A Property Checklist to Evaluate the User Experience for People with Autism Spectrum Disorder

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Abstract. Autism Spectrum Disorder (ASD) refers to a neurodevelopmental disorder which is characterized by repetitive patterns, and difficulties with social interaction and communication. People with ASD have, an affinity with technology; many studies designed and/or developed specific systems for this kind of users. Some studies have evaluated the usability and UX of such systems through general evaluation methods. It is important to consider adaptations to the UX evaluation methods when evaluating systems designed for people with ASD, because these users have a diversity of characteristics, affinities and needs that traditional methods do not consider. Given the need for specific evaluation methods, in this paper we propose a property checklist for interactive systems designed for people with ASD, based on our previous proposal of 9 UX factors. Two versions of the property checklist are proposed, a full version and a compact version, which include 9 categories (directly related to the 9 UX factors), and 50 and 24 items, respectively. These property checklists are intended to assess compliance with specific recommendations and may help evaluating UX in systems designed for people with ASD.

Keywords: Autism Spectrum Disorder · User eXperience · Property checklists · UX factors for ASD

1 Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that people can suffer from, which is characterized by restricted repetitive patterns of behavior, interests, activities, and alterations in social communication and social interaction [1]. After a systematic review of the literature [2] carried out in previous works, we have been able to show an increase in the interest of research in developing and designing systems for people with ASD, mainly because technology provides the users with a reliable and safe environment. Because people with ASD may have a diversity of characteristics, needs, and affinities, we have reviewed in the literature [3] how studies consider these characteristics when developing and designing systems for these users. By analyzing the studies found [2, 3], we have realized that concepts such as usability and/or User

eXperience (UX) are concepts considered and applied by the authors, and some of them have evaluated these concepts through multiple evaluation methods. However, these studies have evaluated their systems through assessment methods without considering the characteristics, affinities, and needs of people with ASD.

Using particularized evaluation methods, that consider the characteristics, needs and affinities of people with ASD, is necessary when evaluating systems designed for said users. Given the need for evaluation methods and a particular evaluation methodology for people with ASD, we have described a preliminary proposal for a methodology to evaluate UX in systems for people with ASD [4]. The methodology recommends a set of user testing and inspection methods that can be applied. Our proposed methodology recommends that the first inspection method to be carried out, when evaluating systems designed for people with ASD, is the property checklist method.

In this paper we propose two particularized property checklists to preliminarily evaluate systems for people with ASD. These checklists are presented as a full version and a compact version, which include 9 categories, and 50 and 24 items, respectively. We have based these property checklists on our proposal of 9 UX factors for people with ASD [5]. These factors are: engaging, predictable, structured, interactive, generalizable, customizable, sense-aware, attention retaining and frustration free.

This rest of this paper is organized as follows. Section 2 presents a theoretical background. Section 3 presents and describes a proposed property checklist based on the nine UX factors for people with ASD. Finally, Sect. 4 presents conclusions and future work.

2   Theorical Background

2.1   Autism Spectrum Disorder

Autism Spectrum Disorder is a condition characterized by repetitive patterns, difficulties with social interaction and communication, as defined in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [1]. DSM-5 remarks that this condition is characterized by two domains of deficits, such as: (1) social communication and social interaction, and (2) restricted repetitive patterns of behavior, interests, and activities. Additionally, depending on the degree of support that people with ASD require, they are categorized under three categories of severity: level 1 "Requiring support", level 2 "Requiring substantial support" and level 3 "Requiring very substantial support".

2.2   User Experience

The ISO 9241-11 standard defines usability as "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [6]. User eXperience (UX) extends the concept of usability beyond effectiveness, efficiency and satisfaction. The ISO 9241-210 standard defines UX as "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" [7]. That is, UX is the degree of "satisfaction" that users obtain when interacting with the system or product.

2.3 Property Checklist

A property checklist is a list of criteria or elements organized in a systematic and logical way [8], allowing users to verify the presence or absence of listed elements to guarantee that all are considered or completed. Property checklists are related to a series of high-level design properties, such as consistency or feedback, and low-level design properties, such as the color or size of the characters on the screen [9].

A property checklist is an inspection method, which means that it is a review carried out by a set of evaluators, who are generally experts, based on their own judgment [10]. There is no final user involvement. The fulfillment of the items detailed in the property checklist are verified by the evaluators. On some occasions the elements of the property checklist can give clues to design solutions [9].

3 Property Checklist Proposals

3.1 Developing the Property Checklist

In a previous systematic literature review [2] we have found that the UX evaluation methods used in multiple studies related to systems designed for people with ASD, were not adequate for these users and needed a particularization. People with ASD present characteristics which must, undoubtedly, be considered when designing solutions for them and evaluating said solutions. It is important to have methods and/or methodologies that consider the characteristics, affinities and needs of people with ASD. For the same reason, in previous works we have proposed a methodology to evaluate the user experience in systems designed for people with ASD [4]. The methodology considers 3 sequential stages, these are: "planning stage", "execution stage" and "results analysis stage". The first step in the "execution stage" is the execution of a property checklist, which considers the execution of the property checklist method, which has the role of providing a quick first view of the shortcomings that the evaluated system may have.

To define our specific property checklist for use in systems for people with ASD, we have relied on studies that have developed checklists focused on evaluating the usability of different systems [11–13]. These studies detail that, to design the questionnaire for a specific property checklist, a usability criteria or factors must be used as the basis to define the questions defined in the checklist.

These criteria must be specific to the context in which the checklist is to be used, so to design a specific questionnaire for systems for people with ASD, we have based it in our proposal of 9 particularized UX factors for people with level 1 ASD [5] (according to the severity levels of the DMS-5 [1]). These 9 particularized UX factors have been created based on Morville's UX factors [14], characteristics, affinities and needs of people with ASD, and guide design recommendations found in the literature. The 9 particularized UX factors are: engaging, predictable, structured, interactive, generalizable, customizable, sense-aware, attention retaining and frustration free.

Considering these 9 UX factors we have created a proposal for a property checklist to evaluate the UX for people with ASD. For each item we are specifying the original references. In some cases, references are missing, as some items are based on our own judgement. This property checklist proposal is presented below.

1. **Engaging.** This category focuses on evaluating how the systems provide elements that commit the user to interact with them. The category is defined as: "The system commits the user to interact with it". Elements like feedback, rewards, and motivational elements are at the core of this category [3, 15–23]. To evaluate compliance with these elements, we propose 6 items:

   1.1. The system delivers constant feedback to the user in a clear and concise manner. This must be not only through text but also through visual elements or audio [19].
   1.2. The system does not deliver demotivating messages to users in the event of a mistake made [18].
   1.3. The system provides rewards to the user for positive actions or good performance [3].
   1.4. The system has a history of the actions performed by the user.
   1.5. The system allows users to see the performance of users over a period of time.
   1.6. The system allows users to view past activities, so they can perform them again.

2. **Predictable.** The predictable category focuses on the structured thinking of people with ASD. Systems need to provide a predictable environment, which is why this category is defined as: "The system has a predictable environment, generating an environment of trust among users". Concepts such as the repetition of actions, control over the system and consistency in the system, have been considered for the fulfillment of this category [3, 15, 18, 20–25]. A total of 4 items details the predictable category:

   2.1. The system doesn't have sudden and unexpected actions.
   2.2. The content of the system is predictable and consistent [3].
   2.3. The system allows the user to pause, restart and/or cancel actions [22].
   2.4. The system allows repeating actions, tasks or activities [15].

3. **Structured.** Category defined as: "The system is structured". Having a clear, logical, and simple structure is important when designing solutions for people with ASDs [3, 15, 18, 19, 21, 22, 24–26]. Considering this, 3 items have been established that address these aspects:

   3.1. The system's navigational setup, aesthetics, and content are structured and consistent [26].
   3.2. Navigation in the system is simple and logical [24].
   3.3. The expressions and language used in the system are consistent and intuitive.

4. **Interactive.** The interactive category focuses on the importance of considering the characteristics, affinities and needs that people with ASD present when interacting with the system. This category is defined as: "The system generates interactions taking into account the characteristics, affinities and needs of the users, as well as their difficulties in social interactions". Memory load, tasks that grow in complexity

and instructions with a clear and simple objective, are some of the aspects considered [3, 15–22, 24, 26, 27]. We propose 6 items for this category:

4.1. The system includes a variety of tasks that are simple, concise, and grow in complexity based on the progress of the user [22].
4.2. Each task has a clear and explicit objective [18].
4.3. Instructions are provided to users from the first interaction.
4.4. Instructions on the system are clear, simple, brief and context-appropriate [20].
4.5. The user can access the instructions at any time.
4.6. The system provides elements to minimize the memory load of the user (for example: grouping and delivering the necessary and concise information to the user) [19].

5. **Generalizable.** Category defined as: "The system is familiar enough and similar to real life to facilitate generalizing skills". Having content, visual and audio elements in the system that are easy to interpret is important when working with people with ASD [3, 19, 20, 26]. Four items detail the generalizable category:

5.1. Activities, tasks or information in the system are based on previously learned activities, tasks or information [20].
5.2. The interaction with the system is familiar and similar to the real life of the users.
5.3. Visual aesthetics, audio and touch inputs are similar to real life.
5.4. The system has language, phrases, and concepts familiar to users [19].

6. **Customizable.** Considering that people with ASD have a diversity of characteristics, affinities and needs, this category focuses on aspects that help personalize the system [3, 15–23, 26, 27]. This category is defined as "The system can be customized considering the needs, abilities and preferences of people with ASD". A total of 5 items have been considered:

6.1. The system allows the user to customize frequent actions [19].
6.2. The system considers personalization in the event of possible fine motor problems in users [22].
6.3. The system allows users and tutors to customize aspects quickly, easily and effortlessly. (eg. disable sounds, configure the level and intensity of the sounds, modify the color palette, font type, size, layout and activity times) [26].
6.4. The system adapts to the level of expertise, needs and/or preferences of the user [19].
6.5. The system has a predefined basic configuration that considers the characteristics, affinities and needs of users with ASD [22].

7. **Sense-aware.** ASD people may have hyper- or hypo-reactivity to sensory input, so it is necessary for systems to consider these characteristics. The sense-aware category is defined as: "The system considers the senses of users with ASD". Having a clear,

understandable and relevant design, graphics and audio are some important aspects to consider [3, 15–29]. Below are 10 items to consider:

7.1. The system provides information to the user through multimedia, texts, among others [22].
7.2. The system provides light and dark color modes, and does not have bright colors, and contrasts that can be uncomfortable [26].
7.3. The visual and sound elements are clear, meaningful, functional, non-disruptive and legible.
7.4. Visual elements (such as icons) are clear and aesthetically pleasing and are provided to communicate ideas [18].
7.5. Each clickable element has a clear functionality and is easily selectable and recognizable [22].
7.6. The actions and states of the system are clear and simple.
7.7. The system interface is clear, simple and minimalist [22].
7.8. There is a prudent number of functionalities, images, texts, animations, among others, in each view of the system [22].
7.9. Texts have clear messages, readable font size and type, and are free of rhetorical figures.
7.10. The system uses a clear, familiar, precise and appropriate language.

8. **Attention Retaining.** The attention retaining category is defined as: "The system retains users' attention and manages time appropriately". Time management of transitions and activities, generating stimuli that help retain attention, avoiding elements that cause distraction, are relevant in systems designed for people with ASD [15, 18–22, 25, 27]. In order to evaluate this category, 5 items have been created:

8.1. The waiting time between transitions, tasks or activities is minimal [27].
8.2. The system responds to user actions in real time and without delays [19].
8.3. Transitions are simple, with no distracting sounds or animations.
8.4. The system provides dynamic stimuli such as animations and/or controlled music to attract users' attention [18].
8.5. The system views do not provide distracting elements [25].

9. **Frustration Free.** The frustration free category is defined as: "The system tries to avoid the frustration of its users during their interaction". Preventing, recognizing and recovering from errors are key elements in order not to frustrate users. In addition, it is important to keep in mind that the information communicated in this error handling must be clear, precise, with a close and simple language [3, 19, 20, 22, 25, 26]. Below is a total of 7 items to consider:

9.1. The system allows you to confirm, cancel or repair unwanted actions [22].
9.2. Impossible actions to be carried out in the system are notified in a timely, clear and simple manner [19].
9.3. Errors are presented in a controlled way, avoiding "strong" colors and loud noises.

9.4. Users are able to quickly find information and solutions to any problem, which are clearly presented and easy to execute [22].

9.5. The system displays error messages in plain language, accurately indicates the problem and constructively suggests how to avoid such errors [22].

9.6. The documentation and help provided by the system is provided in a visual, textual, concrete, not extensive and structured way.

9.7. The system asks the user clearly, precisely, simply and in real time to confirm actions [19].

3.2   An Abbreviated Property Checklist

Considering that the time and resources can be limited when carrying out the UX evaluation, we propose two property checklists:

- **Full version**: proposal that includes the 9 categories and 50 items detailed above. It is recommended to use this version if you have enough time and resources to be able to evaluate the compliance of each of the items and submit any comments.
- **Compact Version**: proposal that contemplates the 9 categories and 24 items. These 24 items have been selected from the full version list, and we believe that they represent the essential elements to comply in each of the categories. We recommend using this version if time and resources are limited.

The compact version of the property checklist is presented below.

1. **Engaging.** The system commits the user to interact with it. Category has 3 items in its compact version. These items have been chosen because they focus on feedback, rewards and progress. These elements are necessary according to the definition of the engaging UX factor [5].

   1.1. The system delivers constant feedback to the user in a clear and concise manner. This must be not only through text but also through visual elements or audio [19].

   1.2. The system provides rewards to the user for positive actions or good performance [3].

   1.3. The system has a history of the actions performed by the user.

2. **Predictable**. The system has a predictable environment, generating an environment of trust among users. Category that has 2 items in its compact version. These items have been chosen because they focus on concepts such as repetition and predictability. These elements are necessary according to the definition of the predictable UX factor [5].

   2.1. The content of the system is predictable and consistent [3].

   2.2. The system allows repeating actions, tasks or activities [15].

3. **Structured.** The system is structured. Category that has 2 items in its compact version. These items have been chosen because they focus on aspects such as structure, consistency and simplicity. These elements are necessary according to the definition of the structured UX factor [5].

    3.1. The system's navigational setup, aesthetics, and content are structured and consistent [26].

    3.2. Navigation in the system is simple and logical [24].

4. **Interactive.** The system generates interactions taking into account the characteristics, affinities and needs of the users, as well as their difficulties in social interactions. Category that has 4 items in its compact version. These items have been chosen because they focus on the characteristics that tasks, instructions and content must have, and minimizing memory load. These elements are necessary according to the definition of the interactive UX factor [5].

    4.1. The system includes a variety of tasks that are simple, concise, and grow in complexity based on the progress of the user [22].

    4.2. Each task has a clear and explicit objective [18].

    4.3. Instructions on the system are clear, simple, brief and context-appropriate [20].

    4.4. The system provides elements to minimize the memory load of the user (for example: grouping and delivering the necessary and concise information to the user) [19].

5. **Generalizable.** The system is familiar enough and similar to real life to facilitate generalizing skills. Category that has 2 items in its compact version. These items have been chosen because they focus on how tasks, activities, content and interaction with the system should be familiar and previously learned by the users. These elements are necessary according to the definition of the generalizable UX factor [5].

    5.1. Activities, tasks or information in the system are based on previously learned activities, tasks or information [20].

    5.2. The interaction with the system is familiar and similar to the real life of the users.

6. **Customizable.** The system can be customized considering the needs, abilities and preferences of people with ASD. Category that has 2 items in its compact version. These items have been chosen because they focus on the customization of system elements in a flexible and fast way. These elements are necessary according to the definition of the customizable UX factor [5].

    6.1. The system allows users and tutors to customize aspects quickly, easily and effortlessly. (eg. Disable sounds, configure the level and intensity of the sounds, modify the color palette, font type, size, layout and activity times) [26].

    6.2. The system has a predefined basic configuration that considers the characteristics, affinities and needs of users with ASD [22].

7. **Sense-aware.** The system considers the senses of users with ASD. Category that has 4 items in its compact version. These items have been chosen because they focus on the importance of having visual, audio and language elements that are clear, legible, understandable, minimalist and functional. These elements are necessary according to the definition of the sense-aware UX factor [5].

   7.1. The visual and sound elements are clear, meaningful, functional, non-disruptive and legible.

   7.2. The actions and states of the system are clear and simple.

   7.3. The system interface is clear, simple and minimalist [22].

   7.4. The system uses a clear, familiar, precise and appropriate language.

8. **Attention Retaining.** The system retains users' attention and manages time appropriately. Category that has 3 items in its compact version. These items have been chosen because they focus on elements to retain attention, elements that are not distracting and the response time of the system. These elements are necessary according to the definition of the attention retaining UX factor [5].

   8.1. The system responds to user actions in real time and without delays [19].

   8.2. The system provides dynamic stimuli such as animations and/or controlled music to attract users' attention [18].

   8.3. The system views do not provide distracting elements [25].

9. **Frustration Free.** The system tries to avoid the frustration of its users during their interaction. Category that has 2 items in its compact version. These items have been chosen because they focus on error handling (preventing, recognizing and recovering from errors) and communicating errors, solutions and documentation in a clear, simple and close manner. These elements are necessary according to the definition of the frustration free UX factor [5].

   9.1. The system displays error messages in plain language, accurately indicates the problem and constructively suggests how to avoid such errors [22].

   9.2. The documentation and help provided by the system is provided in a visual, textual, concrete, not extensive and structured way.

3.3 Using the Property Checklist

When using any of the proposed property checklists, we recommend:

- Having evaluators who are familiar with the context and the system to be evaluated. Considering the complexity and objective of the evaluation to be carried out. If required, and if you have enough time and resources, carry out one or two pilot tests
- Having the support of at least 3 or 5 UX experts.
- Having the support of at least 3 or 5 experts in the ASD domain, such as: experts in the areas of psychology, speech therapy and special education.

- For each item, the evaluator must indicate compliance with it through a 5-point scale. Please note that some items may not be assessed until the end of the assessment.
- The evaluators will be able to grant general observations for each one of the 9 categories.

The evaluators should identify the compliance with each item through a Likert scale of 5 options: "Totally not compliant" (1), "Not compliant" (2), "Neutral" (3), "Compliant" (4) and "Totally compliant" (5). We expect the evaluators to take notes regarding the problems associated to each item and indicate where they were found in the system.

Once compliance with each of the items has been identified, both in the full version or in the compact version, a qualitative and quantitative analysis can be carried out. Obtaining as a result a percentage of satisfaction of the system designed for people with ASD, charts that visually represent said results and observations of the evaluators.

4 Conclusions and Future Work

Several studies have evaluated the usability and/or UX of systems designed for people with ASD through non-specific evaluation methods. People with ASDs have a diversity of characteristics, needs, and affinities that are not considered in standard assessment methods. As a first step to develop particularized evaluation methods for systems designed for people with ASD, we have created a property checklist proposal. Studies [8–10] mention that for the creation of a property verification list it is necessary to have usability criteria or factors that provide a theoretical basis for the items or elements to be considered.

We have created two proposals for property checklists, a full version and a compact version, which have the objective of evaluating the UX in systems designed for people with ASD. These proposals are categorized into 9 categories, which are directly related to our proposal of 9 UX factors (engaging, predictable, structured, interactive, generalizable, customizable, sense-aware, attention retaining and frustration free) for systems designed for people with ASD [5]. The full version property checklist has 50 items, which is recommended to use in case of having enough time and resources to be executed. The compact version property checklist has 24 essential items from each category which is recommended to use if there is not enough time and resources to be executed.

Additionally, we have provided some recommendations that should be considered when using the property checklist. An example of these recommendations is having the support of professionals in the domain, such as experts in the areas of psychology, speech therapy and special education, and experts in usability and/or UX.

We hope that our property checklist will be useful for designers and developers of systems for people with ASD. This checklist can be used to design systems based on the different items presented, as well as be used to evaluate existing systems, and thus ensure a minimum level of quality and satisfaction for users with specific needs such as people with ASD. When applied as a first step in our methodology to evaluate UX in systems designed for people with ASD, this property checklist will provide evaluators a quick first view of the shortcomings that the evaluated system may have.

In future work, we want to validate and refine the property checklist proposal and use it as an inspection method in our proposed methodology to evaluate the UX of people with ASD.

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