E-ISSN: 2710-3927
P-ISSN: 2710-3919
IJRSE 2024; 4(1): 01-10

www.rehabilitationjournals.com/autism-journal/
Received: 02-11-2023
Accepted: 03-12-2023

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How a holistic approach to ASD & neuropsychology could contribute to design for autism more effectively

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DOI: https://dx.doi.org/10.22271/27103919.2024.v4.i1a.29

Abstract
Modern studies reveal an extremely high incidence of autism worldwide. The etiopathogenesis of autism is largely untraceable (although genetic, epigenetic, and environmental factors have been implicated). There is no substantial, permanent, and effective treatment of autism. So, it is imperative to have tools that could help in the treatment/training of people with autism. To design such tools, an in-depth understanding of autism is needed. Design is an interdisciplinary field and already routinely uses knowledge from fields as far apart as computer science, educational psychology, sociology and medicine. In this paper, a holistic approach is proposed that draws upon knowledge about autism, including relevant neuropsychology theories, and principles of "Design for All / Universal Design, in order to formulate principles to govern the design of tools for autistic people. The ultimate aim is that this population is aided to acquire an acceptable level of functionality, autonomy and safety.

Keywords: Autism, design, tools, principles, holistic approach, neuropsychology

Introduction
According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) Autism Spectrum Disorder is a group of changes seen at 12-14 months of age that are characterized by disturbances in social interaction and communication and stereotyped, repetitive behavior. Autism is an extremely complex nosological entity, the etiopathogenesis of the disorder is largely undetectable [1-2] and there is no substantial, permanent and effective treatment for autism.
Modern studies reveal an extremely high incidence of autism worldwide. Many attribute this increase to the intense vigilance of parents and health professionals today in terms of early detection of the phenomenon, but also to the change of diagnostic criteria. In general, however, no one disputes the epidemic explosion of the disorder, and according to recent reports from the US Centers for Disease Control and Prevention (CDC), the overall incidence of autism is 1:68 [3].
However, as the number of patients, as mentioned, is constantly increasing, the number of trained therapists is dwindling. In addition, the cost of these treatments remains high. Therefore, it is hoped that use of advanced modern technologies, could help to supply the urgent need for tools that could aid in the treatment/education of autistic people and be a satisfactory alternative or/and complementary solution along with traditional behavioral therapy. The ultimate goal of these tools is that of achieving as early as possible, the highest level of functional autonomy of this population group.
Along with this, it is necessary to also consider the new attitudes to disability. World Health Organization has revised its view of the concept of "disability" and considers it to be an evolving concept, the result of the interaction of the individual with his or her environment. They note:
"Disability results from the interaction between people with a handicap and various behavioral and environmental barriers that prevent them from participating fully and effectively in society on an equal basis with others".
When these barriers that hinder people with handicaps in their daily lives are removed, then the participatory social interaction of the latter improves. Various forms of assistive technologies, when designed and implemented properly to address the needs of each user and their environment, are effective tools that strengthen independence and improve the participatory capacity of the individual.

Current research consistently demonstrates that technological applications are not only acceptable and effective, but progressively necessary for the therapeutic treatment and education of autistic individuals and those around them in everyday life [4-6]. The aim of all applications, systems and other technology tools designed to be used by autistic people is to strengthen their special features and to overcome as far as possible, their weaknesses [7].

In order to design tools for autistic individuals, we need to have an in-depth understanding of ASD and how these individuals function cognitively. It is also important to include Design, an interdisciplinary domain that already uses knowledge from fields such as computer science and engineering, medicine, psychology, sociology, etc.

Design for autism has developed significantly in recent years, but specific principles for designing tools to help achieve functional autonomy for autistic people are varied and fragmented, while some guidelines are specific to certain technologies, e.g., robots [10], while others are only thoughts and suggestions.

In this study, autism was investigated in terms of systemicity and holism, and the conclusions were used to formulate valid principles to guide the design of tools in autism. Along with the systemic view of the autism disorder, insights from neuropsychology, cognitive psychology and pedagogical/educational psychology as well as the terms of universal design were used to more fully understand the complex problem of design for autism and to formulate the above principles.

Methodological approach

The object of study, namely the formulation of tool design principles in autism, was approached through 3 pathways:

Firstly, it was highlighted that autism is a complex/wicked problem and that design itself is a systemic process. Therefore, the approach to the topic of "design in autism" must be done through holistic consideration and analysis.

The second source of knowledge for understanding the cognitive functioning of autistic people and thus for favorable design for them was the broad fields of neuropsychology, cognitive psychology and educational psychology. The most important theories of autism from these disciplines were selected for investigation and analysis. Subsequently those elements whose use in design can lead to the production of tools that increase the functional autonomy of autistic individuals were extracted.

The third approach was the field of Universal Design. The 7 principles of Universal Design at a general level were studied and an attempt was made to use elements of these general principles as building blocks for formulating specific principles for design in autism.

With the knowledge gained from these 3 study components, 9 principles were formulated to guide the interdisciplinary teams designing tools for autistic people.

A holistic approach to autistic spectrum disorder (ASD)

Autism spectrum disorder is a group of changes observed at the age of 12-14 months and characterized by disorders in social interaction and communication and stereotyped repetitive behaviour. It is a fact, however, that the autistic spectrum is very wide. At the same time, modern studies reveal an extremely high incidence of autism worldwide, the etiopathogenesis of the disorder is largely untraceable and there is no substantial, permanent and effective treatment for the situation. All these make the disorder an extremely complex problem, according to Cynefin framework [8]. Systems theory and the science of complexity in general and their tools can contribute to understand and solve holistically such complex problems as autism [9-10].

1.1 The concept of heterogeneity in autism

Heterogeneity is a major feature of ASD and is found both in its etiopathogenesis and phenotypic expression and natural course, but also in its prognosis and treatment, since so many factors have been disparately and unpredictably implicated.

1.1.1 Heterogeneity in etiopathogenesis of autism

Various genetic, epigenetic and environmental factors have been implicated, without any of them claiming a dominant role in the interpretation of the phenomenon [1-2].

1.1.2 Heterogeneity in phenotypic expression of autism

The phenotypic expression of ASD may vary from a person with severe communication disorder and consequent chronic, severe disability to a highly functional person who may attain the level of tertiary education and further, and being considered as "peculiar" or simply "strange" [11]. The coexistence of other neural (e.g.: convulsions, ADHD, sensory disorders, sleep disorders, etc.) and extra-neural manifestations (e.g., gastrointestinal problems) further increase heterogeneity in phenotypic expression of the disorder [12-13].

1.1.3 Heterogeneity in prognosis and treatment of autism

Heterogeneity penetrates autism in its natural course also. 3-25% of autistic children develop within normal limits, while the rest exhibit varying degrees of dysfunction [14].

1.2 The concept of lost complexity

1.2.1 Stereotyped repetitive behavior in autism: represents reduced complexity & increased entropy of human organism

Kanner in 1943 wrote: "The child's behavior is governed by an anxiously obsessive desire for the maintenance of sameness that nobody but the child himself may disrupt on rare occasions".

Repetitive behavior refers to a broad class of responses characterized by their repetition, rigidity, inflexibility, and frequent lack of obvious function. Repetitive behaviors described in individuals with autism include repetitive sensory motor behaviour (stereotyped motor movements, repetitive manipulation of objects, repetitive self-injurious behavior, specific object attachments, compulsions, rituals and routines) and resistance to change/insistence on sameness, rigidity and inflexibility (compulsions, rituals, insistence on sameness, narrow and circumscribed interests, repetitive use of language, food selectivity, food-neophobia and reduced food diversity).

In novel situations it is commonly observed that people with autism may attempt to get things on their terms through behavioral outbursts, withdrawal into obsessive or ritualistic patterns. This means that they respond to different environmental stimuli uniformly and rigidly. Adaptation does not occur [15-16]. The lack of ability to look at an object as a whole, not just as individual pieces, poses another view of lost complexity in cognitive processing of people with autism. When an individual with ASD is expected to process a large amount of stimuli simultaneously, he or she may find it difficult to “break” the whole image or situation into meaningful parts. In contrast, the individual may focus on the pieces that grab their attention the most [17].

According to aforementioned data, repetitive-restrictive behavior constitutes an emergent property of the human organism as a whole system, which represents linearity, reduced diversity, high predictability, de-complexification (reducing complexity) and loss of adaptation of human organism. In other words, in autism the organism as a whole system has lost its variety. However, for living systems loss of complexity and variety is characteristic of disease.

Repetitive and restricted behavior in autism can be conceptualized also as entropy (according to another tenet of systems level approach of autism) and increases when environmental demands are higher (e.g., a novel situation that autistic individual has to cope with). An autistic individual can’t respond to environmental demands so, he engages in entropic activities (insufficient energy transfer, not available to the required work), such as repetitive, restrictive behavior, in order to regain homeostasis and adaptation as a whole system.

1.2.2 Fever in autism: An example of loss of human organism complexity

1.2.2.1 Fever as defense adaptive mechanism which represents increased variety of human organism as a whole system: Fever is an adaptive defense mechanism and beneficial to the infected host in most cases. In terms of complex-dynamic systems theory, pyrogenic reaction constitutes part of human complexity and diversity, as enables the organism to cope with the hostile environment (for example, the infectious agent) [18].

1.2.2.2 Fever in autistic people

Data from the literature indicate that probably there are differences in susceptibility to various infections between normal and autistic children. In particular, studies have shown that autistic children have statistically significant fewer fevers compared with normal children [19-20]. In addition, autistic children tend to have more chronic problems (e.g., gastrointestinal symptoms) compared with normal children [21]. This might suggest that many autistic children have total or partial loss of the body’s ability to develop first-line mechanisms, such as febrile reaction, and thus easily pass in the second and third level defense mechanism lines, such as the occurrence of chronic symptoms or the occurrence of infections without fever. On the other hand, clinical case reports have suggested that behaviors of some children with autism spectrum disorders may improve with fever and return to their “autistic state” after the febrile incident [22]. This phenomenon may represent the organism dynamicity and plasticity of these children. It has been already hypothesized that possibly there are two subgroups of autistic children, one with the possibility of developing fever and the other with the absence of febrile incidents [23]. If it is real and given that fever is an energy-consuming mechanism, those autistic individuals who do not develop febrile incidents are probably trying to save energy in order to adapt and survive in an evolving environment hostile to them, and autistic children who develop fever are at a very critical stage, where it is very important not to lose the defense mechanism of fever development. Consequently, the possibility of fever development or not, represents the increased or decreased diversity, respectively, of autistic child as a whole system.

1.3 The concept of self-reference in autism and mirror neurons

It is understood that in autistic disorder the concept of self-reference is missing or it takes a clearly disadvantage form. Autistic people do not self-report (this is typical of withdrawal from the environment), thus interrupting the cyclical relationship of cause and effect and leading to the emergence of a behavioral deficit in the fields of sociality and communication [24]. On the other hand, stereotypies or even self-injuries sometimes make up a person’s desire to self-excite in the monotonous environment created by him/her [25]. The same conclusion is drawn by the observation that autistic children have an increased threshold of pain [26]. In this way, self-reference in autism is not absent, but takes a clearly disadvantaged form.

The most frequently reproducible finding in functional brain magnetic resonance imaging of autistic persons is the reduced activation of the brain area associated with the perception of humans as compared to that of perception of objects as well as the disorder in the activation of the mirror neurons, which makes the autistic person incapable of assessing the intentions, purposes, desires, emotions, beliefs in the facial expression of others, resulting in a disorder in their social interaction (failure to activate the fusiform gyrus) [27-28].

1.4 The concept of connectivity in autism (from reduced connectivity to reduced communication)

The concept of “connectivity” runs through ASD from “macroscopic” (phenotypic) to “microscopic” (genetic, molecular etc.) level, in an upwards/downwards causality model [29].

1.4.1 Connectivity in autism at macroscopic level (“macro-connectivity”)

At the clinical level, the main area of disturbance in autism is communication, i.e. connectivity with other people.

1.4.2 Connectivity in autism at microscopic level (“micro-connectivity”)

1.4.2.1 Synaptic disorder in autism: Genetic studies show that 80% of the high-risk genes for ASD affect the level of synapses (the specific areas where neurons communicate with each other) [12].

1.4.2.2 Neurotransmitter disorder in autism

A main disorder in autism is the disturbed levels of neurotransmitters (serotonin, dopamine, epinephrine, norepinephrine, acetylcholine, glutamic acid and GABA). Neurotransmitters are the communication molecules that are released at the presynaptic level and guarantee the communication of different areas of the brain with each other, and between brain and other systems of organism [30].

1.4.2.3 Imaging and EEG findings of connectivity disorder in autism

Neuroimaging and electroencephalographic studies show that the connection of brain areas with each other is made in an abnormal way, resulting in poor acquisition and transfer of information leading to the onset of autistic disorder. In particular, connectivity patterns in autism include long-distance under-connectivity and local over-connectivity of the frontal cortex [31]. Consequently, a current model proposes autism as a developmental disconnection syndrome.

1.4.2.4 Disorder in the connection between the nervous and digestive systems in autism: Gastrointestinal problems have been implicated in many people with autism and there is a possible link between the gut and autism pathogenesis. Disruption of tight junctions leads to intestinal hyper-permeability (the so-called "leaky gut") which is implicated in the pathogenesis of diseases such as autism. Indeed, the severity of the disorder is positively associated with the severity of the digestive system symptoms, which has led to the hypothesis that inappropriate communication in autism between these two systems is an etiopathogenetic factor of the disorder [10].

1.4.2.5 Sleep disorder in autism: Sleep problems presented by autistic people are yet another expression of connectivity disorder in autistic disorder, as sleep is critical for the satisfactory communication between brain areas and optimal synaptic functioning [32].

1.4.2.6 Oxytocin in autism: The positive effect of oxytocin administration in autistic people [33], as well as the knowledge that oxytocin is positively involved in the development of close personal and social ties [34], further suggest that the concept of connectivity dominates in autistic disorder.

Based on all of the above, it appears that connectivity disorder characterizes autism both at a high-microscopic level (phenotype) and at a lower level (genetic, molecular, etc.). The reduced/impaired connectivity at lower-scale in autism refers to reduced communication/socialization as an emergent property at the higher-macroscopic scale in autism. When cells-molecules-networks-systems in the brain or elsewhere in the body cease to be connected, then people cease to communicate.

1.5 The concept of abundance in autism

Is autism an anabolic state where overdevelopment results in exhaustion of feedback loops and subsequently reduced system performance?

Autism may represent adaptive metabolism increase program and a "thrifty-less", "over-supply" phenotype, originated from enriched early-life metabolic and nutritional environment, either maternal or of the child itself. However, as with dearth and scarcity, over-supply can also lead to a disorder. In other words, some cases of autism may represent another offspring phenotype of mothers exposed to a "toxic" western life-style, with high fat diet consumption and reduced exercise activity. In systems terms, in this case, the human body as a holistic system is exhausted by the sustained positive feedback cycles due to increased resources and energy, resulting in the emergence of autistic behavior [35].

2. Neuropsychology theories about autism

The broad field of neuropsychology, cognitive psychology and educational psychology provides many theories about the understanding of autistic behavior. The most important theories of autism from the aforementioned disciplines were selected for investigation and analysis and those elements whose use in design can lead to the production of tools that increase the functional autonomy of autistic individuals were extracted [36].

2.1 Theory of mind

Theory of mind refers to the ability of an individual to recognize the mental states of others, including beliefs, desires, intentions, imagination, and emotions.

Individuals with ASD do not understand that other people have thoughts and that those thoughts may be different from their own (mind-blindness). All verbal messages are taken literally and unlike neurotypical children, children with ASD may have difficulty reading and relating to others [37].

2.2 Theory of Executive Dysfunction

Executive function is an umbrella term for functions such as planning, working memory, impulse control, inhibition and mental flexibility, as well as for the initiation and monitoring of action. The set of cognitive control processes enables self-regulation and self-directed behaviour towards a goal, allowing us to make decisions, evaluate risks, plan for the future, prioritize and sequence our actions, and cope with novel situations.

Many individuals with autism are thought to lack certain executive functions that lead to trouble reorienting attention from one task to another, poor impulse control, disorganized and inflexible thoughts or actions, and inappropriate, out-of-the context behaviour. This impairment would also be the origin of stereotyped and repetitive behaviours [38].

2.3 Weak Central Coherence Theory

This theory refers to enhanced local processing and "weak" part-whole integration and explain unusual attention to details among individuals with ASD. Weak central coherence involves the inability of people with ASD to integrate details into a meaningful whole and their unusual focus on parts rather than the whole (failure to see the big picture). Without central coherence, individuals lack the ability to interpret emotions based on facial expressions, they have abnormal attention to detail and distress over even the smallest changes in the physical environment. In language, some higher-functioning individuals with ASD understand the meanings of individual words but struggle to understand the meaning of complete sentences or they have issues discerning irony, metaphors, or mere jokes [39].

2.4 Gestalt Theory

Gestalt theory is used to understand how individuals organize the stimuli they are presented with and how one organizes their perceptions into a coherent whole. The Besides the weak central coherence perception, Gestalt theory emphasizes that the whole of anything is greater than the sum of its parts. According to Bogdashina [40], a typical brain "fills in the gaps" and "predicts" the final picture.

When an individual with ASD is expected to process many stimulations simultaneously, he or she may find it difficult to "break" the whole image or situation into meaningful parts. In contrast, the individual may focus on the pieces that grab their attention the most and lacks (they may not see the forest for the trees).

2.5 Sensory Integration Theory

Individuals with ASD often have abnormal responses to incoming sensory information from the surrounding environment or they have deficits in sensory integration due to the inability to process information from several senses at once [41]. As a result, the individual feels confusion, irritation, or an inability to participate and act properly. This maybe manifested through being hyper-sensitive to stimuli or being hypo-sensitive (under-reactive) to stimuli. Hypo-sensitive cases appear to be under-responsive, as if certain sensory information goes unnoticed or certain senses are impaired. Hypo-sensitive cases are often qualified as "sensory-seeking", meaning they often create or generate their own sensory experiences either for pleasure or to block out other unpleasant stimuli. Conversely, hyper-sensitive cases are over-responsive to sensory stimuli. Children with hyper-sensitivity can be easily overwhelmed by incoming sensory information [42].

2.6 Intense World Syndrome & Relative Theories
According to this theory, autistic people suffer from excessive neuronal processing that may render the world painfully intense for them. This may lead to obsessively detailed information processing of fragments of the world and an involuntarily and systematic decoupling of the autistic person from what becomes a painfully intense world. It is suggested that they are prefer to become trapped in a limited, but highly secure internal world with minimal extremes and surprises [43].

In accordance with this view, it is also suggested that people with autism might be living in a "world changing too fast": they can't follow what's happening around them, so they withdraw from their surroundings. Recent functional magnetic resonance imaging (fMRI) and electrophysiological studies support these hypotheses [44-45].

2.7 Flow Theory
Flow state is the mental state in which a person performing an activity is fully immersed in a feeling of energized focus and enjoyment. In other words, the state of concentration is so focused that it amounts to absolute absorption in an activity [46].

Flow theory has been used quite extensively in assistive technology design and methodology and the accomplishment of flow state is very important also for the self-actualization of people with ASD and it increases their self-esteem [47]. So, it is a target when designing for them.

2.8 Monotropism & Stimulus Overselectivity
Monotropism is a cognitive strategy posited to be the central underlying feature of autism. A monotropic mind is one that focuses its attention on a small number of interests at any time, tending to miss things outside of this attention tunnel. Murray *et al*. [48] propose that strategies for the way attention is used is normally distributed, and to a large degree genetically determined, between those with a broad use of attention, and those who concentrate attention on a small number of interests. Those at the tightly focused end of this spectrum are those diagnosed as on the autism spectrum.

Monotropism also suggests a reason for the sensory integration difficulties found in the accounts of autistic people, as they suggest there is a 'hyper-awareness' of phenomena within the attention tunnel, but hypo-sensitivity to phenomena outside of it. A monotropic focus leads to a fragmented view of the world, and from such a viewpoint it is exceptionally hard to make sense of social interactions [49].

2.9 Social Learning Theory
Bandura's Social learning theory emphasizes the importance of observing and modeling behaviors, attitudes, and emotional reactions of others, as well as imitation. Bandura states [50]: "Most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action".

There is impaired social learning in autism: autistic people are not interested in other people or perhaps they perceive them as objects – not persons [51].

2.10 Multiple Intelligence Theory
Learning styles have a great impact on how individuals learn or process information given to them. Multiple intelligences, including spatial, linguistic, logical-mathematical, bodily-kinesthetic, musical, interpersonal, intrapersonal, existential and naturalistic, are factors in determining how individual sees and process the surrounding environment [52].

The most common intelligences in autism are spatial (visual) intelligence (learning through pictures is a major strength for children with autism) and bodily-kinesthetic intelligence. Also, strengths in the musical and other non-personal intelligence are commonly found in those with autism but least common is the intrapersonal intelligence (autistic child may not even be able to refer to himself) [53].

The learning needs of children with autism can be encouraged through the use of their learning strengths of multiple intelligences and learning styles [54].

3. Design for all / Universal design
"Universal Design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design", according to the Centre for Universal Design at North Carolina State University. This is an adaptive and flexible approach that encourages tolerance and acceptance of diversity, providing multiple and varied opportunities in order to information construction. Universal Design is a goal that puts high values on diversity, equality, and inclusiveness [55].

Following are the principles of Universal Design, each followed with an example of its application:

1. **Equitable use:** The design is useful and marketable to people with diverse abilities. For example, a website that is designed to be accessible to everyone, including people who are blind and use screen reader technology, employs this principle.
2. **Flexibility in use:** The design accommodates a wide range of individual preferences and abilities. An example is a museum that allows visitors to choose to read or listen to the description of the contents of a display case.
3. **Simple and intuitive:** Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. Science lab equipment with clear and intuitive control buttons is an example of an application of this principle.

4. **Perceptible information:** The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities. An example of this principle is captioned television programming projected in a noisy sports bar.
5. **Tolerance for error:** The design minimizes hazards and the adverse consequences of accidental or unintended actions. An example of a product applying this principle is software applications that provide guidance when the user makes an inappropriate selection.
6. **Low physical effort:** The design can be used efficiently, comfortably, and with a minimum of fatigue. Doors that open automatically for people with a wide variety of physical characteristics demonstrate the application of this principle.
7. **Size and space for approach and use:** Appropriate size and space are provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility. A flexible work area designed for use by employees who are left – or right-handed and have a variety of other physical characteristics and abilities is an example of applying this principle.

4. Basic principles to guide tool design in autism
Based on the systemic view of autistic disorder, the theories from the individual scientific fields of neuropsychology, cognitive, pedagogical and educational psychology and the application of systemic thinking in design and education analyzed in the relevant chapters, the principles that can give good guidance in the design of tools and systems aimed at achieving the functional autonomy of autistic individuals, are listed below [56]:

4.1 Principle of individualization
In autism there is no "average patient type" ("the average disabled person" or "average context") and therefore there is no one-size-fits-all solution [57]. International guidelines for the treatment and management of autistic people recommend that any treatments and other types of interventions for these individuals should be characterized by a high level of specificity and individualization [58]. Individualization should concern not only the autistic person (his/her characteristics and skills) but also the environment of the person [59] and the type of skill to be learned: some tools are more effective at training and learning a skill than others [7].
The principle of individualization derives from the concept of heterogeneity (lack of homogeneity) that "runs through" the autistic disorder as a whole, as was developed earlier. Moreover, the theory of multiple intelligences and its application to autism, can contribute to tracing the "strengths" of each autistic child, to enhance and encourage them to create a feeling of "belonging", which finally results to their functional autonomy. Moreover, the theory of sensory integration dysfunction in autism (according to which some children are over-responsive to sensory stimuli in the environment and others are under-responsive) also captures this heterogeneity underlying autistic disorder and consequently the need for individualization in any design efforts for autistic people. Finally, the principle of individualization, as described in this section, aligns with the first principle of Universal Design, called "Equitable Use", which dictates that design should to provide the same means for use by all users, equal when possible, equitable but individualized when not.
It is clear that understanding the principle of individualization in design ("user-centered" design concept) creates the conditions for the designer to mentally grasp the target group for which he or she is going to design, to know that by definition some children will be more responsive than others to the design intervention, and to define the skills in the learning or improvement of to which the design product can contribute [7].

4.2 Principle of complexity or unpredictability
In autism the human body as a holistic system has lost its complexity and behaves in a uniform and predictable way. Autistic children have difficulty developing new behaviors [60]. This lack of creativity leads to rigid behavior, which manifests itself in the way autistic children play: this way is more primary and characterized by a lack of variety, compared to children of neurotypical development of similar age and functional skills [61].
The aim is to re-introduce the complexity of the individual when interacting with his/her environment, as well as to learn the concept of accepting the unpredictability that governs the real world.
Autistic people find it difficult to analyze and process complex scenarios that involve a wide range of variables and choices. In contrast, autistic individuals learn easily in well-structured, demarcated, and predictable environments, through practices that are consistently repeated with a specific ("stereotypical" we would say) sequence of actions (it is precisely this way of learning and education that takes advantage of autistic people's ability to stereotype) [59].
The ability of a tool to create environments that gradually become more complex increases its effectiveness (leading to the functional autonomy of the autistic person) through processes of safety and tolerance. The overall stimulation experienced by the individual can be reduced or diminished and the mistakes that may occur are not catastrophic [62].
In conclusion, principle of complexity is originated from the idea of the lost complexity of the human organism as a holistic system in autism, while neuropsychology theories (theory of mind, theory of weak central coherence, Gestalt theory, theory of sensory integration dysfunction, theory of monotropism and stimulus hyper-selectivity). This principle is also in line with the 3rd principle of Universal Design ("simple and intuitive use"), according to which the goal in design should be to reduce unnecessary complexity, and the 4th principle of Universal Design ("perceptible information"), according to which the design should provide the information to be learned in a multiple ways, levels and contexts in order to increase the possibility of its assimilation.

4.3 Principle of escalation or scaling
The complexity to be offered for learning must be scaled, i.e. gradually enriched, so that it can be accepted by the autistic person and they can achive training. That is, the image of the world, when we use a tool with the autistic person, should gradually become complex (to a degree proportional to the receptivity of each individual) until it reaches the complexity of realistic situations, because it is the lack of flexibility and imagination, the rigid behavior and the increased anxiety that the autistic person presents to

new challenges.

The concept of complexity, as discussed in the section on the systemic view of autism, and the theories of mind deficit, weak central coherence, sensory integration dysfunction, intense world syndrome, monotropism and multiple intelligences are the sources of inspiration and of cognitive material for the construction of this principle. Also, the 2nd (flexibility in use), 3rd (simple and intuitive use) and 4th (perceptible information) principles of Universal Design are contained in this principle.

4.4 Principle of controlled variability and flexibility

Flexibility is a concept that plays a central role in every social situation. Each social situation is unique and therefore requires flexibility in response, depending on the subtle nuances of each case.

Flexibility is related to control and safety. Flexibility is a prerequisite for control (when a tool is flexible it means that it operates in a controlled environment) and it results in safety (when the environment where the tool is applied is under control, the anxiety of autistic children is reduced, the latter become able to design how they will act next and they do not need to produce the stereotyped, repetitive movements [63].

Flexibility is also related to variability. The ability to be flexible provides a high level of variability and therefore variety. Autistic individuals show reduced variability and variety in their behavior, which is evident in their reduced ability for symbolic play, creativity and imagination [64].

Similarly, flexibility is critical in autistic disorder, where sociability and communication are at a disadvantage. This signals rigidity (lack of flexibility) in their thinking and difficulty in shifting their attention between objects, people and topics of interest [63].

In the case of designing in autism, the tool should allow the complexity of the situation to be learned/managed to be either increased (if the learning of the process is progressing so that it can move on to the next phase or if the child becomes distracted and seems bored so that the level of attention is maintained) or decreased (if it is not progressing). It is valid argument for the tool to be easy to use to the extent that it is tolerable to, and capable of being managed by, the autistic person [62].

Stereotypies, on the other hand, a central-nuclear symptom of the autistic disorder, are associated with its severity. Thus, as the flexibility of a tool may be related to the reduction of stereotypies, it is concluded that it is a key feature that is legitimately governs the design of tools for autism, that lead to increased functional autonomy of individuals in this group.

The analysis of the concepts of heterogeneity and complexity in autism in the relevant section, as well as the theories of executive dysfunction, deficit of mind and weak central coherence have contributed to the formulation of this principle. This principle is in line with the 2nd principle of Universal Design, which includes flexibility of use in general, as the design must serve a wide range of abilities and preferences of individuals.

4.5 The Familiarity Principle

The autistic person has extreme resistance to unfamiliar experiences, as has already been analyzed. Thus, the basic principle of designing tools for this category of people is that the tools should include features, activities or programs that are familiar to them.

This principle is derived from the analysis of the concepts of complexity and abundance in autism, while the central theories (deficit of mind, weak central coherence), as well as the theory of Intense World Syndrome and the theory of monotropism and stimulus hyper-selectivity provide a theoretical background for the above principle. This is also a guideline from the Universal Design principle 3 of Simple and Intuitive use, which advises that designs be consistent with user expectations, or what the persons knows.

The fulfillment of the familiarity principle prepares the ground for the fulfillment of the generalization principle [64] discussed below, and thus enhances the effectiveness of the tool and subsequently the functional autonomy of the autistic person.

4.6 Principle of repeatability

The tool should provide the possibility of repetition, as autistic people learn best in well-structured environments through practices that are repeated in a stereotyped ritualistic way. Repetition helps to encode acquired knowledge into meaningful internal symbols and then store it in memory [65]. Maintaining this knowledge in turn is a prerequisite for generalization, i.e. transferring the acquired skill to the real world by producing the corresponding behavior.

The principle takes advantage of the ability of autistic people to stereotype and derives from the concept of reduced complexity in autistic disorder.

4.7 The principle of generalization

Generalization is the way of developing knowledge through the cognitive transition from the specific to the general. This ability is strongly associated with the ability to find similarities in different situations, an ability that is strongly associated with abstraction, while at the same time it is a prerequisite for adaptability to new conditions, a property inherent to most people with normal development.

When autistic people faced with a new situation they do not know where to begin. The result is that the presence of novel situations does not lead to adaptation. The lack of generalization ability in autism leads to the stereotyped behavior and obsessive thinking of autistic people [15, 62].

An effective tool/application must therefore meet the principle of generalization. Generalization in this case is the property to apply the newly acquired abilities of the autistic person to the real world. Thus, the tool should ultimately enable the autistic person to transfer the skill acquired during his/her interaction with it (the tool) to the real world, i.e. beyond the time and place where the training/therapy took place. Such a tool is governed by the principle of generalization, which it gradually promotes [62]. Fulfillment of the principle of generalization is a criterion of the effectiveness of the tool.

In short, the concept of lost complexity of the human organism as a holistic system in autism and neuropsychology theories (deficit of mind theory, weak central coherence theory and Gestalt theory) contribute to the construction of this principle.

4.8 Principle of self-control

It would be important for the tool to enable the person to monitor himself/herself to perform the task in which he/she has been trained.

This would, as has been analyzed, contribute to the activation of mirror neurons (whose deficiency in autistic disorder is significant) through imitation, to the optimization of the autistic person's self-report and finally to generalization, i.e. the transfer of the behavior/skill acquired to the real world and environment.
The principle of self-control derives from Bandura's theory of social learning, discussed earlier. According to this theory, human behavior is primarily learned through observational learning [65]. This observation of behavior can be done either by watching live models perform a behavior (vivo modelling), by watching recordings (film, video) (video modelling), or by imagination.
Video modelling has been found to be effective (for a variety of skills - social, language, play, shopping, etc.) not only in neurotypical people [66], but also in autistic children, as it takes advantage of the ability of autistic people to be over-focused, to like visual (rather than other, e.g. vocal) stimuli and their inherent avoidance of social interaction [67-68].
Theory of social learning and the concept of self-reference, which were analyzed in the relevant sections, contribute to the construction of this principle.

4.9 The human factor

The human factor when using tools for learning skills (especially when it comes to social communication, emotional stimuli, imitation, eye contact) is necessary so that the "autistic person does not become more autistic". The human factor (in the sense of the therapist and/or peers, parents, etc.) [69-70] has a dominant role in design, as the concept of connectivity is predominant in autism.
The above principles should be taken into account when designing tools for ASD, as it is known that autistic people have strong and "rigid" likes and dislikes [71] Furthermore, fulfilling these principles increases the likelihood of creating a "flow state" when the individual interacts with the designed product (self-activation of autistic individuals and an increase in their self-esteem eventually), which is crucial as it indicates the strong effectiveness of the tool, which is the ultimate goal.

Conclusions

In this study we are attempting to see how the systemic approach to the autistic disorder, the "Design for All/Universal Design" Principles and neuropsychology theories can be used to formulate principles to govern to the design of tools for autistic people, to aid them to obtain an acceptable level of functionality, autonomy and safety within society. With the knowledge gained from these 3 study components, 9 principles were formulated that are important to guide the interdisciplinary team designing tools for autistic people. It is shown that holisticity/wholeness (the lack of which is a major feature of the autistic view of the world) and interdisciplinary are key to designing for autistic people.
We hope this study provides some insight into the experiential world of autistic children and the principles can contribute to make a bridge between scientists and the design research community.

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