same study revealed that acute psychological stress, such as the Trier social stress test (TSST), leads to increased cortisol levels. According to Ma et al., diaphragmatic breathing has been shown to reduce negative emotions, enhance mindfulness, and decrease cortisol levels. Dopamine is an organic substance belonging to the catecholamine family, which serves as a neurotransmitter responsible for transmitting feelings of satisfaction to the brain. It is often referred to as the "neurotransmitter of euphoria." Dopamine synthesis occurs in various areas of the brain, particularly the substantia nigra and the ventral tegmental area. Additionally, dopamine is synthesized in the autonomic nervous system, gastrointestinal system, and kidneys, where it helps regulate blood pressure and fluid balance through its diuretic and natriuretic actions. Dysregulation of dopamine production and function can contribute to oxidative stress, kidney failure, edema, and hypertension. Cortisol is a hormone associated with stress that can have detrimental effects on an individual's well-being when present in excessive amounts and for prolonged periods of time. Produced by the adrenal glands, cortisol helps the body respond to emergencies by increasing energy levels. Under normal circumstances, cortisol plays a crucial role in regulating fluid balance, blood pressure, and other physiological functions. However, uncontrolled secretion of cortisol can lead to conditions such as depression, weakened immune responses, and other adverse effects.

Epinephrine and norepinephrine are hormones that play a crucial role in the regulation of blood pressure. They induce vasoconstriction, increase heart rate and strength of contractions, relax airway muscles, and modulate glucose metabolism. These hormones are released into the bloodstream in response to certain stimuli, leading to various physiological changes in the body. Consequently, the heart beats at an accelerated pace, supplying blood to vital organs and muscles. Pulse rate and blood pressure elevate, while respiration rate intensifies, facilitating enhanced oxygen intake. This surplus oxygen is directed to the brain, heightening alertness and sharpening sensory perception. Simultaneously, adrenaline prompts the release of glucose and fat from temporary storage sites, providing energy to all bodily functions. Notably, these alterations occur rapidly and unconsciously due to the efficient neural connections between brain nuclei. The amygdala and hypothalamus initiate this sequence of responses even before the brain's visual centers fully process the situation. This phenomenon elucidates how individuals instinctively react, such as swiftly jumping out of harm's way when faced with an approaching car, without conscious deliberation. Negative emotions and stress trigger the release of stress hormones, including adrenaline and cortisol, which in turn stimulate the secretion of insulin. Consequently, individuals experiencing chronic stress develop insulin resistance, whereby insulin receptors in human cells become limited, resulting in elevated blood glucose levels and heightened insulin production. Oxytocin, also known as the anxiety hormone, plays a significant role in promoting feelings of calmness, peace, contentment, and overall well-being. It is produced in specific regions of the hypothalamus in the brain, namely the paraventricular and superior nucleus. Oxytocin functions by reducing the reactivity of the amygdala, a brain structure involved in emotional processing, and enhancing its connectivity with areas responsible for regulating emotions and social cognition. This neurobehavioral hormone also regulates a wide array of positive social behaviors. In a recent study conducted by Yoon et al. (2020), it was found that oxytocin has anxiolytic effects, mitigates hyperactivity, and improves mental representations. Conversely, low levels of oxytocin are associated with anxiety and suggest a diminished capacity for engaging in social interactions. Serotonin is a hormone that plays a crucial role in promoting relaxation, fostering a positive self-image, and cultivating optimism. It exerts control over mood, emotions, as well as aggression and impulsivity. Moreover, it enhances self-assurance, engenders resilience, and fosters a sense of contentment.

Consequently, individuals with balanced serotonin levels are more likely to exhibit determined and socially adept behaviors. In contrast, decreased serotonin levels are associated with anxiety, and various factors such as chronic stress, prolonged cortisol release, and persistent inflammation can contribute to serotonin depletion, resulting in symptoms of depression. During times of stress, serotonin levels decline, thereby giving rise to negative emotions like anger or fear. Thyroid hormones are crucial in responding to stress as they regulate the production of cortisol by the adrenal glands. This cortisol production is an adaptive mechanism designed to protect against natural threats. Both thyroid hormones and cortisol have receptors in every cell of the body, and they act together at the epigenetic level to ensure optimal functioning. The appropriate fluctuation of cortisol levels is necessary for binding to receptors and facilitating the proper functioning of not only the thyroid gland but also all tissues in the body. However, excessively high levels of cortisol can prompt tissues to further respond to the signal from thyroid hormones.

5. Stress management options for students

Another study found that a substantial portion of high school students' stress originates from school and extracurricular activities, and this chronic stress can persist into their college years, leading to disengagement from academics and mental health issues. According to research conducted by the American Psychological Association (APA), teenagers report stress levels comparable to those of adults. This suggests that teenagers experience significant levels of chronic stress and feel that their ability to cope with stress is generally inadequate. Stress can also impact health-related behaviors, with stressed students being more likely to experience disrupted sleep, poor diet, and lack of exercise. This can be attributed to the fact that nearly half of the respondents in the APA survey reported spending three additional hours on schoolwork each night, in addition to their full day of academic and extracurricular activities. A study conducted in German educational institutions examined the potential for implementing interventions within schools to address stress, a significant precursor to various psychosocial illnesses. The study aimed to alleviate stress through a concise prevention education program that incorporated emotion regulation, mindfulness, and self-compassion. In addition to providing informative materials for self-study, students were actively engaged in exploring stress and developing coping strategies within a short timeframe of 90 minutes. The program demonstrated that effectively managing stress can enhance and preserve students' mental health. Child psychiatrists collaborated on the program, contributing to the prevention of anxiety disorders among young people and facilitating student participation in school lessons, while also supporting the work of educational staff. The study's findings indicated that a healthy school environment was maintained for adolescents and teachers.

The most common causes of stress for students are:

- School
- Homework
- Extracurricular activities
- Social challenges
- Transitions (eg graduation, moving, independent living)
- Relationships
- Pressure to succeed
- Work

High school students face the intense competitiveness of taking difficult classes, juggling impressive extracurriculars, studying for and taking college placement tests, and deciding on important, life-changing plans for their future. At the same time, they must navigate the social challenges inherent in the high school experience (Leonard NR et al., 2015).

This stress continues if students decide to attend college. Stress is an inevitable part of life, but research has found that increased daily stressors put college-age young adults at higher risk for stress than other age groups.(Acharya L. et al., 2018)

Students often recognize that they need to relieve stress. However, all the activities and responsibilities that fill a student's schedule sometimes make it difficult to find time to try new stress relievers that will help eliminate stress.

The most common stress management techniques for students are the following:

- Sufficient sleep

Research shows that sleep deprivation & daytime sleepiness are linked to lower mood, higher risk of car accidents, lower grade point averages, lower learning performance and higher chances of academic failure. For students as well

as the entire population that is required to be productive, scientists recommend 8 hours of sleep at night in order to receive the strength required by their busy schedule.

- Using guided imagery

It is suggested that students use guided imagery as it is an effective tool for dealing with academic, social and other stressors. Visualizations help students calm down and get away from things that are stressing them out as well as reduce their body's stress response. They can use guided imagery to relax their bodies by sitting in a quiet, comfortable place, closing their eyes and imagining a peaceful scene. In this way they can relax by mentally enjoying the restful image. (Gordon JS et al., 2021)

- Gymnastics

One of the most common ways to manage stress is to get regular exercise. As research reports (Cowley J, et al., 2017), students who participate in regular physical activity report low levels of perceived stress. While students still struggle with the same social and academic pressures in their daily lives, they feel less stressed and find daily challenges more manageable than their less active peers.

Finding time to exercise can be a challenge, but there are strategies students can use to add more physical activity to their day. Some routines they can incorporate into their daily routine are morning stretching or yoga, walking or biking to school, participating in a school or extracurricular sport, and more.

- Calm breathing

When the body is experiencing a stress response, the mind is not thinking clearly. Research shows that it is possible at that time that the person is not breathing properly and is taking short, shallow breaths. When a person breathes improperly, it disrupts the exchange of oxygen and carbon dioxide in their body. This imbalance can contribute to various physical symptoms such as increased anxiety, fatigue, stress, emotional problems and panic attacks. (Paulus MP, 2013)

Breathing exercises are indicated to deal with moments of intense stress such as just before an exam or a presentation. Breathing exercises can also help manage long-term stress such as dealing with relationship, work or financial problems.

- Practicing progressive muscle relaxation (PMR)

Another stress management technique for students that can be used during tests, before bed, or at other times of stress is progressive muscle relaxation (PMR). This technique involves stretching and relaxing all muscles until the body is completely relaxed. With practice, the person manages to release stress from their body in seconds. (Toussaint L, et al., 2021) This can be especially helpful for students as it aids relaxation efforts for deeper sleep. Once the individual learns how to use PMR effectively it becomes a handy way to induce relaxation in any stressful situation.

- Play relaxing music

Music has many benefits and is known to relieve symptoms of anxiety. Research shows that playing upbeat music improves processing speed and memory. (Gold BP, et al., 2013) Stressed students may find that listening to relaxing music can help calm their body and mind. A study found that students who listened to the sounds of relaxing music were able to recover faster after a stressful situation. (Thoma MV, et al., 2013)

Students can enjoy the benefits of music by listening to classical music while studying, listening to upbeat music to start their day, or relaxing with their favorite tunes.

- Create a support network

Emotional support can help create a buffer against stress. Interpersonal relationships are often a source of stress for students. Changes in friendships and changes in students' lives such as moving away from the school environment can create significant upheavals in students' psychology and cause them anxiety. For this reason it is recommended that they have friends and classmates nearby so that they can lean on in times of need, fight the feeling of loneliness by expanding their support network and cultivate their relationships. Students should look for opportunities to meet new people whether it is joining study groups or participating in other academic, social and recreational activities.

Different types of relationships offer different types of support. Relationships with their friends and classmates offer them emotional and practical support. Widening the social circle combats student anxiety.

- Healthy diet

It is widely held that diet can either boost one's brainpower or drain one's mental energy. It can also increase the anxiety the person is feeling. (Nguyen-Rodriguez ST et al., 2009)

A healthy diet can help combat stress in many ways. Improving nutrition can help prevent diet-related mood swings, dizziness, and more.

Students are often prone to poor eating habits. Feeling stressed can make it more difficult to stick to a healthy diet. There are tactics that can help students make healthy food choices by eating regularly, bringing a water bottle to class, eating healthy snacks like fruits and nuts, and limiting caffeine and alcohol intake.

- Mindfulness

Mindfulness is an innate and modifiable capacity of the human mind, commonly defined as "the awareness that emerges through attention, in the present moment, and non-judgmentally to the unfolding of moment-to-moment experience." Mindfulness meditation, in turn, represents a systematic framework and process for cultivating mindfulness in everyday life through deliberate and sustained practice (Bossi, F. et al., 2022). When a person is faced with stress, whether it is due to academic reasons or from relationships, financial pressures or social challenges, the first stage of coping is to become aware of how they feel in order to help them respond effectively.

Mindfulness is characterized by increased awareness of the present moment, with the aim of focusing on one's current experiences, recognizing and observing emotions and reactions, and accepting them non-judgmentally. Studies indicate that engaging in mindfulness-based stress management techniques can be an effective means of regulating stress levels, as well as reducing symptoms of anxiety and depression (Parsons D, et al., 2022). Mindfulness training is an area of growing research, particularly in the context of its usefulness for stress management and burnout prevention (Mann et al., 2021). While it is commonly believed that the regulation of thoughts, emotions, and stress predominantly relies on the brain, practices that involve both the mind and body demonstrate otherwise. Activities such as meditation, yoga, martial arts, and various physical or mental exercises that enhance awareness skills can promote the growth of new neurons and the formation of new connections between existing neurons, which in turn enhance cognitive and metacognitive abilities and lead to significant improvements in stress management (Mahajan, A.S., 2014). In recent years, technology has also played a role in reducing stress symptoms for an increasing number of individuals. Mobile phone applications have been developed to provide helpful information about mental health problems and offer relaxation exercises, breathing exercises, and emotional state monitoring features through simple and user-friendly text questions (Gaggioli, A et al., 2014). These applications aim to assist more users in effectively managing stress (Wang, K et al., 2018).

6. Autism Spectrum Disorder & Internet of Things Applications

Autism Spectrum Disorder (ASD) is a broad term encompassing a range of neurodevelopmental disorders characterized by challenges in communication, social interaction, and repetitive behaviors. Each individual with ASD faces unique opportunities and difficulties, and the disorder affects individuals worldwide regardless of race, ethnicity, culture, or socioeconomic background. The causes of ASD are influenced by a combination of genetic and environmental factors, leading to variations in learning, problem-solving, and cognitive abilities among individuals with the disorder. Some individuals with ASD require significant support in their daily lives, while others need less assistance or can live independently. Early signs of autism typically emerge around the age of 2 or 3, and early intervention has been shown to have positive outcomes. Individuals with ASD often experience comorbidities with other developmental disorders such as learning disabilities and speech impairments. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) outlines criteria for diagnosing ASD, including limited and repetitive behaviors, difficulties in social communication, and sensory difficulties. The severity of ASD is categorized into three levels based on the individual's level of functioning. Children with ASD require systematic assessment to determine appropriate therapeutic and educational goals within a specialized framework. In the school setting, symptoms of ASD may manifest as learning difficulties, hyperactivity, anxiety disorders, emotional disturbances, and sensory challenges. Sensory regulation and processing difficulties are a prominent feature of ASD, impacting social functioning, behavior, and emotions. Sensory integration plays a crucial role in the cognitive and social skills development of individuals with ASD, and identifying sensory overloads can help manage unwanted responses in hypersensitive individuals.

In the context of assisting individuals with Autism Spectrum Disorder (ASD), touch and pressure sensors are utilized to monitor bodily movements and facial expressions. Heart rate sensors are employed to collect and manage information related to emotions, including happiness, anger, and even absence of pulse. Additional sensors are also utilized to adjust the current environment in real-time. Additionally, there have been advancements in light control to regulate room lighting, odor control to manage room smell, and sound control to emit soothing sounds. The objective of utilizing Internet of Things (IoT) tools is to provide supportive interventions for hypersensitive individuals with ASD through three main axes of operation. The first axis involves collecting data by identifying sensory information relevant to understanding the individual's situation. The second stage involves monitoring, analyzing the collected data, and making real-time decisions based on this information. Finally, alerts are sent to caregivers, parents, and therapists depending on the individual's environment. The ultimate goal is to provide sensory information about the individual through physical stimuli. It is evident that combining smart environments with IoT technologies can enhance the quality of life for individuals with ASD, both in homes and in educational and support centers. These solutions not only benefit the individuals themselves but also their caregivers, therapists, teachers, and parents. Understanding the rights and needs of each child and utilizing digital technologies for high-quality teaching, assessment, and treatment are crucial for improving their quality of life. The potential of technology in complementing existing approaches and inventing new rehabilitation methods for children with autism has been recognized. IoT devices allow therapists, teachers, and parents to track the progress of individuals with autism, recording their daily treatments and discerning their emotions. Technology, when integrated with special education, provides individuals on the autism spectrum with the opportunity to acquire additional skills and enables parents to be more aware of their children's treatments, whether they are at home or remotely through corresponding applications. By utilizing these tools, timely information can be provided to individuals with ASD and their surroundings. The use of these tools has shown positive outcomes, such as reducing hyperactivity and aggression, improving attention maintenance and memory, and enhancing learning readiness and social communication. Additionally, incorporating IoT technologies into games has proven to be beneficial.

7. Teachers' anxiety about managing autistic people

Workers in roles that involve managing human behaviors, such as teachers, often experience high levels of occupational stress (Nwimo et al., 2015). Globally, approximately 88% of teachers experience occupational stress (Cappe et al., 2016). Specifically, teachers who work with autistic students in their classrooms experience even higher levels of psychological distress compared to those who teach typically developing children (Cappe et al., 2016). This increased stress is due to the unique challenges associated with Autism Spectrum Disorder (ASD) and the difficulties teachers face in understanding these students (Swierczynski, 2019; Davarani, 2017). Implementing the REOHC framework can lead to improved work experiences, subjective well-being, and work ability for employees (Ellis, 2005). By helping individuals understand their feelings of stress and providing practical coping skills, this approach aims to alleviate occupational stress and its associated negative effects on individuals and organizations. Occupational stress has been found to have negative effects on workers' productivity, health, and well-being (Davarani, 2017). Symptoms of occupational stress include sleep disorders, depression, fatigue, exhaustion, headaches, reduced immune function, musculoskeletal pain, cardiovascular disease, absenteeism, and inefficiency (Davarani, 2017; Hamlett & Media, 2017; Rao & Chandraiah, 2012). These stress symptoms not only impact teachers' job performance but also hinder students' overall development and school outcomes (Cappe et al., 2017; Okwaraji & Aguwa, 2015). Perceived job stress may not solely be a result of job stressors themselves, but also influenced by individuals' subjective perception of their experiences (Kok et al., 2016). Rational affective occupational health guidance (REOHC) is a therapeutic approach aimed at reducing stress by addressing negative cognitive appraisals and emotions related to work (Ogbuanya et al., 2017). This approach, based on Rational Emotive Behavioral Therapy (REBT), can be delivered through smartphone applications or group sessions and incorporates cognitive, behavioral, and affective techniques to help individuals change negative perceptions and improve their work ability (Onyishi et al., 2021; Ellis, 2005).

Teachers who work with children with special learning needs, such as those with autism, cannot rely on predetermined approaches like their counterparts who teach typical students (Atiyat, 2017). The nature of working with autistic individuals is characterized by ambiguity due to the diversity and ever-changing nature of the disorder (Atiyat, 2017). Nevertheless, these teachers can receive training to effectively manage their perceptions of these conditions and the accompanying physical and psychological symptoms. Although the work conditions, or stressors, may not undergo significant changes, teachers have the ability to alter their perceptions of the stressful experiences associated with teaching children with autism, ultimately leading to a reduction in stress symptoms. In a recent study conducted by Ogba et al. (2020), the effectiveness of the REOHC method in reducing occupational stress among teachers of children with autism was examined. The findings revealed that this method was successful in altering teachers' negative perceptions of their work experiences. Specifically, implementing rational stress management interventions proved to be effective in reducing burnout and dysfunctional distress among special education teachers. Furthermore, evidence-based training in cognitive behavioral coaching resulted in reduced anxiety and improved performance among teachers.

This study highlights the significance of the REOHC method in alleviating stress and irrational beliefs among special education teachers in Nigerian primary schools, thereby reducing their stress levels and anxieties related to teaching both children with autism spectrum disorder (ASD) and typical students.

8. Methods of stress detection, including sensors and other forms of stress assessment

As previously mentioned, stress poses a significant obstacle in the daily lives of many individuals. The detrimental effects of mental stress on human health and psychology have been well-documented for numerous years. Conversely, technology has emerged as a means to address people's needs and challenges. With the introduction of wearable devices that have become integrated into people's everyday routines, researchers have identified sensors, artificial intelligence algorithms, and machine learning methods to detect stress levels. In a study conducted by Can et al. (2019), a framework was devised to easily detect stress levels by analyzing signals from sensors on wrist-worn devices during users' daily activities. Specifically, sensors were used to measure heart activity (Heart Rate), electrodermal activity of the skin (EDA), and accelerometer signals. The combination of EDA and Heart Rate measurements proved to be the most effective for stress detection in laboratory settings. However, measurements obtained through electroencephalogram devices were also effective but deemed inconvenient for subjects. It was found that subjects were hesitant to wear cumbersome measurement instruments and were uncomfortable with each device. Consequently, research efforts focused on the development of a discreet stress detection system should aim to create a device that is user-friendly and seamlessly integrates into users' daily lives. Given that smartphones and mobile devices have become essential components of modern society, they were chosen as the instruments to detect stress in daily life. In order to collect data during individuals' daily activities, stress measuring devices should be non-intrusive. Users should be able to wear these devices without feeling discomfort throughout their daily routines, including during sleep, meetings, and other activities. The presence of an uncomfortable device may even contribute to additional stress for participants. Ideally, the system should collect data without the user's awareness. According to research by Mitra (2008), the most commonly utilized indicators of stress are derived from the following data.

- Through GSR (Galvanic skin response) using changes in skin conductance. During stress, skin resistance drops due to increased secretion in the sweat glands. (Shi, Y et al., 2007)
- Electromyogram (EMG) is detected by measuring the electrical activity of the muscles. Stress causes differences in muscle contraction that can be used to identify stress. (Lundberg, U et al., 2004)
- Skin temperature: changes in skin temperature are related to stress level. (Yamakoshi, T. et al., 2008)
- Heart rate measurement and heart rate variability. The most commonly used parametric stress indicators derived from the electrocardiogram (ECG) are heart rate and heart rate variability. (Heart Rate Variability). (Taelman, J., et al., 2009)

In recent years, non-contact methods for measuring stress have also emerged. These include hyperspectral imaging technique (Chen et al., 2014), analysis of human voice (Lu et al., 2012), measurement of pupil diameter (Ren et al., 2014), visible spectrum camera (Kaur et al., 2015), and the use of stereo thermal and visible sensors (Mohd et al., 2015). Heart rate (HR) and heart rate variability (HRV) measurement serve as practical tools for recording physiological signs of stress (Taelman et al., 2009; Melillo et al., 2011). However, there are various challenges associated with this approach, as HR and HRV responses to psychosocial stress are influenced by individual factors such as health status, age, gender, fitness level, psychological assessment skills, genes, breathing rate, and recovery status from previous exercises (Koskinen et al., 2009; Assoumou et al., 2010; Rimmele et al., 2007; Mücke et al., 2018; Gaab et al., 2005; Kupper et al., 2004; Mourot et al., 2004). Similar difficulties arise when measuring endocrine stress data (Kudielka and Kirschbaum, 2003; Otte et al., 2005). Wearable technology utilized for self-monitoring of well-being can offer cost-effective tools to quantify and prevent stress, as well as mitigate the negative effects of excessive stress. In the case of individuals with autism spectrum disorder, HRV response analysis methods can be employed to detect anxiety levels, as demonstrated by Hufnagel, Chambres et al. (2017). Specifically, the electrocardiogram is recorded in 5-minute intervals, and sudden changes in heart rate are detected, followed by calculation of the average HRV value between two consecutive sudden changes. The detection of abrupt changes employs an individual statistical approach without the use of a control group (Hufnagel, Chambres et al., 2017). Additional indicators such as the accelerometer, typing dynamics, and eye blinks can also be utilized to detect stress (Garcia-Ceja et al., 2015; Gunawardhane et al., 2013; Marcos-Ramiro et al., 2014). It is common practice to combine multiple indicators in order to determine the most cost-effective approach based on the number of users requiring data. For instance, Fernandes et al. (2014) employed both galvanic skin response (GSR) and blood pressure indices to identify stress, while Sun et al. (2012) utilized data from electrocardiogram (ECG), GSR, and accelerometer to detect mental stress. Santos Sierra et al. (year) used GSR and heart rate (HR) sensors, Rigas et al. (year) incorporated ECG, GSR, and respiration to detect stress during driving, and Wijsman et al. (year) utilized ECG, respiration, GSR, and trapezius electromyography (EMG) to detect mental stress. Riera et al. (year) combined electroencephalography (EEG) and EMG indicators, while Singh and Queyam (year) employed GSR, EMG, respiration,

and HR to detect driving stress. Mokhayeri et al. (year) used pupil diameter, ECG, and photoplethysmogram as indicators, Baltaci and Gokcay (year) utilized pupil diameter and temperature features, and Choi (year) incorporated heart rate variability (HRV), respiration, GSR, EMG, acceleration, and geographic location in stress detection.

The positive and useful contributions that digital technologies provide to the field of stress reduction and education should be highlighted as a final point. Mobile devices (112–115), a range of ICT apps (116–127), AI & STEM ROBOTICS (128–132), and games (133–135) are some examples of the technologies that enable and improve educational processes including evaluation, intervention, and learning. Additionally, the use of ICTs in conjunction with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [136-162], accelerates and improves educational practices and outcomes, especially for students with stress issues.

9. Conclusion

Based on the insightful contributions of researchers, it has been recognized that smart devices have the capability to identify stress levels in both neurotypical individuals and those with autism. These devices serve not only as sources of entertainment but also as tools for monitoring one's mental state. Furthermore, the advantages of smart devices extend to the individuals themselves as well as their caregivers and teachers. In conclusion, Papoutsi, Driga, and Skiani (2018) emphasize the importance of developing specialized applications that cater to the specific needs of individuals with autism. These applications, particularly those focused on emotion recognition, can facilitate the development of emotional intelligence and improve social interaction skills. However, it is important to acknowledge the limitations of this research. Participants in the study experienced temporary anxiety due to their unfamiliarity with the researcher, and their first-time use of a smart watch may have been distracting. To conduct this research, an exploration of IoT technology, stress and its causes, and the incorporation of stress-detecting sensors into smart devices was necessary. While the study primarily focused on individuals with autism, it does not discount the possibility of a correlation between the variables and neurotypical participants. Further investigation with a larger sample size is required to validate or refute these findings.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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