applied sciences

MDPI

Article

Requirements of a Supportive Environment for People on the Autism Spectrum: A Human-Centered Design Story

Lukas Wohofsky [1,*], Arianna Marzi [2], Federica Bettarello [3], Luca Zaniboni [2,4], Sandra Lisa Lattacher [1], Paola Limoncin [3], Anna Dordolin [3], Simone Dugaria [2], Marco Caniato [2,*], Giuseppina Scavuzzo [3], Andrea Gasparella [2] and Daniela Krainer [1]

[1] Research Unit Active and Assisted Living & Institute for Applied Research on Ageing, Carinthia University of Applied Sciences, 9020 Klagenfurt, Austria
[2] Faculty of Science and Technologies, Free University of Bozen-Bolzano, 39100 Bolzano, Italy
[3] Engineering and Architecture Department, University of Trieste, 34127 Trieste, Italy
[4] Department of Environmental and Resource Engineering, Indoor Environment, Technical University of Denmark, 2800 Kongens Lyngby, Denmark
* Correspondence: l.wohofsky@fh-kaernten.at (L.W.); marco.caniato@unibz.it (M.C.); Tel.: +43-5-90-500-3219 (L.W.); +39-0471-017145 (M.C.)

check for updates

Citation: Wohofsky, L.; Marzi, A.; Bettarello, F.; Zaniboni, L.; Lattacher, S.L.; Limoncin, P.; Dordolin, A.; Dugaria, S.; Caniato, M.; Scavuzzo, G.; et al. Requirements of a Supportive Environment for People on the Autism Spectrum: A Human-Centered Design Story. *Appl. Sci.* **2023**, *13*, 1899. https://doi.org/10.3390/app13031899

Academic Editor: Jing Zhao

Received: 20 December 2022
Revised: 24 January 2023
Accepted: 29 January 2023
Published: 1 February 2023

Abstract: People on the autism spectrum have a different perception of the environment than neurotypical people and often require support in various activities of daily living. Assistive technology can support those affected, but very few smart-home-like technologies exist. To support people on the autism spectrum in their autonomy and safety and to help caregivers, a smart home and interior design environment was developed. Requirements were gathered by employing a holistic human-centered design approach through interactive workshops and questionnaires to create a useful and user-friendly solution. From this process, requirements for a comprehensive solution (the SENSHOME environment) emerged. These requirements include a set of functionalities tailored to the needs of people on the autism spectrum, such as a crowd warning that informs when many people are in a certain area (for example, the entrance), an automatic light regulation system, or a daily life planner that supports task completion. Furthermore, inclusive furniture elements such as a refuge seat or a table with dividers can support wellbeing, autonomy, and safety. This paper demonstrates a consequent and considerable participatory research approach and the story from the target group and context of use through design requirements to the initial design solution of the SENSHOME environment.

Keywords: autism spectrum; human-centered design; smart home; interior design

1. Introduction

People on the autism spectrum experience the environment differently than neurotypical people. Environmental factors such as sounds, temperature, or light can be triggers for critical behavior [1–9]. Due to a lack of the filtering function, stressors cannot be processed properly and can lead to an overload. When it comes to an overload, (auto-)aggressive behavior or other dangerous situations can occur. Dependent on the different characteristics of the autism spectrum, people do often need support, which is mostly provided by formal and informal caregivers [10].

The diagnosis of autism spectrum conditions has increased in recent years. According to recent research, prevalence rates make up about 0.6% of the world's population [11].

Assistive technologies can support people on the autism spectrum in multiple dimensions of daily living [12–17]. A literature review was conducted looking for digital tools and assistive technologies that support people on the spectrum. According to the review, very few smart-home-like technologies exist, aiming at increasing the autonomy of people with autism. At present, the majority of assistive technology for people on the autism spectrum is based on wearable devices or smartphones. Anyway, the advantage of a smart home in comparison to wearable technology is its unobtrusiveness [18].

In this framework, it is important to find new solutions capable of improving individuals' independence, indoor comfort, and safety. This will help people on the spectrum, their families, and caregivers live an easier everyday life. For this reason, the European project SENSHOME was designed and funded. It concerns a research process that aims to develop a smart home and interior design solution that is tailored to the needs of people on the autism spectrum and their caregivers. The main aim of this solution is to support people with autism in their own home environment (which can either be assisted living facilities or private settings), to be more autonomous and to increase their safety and wellbeing, and to assist the caregivers [19]. SENSHOME was a cooperative project combining different professions and thus knowledge in the consortium (acoustics, indoor comfort, architecture, interior design, assistive technology, participatory research, automation, and software development). To meet the resources, needs, and challenges of people on the autism spectrum and caregivers, a holistic human-centered design (HCD) approach [20] was applied from the very beginning of the project and followed throughout. Different needs of potential users were gathered and transformed into tailored smart home and digital functionalities.

The objectives of design for people on the autism spectrum have been reoriented and broadened to work not only based on deficits but also on the skills that people with autism have, sometimes in a particularly developed way [21]. The chances of an independent life, which the project aims to improve, also depend on the role and social image of the person with autism [22]. These aspects have been investigated, focusing on spheres such as language and sociality, identity and subjectivity, or narrations. In light of this, the involvement of the environment among future users is essential for the fruitful personalization and enhancement of specific skills, such as visual and spatial skills [23,24]. The research on architecture for people with autism has also identified some critical issues related to the different design guidelines and manuals usually used to guide autism-friendly projects. A comparison of the available technical documents [25] showed that the best way to achieve good results is by using a HCD approach: as previously demonstrated [26], architects' attention has to focus on listening as well as involving users and other experts in this field. These data should be used to sort design choices with regard to spaces and materials. Consequently, designers will be able to foster reciprocity in creating an inclusive process by exploiting the potential of diversity.

The aim of this paper is to show the pathway and results of a holistic HCD process to identify the requirements and develop a smart home and interior design solution to foster autonomy, wellbeing, and safety for people on the autism spectrum and also support their caregivers. The focus is on the requirements of an environment that can be used independently by people on the autism spectrum with low or medium severity (DSM-V Level 1 and 2) [27] and can be used equally by caregivers. Thus, people with more severe types of autism can also profit from SENSHOME.

2. Materials and Methods

Throughout the entire SENSHOME project, a holistic HCD process was followed to develop a solution that meets the needs and requirements of the main target group of people on the autism spectrum but is also useful for caregivers. Therefore, people on the autism spectrum and their caregivers were put at the center of the development process. To gather a comprehensive overview of the resources and needs of people on the autism spectrum and thus collect the requirements of a supportive environment, the experience of caregivers was a main input for SENSHOME. HCD comprises four phases that are typically conducted in an iterative manner: (1) understand the users in their context of use; (2) specify design requirements; (3) design solutions; and (4) evaluate the design against the requirements [20]. In the presented work, phases 1 to 3 of the approach are mainly described, showing the process from the initial target group definition to the functionalities and furniture elements of a comprehensive solution to foster the autonomy and safety of people on the autism spectrum.

Before reaching out to the users and gathering their information and requirements, a literature review on all issues concerning the research aspects of the project was conducted ([18,25,28,29]). After this, various stakeholders were involved in the development process, and the results gathered were set in the context of the literature findings.

A total of 25 workshops with different stakeholders were held between January 2020 and April 2021. Due to the COVID-19 pandemic that had its first peak at the beginning of the user interactions in the project, all events took place online via video calls and supportive tools (MURAL [30], PaletteHome [31]). The workshops followed different aims that built on each other. Starting from the target group definition and the context of use, the needs and requirements of people on the autism spectrum were gathered (UI1.x-series). This comprised two workshop series with caregivers (UI1.1 and UI1.2) where the characteristics, needs, challenges, and daily routines of the later users were gathered. Furthermore, design guidelines for people on the spectrum were collected (UI1.3), and a questionnaire to assess the sensitivity to indoor environmental parameters (namely thermohygrometric, acoustic, visual, and air quality factors) (UI1.4) was conducted.

Based on that first phase, the features and functionalities of the SENSHOME solution were developed and validated with stakeholders. Additionally, first drafts of the main elements of the user interface (the central monitoring and control unit for the SENSHOME environment) were designed within the user interactions (UI2.x series). In workshops UI2.1, UI2.2, and UI2.3, features and functionalities were developed and validated. Then, first design drafts of the furniture were evaluated (UI2.4), and further requirements for interior environments were gathered (UI2.5). A combination of these processes, together with the literature results ([18,25,28,29]) and discussions within the consortium, led to a comprehensive smart home and interior design solution specifically focused on people on the autism spectrum (named the SENSHOME environment). The process, including different methods and user interactions, is shown in the flowchart in Figure 1.

For an overview of the conducted workshops and questionnaires, their participants, and the aims of each user interaction, see Table 1.

Table 1. Overview of conducted user interactions.

User Interaction (UI)	Target Group	Aim
UI1.1 (workshops)	Formal caregivers (5 participants)	Understanding of the target group and context of use (personas, user days)
UI1.2 (workshops)	Informal caregivers (3 participants)	Understanding of daily routines, challenges, context of use (user days)
UI1.3 (questionnaire) "ask the architect"	Designers, architects (16 participants)	Learn about design guidelines and best practices to design for people on the autism spectrum
UI1.4 (questionnaire)	People on the autism spectrum, formal and informal caregivers (146 participants)	Information about stress perception of environmental factors
UI2.1 (workshops)	Formal caregivers (8 participants)	Elaboration of features and functionalities of SENSHOME; drafts of the user interface
UI2.2 (workshops)	Informal caregivers (3 participants)	Presentation, validation, and further development of functionalities; drafts of the user interface
UI2.3 (workshop)	People on the autism spectrum (1 participant)	Validation of features and functionalities of SENSHOME; drafts of the user interface
UI2.4 (workshops)	Formal and informal caregivers, people on the autism spectrum (22 participants)	Validation of interior design elements
UI2.5 (workshop) "in my room"	People on the autism spectrum (5 participants)	Understanding of internal environment perception

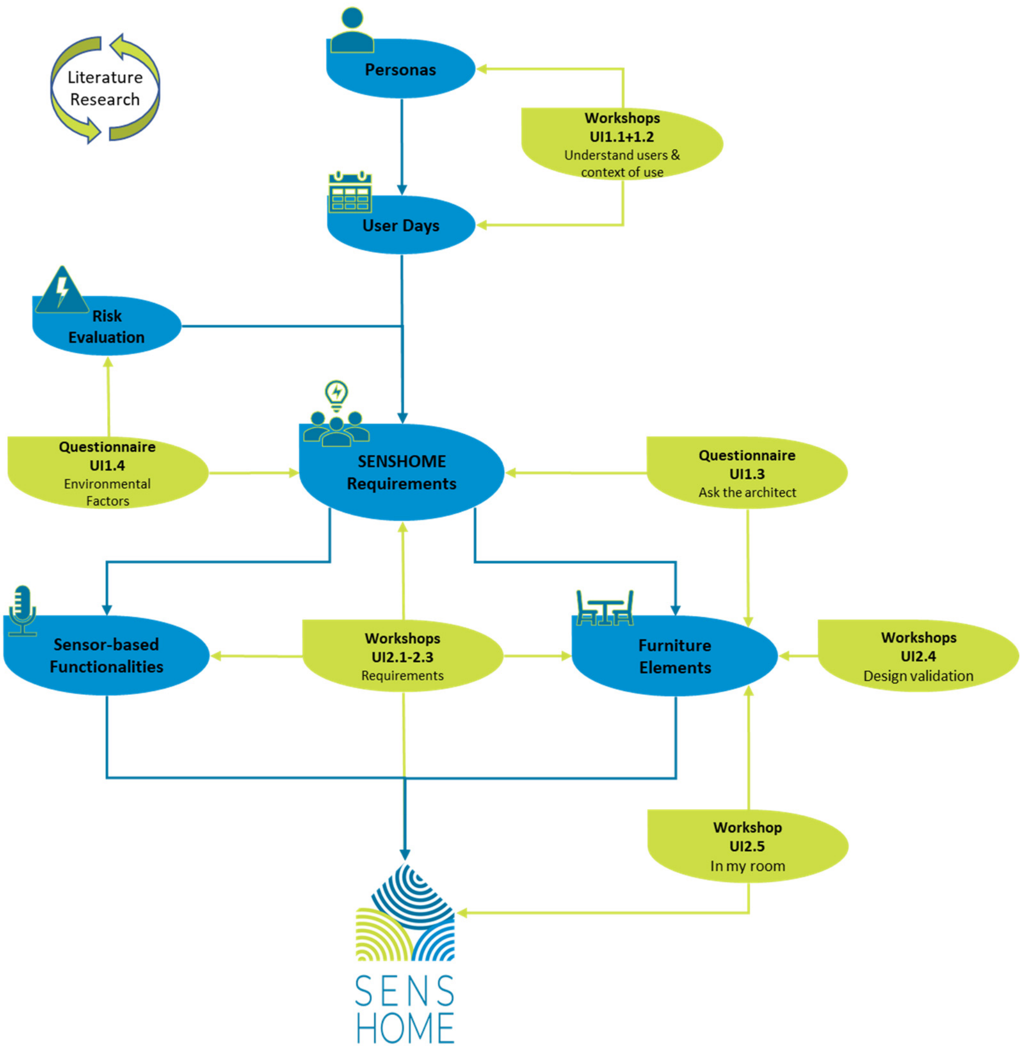

Figure 1. Processes that led to the SENSHOME environment.

2.1. Users, Routines and General SENSHOME Requirements

Within the HCD approach, different supportive methods can be used to permit a structured and congruent process from the very beginning. These methods include "personas", which are useful to graphically and generally represent the later users. These archetypes of the actual users show people on the autism spectrum with their resources and needs and give insights into different contexts of use. They are helpful to foster a common understanding of the target group [32]. Based on the personas, "user days" were developed, including common activities of daily living in the different settings the SENSHOME solution can be used in (care facilities and private households). The user days give insights into potential risk factors, such as stressful situations, and show how mitigating measures can provide assistance and, thus, how assistive technologies might support people concerned to live an autonomous, safer, and more comfortable life.

A total of 8 participants took part in workshops UI1.1 and UI1.2. Three different personas and user days were developed with the help of the experience and knowledge of the participants of the workshops. Through the different backgrounds of the participants, multiple aspects of personas and user days were considered. Personas and user days representing the institutional context, such as an assisted living environment, were based on the experience of formal caregivers. The home environment with its routines and challenges in this setting was developed based on the knowledge of informal caregivers.

In workshops UI2.1–UI2.3, a total of 12 participants were involved. The content of the workshops was the discussion and elaboration of features and functionalities that the

SENSHOME environment should comprise. The proposed elements of the environment were based on the resources and needs of the different target groups gathered from previous user interactions and the literature. The participants rated all of the proposed elements in terms of importance and were asked what other functionalities the smart home and interior design solution should include (what is missing). Furthermore, the user interface was drafted based on the suggestions of the participants to define the main elements that are needed.

2.2. Sensitivity Assessment for Environmental Factors

National and international standards dealing with comfort, security, and accessibility have been found to generally refer to the needs of neurotypical users in defining design requirements and thresholds, while details or sections dedicated to users with divergent needs are missing [33]. Thus, focused considerations and adjustments based on the results of a questionnaire (UI1.4) and workshops were necessary. Since environmental factors are potential stressors for people on the autism spectrum and can trigger critical reactions, the questionnaire (UI1.4) aimed at detecting the specific sensitivity to the 4 considered environmental domains (thermo-hygrometric, acoustics, visual, and indoor air quality).

Particularly, this questionnaire was designed to be answered by both people on the autism spectrum and their caregivers. As described by the DSM-V [27], autism can feature several comorbidities, including difficulties in written and oral communication [34,35]. For this reason, it is common to use surveys among proxy respondents to receive indirect feedback on daily conditions, stress factors, or perceptions of non-verbal people with autism. Since the project is aimed at autonomous and assisted living environments, the questionnaire was administered to as many people on the spectrum as possible, regardless of comorbidity or severity of the spectrum. To identify the specific problems and needs of people living in these environments, parents and formal caregivers were included in the questionnaires.

Participation was voluntary and promoted through the network of associations participating in the project on the Italy–Austria territory, and then extended to the European level through cooperation with Autism Europe.

In addition to a module dedicated to the collection of biographical data, such as spectrum severity, comorbidities, gender, and age, a sensory stimulus perception survey was conducted for each of the four environmental aspects. A specific sensitivity scale was developed to characterize each individual considered in the survey concerning the four aspects (thermal, visual, acoustic, and air quality comfort), asking the respondent to classify the individual according to four levels (0–3) by increasing sensitivity or a hyposensitivity level (H). In addition, sensitivity was classified according to its occurrence: regular or sporadic (S). Below is a description of the different options:

- Absent (0): no abnormal stress levels from the indicated factor;
- Minor (1): an increase in stress levels of limited and/or non-systematic intensity and/or frequency from the indicated factor;
- Average (2): a systematic increase in the stress level of average intensity and/or frequency from the indicated factor;
- Extreme (3): an increase in the level of stress of high intensity and/or frequency from the indicated factor;
- Sporadic (S): increased sensitivity cases present in a sporadic and non-systematic way (few observations, low repeatability, or predictability), even if of high intensity. Same scale as above (0,1,2,3);
- Hyposensitive (H): a hyposensitive form of the indicated factor (i.e., no reaction despite an obvious stimulus). Box "H" is to be ticked alone in this case.

Results were collected both via an open online questionnaire and an offline questionnaire administered on-site at an organization of daycare services [36,37].

2.3. Risk Evaluation

Environmental and accidental risks were investigated to set the requirement priorities for the SENSHOME solution. Their detection is useful to foster wellbeing and avoid risks for people on the autism spectrum. These risks can also be identified as changes in environmental parameters, which can cause discomfort, severe stress, and even crises. Accidental risks can be identified as unexpected events ("accidents"), the consequences of which may not only provoke stress in individuals but also expose them to dangerous conditions [28].

The results of the above-described questionnaires on the sensitivity to environmental domains allowed for the identification of the conditions (or their changes) that can potentially affect the wellbeing of persons on the autism spectrum. The results would then be used to develop the SENSHOME environment.

In addition, national and international guidelines on the safety of living environments were compared with the specific needs of people on the autism spectrum identified during the workshops [28]. The final list of the considered accidental risks combines the results of the workshops, the review of national and international guidelines, and the scientific literature [38–42].

For each environmental and accidental risk, a severity (level of danger, seriousness) and a probability (possibility of the risk happening) score were assigned to each possible room of a typical dwelling, according to the process described in [28]. At this point, a dedicated scale (the MoSCoW scale) was used (Table 2) to highlight the priorities in environmental and accidental risk avoidance and the parameters to be monitored by the sensor system integrated into the furniture elements. This scale considered the severity of the risks identified.

Table 2. Association of the priority MoSCoW scale with the levels of severity.

M—Must Have	S—Should Have	C—Could Have	W—Will Not Have
severity = 4 ÷ 5	severity = 2 ÷ 3	severity = 1	/

2.4. Interior Design

The development of the furniture elements was based on several pillars: the literature research, the results from workshops, the results of a survey administered to designers and architects (UI1.3), the intermediate validation of furniture elements (UI2.4), and the results of a design workshop with people on the autism spectrum (UI2.5).

An analysis of existing furniture for autism was conducted to understand which elements the market is lacking and how these elements can be designed/integrated to foster and support a more independent life, as well as improve the quality of life of families and caregivers. The most relevant aspects of wellbeing and quality of life in everyday life were explored: acoustic comfort, spatial sequencing, escape space, compartmentalization, sensory zoning and safety [43], and adaptability.

A specific interview and online questionnaire named "Ask the architect" (UI1.3) was developed to investigate architects' points of view, specifically dedicated to the design of residential spaces for people on the autism spectrum. This was also useful to understand how guidelines for autism-friendly design were known and used by designers. Another aim was to understand which references were consulted the most. In fact, the available design guidelines tend towards simplification, focusing on the identification of constants and common elements and not on differences and individualities. For this reason, designers were asked if the application of such guidelines leads to problems when designing for a specific person or a specific group of people. Specific questions on projects and open questions on architects' points of view have been obtained involving designers from different regions. Recruitment was conducted via emails to more than 100 single architect's offices and associations in Italy and Austria (areas of the project region). Furthermore, experienced professionals in autism-friendly design from all over the world were invited to participate in the questionnaire. In total, 35 designers replied, and questionnaires were sent to all of them. Of the 35 professionals reached, 16 returned completely answered and five partially answered questionnaires (not all the designers had participated in all the phases of the design process investigated by the questionnaire). The majority of participants came from Italy (13), but also from the U.S.A. (2), the U.K. (3), Denmark (2), and Spain (1).

After the design process of the SENSHOME furniture, an intermediate validation procedure was conducted involving stakeholders and potential users (UI2.4) by the means of workshops. In these, a detailed presentation of each designed object was followed by a discussion with the working group, dealing with three main aspects: the appearance and aesthetic quality, the usefulness and practicality of it, and its usability in a safe way. For each aspect, participants were required to express a score from 1 to 10 (1 = poor, 10 = excellent), with the possibility of adding notes and suggestions. All furniture elements were presented, also indicating the integrated sensors and the events they are intended to detect. It should be noted that the SENSHOME environment can be customized to be integrated into existing furniture.

The next step focused on the study of the indoor space; the aim was to define more specifically the spaces that would make up the SENSHOME environment. Therefore, an interactive design workshop named "In my room" (UI2.5) was held. The workshop involved five young adults on the autism spectrum with low severity (DSM-V Level 1), supported by a psychologist and four designers. Participants designed a model of their own room and were assisted by designers (from a technical point of view) in transforming their ideas into drawings and models. This activity was performed using the same procedure as used in university design workshops. The participants were autonomous in using tools such as cutters and scissors and making their own choices of favorite objects, shapes, and colors. They were provided with samples of the materials (fabrics, woods, and finishes), magazines from which to cut out pictures of objects, and a basic plan of the room with appropriate minimum dimensions. The participants started with this empty plan to create the design and three-dimensional model of their room. Their involvement has allowed them to identify the needs and desires for a space where they can live independently. It was an opportunity to observe how they live and what they would like their living space to be like.

3. Results

As proposed in the HCD process, the results start with the initial target group and context of use analysis by means of personas and user days. The literature served as a basis for setting up a first draft of the personas [10], which were further developed in UI1.1. In total, three personas were designed to cover a broader spectrum of aspects in different areas to better understand future users. An overview of the severity of autism, the care needs, and the communication skills gives an impression of the personas' capabilities and needs. In the personas' descriptive part, information is provided about the characteristics of autism, social life and communication, education and occupation, interests and hobbies, as well as comorbidities and other symptoms. An individual picture of this fictive person is shown and extended with the needs of the person and the assistance that is required. Through that, the framework of possible requirements and functionalities can be derived.

Based on the personas, the user days show the first requirements and occurrences of the SENSHOME environment, which was further elaborated and validated in workshops with stakeholders (UI1.2). General daily routines describing (instrumental) activities of daily living are graphically presented. One of the three developed user days is shown in Figure 2. The combination of persona and user day can be seen in [44].

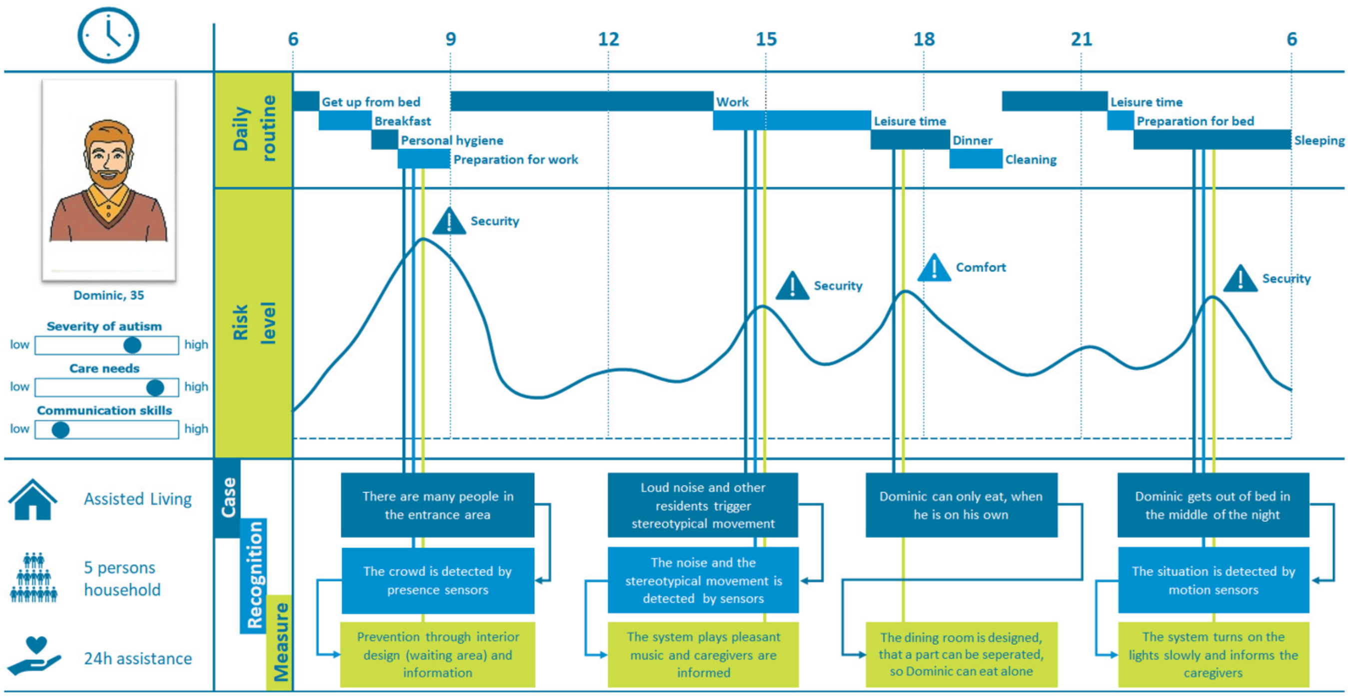

Figure 2. User day of a fictive person on the autism spectrum.

3.1. Results of the Sensitivity to Environmental Domains

A total of 146 participants completed the questionnaire on environmental domains. In general, most of the questionnaires were filled out by caregivers, followed by parents, and only to a small extent by people on the autism spectrum (Table 3).

Table 3. Overview of participants from the questionnaire on environmental domains.

	Participants	Local Survey	Online Survey	Total
Respondents	People on the AS	3	5	8
	Caregivers	41	38	79
	Parents	26	33	59
	Total	70	76	146
Gender distribution	Female	19	29	48
	Male	49	44	93
	Other	2	3	5
	Total	70	76	146
Autism severity distribution	Low severity	33	23	56
	Medium severity	24	21	45
	High severity	13	32	45
	Total	70	76	146

From the analysis of the questionnaire answers, it emerged that the thermal, visual, and indoor air quality (IAQ) topics showed the same trend. It can be seen that the majority of people on the autism spectrum were not particularly sensitive ("not at all") to the variations of these parameters. Conversely, acoustic perception showed a different trend, where more than 80% of the people on the autism spectrum were classified as "minorly", "averagely", or "extremely" sensitive to this environmental factor. The sensitivity of the "sporadic" type was about 5% for all 4 comfort domains (Figure 3). In this paper, only general results on the four comfort domains are reported, while a complete analysis of all the questions explored in the sensitivity questionnaire is reported in [36,37].

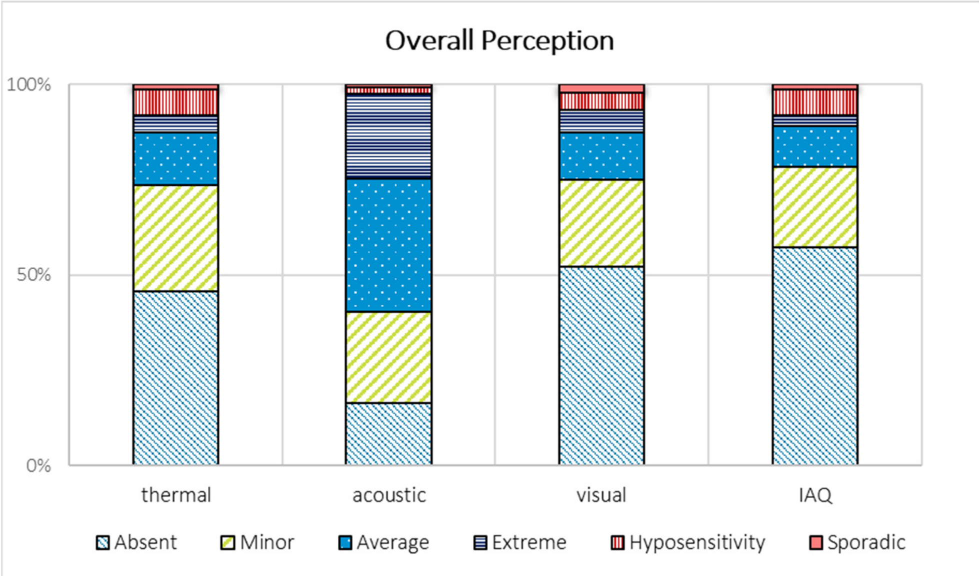

Figure 3. Overall sensitivity of people on the autism spectrum.

The special sensitivity to environmental stimuli of people on the autism spectrum allowed for the development of requirements and suggestions for the SENSHOME solution. It contributed to understanding which rooms of living environments are most risky for people on the autism spectrum.

3.2. Results of Risk Evaluations

This section shows the results of the risk analysis for both environmental and accidental risks. Risk detection is derived from information retrieved from the literature ([38–42]) integrated with the results of the questionnaire (environmental risks) and workshops (accidental risks).

In this way, it was possible to identify the main risks affecting people with autism in their living environments, as well as the rooms where environmental and accidental risks are most likely to happen (i.e., the kitchen and bathroom). As an example, spider plots with a probability and severity of risks in the kitchen of a typical dwelling are shown in Figures 4 and 5. Results regarding all the rooms of a typical dwelling are reported in spider plots in Appendix A (Figures A1 and A2).

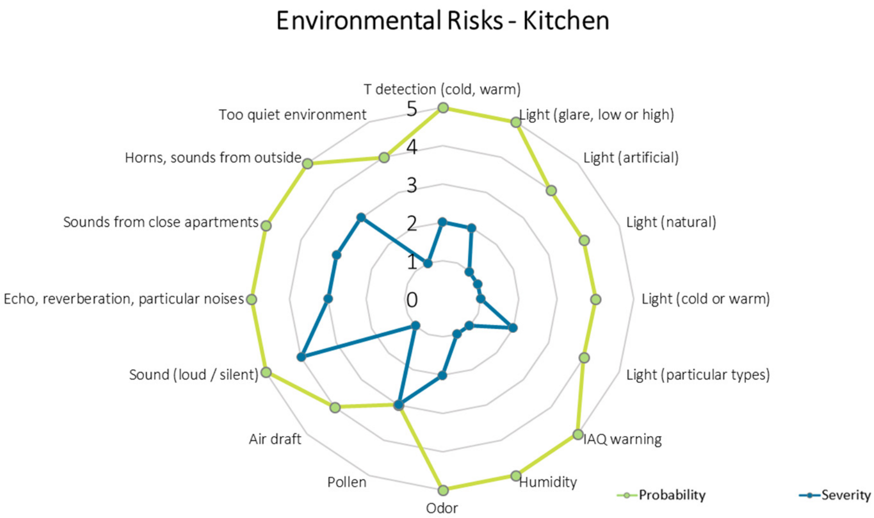

Figure 4. Probability and severity in the kitchen of a typical living environment: Environmental Risks.

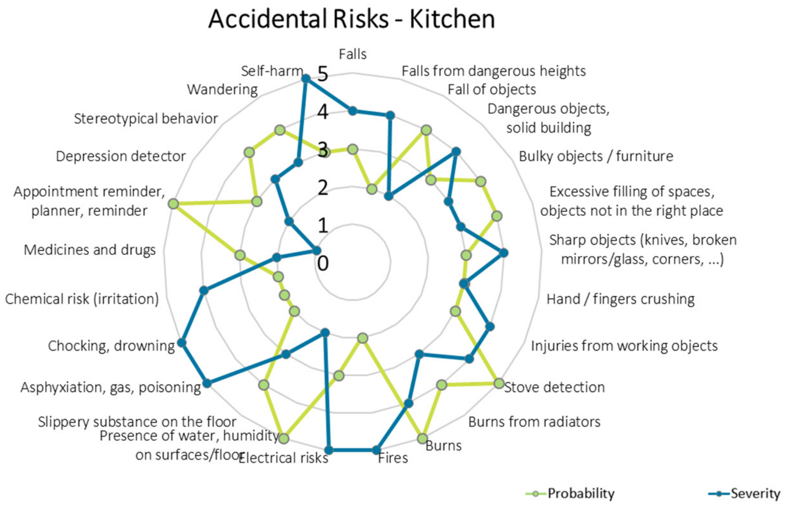

Figure 5. Probability and severity in the kitchen of a typical living environment: Accidental Risks.

Due to the higher impact reported in questionnaires (see previous paragraph), acoustic-related environmental risks show the highest values of severity. Nevertheless, shares of the population being sensitive to light, temperature, and odor exist; therefore, these elements should not be neglected in the development of autism-friendly living solutions. General casualties (electrical, fires, etc.), as well as events that are typically dangerous for people with autism (e.g., presence of bulky objects, access to medicines, self-harm), constitute accidental risks. An opposite tendency can be observed when analyzing environmental and accidental risks. Focusing on environmental risks (Figure 4), it can be seen that, although the severity of the events is low, the probability is always high (≥ 4). Conversely, focusing on accidental risks (Figure 5), it can be seen that when the severity of an event is low, its probability is high, and vice versa. Further discussion about these results is reported in [28].

To further help to understand the priorities in the living environment design and monitoring (i.e., sensors needed to be integrated into the furniture), the information derived from the spider plots was interpreted in a MoSCoW matrix. The matrix with environmental and accidental risks in rooms (kitchen, living room, bedroom, bathroom, corridor, and storage room) is listed in Tables A1 and A2 (Appendix A).

By adopting the MoSCoW scale, it was possible to identify the environmental risks to be monitored, e.g., in the kitchen. In this case, the only environmental risky event with a high priority (Must Have) is the sound environment. Conversely, the accidental risks to be monitored for the kitchen are the following: falls; access to and the presence of dangerous objects; injuries from dangerous objects; possible burns; the presence of cookers and the possibility of detecting their unattended ignition; fire and electrical risks; and the risk of asphyxiation and inhalation of dangerous gases and self-harm.

Even though risks with lower severity are not to be underestimated either, this matrix can provide important information in the priority considerations for the dedicated design of safe environments for people on the autism spectrum, contributing to the development of the combined requirements (Figure 1) of the SENSHOME environment (crowd warning, sound, light, temperature, humidity, and air draft detection, IAQ, controlled compartments, home safety, solid buildings, and ceiling lamps).

3.3. Results from Interior Design Questionnaires and Workshops

The designers who choose to involve users with autism or their families in the design process have elaborated new strategies to meet the users' wishes and needs. Putting together those architects' opinions, considering their difficulties (also related to timing and budget), and analyzing their achievements have been important steps in the design process of the SENSHOME environment.

According to the findings of the questionnaires (UI1.3 and UI1.4) and workshops (UI1.1, UI1.2, UI2.1, and UI2.2), as well as visits to facilities for people on the autism spectrum and the literature [45–50], first drafts of furniture and interior design elements were developed. In total, eight functional elements were designed. The design images and details of the components are shown in Figure 6 and Table 4.

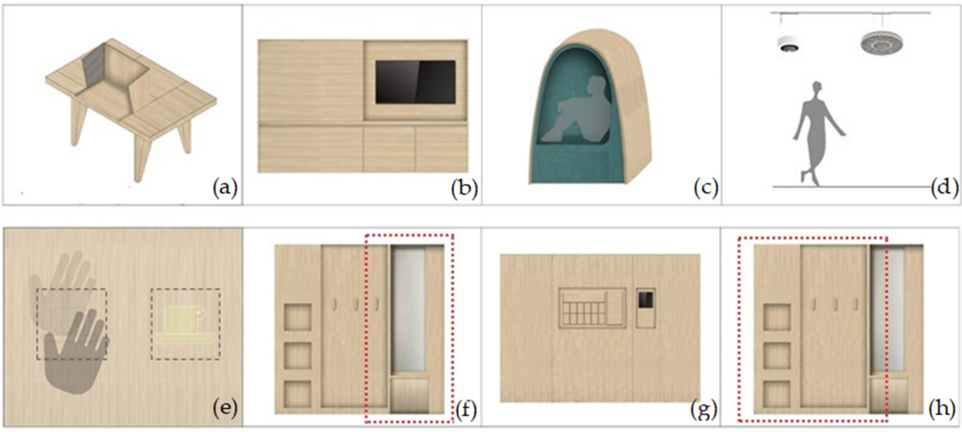

Figure 6. Design images of the SENSHOME furniture: table with dividers (**a**); TV cabinet (**b**); refuge seat (**c**); ceiling lamps (**d**); lighting pictograms (**e**); threshold cabinet (**f**); visual agenda (**g**); and entrance wardrobe (**h**).

Table 4. Overview of SENSHOME components.

Component	Background	Functionality
	Sensor based functionalities	
Crowd warning	People on the autism spectrum might face stressful situations when they enter a crowded area.	Monitoring the number of people in a certain area, e.g., the entrance, and providing information and notification on the user interface.
Sound detection	Sudden, persistent, or intense sounds can create stressful situations for people on the autism spectrum.	Monitoring of the sound level and providing information on the user interface; absorbing materials integrated into the furniture to minimize the reverberation time and facilitate sound monitoring.
Light detection	Intense light can be a source of stress for people on the autism spectrum; moreover, light can alter the level of attention.	Monitoring of the illuminance level, providing information on the user interface, and the possibility to adjust the light (direct or diffuse light, intensity, and color temperature); if feasible, adoption of automatable direct sunlight shading and lighting systems as well as non-reflective surface finishes.
Temperature andhumidity detection	In some people on the autism spectrum, a condition of thermal discomfort can lead to stressful situations.	Temperature and humidity detection, providing information on the user interface and the possibility of zonal temperature/humidity control.
Air draft detection	An air draft can be a source of local thermal discomfort; doors/windows can be closed and opened by an air draft which can lead to stressful conditions for people on the autism spectrum.	Monitoring the condition of doors and windows; notification of open doors and windows in the same room.
Indoor air quality	The perception of intense odors and stale air can be a source of stress for some people on the autism spectrum.	Measurement of VOC and CO_2 concentration as indicators of indoor air exchange and thus indoor air quality and information on the user interface; adoption of low-emission and odors-capturing materials in strategic positions.

Table 4. *Cont.*

Component	Background	Functionality
	Sensor based functionalities	
Wandering	Leaving home without communicating it to caregivers is an event that may occur with people on the autism spectrum.	Synergic use of door opening status and detection of the presence of persons in the house or certain day times (e.g., night).
Controlled access to compartments	Access to dangerous objects or drugs can be a risk factor for people on the autism spectrum.	Status sensors integrated into the furniture can detect (attempted) access to drawers, compartments, etc.; possibility of integrating the unlocking/locking of a specific compartment.
Home safety	In living contexts with people on the autism spectrum, it is useful to monitor events concerning safety in the home (fire, dangerous gas, electrical risk, etc.).	Recognizing falls; smoke detectors and gas sensors (CO, CO_2); monitoring of the fuse protecting the electrical circuit, risk of electrocution; and detection of switched on stove without people in that area.
Utility management and energy saving	A structured household appliance may be a challenge for people on the autism spectrum; they may find it very difficult to manage utilities (water, gas, electricity, garbage, etc.).	Monitoring of energy consumption and set-point values of the heating and air-conditioning system, related to the occupancy status of the house to ensure good indoor comfort; monitoring of water tap opening status, indication of water temperature, and garbage fill level can be implemented.
	Furniture elements	
Table withdividers (a)	For some people on the autism spectrum, conducting activities at a table (e.g., eating, homework) shared with other people can be stressful.	A table with dividers that can be pulled out if necessary to cover a person from distracting sights, smells, and sounds; the dividers are equipped with sound-absorbing and odor-absorbing elements.
Solid building and furniture protection/TV cabinet (b)	Certain events may trigger violent reactions towards objects and furniture; objects such as TVs, radios, and PC screens may lend themselves particularly well to this type of reaction.	Components must be solid, durable, and firmly anchored; furniture is integrated with sensors that can detect shaking, knocking, and tilting; and objects such as TVs, radios, and PC screens are equipped with protective screens.
Refugee seat (c)	Many stimuli throughout the day may lead to stressful conditions for people on the autism spectrum.	A refugee seat that is a sensory balanced seat in a solid structure and a soft sound-absorbing textile for internal lining; it can be equipped with several sensors to monitor and specifically control the micro-environment and eventually detect crisis.
Ceiling lamps (d)	Intense light can be a source of stress for people on the autism spectrum.	Ceiling lamps offer strategic positioning for sensors; absorbing materials help to control the acoustic condition in the room; the light and color of the lamp are customizable according to a person's sensitivity.
Visual support system/Lighting pictograms (e)	Pictograms are common helping aids for people on the autism spectrum.	Backlighted pictograms integrated into furnishings; the image lights up when touched or when programmed to mark sequences of actions or contents.
Crossing the threshold/threshold cabinet (f)	Some people on the autism spectrum might face stressful situations when crossing a threshold, especially if they do not know what happens beyond.	A "peek window" is integrated in the furniture to allow the visual connection of two rooms and thus facilitate the transition.
Planner and reminder/visual agenda (g)	People on the autism spectrum may tend to forget appointments and tasks and need to be reminded; furthermore, instructions can be necessary.	A planner and reminder function that can be adjusted to individual needs (instructions, pictograms); the inclusion of the caregivers is possible to check the completion of certain tasks.
Entrance wardrobe cabinet (h)	Some people on the autism spectrum may have difficulties in choosing the right clothes; people on the autism spectrum may forget items when they go out (e.g., keys, hat).	An organized wardrobe cabinet with large hangers, shoe rack, and the possibility of placing objects; objects are arranged frontally and placed as visible as possible; and it could be integrated with pictograms and information about the weather and planned activity.

The table with dividers responds to the need to be able to isolate oneself during a meal or a study moment without having to change rooms. The TV cupboard with protection and closing screens responds to the need to preserve the appliance during possible moments of aggressive behavior, or not to see it so as not to focus attention on using the TV. The refuge armchair is a sensory rebalancing space, allowing one to recover without having to leave the room. Ceiling lights equipped with sound-absorbing material and environmental sensors allow the room to be acoustically conditioned and support sensors to be set up without making them visible. Lighting pictograms, useful for non-verbal communication, become a valid support for independence in performing everyday actions, being visible only when needed. The threshold cabinet allows observation before moving on, respecting everyone's time for action. The front-view wardrobe cabinet supports immediacy in the use of the cabinet. The visual agenda integrated into the entrance cabinet is the central user interface of the entire SENSHOME environment.

The workshops to evaluate the first design solutions (UI2.4) showed overall high ratings for all furniture elements. The appearance and aesthetic quality were rated highest among the pictograms (Figure 6e), the entrance wardrobe (h), and the visual agenda (g). The entrance wardrobe, the visual agenda, and the refuge seat (c) were rated as the most useful/practical elements. In terms of safety, the entrance wardrobe, the visual agenda, and the refuge seat were rated highest. Overall, only the table with dividers (a) was rated average; for details, see Figure 7.

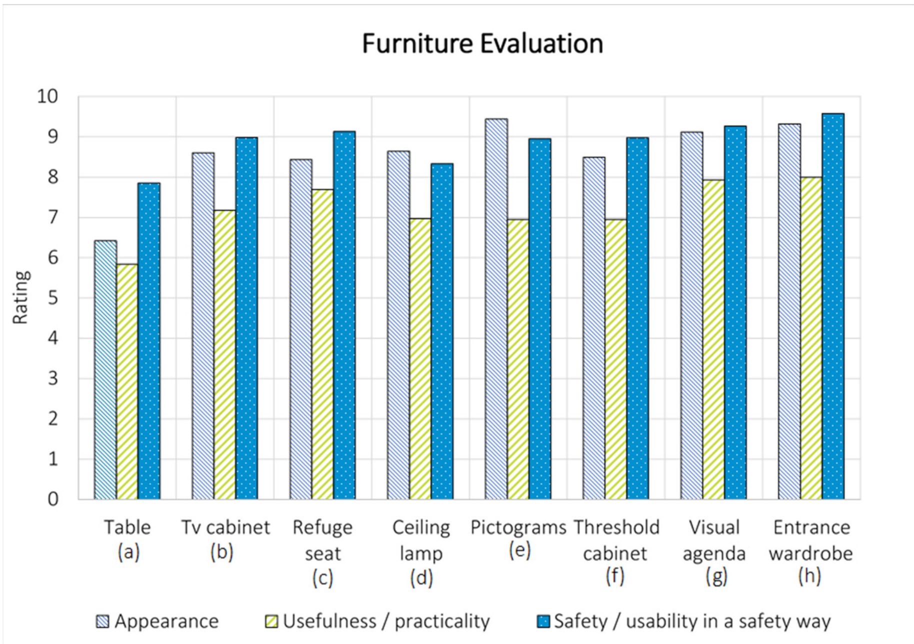

Figure 7. Rating the obtained furniture after the dedicated workshop.

In the workshop "In my room", preferences (materials and colors) often diverged from the widely used autism-friendly architecture guidelines, confirming the relevance of a direct relationship between architects and users. For example, the colors most frequently proposed by the guidelines are pastel shades, while people on the autism spectrum prefer very strong shades (yellow and blue). Another example is related to light: the guidelines indicate a preference for natural lighting preferably coming from the top of the room (skylight); on the other hand, the people on the spectrum showed a marked preference for having a window at eye level to be able to look out across the room.

3.4. Combined Requirements of the SENSHOME Environment

The literature, initial workshops (UI1.1 and UI1.2), personas, user days, and results from the questionnaire on environmental factors (UI1.4), along with risk evaluations and the interior design questionnaires (UI1.3), served as a basis to derive requirements for a comprehensive smart home and interior design solution. In further workshops with stakeholders (UI2.1–UI2.5) and discussions within the project consortium, a list of components (features/functionalities, and furniture elements) of the SENSHOME environment was developed. For each component, details on the background (what is the reason and purpose of the component) and the functionality (what does the functionality or furniture element do) are shown in Table 4. The SENSHOME environment was designed to be modular and customizable (e.g., in terms of thresholds of environmental factors) in order to be usable by different target groups and by people with different levels of autism.

3.5. User Interface

In addition to the functionalities and furniture elements described, drafts of user interfaces were designed during workshops UI2.1–UI2.3, and the participants were directly asked for their feedback on the proposed drafts. The main opinions on the user interfaces did not differ between formal and informal caregivers and can be summarized in the following sections that the interface should include:

1. Notifications: push messages on incidents where an urgent reaction is needed;
2. A floor plan to see where critical situations might occur or also for other information (such as environmental factors in a room);
3. A planner and reminder to increase the chance to enter and accomplish (daily) tasks or appointments;
4. Environmental parameters such as temperature or light should be adjusted automatically at predefined values, but there should also be the possibility to manually adjust them.

Furthermore, it is important that the user interface be adjustable to individual needs, as it should be usable for both caregivers and people on the autism spectrum. The user interface can be accessed through the smartphone as a portable application. This application is of particular importance for caregivers to be informed about critical events in real time. TVs, tablets, smartwatches, and PCs were mentioned as other devices the system should work on.

4. Discussion

“Nothing about us without us” proved once more to be a legitimate statement when designing assistive systems for people. A steady user inclusion in all processes—from the very beginning to the evaluation of single components (and beyond this paper, the evaluation of the whole SENSHOME solution)—enabled the design and realization of a set of functionalities, features, and furniture elements developed and designed for people on the autism spectrum and their caregivers.

4.1. Analysis of Obtained Results

The bridge from the initial target group definition and requirement analysis to a set of features and functionalities can be illustrated by the following examples: from the user’s day and the daily routines of the persona Dominic (Figure 2), which are based on real scenarios reported by caregivers, different components of SENSHOME were derived. The case of too many people in the entrance area as a stress factor can be met in two ways: On the one hand, the sensor-based crowd warning functionality detects the number of people and provides information on the user interface. On the other hand, it can be carried out by the furniture element threshold cabinet (the peek window), which provides the possibility to see what is happening in the entrance area from the outside. Another example of the transition of needs to functionalities is shown in the user day and was also found in the questionnaire on sensitivity to environmental factors (UI1.4), where loud noise was assessed as a potential stress factor. This stress factor can be detected by the sensor system (sound detection) and mitigated by the refuge seat, where a calm and stress-reducing environment is provided.

In order to investigate architectural comfort aspects for people on the autism spectrum, an analysis was carried out through design guidelines, the direct experiences of researchers and practitioners, and workshops with people with autism and their relatives and caregivers. The different scenarios showed how the direct involvement of the end users and consideration of their sensorial peculiarities and uniqueness can allow a design process aimed at developing dedicated environments and furnishing complements. This is able to offer valid support focused on both strengthening the independence and offering inclusiveness. Furthermore, it was possible to integrate existing guidelines and suggestions to meet the needs of people on the spectrum through dedicated sensitivity questionnaires, workshops, and considerations on risks that may occur in households or care facilities.

The interaction with users highlighted the importance of automatic systems to monitor and regulate indoor environmental variables to ensure comfortable conditions for each user and preserve them from potentially dangerous situations and risks. In this way, the integrated sensor system is intended for both early warning of dangerous events (falling objects or people, presence of fires or harmful gases, etc.) and the recognition of environmental conditions that can foresee possible crises (loud noises, presence of too many people, lack of air exchange, etc.). However, it not only comprises sensor-based technology to cover different needs in everyday life challenges. The planner and reminder functions work solely on the user interface and make the smart home system useful for a broader target group with diverse requirements.

The SENSHOME environment offers a passive aid system. Accordingly, it does not intervene in the performance and functionality of the various systems serving a home, but through the inclusion of dedicated furnishings, it intends to create the optimal conditions for independent living in safety and privacy for persons with autism and their relatives and caregivers. The comprehensive solution may increase the efficiency of caregivers and thus reduce the burden of care.

Furniture makes it possible to create aesthetically pleasing living environments that are not characterized by typical supportive elements. A further benefit is a dual possibility offered by many objects, e.g., the entrance furniture allows one to cross the threshold, but also to stay, sit, wait, and observe; the table with dividers allows for isolation or concentration, as well as performing activities (lunch/study) in the same environment with other people; the furniture with pictograms offers help to perform activities only when the pictogram lights are on. However, when the pictogram lights remain off, the furniture takes on the appearance of an ordinary piece of furniture; and the refuge space offers both a place for sensory rebalancing and personal protection when the environment is to be shared with other people. All furniture elements are designed to facilitate optimal sensory conditions in the environment in which they will be inserted; pendant lamps, for example, allow variations not only in the light field but also in the acoustic field of the room. The implementation of a dedicated smart sensor system in such elements makes it possible to support autonomous living and privacy without the feeling of being observed. The system realized is also adaptable to existing living environments of modest dimensions. It is designed so that it can be integrated into existing pieces of furniture without the need for major changes.

4.2. Limitations

Not every single component, though, will be useful or even usable for everybody (the autism spectrum is broad in terms of resources and needs). Therefore, a special focus was laid on the modularity of the SENSHOME environment. The vision that people in need can choose the components they require and adjust parts of it, such as the user interface design and the thresholds of environmental factors (temperature, light, etc.), shall ensure that the system is potentially useful for a broad spectrum of users. Optimizing the functionalities is not an easy task, though, especially the calibration of environmental aspects, which requires a lengthy process based on the personal needs of each user.

One of the main limitations of the SENSHOME solution is that it is not portable, as all components are statically placed in a living environment. Having a "SENSHOME to-go" would be a benefit for people on the autism spectrum, as many situations containing insecurities and potential stress factors happen outside their homes.

The principle of "Nothing about us without us" was followed with the inclusion of different target groups (people on the spectrum, formal and informal caregivers) in the interaction phases. In reflecting the distribution of the individual target groups, a limitation of the conducted HCD process is the predominant participation of caregivers in different user interactions. This was due to the characteristics and challenges of the autism spectrum, as people often have issues with social situations or expressing themselves properly. Additionally, a meta-view of the resources and needs of people on the autism spectrum was necessary to capture a broad view of different aspects of the spectrum, which was provided by caregivers and other experts. The involvement of people in the evaluation phase of the SENSHOME solution ensured the inclusion of the opinions of all target groups.

4.3. Potential Future Developments

The SENSHOME technology is not intended to replace the users, causing them to reduce their activities or choices. On the contrary, it works by stimulating the users to act and choose autonomously by clearly illustrating the alternatives available to them (contained objects, adjustment of environmental conditions), encouraging independence not only from caregivers but also avoiding forms of dependence on technological support systems. Therefore, the designed SENSHOME environment (or at least parts of it) can be valuable support not only for living environments but also for collective spaces such as schools, museums, and commercial spaces.

Potential future developments would include a deployment of the system to monitor environments and identify common sensitivity thresholds for its occupants. Short-term future developments foresee a necessary phase of evaluation of the furniture and the integrated system by potential users. The validation of SENSHOME could easily be implemented even for different frailties (elderly people) or disabilities (physical or mental). Long-term future developments will depend on the market interests in developing lines intended for specific users; perhaps discovering that what makes a space more inclusive can become more livable by all.

4.4. Conclusions and Future Perspective

SENSHOME can be a trigger for demanding change in society rather than requiring autistic people to conform. The intended design solutions must also focus on neurodiversity peculiarities and the different sensory perceptions of each person on the spectrum. In this way, the results will also promote cultural and social relationships between neurodiverse and neurotypical people.

The SENSHOME environment (smart home and furniture elements) was set up and tested in two lab environments in Italy and Austria. The focus of the evaluation was on acceptance aspects such as usefulness and usability. The results of the evaluation with people on the autism spectrum and their formal and informal caregivers will provide a first impression of how a comprehensive system for autism performs but also where improvements are needed.

Conclusively, an HCD process requires extra efforts by the whole project consortium, as could be shown in this paper. Employing a holistic HCD process is time consuming due to the inclusion of various stakeholders in different user interactions as well as iterative development steps and constant improvements to the technology. Nevertheless, it proved that it was worth the effort, as feedback from the constant validations and evaluations during the development phase showed.

Author Contributions: Conceptualization, L.W., D.K., M.C. and G.S.; methodology, L.W., D.K., S.L.L., A.M., L.Z., S.D., M.C., F.B., A.D., P.L. and G.S.; investigation, A.M., L.W., S.L.L., L.Z., S.D., M.C., F.B., A.D., P.L. and G.S.; writing—original draft preparation, L.W., A.M., L.Z., F.B., A.D., P.L. and G.S.; writing—review and editing, L.W., D.K., A.M., L.Z., S.D., M.C., F.B., A.D., P.L., G.S. and A.G.; visualization, A.M., F.B., L.W., L.Z. and P.L.; supervision, L.W. and M.C.; project administration, D.K. and M.C.; funding acquisition, M.C., G.S., D.K. and A.G. All authors have read and agreed to the published version of the manuscript.

Funding: The research leading to this paper is co-financed by the European Regional Development Fund under the framework of INTERREG IT-AT (SENSHOME project), ITAT 1088 CUP: I54I18000310006; CUP: J94I19000920007; and the Carinthian Economic Promotion Fund (KWF).

Institutional Review Board Statement: The questionnaire on environmental factors was conducted after receiving approval from the Ethics Committee of the Free University of Bozen-Bolzano.

Informed Consent Statement: Informed consent was obtained from all participants involved in this study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical and privacy reasons as sensible data from people on the autism spectrum, families and care facilities were gathered.

Acknowledgments: The authors would like to thank the project partner Eureka System, the associated partners Fondazione Progettoautismo FVG, A&B, Associazione Medea-La Nostra Famiglia, Televita Spa, Inklusion:Kärnten, and P.SYS, as well as other organizations such as Diakonie de La Tour, Gruppo Autismo Belluno, and autArK. Generally, we want to thank all participants in workshops and questionnaires who enabled the development of the SENHOME solution.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Priority MoSCoW scale associated with the environmental risks.

#	Risk	Type	PRIORITY					
			Kitchen	Living Room	Bedroom	Bathroom	Corridor	Storage Room
1	T detection (cold, warm)	Com, Sec	S	S	S	S	S	S
2	Light (glare, low or high)	Com, Sec	S	S	S	S	S	S
3	Light (artificial)	Com, Sec	C	C	C	C	C	C
4	Light (natural)	Com, Sec	C	C	C	C	C	C
5	Light (cold or warm)	Com, Sec	C	C	C	C	C	C
6	Light (particular types)	Com, Sec	S	S	S	S	S	S
7	IAQ warning	Com, Sec	C	C	C	C	C	C
8	Humidity	Com, Sec	C	C	C	C	C	C
9	Odour	Com, Sec	S	S	S	S	S	S
10	Pollen	Sec	S	S	S	S	C	S
11	Air draft	Com, sec	C	C	C	C	C	C
12	Sound (loud/silent)	Com, Sec	M	M	M	M	M	M
13	Echo, reverberation, particular noises	Com, Sec	S	S	S	S	S	S
14	Sounds from close apartments	Com, Sec	S	S	S	S	S	S
15	Horns, sounds from outside	Com, Sec	S	S	S	S	S	S
16	Too quiet environment	Com, Sec	C	C	C	C	C	C

Table A2. Priority MoSCoW scale associated with the accidental risks.

#	Risk	Type	PRIORITY					
			Kitchen	Living Room	Bedroom	Bathroom	Corridor	Storage Room
1	Falls	Sec	M	S	S	M	S	S
2	Falls from dangerous heights	Sec	M	S	S	M	S	M
3	Fall of objects	Sec	S	C	C	S	C	S
4	Dangerous objects, solid building	Sec	M	S	S	M	S	M
5	Bulky objects/furniture	Sec	S	S	S	S	S	S
6	Excessive filling of spaces, objects not in the right place	Sec	S	C	C	S	C	S
7	Sharp objects (knives, broken mirrors/glass, corners, . . .)	Sec	M	S	S	M	S	M
8	Hand/fingers crushing	Sec	S	S	S	S	S	S
9	Injuries from working objects	Sec	M	S	S	S	S	M
10	Stove detection	Sec	M	S	S	S	S	C
11	Burns from radiators	Sec	S	S	S	S	S	S
12	Burns	Sec	M	S	S	S	S	S
13	Fires	Sec	M	M	M	M	M	M
14	Electrical risks	Sec	M	M	M	M	M	M
15	Presence of water, humidity on surfaces/floor	Sec	S	C	C	S	C	C
16	Slippery substance on the floor	Sec	S	S	S	S	S	S
17	Asphyxiation, gas, poisoning	Sec	M	M	M	M	M	M
18	Chocking, drowning	Sec	M	M	M	M	M	M
19	Chemical risk (irritation)	Sec	M	S	S	M	S	S
20	Medicines and drugs	Sec	S	S	S	S	S	S
21	Appointment reminder, planner, reminder	Aut, Sec	C	C	C	C	C	C
22	Depression detector	Sec	S	S	S	S	S	S
23	Stereotypical behaviour	Sec	S	S	S	S	C	S
24	Wandering	Sec	S	S	S	S	C	S
25	Self-harm	Sec	M	M	M	M	M	M

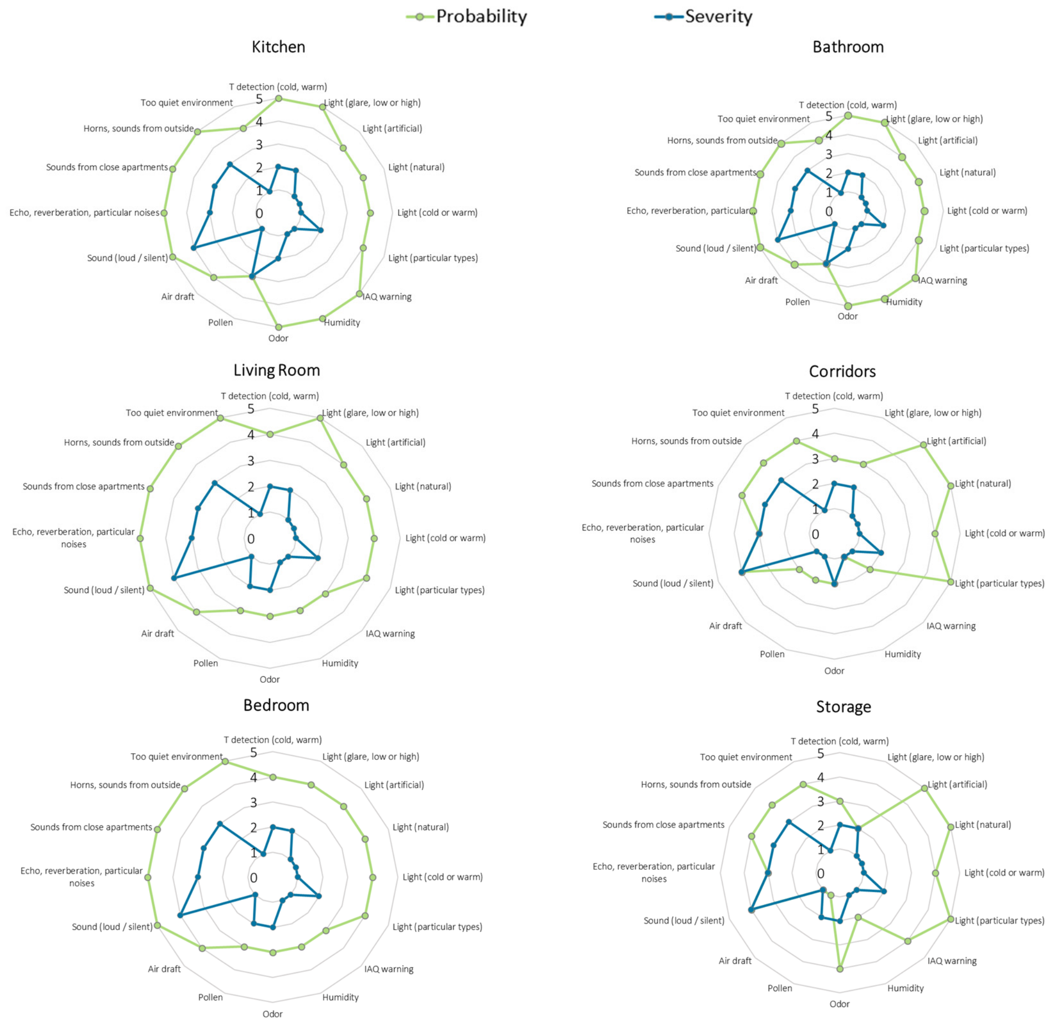

Figure A1. Environmental risks: probability and severity in the rooms of a typical living environment.

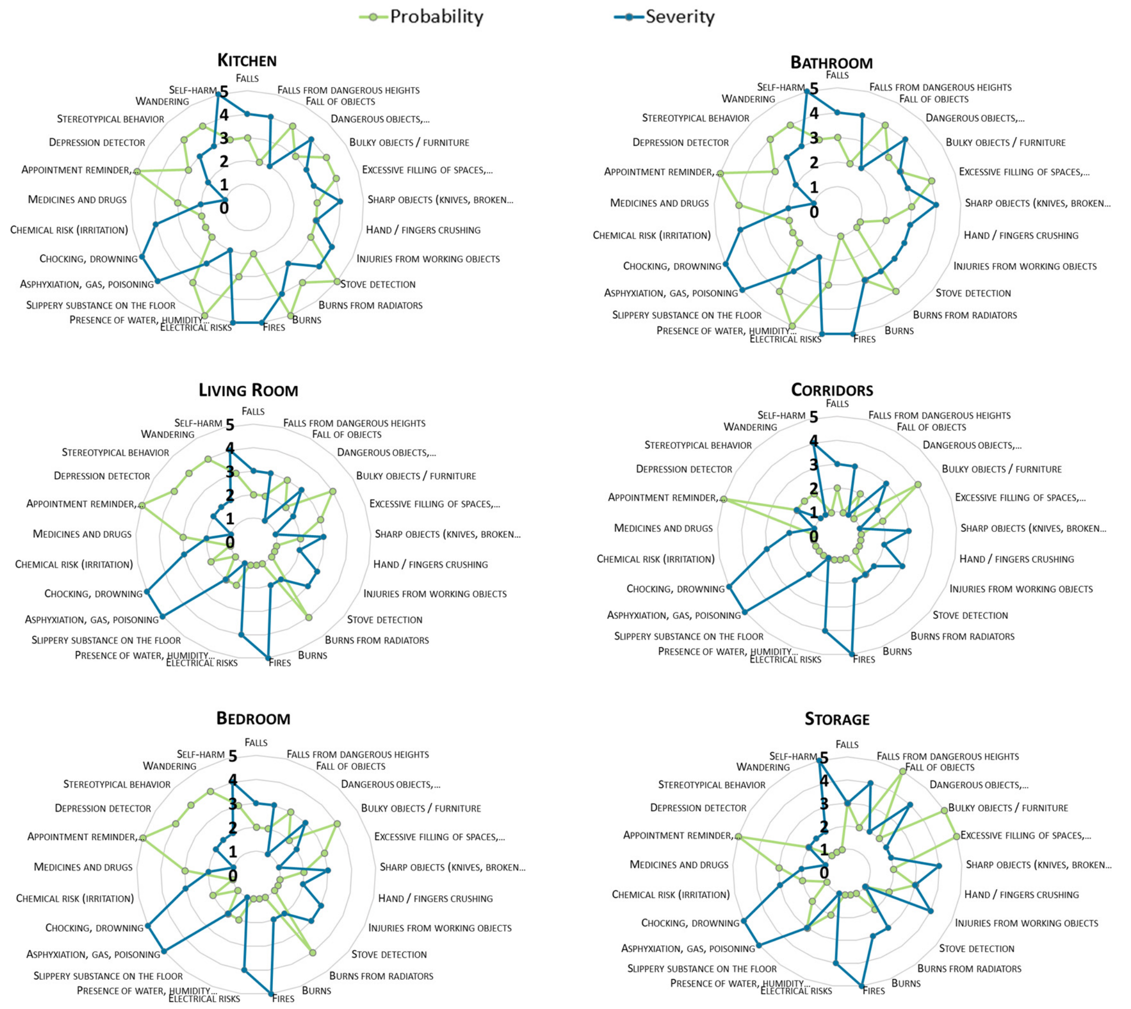

Figure A2. Accidental risks: probability and severity in the rooms of a typical living environment.

References

1. Jones, E.K.; Hanley, M.; Riby, D.M. Distraction, distress and diversity: Exploring the impact of sensory processing differences on learning and school life for pupils with autism spectrum disorders. *Res. Autism Spectr. Disord.* **2020**, *72*, 101515. [CrossRef]
2. Noble, B.; Lamb, S.; Isaacs, N. The impact of IEQ factors on people on the autism spectrum. In *Engaging Architectural Science: Meeting the Challenges of Higher Density*; The Architectural Science Association and RMIT University: Melbourne, Australia, 2018; pp. 27–33.
3. Williams, Z.J.; Failla, M.D.; Davis, S.L.; Heflin, B.H.; Okitondo, C.D.; Moore, D.J.; Cascio, C.J. Thermal Perceptual Thresholds are typical in Autism Spectrum Disorder but Strongly Related to Intra-individual Response Variability. *Sci. Rep.* **2019**, *9*, 12595. [CrossRef] [PubMed]
4. Duerden, E.G.; Taylor, M.J.; Lee, M.; McGrath, P.A.; Davis, K.D.; Roberts, S.W. Decreased Sensitivity to Thermal Stimuli in Adolescents with Autism Spectrum Disorder: Relation to Symptomatology and Cognitive Ability. *J. Pain* **2015**, *16*, 463–471. [CrossRef]
5. Kanakri, S.M.; Shepley, M.; Tassinary, L.G.; Varni, J.W.; Fawaz, H.M. An Observational Study of Classroom Acoustical Design and Repetitive Behaviors in Children with Autism. *Environ. Behav.* **2017**, *49*, 847–873. [CrossRef]
6. Gee, B.M.; Thompson, K.; St John, H. Efficacy of a Sound-based Intervention with a Child with an Autism Spectrum Disorder and Auditory Sensory Over-responsivity: TLP and ASD. *Occup. Ther. Int.* **2014**, *21*, 12–20. [CrossRef]
7. Mostafa, M. An Architecture for Autism: Concepts of Design Intervention for the Autistic Use. *Int. J. Archit. Res.* **2008**, *2*, 24.
8. Colman, R.S.; Frankel, F.; Ritvo, E.; Freeman, B.J. The effects of fluorescent and incandescent illumination upon repetitive behaviors in autistic children. *J. Autism Child. Schizophr.* **1976**, *6*, 157–162. [CrossRef]
9. Fenton, D.M.; Penney, R. The Effects of Fluorescent and Incandescent Lighting on the Repetitive Behaviours of Autistic and Intellectually Handicapped Children. *Aust. N. Z. J. Dev. Disabil.* **1985**, *11*, 137–141. [CrossRef]
10. Kamp-Becker, I.; Bölte, S. *Autismus*; 2. Auflage; Ernst Reinhardt: München, Basel, 2014; ISBN 978-3-8252-4153-7.

11. Elsabbagh, M.; Divan, G.; Koh, Y.-J.; Kim, Y.S.; Kauchali, S.; Marcín, C.; Montiel-Nava, C.; Patel, V.; Paula, C.S.; Wang, C.; et al. Global Prevalence of Autism and Other Pervasive Developmental Disorders: Global epidemiology of autism. *Autism Res.* **2012**, *5*, 160–179. [CrossRef]
12. Burleson, W.; Newman, N.; Brotman, R. Empowering Independent Living for People with Autism: Designing Supportive, Low-Cost, Interactive E-Health Environments. In *Persuasive Technology. Design for Health and Safety*; Bang, M., Ragnemalm, E.L., Eds.; Springer Berlin Heidelberg: Berlin/Heidelberg, Germany, 2012; Volume 7284, pp. 13–30. ISBN 978-3-642-31036-2.
13. Tomchek, S.D.; Huebner, R.A.; Dunn, W. Patterns of sensory processing in children with an autism spectrum disorder. *Res. Autism Spectr. Disord.* **2014**, *8*, 1214–1224. [CrossRef]
14. Hong, H.; Kim, J.G.; Abowd, G.D.; Arriaga, R.I. Designing a social network to support the independence of young adults with autism. In Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work, Seattle, Washington, USA, 11–15 February 2012; ACM: New York, NY, USA, 2012; pp. 627–636.
15. Chia, G.L.C.; Anderson, A.; McLean, L.A. Use of Technology to Support Self-Management in Individuals with Autism: Systematic Review. *Rev. J. Autism Dev. Disord.* **2018**, *5*, 142–155. [CrossRef]
16. Desideri, L.; Di Santantonio, A.; Varrucciu, N.; Bonsi, I.; Di Sarro, R. Assistive Technology for Cognition to Support Executive Functions in Autism: A Scoping Review. *Adv. Neurodev. Disord.* **2020**, *4*, 330–343. [CrossRef]
17. Wali, L.J.; Sanfilippo, F. A Review of the State-of-the-Art of Assistive Technology for People with ASD in the Workplace and in Everyday Life. In *Digital Transformation for a Sustainable Society in the 21st Century*; Pappas, I.O., Mikalef, P., Dwivedi, Y.K., Jaccheri, L., Krogstie, J., Mäntymäki, M., Eds.; Springer International Publishing: Cham, Switzerland, 2019; Volume 11701, pp. 520–532, ISBN 978-3-030-29373-4.
18. Wohofsky, L.; Scharf, P.; Lattacher, S.; Krainer, D. Assistive technology to support people with autism spectrum disorder in their autonomy and safety: A scoping review. *Technol. Disabil.* **2021**, *34*, 1–11. [CrossRef]
19. Interact The SENSHome Sensitive Home: Sensors for Special Environments. Keep.eu. 1 October 2019. Available online: https://keep.eu/projects/22491/The-SENSHome-Sensitive-Home-EN/ (accessed on 17 January 2023).
20. *ISO 9241-210:2019*; Ergonomics of human-system interaction—Part 210: Human-centred design for interactive systems. Austrian Standards International Standardization and Innovation: Vienna, Austria, 2019.
21. Halladora, A.; Sanchez Merina, J. *Manual de Arquitectura para Familias Afectadas por el Autismo. La CASA Pictograma*; Universidad de Alicante: San Vicente del Raspeig, Spain, 2015; Available online: https://autismomadrid.es/asociaciones-espana/manual-de-arquitectura-para-viviendas-de-personas-con-tea/ (accessed on 31 January 2023).
22. Belek, B. An Anthropological Perspective on Autism. *Philos. Psychiatry Psychol.* **2019**, *26*, 231–241. [CrossRef]
23. Kellmann, J. *Autism, Art, and Children. The Stories We Draw*; Bergin & Garvey: Westport, Connecticut, 2001; ISBN 0-89789-735-8.
24. Grandin, T. *Thinking in Pictures*; Doubleday: London, UK, 1995.
25. Dordolin, A. Current status of living environments for autistic people: The significant aspects of design in literature and guidelines. In Proceedings of the International Conference Architecture and Autism. Sensory Perception and Independent Living, Trieste, Italy, 20 April 2021; EUT—Ed. Università di Trieste: Trieste, Italy, 2022; pp. 29–37.
26. Limoncin, P. Living environments and autism: Design aspect in architectural projects. In Proceedings of the International Conference Architecture and Autism. Sensory Perception and Independent Living, Trieste, Italy, 20 April 2021; EUT—Ed. Università di Trieste: Trieste, Italy, 2022; pp. 39–47.
27. American Psychiatric Association (Ed.) *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*, 5th ed.; American Psychiatric Publishing: Washington, DC, USA, 2013; ISBN 978-0-89042-555-8.
28. Zaniboni, L.; Marzi, A.; Caniato, M.; Gasparella, A. Comfortable and safe environments for people with autism: Preliminary analysis of risks and definition of priorities in the design phase. *J. Phys. Conf. Ser.* **2021**, *2069*, 012177. [CrossRef]
29. Caniato, M. Recent Advances on Indoor Comfort for Autistic Individuals. In Proceedings of the International Conference Architecture and Autism. Sensory Perception and Independent Living, Trieste, Italy, 20 April 2021; EUT—Ed. Università di Trieste: Trieste, Italy, 2022; pp. 23–26.
30. Tactivos, Inc. MURAL. 9 November 2021. Available online: https://www.mural.co/ (accessed on 31 January 2023).
31. Palette CAD AG, PaletteHome. 6 November 2020. Available online: https://palettehome.de/DE/home/03_wohnen/ (accessed on 31 January 2023).
32. Dam, R.F.; Siang, T.Y. Personas—A Simple Introduction; Interaction Design Foundation: 2022. Available online: https://www.interaction-design.org/literature/article/personas-why-and-how-you-should-use-them (accessed on 7 July 2022).
33. Bettarello, F.; Caniato, M.; Scavuzzo, G.; Gasparella, A. Indoor Acoustic Requirements for Autism-Friendly Spaces. *Appl. Sci.* **2021**, *11*, 3942. [CrossRef]
34. Tager-Flusberg, H.; Caronna, E. Language Disorders: Autism and Other Pervasive Developmental Disorders. *Pediatr. Clin. N. Am.* **2007**, *54*, 469–481. [CrossRef] [PubMed]
35. Félix, J.; Santos, M.E.; Benitez-Burraco, A. Specific Language Impairment, Autism Spectrum Disorders and Social (Pragmatic) Communication Disorders: Is There Overlap in Language Deficits? A Review. *Rev. J. Autism Dev. Disord.* **2022**, 1–21. [CrossRef]
36. Caniato, M.; Zaniboni, L.; Marzi, A.; Gasparella, A. Evaluation of the main sensitivity drivers in relation to indoor comfort for individuals with autism spectrum disorder. Part 1: Investigation methodology and general results. *Energy Rep.* **2022**, *8*, 1907–1920. [CrossRef]

37. Caniato, M.; Zaniboni, L.; Marzi, A.; Gasparella, A. Evaluation of the main sensitivity drivers in relation to indoor comfort for individuals with autism spectrum disorder. Part 2: Influence of age, co-morbidities, gender and type of respondent on the stress caused by specific environmental stimuli. *Energy Rep.* **2022**, *8*, 2989–3001. [CrossRef]
38. Ministero della Salute (Ed.) *Infortuni nelle abitazioni. Manuale Tecnico per Gli Operatori Della Prevenzione*; Dipartimento di Prevenzione: Regione Autonoma Friuli Venezia Giulia, Italy, 2010.
39. Department of Health, Social Services and Public Safety, Eds. *Home Accident Prevention Strategy 2015–2025*; Department of Health, Social Services and Public Safety: Belfast, Ireland, 2015.
40. RoSPA Preventing Accidents in the Home. Available online: https://www.rospa.com/home-safety/advice/general/preventing-accidents-in-the-home.aspx (accessed on 31 August 2020).
41. Mackessack-Leitch, K. Domestic accidents: Their cause and prevention. *J. R. Coll. Gen. Pract.* **1978**, *28*, 38–45. [PubMed]
42. Ministry of Social Affairs and Health. *Target Programme for the Prevention of Home and Leisure Accident Injuries 2014–2020*; Ministry of Social Affairs and Health: Helsinki, Finland, 2014; Volume 1, p. 2014, [Online]; Available online: https://julkaisut.valtioneuvosto.fi/handle/10024/74508 (accessed on 31 January 2023).
43. Mostafa, M. Architecture for Autism: Built Environment Performance in Accordance to the Autism ASPECTSS Design Index. In *Autism 360°*; Das, U.N., Papaneophytou, N., El-Kour, T., Eds.; Academic Press is an imprint of Elsevier: London, UK; San Diego, CA, USA, 2019; ISBN 978-0-12-818466-0.
44. Wohofsky, L.; Krainer, D.; Lattacher, S.; Scharf, P.; Fink, S. Participation of Users in Research: Human-Centered Design in the Project SENSHome. In Architecture and Autism. Sensory Perception and Indipendent Living. Prooceedings of the International Workshop, Trieste, Italy, 20 April 2021; EUT—Ed. Università di Trieste: Trieste, Italy, 2022; pp. 63–69.
45. Ahrentzen, S.; Steele, K. *At Home with Autism. Designing Housing for the Spectrum*; Bristol University Press: Bristol, UK, 2015; [Online]; Available online: https://www.press.uchicago.edu/ucp/books/book/distributed/A/bo22204829.html (accessed on 31 January 2023).
46. Gaines, K.; Bourne, A.; Pearson, M.; Kleibrink, M. *Designing for Autism Spectrum Disorders*; Routledge: England, UK, 2016.
47. Brand, A. *Living in the Community: Housing Design for Adults with Autism*; Helen Hamlyn Centre, Royal college of Art: London, UK, 2010; ISBN 978-1-907342-25-7.
48. Wienberg, M.; Wienberg, M. Wienberg Architects. Available online: https://wienbergarchitects.dk/arkitektur/hinnerupkollegiet (accessed on 20 January 2023).
49. GA Architects. Design Environments for Children & Adult with ASD. [Online]. Available online: www.autism-architects.com (accessed on 20 January 2023).
50. Medical Architecture. Challenging Stereotypes—Mitford Autism Inpatient Unit, Morpeth, Northumberland. 24 January 2018. Available online: https://www.architectsdatafile.co.uk/news/challenging-stereotypes-mitford-autism-inpatient-unit-morpeth-northumberland/ (accessed on 20 January 2023).