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Preliminary Analysis On The Sensitivity To The Four Comfort Domains Of People With Autism Spectrum Condition

Arianna Marzi

Luca Zaniboni

Marco Caniato

Andrea Gasparella

Preliminary Analysis on The Perception Of The Four Comfort Domains Of People With Autism Spectrum Condition

Arianna Marzi[1]*, Luca Zaniboni[1], Marco Caniato[1], Andrea Gasparella[1]

[1]Free University of Bozen, Faculty of Science and Technology,
Bozen, Italy

*Contact author e-mail: arianna.marzi@natec.unibz.it

ABSTRACT

Autism Spectrum Condition (ASC) is a neurodevelopmental disorder affecting one child over 160 worldwide. People in the spectrum may show different sensitivity in the perception of the different stimuli provided by the surrounding environment. On the one hand, this can affect the perceived level of comfort and increase the environmental requisites, also in relation to the dangerous effects of stressful conditions. On the other hand, in the case of reduced sensitivity, this can harm the subject unknowingly exposed to inappropriate or unhealthy conditions. Furthermore, if individual comfort has been typically investigated by means of subjective approaches, such as questionnaires, administered to individuals in laboratory conditions, individuals on the spectrum can face some difficulty with communication and, even worst, can be endangered by harmful reactions to discomfortable or stressful environments. This makes it more difficult to collect direct feedbacks on the perception of their own well-being and prevents from conducting experiments involving the most fragile individuals for whom the research would be particularly beneficial. In this framework, an analysis of the Indoor Environmental Quality (IEQ) is here provided with attention to acoustic, thermo-hygrometric, visual environments and indoor air quality and their relative importance in determining comfort or discomfort to individuals with ASC. In order to investigate the subjective sensitivity of individuals with severe comorbidities or communication problems, this study interviewed people who most directly are taking care of them and follow their activities daily. In more details, a controlled group of 19 young adults with a diagnosis of autism were analyzed by collecting the opinions provided by both family members (parents) and professional caregivers, by means of questionnaires evaluating the sensitivity to the four comfort domains. Biases in answers due to the different proxy respondents involved were analyzed.

1. INTRODUCTION

Design of buildings requires particular attention not only to ensure structural stability or energy efficiency, but also to guarantee the occupants the indoor comfort necessary to carry out the activities (Lai & Yik, 2009) (Frontczak, Schiavon, et al., 2012). The indoor comfort is therefore of paramount importance as it influences the quality of life (Pinto et al., 2017) health (Kim et al., 2015), productivity (Wang & Hong, 2020) and performance (Catalina & Banu, 2014) in residences, offices, educational and therapeutic environments affecting both psychological and physiological factors. To ensure this, there are a number of measures that international standards tend to monitor in the design phase, providing suggestions, suitable ranges of indoor conditions and minimum criteria to be met (Comite'Europe'en de Normalisation, 2007; European Committee for Standardization, 2011; European Committee for Standardization, 2019).

When managing indoor comfort perception and evaluation, it is a common procedure to collect physical measurements by means of monitoring campaigns in order to associate the objective data measured by the instrumentation to the subjective data from interviewing the individuals (Fransson et al., 2007; Castaldo et al., 2017). In this way, parameters such as temperature, relative humidity, mean radiant temperature, illuminance, sound pressure levels, clothing insulation or metabolic rate can be collected and associated with the data on the perception of the occupants (American Society of Heating, Refrigerating and Air Conditioning Engineers, 2010; Castaldo et al., 2018). The use questionnaires is recommended to both collect data on clothing to be linked to the metabolic rate and link the physical data observed by the instrumentation to the stimuli (temperature, humidity, intensity of natural or artificial light, air quality, acoustic environment quality) perceived by occupant (Frontczak, Andersen, et al., 2012).

A suitable indoor comfort is even more important when approaching either therapeutic or healthcare environments (Pinter & Kiss, 2019; Wong et al., 2014; Leung et al., 2019) or when considering people with special needs (Vilcekova et al., 2017; Van Hoof et al., 2008). Thus, understanding the environmental stimuli perception of people with special

needs is an increasingly important requirement in the development of user-centered design, user well-being and perceived comfort.

Particularly, Autism Spectrum Condition (ASC) is a neurodevelopmental disorder increasingly growing among world population (Johnson et al., 2018; Maenner et al., 2020). Thus, understating the perception process of this special users will help building an inclusive approach to design and optimize the occupants' comfort of those who are not always able to manifest their perceptions, because of difficulties in communication and expression. For the above-mentioned reasons, people with ASC are not only acknowledged as neurodiverse, but also identified by the Declaration of World Medical Association as fragile individuals. Therefore, an indirect methodology of investigation is the most suitable to evaluate their perception and wellbeing. Besides increased sensitivity to specific stressors, people on the spectrum may feature hyposensitivity to some comfort domains (American Psychiatric Association, 2013).

Particularly, William et al (Williams et al., 2019) tested the hypothesis that individuals with ASD exhibit significantly elevated warm and cool detection thresholds. The study focused on thermal perception (heat and cold) of two sample groups: individuals with ASC and Typically Developed (TD) groups of occupants. The participants completed a self-reported questionnaire measuring autistic traits and sensory features and then carried out a thermal detection task conducted according to the Declaration of Helsinki. Results showed that no difference was found in thermal detection thresholds between ASC and TD groups despite large differences between groups in sensory reactivity questionnaire. Conversely, Duerden et al. (Duerden et al., 2015) focused on the pain hypo-reactivity that in some cases could distinguish ASC individuals. They studied a group of adolescents: 20 with a diagnosis of ASC and 56 typical development (TD) adolescents composing the control group. The probands to the study were subjected to 4 separated thermal trials (warm, cool, heat and cold) using the method of limits protocol of thermal detection and pain thresholds. From the analysis of the results, it was highlighted that adolescents with ASC were less sensitive to warm and cold stimuli compared to the TD group.

Kanakri et al. (Kanakri et al., 2017) investigated the impact of noise on ASC learning process in three schools. A survey on impact noise in learning environment was distributed to teachers and the results showed that sound insulated walls and the presence of carpets in the classroom were the most important solution for children with ASC. The study indeed showed how, when modifying the built environment in acoustically friendly ways, the treatment and education of children with autism may be greatly enhanced. Although this study considers hypo-sensitive hearing behavior, in which phenomena such as tapping or making noise (that may highlight that the individual is enacting to increase sensory stimulation) are analyzed, a dedicated hyposensitivity scale or analysis was not adopted.

Another study focusing on the impact of noise on ASC people was performed by Keith et al. (Keith et al., 2019) who examined the relationship between sensory processing, arousal, and cognitive performance in adolescents with ASD and TD controls matched on age, gender, and Full-Scale IQ. The results were obtained by performing two cognitive tasks of different difficulties and varying the noise level in background. The results obtained suggested that individuals with ASC could experience an energizing effect of auditory stimulation during manageable tasks. Furthermore, an hyperresponsivity to noise was observed in ASC probands.

Then, approaching to the four comfort domains, Noble et al. (Noble et al., 2018) explored the perception of environmental stimuli with a comprehensive survey. By means of the collected results, it was highlighted that participants on the autism spectrum reported that people, people noise and indoor/other noise were the greatest causes of discomfort and avoidance, followed by glare and electric light. From the results, it was also showed that the thermal comfort and IAQ may not be the most important factors for people on the autism spectrum. In this case mention is made of a possible hyper response of individuals on the spectrum, but an analysis of hyposensitivity has not been addressed. A former study was already conducted by the authors (Caniato et al., 2022, p. 1; Caniato et al., 2022, p. 2). This explored the perception of people on the spectrum among the 4 domains of comfort, highlighting how the acoustic environment is the most critical for this type of users both in care facilities and in households. Furthermore, the analysis performed showed how gender, severity of autism, age and presence of other disorders among co-morbidities, strongly influenced the perception of the indoor comfort for people with ASC.

In the present study, a smaller sample is analysed (19 individuals). Due to the frequent communication disorder that may occur, the questionnaire was developed to be completed by proxy respondents, namely parents and professional caregivers (named as "caregivers" from now on). The results collected were then analysed to understand if the reported perception could vary based on the proxy respondents. Furthermore, an analysis was conducted to understand only whether the average grades provided by the two types of respondents were similar (with a Mann-Whitney U-test), but also to assess whether response trends can be assimilated to an increasing or decreasing monotone function (through Spearman's test). In addition, a further analysis was conducted on understanding the influence of personal data of individuals with ASC on reported perceptions. This survey was conducted in accordance with the Declaration of Helsinki and the Ethical Committee of the Free University of Bozen.

2. MATERIALS AND METHODS

In order to investigate the ASC users' indoor comfort, questionnaires on the environment perception are a common tool among experts and researchers (Katafygiotou & Serghides, 2014; Dykes & Baird, 2013; Fransson et al., 2007). Unfortunately, questionnaires may not be suitable to investigate the indoor comfort of people with communication difficulties, who would need support in their daily activities and life. For this reason, also thanks to the contribution of a psychologist expert in this field, it was possible to develop a questionnaire asking parents and caregivers the perception of the ASC individuals to the different indoor comfort domains. Thus, it was asked to report if the cared individuals perceived any disturbances related to thermo-hygrometric, acoustic, visual environments and indoor air quality. Moreover, it was also possible to collect personal data such as age, information on the severity of autism and presence of other co-morbidities. The questionnaire was structured in order to provide answers both on persistent aspects of perception and on hyposensitivity and sporadic conditions. Figure 1 summarizes the *ad hoc* perception scale which was built for the survey.

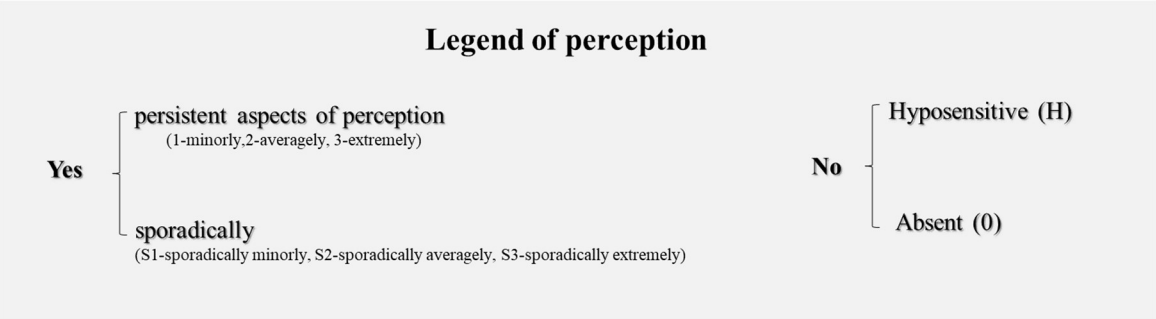

Figure 1: Perception scale designed for the questionnaire

2.1 Data collection

Parents provided answers related with the experiences of individuals in their own households, while caregivers focused on the same sample of persons in the care facility. This coupled analysis was useful to explore whether any variation in assessment due to personal biases or environmental features was present. The care facility involved in this study is an environment dedicated to young adults in which experienced psychologists and caregivers take care of them in order to increase their independence and autonomy in communication, activities and daily life.

Figure 2: Pictures of the care facility of the Association involved in this study.

A total of 19 users were involved, therefore 38 evaluations were provided by the proxy respondents (19 by parents and 19 by caregivers). Moreover, since the users involved in this study were all in the pre-adolescent or adolescent age, in which the need for autonomy and the difficulties linked to the autistic spectrum most influence behavior and perception of the environment, two different groups were considered: under 15 and over 15 years old. Indeed, Hume et al. (Hume et al., 2018) explained how, when 15 years old, an individual with ASC starts not only to process stimuli (learning, perceptual and emotional stimuli) but also to manifest them through behavioral or physical manifestations

(motor stereotypies). Furthermore, the influence of the spectrum severity and the presence of co-morbidities were here considered. A summary is shown in Table 1.

Table 1: Personal data of the individuals in the spectrum reported by the two types of proxy respondents

		Parents [n°]	Caregivers [n°]
Age threshold	Under 15 y.o.	9	10
	Over 15 y.o.	10	9
Severity of autism	A	8	6
	B	7	9
	C	4	4
Co-morbidities	OCD	0	1
	ID	9	6
	AD	3	0
	Other	1	0

2.2 Data analysis

In order to compare properly the perception of the ASC users in the two environments, a qualitative preliminary analysis based on the comparison of frequency distributions followed by a statistical analysis, were conducted . The methodological analysis is structured as follows:

1) A preliminary percentage analysis was performed in order to highlight whether a difference could exist in the perception detected by the two types of proxy respondents.

2) A Mann-Whitney test (McKnight & Najab, 2010) was performed to explore the possibility of obtaining different reports of perceptions from the two proxy respondents. In this case the null hypothesis in the Mann-Whitney test was that the two perceptions were drawn from the same ASC population and therefore that their probability distributions were equal.

3) A Spearman's rank correlation test (Artusi et al., 2002) was performed in order to measure the degree of correlation between the perception detected by the two types of proxy respondents on each comfort domain. The Spearman's coefficient does not measure a linear relationship but permits to determine how well a relationship between two variables can be described using a monotonic function. In this case it is a useful test to see if, even if in different perceptual degrees, there is a similar response trend between the two perceptions measured by the proxy respondents. Thus, Spearman's test provides information not only whether the mean value assigned for that domain by the proxy respondents is similar, as in the case of the Mann-Whitney test, but describes how similar are the two response trends reported by the two proxy respondents.

4) Finally, a further analysis with a Spearman's correlation test was performed in order to evaluate if there were correlations between the perceptions and personal data of the ASC individuals (age, presence of comorbidities and severity of autism). In particular, the correlations between the answers of parents and caregivers were studied restricting the sample to individuals with and without co-morbidities, under- and over-15, with low severity and high severity autism.

3. RESULTS AND DISCUSSION

Figure 3 shows that the perception reported by parents tended to be always higher than the one reported by caregivers in the care facility. Particularly, caregivers reported higher response rates "0 not at all" for almost all 4 comfort domains and lower presence of sporadic perception of discomfort. As regards hyposensitivity, it can be seen that while parents report an equal share of hyposensitive individuals for thermal, visual and indoor air quality, caregivers report it only for indoor air quality and thermal environment (a higher percentage with respect to parents' in the latter case). In both cases, the acoustics seems to be the comfort domain with the highest percentage of "2- averagely" and "3-extremely", highlighting that it is the comfort field to which users with ASC seem to require more precautionary measures.

These results can indeed be justified precisely by the fact that the care facility was designed *ad hoc* to reduce possible discomfort for ASC individuals, whereas the same adjustments could be more difficult to be present in private households.

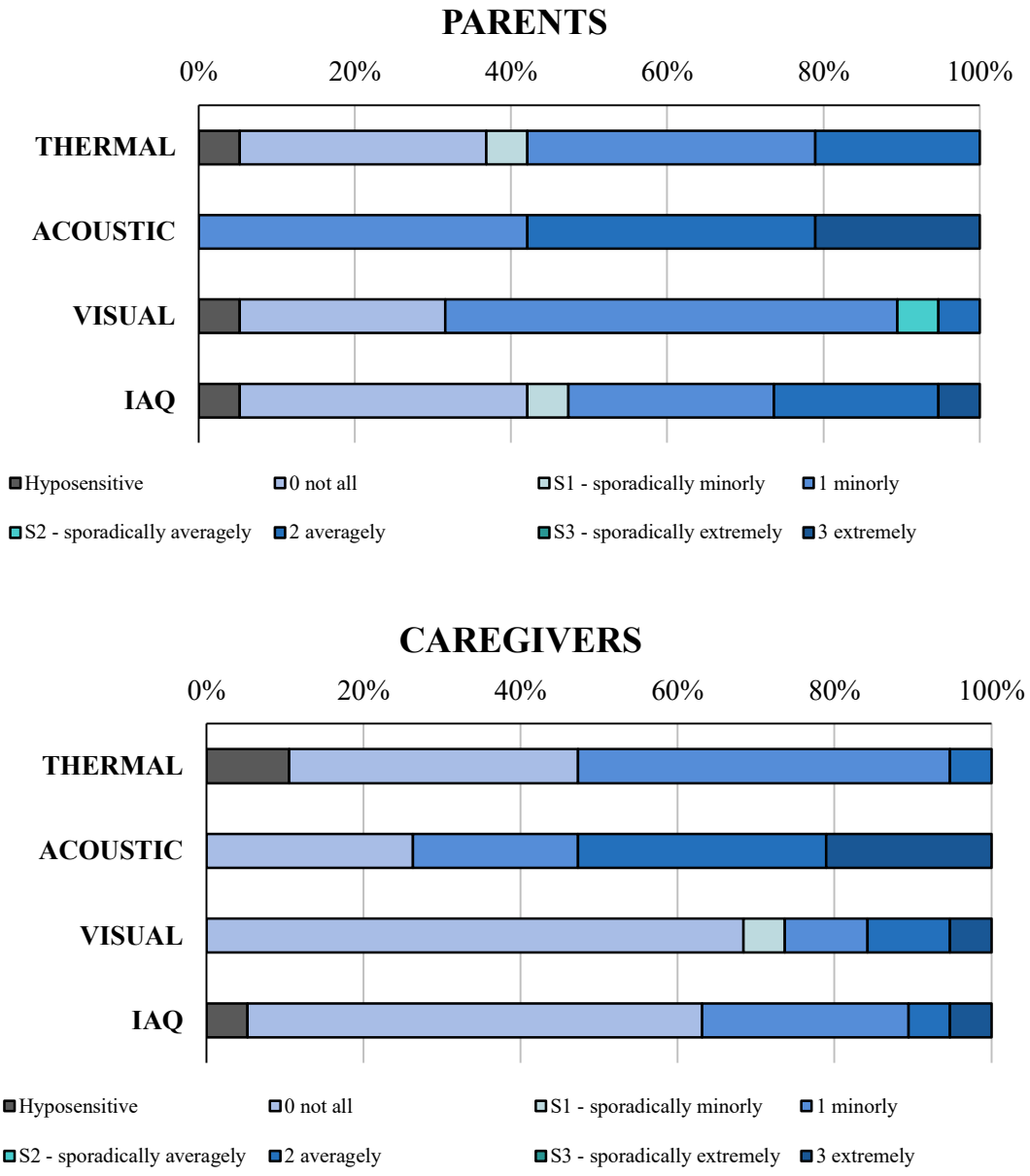

Figure 3: Answers provided by the proxy respondents- comparison between Parents and Caregivers

Table 3 depict the results of the Mann-Whitney test. This statistical analysis shows that, with the exception of visual environment, the differences between answers in the everyday life (provided by parents) and care environments (provided by caregivers) were not significant. In terms of the visual indoor environment, the results depicted in Figure 3 show a major perception of visual environment provided by parents, in the range of "minor" perception (60 % by parents vs. 10% by caregivers). This difference can be correlated to the design of the care unit, specifically designed to be utilized by ASC people, such as the presence of proper illumination, lamps and light colors, or proper daylight exploitation (e.g., rooms with large fenestration areas and a proper view to the outside). This could be in contrast with normal conditions in domestic environments.

Table 3: Mann-Whitney test between the answers provided by proxy respondents

	Control sample (N_P =19; N_C =19)
Thermal	0.405
Acoustic	0.435
Visual	**0.098***
IAQ	0.203

Finally, Table 4 explores the correlation between the answers provided separately by parents and caregivers to check if a similarity in the trends provided by the two proxy respondents was present. In this case, a good correlation on indoor air quality was detected. The correlation coefficient was positive, meaning that when one perception detected by a proxy respondent increases, the other one increases too. This last result on indoor air quality shows that, regardless of the facility where the user with ASC was located, the response was quite similar. In fact, the IAQ domain seemed to be the one causing the least discomfort in both cases.

Table 4: Spearman's correlation test between the answers provided by parents and caregivers on the four comfort domains

Cross Correlation between Parents and Caregivers				
		Caregivers		
	Domain	Thermal	Acoustic	IAQ
Parents	Thermal	corr. coeff=0.186 p=0.445		
	Acoustic		corr.coeff=0.023 p=0.925	
	IAQ			**corr. coeff=0.527 p=0.020**

Table 5 explores the influence of age, presence of comorbidities and spectrum severity with a dedicated Spearman's rank correlation analysis. Results showed that in three cases the reported perception by the two different proxy respondents were similar. In particular, acoustic and indoor air quality perceptions of ASC individuals over 15 years old were depicted as quite similar. Furthermore, acoustic perception was also identified by Spearman's statistical test to be perceived similarly by individuals with a low severity ASC by both parents and caregivers. In all these cases, the cross-correlation coefficient was positive, meaning that, as one perception detected by a proxy respondent increases, the other one increases too.
No correlations related with the presence or absence of comorbidities were identified.

Table 5: Spearman's correlation test between the answers provided by parents and caregivers on the four comfort domains, restricting the sample according to different personal data of individuals

Cross Correlation between Parents and Caregivers							
		Age		**Comorbidities**		**Severity**	
Parents	**Caregivers**	Under 15 y.o.	Over 15 y.o.	With comorbidities	Without comorbidities	Low Severity	High Severity
Thermal	Thermal	cross.coeff= -0.035 p=0.929	cross.coeff= 0.500 p=0.170	cross.coeff= -0.542 p=0.063	cross.coeff= 0.484 p=0.206	cross.coeff= -0.530 p=0.358	cross.coeff= -0.272 p=0.418
Acoustic	Acoustic	cross.coeff=	**cross.coeff=**	cross.coeff=	cross.coeff=0	**cross.coeff=**	cross.coeff=

		0.052 p=0.895	**0.797** **p=0.010**	-0.024 p=0.754	p=0.99	**0.968** **p=0.007**	0.225 p=0.505
Visual	Visual	cross.coeff= -0.082 p=0.834	cross.coeff= 0.456 p=0.217	cross.coeff= -0.310 p=0.398	cross.coeff=0 p=0.99	cross.coeff= 0.408 p=0.495	cross.coeff= -0.420 p=0.198
IAQ	IAQ	corr.coeff =0.635 p=0.066	**corr.coeff** **=0.673** **p=0.047**	corr.coeff= 0.561 p= 0.116	corr.coeff= 0.074 p= 0.838	corr.coeff<0. 001 p= 0.99	corr.coeff= 0.11 p= 0.974

4. CONCLUSIONS

Results show that, with exception made for the visual environment, differences between the perception reported by the two proxy respondents are not significant. The difference detected by the Mann-Whitney test in the perception of the visual environment can be directly linked to the attention paid in the care facility design of lights and daylight exploitation.

Moreover, analyzing the correlation between the responses provided by both proxy respondents as regards the perception of the four comfort domains, it was found that when the IAQ perception determined in the households increases, it also increases in care facilities.

Finally, in order to understand if the results were connected to the personal data of the ASC individuals, a further Spearman's correlation analysis was performed. The results of this test showed that, for individuals over 15 years old, the trend of responses described by the two proxy respondents is similar for both the IAQ domain and the perception of the acoustic environment. Moreover, for individuals featuring low autism severity, a cross-correlation between the answers provided by parents and caregiver was found for the acoustic domain, showing that the answers provided for these individuals had similar trends. No relationship as regards co-morbidities was found.

Since the sample was rather restricted, the future perspective of the presented research is to enlarge the control sample in order to evaluate if, on a larger population, there are further correlations between the perceptions detected by parents and caregivers in diverse environments (household and care facility).

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