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Research Article

Sensory Processing, Gastrointestinal Symptoms and Parental Feeding Practices in The Explanation of Food Selectivity: Clustering Children with and Without Autism

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Abstract

Children with Autism Spectrum Disorders are a group of neurodevelopmental disorders (ASD) and compared to Typically Developing Children (TDC), experience significantly more feeding problems. Food selectivity is a complex phenomenon that involves individual and contextual factors (sensory abnormalities, severity of behavioral problems, gastrointestinal disorders, parenting styles and so on). The clarification of these key factors is the aim of the current study, comparing a group of children with ASD with a group of TDC on different variables such as food selectivity, anthropometric measures, gastrointestinal symptoms, diet, sensory processing and caregiver feeding practices. Moreover, the same variables described above are studied using a classification model for both groups. Results display that parenting style, sensory anomalies and gastrointestinal symptoms were associated with food refusal of children. Moreover, it is possible to observe similar profiles in children with feeding problems in both groups.

Autism Spectrum Disorders (ASD) are a group of neurodevelopmental disorders characterized by social communication deficit and a tendency to engage in a pattern of restricted and repetitive behaviors, in which sensory issues are included (American Psychiatric Association [APA], [1]). Children with ASD, compared to Typically Developing Children (TDC), experience significantly more feeding problems [2], with food selectivity being the most frequently reported. Food selectivity could be operationally defined on the basis of the occurrence of the following behaviours: food refusal, limited repertoires of food, high frequency single food intake [3]. Several research studies observed a prevalence between 70% and 80% of food selectivity among children with ASD [4-6], despite parents never having described their children as in appetent [7]. Klein and Nowak (1999) [8] found that 53% of children were reluctant to try new foods. Whiteley, Rodgers, and Shattok (2000) [9] indicated a prevalence of 83% of children with a restricted repertoire of foods eaten. Similarly, Schreck and Williams (2006) [6] found that 57% of children refused food, while 72% accepted limited variety.

A more consistent prevalence was found by Lockner, Crowe, and Skipper (2008), [10] who thought that new foods refusal in children with ASD was higher compared to TDC (95% vs. 47%). Furthermore, children with ASD were characterized also by a limited variety of food intake (16% vs. 58%). However, Bandini et al. (2010) [3] found lower rates of refusal in both groups compared to previous studies (41.7% vs. 18.9%). Methodological differences in research studies such as different approach mechanisms may have accounted for conflicting results. Food selectivity in ASD is really important because it is linked to health risks for children, and it may require some medical intervention [11]. In fact, in a recent review by the same authors, BMI and other anthropometric values in children with autism seem to differ from that of TDC, along with nutritional insufficiency [12]. However, in this survey as well as other recent studies [13,14] this difference was not always confirmed, with the literature still seeming incomplete. At the same time several studies tried to identify some of the causes for food selectivity in children with ASD. Some researchers investigated the role of motor coordination disorders and/or gastrointestinal problems. Children with praxis difficulties may lack the necessary motor skills to adequately handle food, leading to negative emotions avoidance [15]. Also, researchers have found contrasting results in Gastrointestinal Disorders (GID).

According to a recent survey, a higher frequency of GID may be associated with a more severe food selectivity in children with ASD [16], while for others, the two phenomena seem largely independent in children with autism [17]. Indeed, children with and without autism experiencing frequently bowel problems and/or gastroesophageal reflux could display more feeding-related problems, since they could try to avoid foods associated with adverse circumstances. On the other hand, many children with autism commonly well-defined as picky or choosy eaters do not show gastrointestinal issues. In fact, other authors explained food selectivity in children with ASD as a consequence of repetitive behaviour and restricted interests [18,19]. However, the most accepted etiological hypothesis would seem to postulate a relationship between sensory perception abnormalities and rejection of food [20] both from children with typical and atypical development. As shown by Nadon, Feldman, Dunn, and Gisel (2011) [21], almost 90% of children with ASD show impairment in sensory processing information, including a hypo and or hypersensitivity to environmental stimuli. The differences in sensory processing in children with ASD have been well documented [22]. These abnormalities have been associated with both behavioural and emotional problems [23,24] and the severity of symptoms [25]. Since foods have several properties which can stimulate sense organs, it is possible that children who have sensory perception alteration might refuse them to a greater extent as they are more or less stimulating. From interviews with parents and behavioural observations it has been proven that children with ASD are adverse towards food characteristics such as texture, smell, taste and temperature [10,14,23,26-28], yet other food properties seem to be more important to them such as brand, packaging (patterns/colours), food presentation and even cutlery [4,6,9]. Finally, eating behaviours not only have a biological matrix but are also influenced by social and cultural variables [29], therefore it's possible that in addition to the individual dimensions, parental feeding practices can also play a significant role in food selectivity. Currently, a research study [13] evaluated the parental feeding style and the food selectivity in children with ASD, indicating strategies as prompting/encouragement as the most used among parents. This direction of research is of particular interest not only scientifically but also in the way of application. If a relationship between parental feeding practices and food selectivity is found, it will be possible to devise intervention programs aimed at promoting functional parenting styles in order to achieve healthy eating behaviors. Hence, the aim of the current study is to compare a group of children with ASD with a group of TDC on different variables such as food selectivity, weight, gastrointestinal disorders, diet, sensory process and caregiver feeding practices. To sum up, we want to explore the following research questions: a) if the group of children with ASD shows more levels of food selectivity than controls; b) if the children with ASD report lower scores of BMI than controls; c) if the clinical group shows more sensory abnormalities than controls; d) if an association between food selectivity, BMI, GID, sensory dimensions and parental feeding styles can be established in both groups of children, e) if it is possible to discover similar profiles of children in both groups.

Method

Participants

The sample of participants (N=100) comprised two-paired groups of children. The first group was selected on the basis of the diagnosis of autism spectrum disorder, made by experienced clinicians, based on the criteria of the DSM-5 and assessments by means of standardized diagnostic instruments: The Autism Diagnostic Observation Schedule (ADOS) [30], the Autism Diagnostic Interview-Revised (ADI-R) [31], the Griffiths Mental Development Scales- Extended Revised (GMDS-ER) [32] and the Social Communication Questionnaire (SCQ) [33]. The age of the clinical group was between 25 and 98 months (M=54,4; SD=17,09; 84% of males). The second group consisted of typical children enrolled by schools in the same community. This control group didn't surpass the criteria for autism at the SCQ total score while the age range was between 25 and 89 months (M=55,78; SD=18,27; 78% of males). In order to investigate the hypotheses

of the current study concerning the food selectivity of the children with and without autism along with related parental feeding practices, the mothers of both groups filled some questionnaires and answered to interviews provided by researchers. Furthermore, the exclusion criteria for both groups of children included the presence of genetic abnormalities, organic disorders and other psychiatric disorders. All the analyses were adjusted if children were on a diet at the intake of the study as well as if they followed some clinical or nutritional interventions. However, none of the enrolled children had received treatment for feeding problems before and during the current study, as a result their parents applied common parental feeding strategies in order to manage feeding problems of their child when needed. Moreover, the groups were similar regarding quasi-experimental variables such as age, sex, and mothers level of education. Especially, for the last aspect we have assigned three codes (from 1 to 3) to the corresponding mothers' education levels (1: primary school; 2: high school and 3: degree), for more information see (Table 1).

		Children with ASD (n=41/50)		Children without ASD (n=48/50)		Group Differences		
Characteristics	Variable	Mean(SD)/ Proportion	Range	Mean(SD)/ Proportion	Range	F(df)/χ^2(df)	P-Value	Effect Size
Age	Months	54 (18)	25-98	56 (18)	25-89	.12 (1,88)	.72	.001
Mother's Education	Levels	2 (.49)	1-3	2 (.50)	1-3	.97 (1,88)	.32	.01
GID	Vomiting	0.32 (.61)	0-3	0.27 (.60)	0-3	.25 (1,85)	.61	.003
	Diarrhoea	0.63 (.62)	0-3	0.63 (.78)	0-3	.007 (1,85)	.93	<.001
	Constipation	1.07 (1.25)	0-3	0.49 (.98)	0-3	4.64 (1,85)	.03*	.05
	Reflux	0,03 (.16)	0-3	0.11 (.31)	0-3	2.23 (1,85)	.13	.02
SSP	Tactile Sensitivity	28.82 (4)	16-35	32.14 (3)	22-35	15.82 (1,84)	<.001*	.15
	Taste/Smell Sensitivity	13.73 (6)	3-20	17.37 (3)	2-20	14.02 (1,84)	<.001*	.14
	Movement Sensitivity	12.58 (3)	3-15	14.29 (1)	10-15	10.89 (1,84)	.001*	.11
	Seek Sensation	23.39 (6)	11-34	28.02 (6)	14-35	12.64 (1,84)	.001*	.13
	Auditory Filtering	17.92 (5)	6-26	27.08 (4)	16-35	85.57 (1,84)	<.001*	.50
	Low Energy/Weak	26 (6)	6-30	28.8 (3)	18-35	7.6 (1,84)	.007*	.08
	Visual/Auditory Sensitivity	18.03 (5)	5-25	22.41 (3)	15-30	29 (1,84)	<.001*	.25

BAMBI	Refusal	9 (4)	5-21	7.49 (3)	5-16	4.85 (1.88)	.03*	.05
	Limited Variety	19.32 (6)	8-32	16.98 (5)	8-29	4.01 (1.88)	.04*	.04
	Autism Characteristics	9.9 (3)	5-15	8.14 (3)	5-19	8.17 (1.88)	.005*	.08
CFSQ	Parent Centered/ High control	2.34 (.90)	1-4	1.88 (.86)	1-4	6,15 (1,87)	.01*	.06
	/Contingency Management	1.96 (.77)	1-4	2.02 (.89)	1-4	.107 (1,87)	.74	.001
	Child Centered	2.64 (.60)	1-4	2.73 (.90)	1-4	.31 (1,87)	.57	.004
Note. *α<0.05; GID = Gastrointestinal Disorders [34]; BMI = Body Mass Index; SSP = Short Sensory Profile [35]; BAMBI = Brief Autism Mealtime Behavior Inventory [36]; CFSQ = Caregiver Feeding Style Questionnaire [37]. The number of participants has been reduced excluding children on a diet.								

Table 1: Comparing children with and without autism on all variables investigated: age of children, mothers' education levels, gastrointestinal disorders, sensory anomalies, food selectivity and parental feeding practices.

Assessment of Gastrointestinal Disorders, Weight and Diets

In order to assess the growth curves, any gastrointestinal disorders and the quality/quantity of food intake, we chose an interview adapted by Badalyan and Schwartz (2012) [34]. Firstly, through the interview with mothers, the weight and height of all children were collected, subsequently the relative Body Mass Index (BMI) (kg/m^2) was calculated as reliable measurements in the diagnosis and monitoring of children's weight [38]. Each child was then classified, according to their BMI, in four subclasses: obese (Equal to or greater than the 95th percentile), overweight (85th to less than the 95th percentile), normal weight (5th percentile to less than the 85th percentile) and underweight (less than the 5th percentile). For further information about this classification please see the website http://www.cdc.gov/healthyweight/assessing/bmi. In addition, the mothers were interviewed about the frequency and duration of four main gastrointestinal disorders in children including: constipation, diarrhoea, vomiting and gastroesophageal reflux. In particular, "constipation" was defined by a lack of defecation by the child for more than three days, "diarrhoea" was defined by the presence of more than three runny bowel movement per day, while "vomiting" and "reflux" was defined by a single episode shown by the child. The mothers responded to each question in respect to both the frequency of each disorder (4-point scale from "never" to "often") and its duration (4-point scale from "never", "six months", "year" to "more than a year"). Finally, mothers were asked if the children were at that time on any specific diet (gluten-free, casein-free, soy and carbohydrate) and if they were assuming foods in these categories: carbohydrates, vegetables/legumes, fruits, milk and dairy, meat/fish. The children who followed a special diet (especially for food allergy and intolerance) were excluded in all the analyses in order to control the reliability of data.

Assessment of Child Eating Behaviors

In order to investigate the child's food selectivity, applying the definition of rejection of food and lack of variety of foods consumed [3], eating behaviors of children were evaluated with the Brief Autism Mealtime Behavior Inventory (BAMBI) [36]. The BAMBI is a scale of 18-items, validated for preschool children and created to evaluate the nature of behavioral problems at meal times in children with autism. The answers are provided on a 5-point Likert scale. In addition, for each item, the parents had to judge whether they perceived behavior as stressful. The total score is calculated as the sum of items and high scores are the most problematic behaviors. In addition, it is possible to calculate the percentage of stress perceived by parents for each of the three scales considered. The first scale (Refusal) refers to the child's refusal or denial of foods as "My child expels (spits out) food that he/she has eaten". The second scale (Limited Variety) includes questions about a restricted consumption of specific categories of foods as "My child prefers the same foods at each meal" while the last scale (Autism Characteristics) highlights some challenging behaviors which can occur during mealtime as "My child displays self-injurious behavior during mealtimes".

Assessment of Child Sensory Processing

To evaluate the sensory abnormalities in children, the Short Sensory Profile (SSP) adapted from Dunn (1999) [35], was submitted to the mothers. This tool is a standardized questionnaire

that enables clinicians and researchers to identify problems in sensory processing in children. This instrument consists of 38-items extracted from a long version (Sensory Profile of 125-items). It is divided into seven subscales: Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Under Responsiveness/Seek Sensation, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity. The mothers answered the questions on a five-point Likert scale, from never (for 0% of the time) to always (100% of the time). The responses are added up to calculate the score of each subscale so as to obtain a total score, which will be classified as Typical if within 1 Standard Deviation (SD) from the reference mean, Probable Difference, if between 1 and 2 SD and Definite Difference if 2 SD below the mean. Low scores on each subscale indicate a greater sensitivity in the child, for this reason in all the analyses the scores were reversed apart from the (Table 1). In the application of this instrument or its long version, some authors found that 85% of the items discriminated children with ASD by TDC [39]. The differences were most evident in the way in which children with ASD responded to the touch or to auditory input. Also Watling, Deitz, and White (2001) [40] found that 85% of young children with ASD (3-6 years) reported lower scores than children without autism, at least on one factor. Similarly, Baker, Lane, Angley, and Young (2008) [41], reported that children with autism (2-9 years) had more than two SD below the mean on the SSP to the domain of Under Responsiveness/Seek Sensation.

Assessment of Caregiver Feeding Practices

To evaluate parental feeding style on children's eating habits, the Caregiver's Feeding Style Questionnaire (CFSQ) was submitted [37]. This self-report instrument, suitable for parents of preschoolers, is composed of 19-items. The mothers answered questions in the questionnaire on a five-point Likert scale (from never to always) regarding some behaviors adopted with their child during mealtime. This instrument allows us to classify caregiver feeding styles according to a qualitative or quantitative approach. The first approach provides four qualitative categories, calculated through the median of two main scores. Following this data collection methodology, caregiver feeding style is classified as Authoritative, Authoritarian, Indulgent or Uninvolved. On the other hand, the second approach classifies caregiver feeding styles into three quantitative factors: Parent-Centered/High-Control, Parent-Centered/Contingency Management and Child-Centered Feeding Practices. We chose this method to analyse the difference between the groups and a possible association between the variables examined. When a caregiver adopts a strategy based on Parent-Centered/High-Control scale he or she physically and verbally struggle with the child to get him or her to eat (for example, putting the child in the chair or begging the child to eat dinner). Conversely, a parent assuming Contingency Management strategies can promise or take something away from the child other than food (for example, reducing play time after dinner or offering preferred foods after functional behaviors). Lastly, the third parental feeding style composing the questionnaire is child-centered. In these cases, the parent merely helps the child to eat dinner (for example, cutting the food into smaller pieces, saying something positive about the food the child is eating, arranging the food and cutlery in a more interesting way).

Data Analysis

Preliminarily, a set of descriptive analyses on the sample were conducted. Successively, to study the differences between the clinical group and controls an ANOVA-between for quantitative data and Chi-square test regarding frequencies were conducted on the following variables (socio-demographic data, food intake, presence of gastrointestinal disorders, distribution levels of BMI, sensory scales, food selectivity scales and caregiver's feeding styles). Previously to perform a classification model, it was necessary to transform the categorical variables of GID in numeric dimension. For this reason, we applied a multiple correspondence analysis including seven input variables (sex, diagnosis, classification of BMI, Vomiting, Constipation, Reflux and Diarrhoea). Through this methodology we extracted three quantitative dimensions see (Table 2). The first dimension (named GID) captured the high scores of the main gastrointestinal symptoms (constipation, vomiting and reflux) and could be included either in correlation or in the clustering model. As a result, two separate correlation analyses using the Pearson coefficient were conducted to investigate the relationship between the main variables for each group as age, BMI, GID, sensory scales, food selectivity and parental feeding practices. Finally, a K-means clustering algorithm (number of clusters=3, 4 and 5, random iterations=10) was performed for both groups including all the quantitative variables (AGE, BMI, GID, SSP, BAMBI and CFSQ). Data analyses were performed using the R Package Version 3.3.3, SAS Enterprise Guide Version 7.14 and SAS Enterprise Miner version 14.1. Note that the first author is an international certified SAS data analyst.

Variable	Label	Dimension 1	Dimension 2	Dimension 3
Vomiting	Never	-0,394	0,158	0,086
Constipation	Never	-0,358	-0,088	-0,169
Reflux	Never	-0,341	0,279	0,216
Diarrhoea	Never	-0,174	0,124	-0,116
Vomiting	Rarely	0,292	-0,221	-0,137
Constipation	Rarely	0,097	-0,021	0,231
Reflux	Rarely	0,205	-0,243	-0,096
Diarrhoea	Rarely	0,186	-0,168	0,131
Vomiting	Sometimes	0,183	0,085	0,014
Constipation	Sometimes	0,192	0,179	-0,071
Reflux	Sometimes	0,163	-0,203	-0,214
Diarrhoea	Sometimes	0,038	0,149	0,060
Vomiting	Often	0,143	-0,009	0,085
Constipation	Often	0,231	-0,012	0,077
Reflux	Often	0,219	0,042	-0,066
Diarrhoea	Often	-0,072	-0,022	-0,103
Weight	Underweight	0,227	0,151	-0,084
Weight	Normal	-0,162	-0,084	-0,227
Weight	Overweight	-0,049	-0,177	0,292
Weight	Obese	0,047	0,138	0,149
Note: Total number of input variables: 7 (Sex, diagnosis, classification of BMI, Vomiting, Constipation, Reflux and Diarrhoea); Total variation explained by the selected principal components: 0.350				

Table 2: Multiple Correspondence Analysis: transforming categorical variables as gastrointestinal issues in three numerical dimensions.

Results

Characterization of the sample

All participants were Italian and came from rehabilitation facilities and schools. None of the participants, even if needed, had followed treatment for feeding problems before and during the current study. The majority of children with ASD followed weekly behavioural treatment along with standard health service (locomotor and speech therapy), while the typical children regularly followed school curriculum without additional educational support. After the conclusion of the study some children with ASD started a sensory or behavioural intervention for feeding issues. Through the structured interview [34] we have detected that nine children with ASD followed a gluten free diet, lactose or casein (five of whom presented food allergies), while only two of the children in the control group were on a diet for feeding intolerance. Note that the following data has been calculated excluding all children who followed a specific diet. Regarding the food intake of both groups, children with ASD displayed a lower percentage of accepted food categories than TDC such as bread (75% vs. 87,5%), vegetables and legumes (51,2% vs. 68,8%), fruits (51,2% vs. 83,3%), dairy products (73,2%% vs. 89,6%), meat and fish (80,5% vs. 91,7), even though these differences didn't surpass the significance criteria. Likewise, the differences in the percentages on BMI categories among the ASD and TDC were not significant showing a similar distribution between the groups: underweight (17% vs. 8%), normal weight (61% vs. 69%), overweight (10% vs. 16%) and obese (12% vs. 6%).

Concerning gastrointestinal disorders, we have found a low frequency of the four conditions examined in both samples except for the constipation dimension in the group of children with autism (ASDm=1.07, TDCm=0.49; F=4.64, p=.03). Moreover, children's eating behaviors were observed through the subscales of BAMBI questionnaire showing significant differences between the groups, respectively for refusal scale (ASDm=9, TDCm=7.49; F=4.85, p=.03), limited variety (ASDm=19.32, TDCm=16.98; F=4.01, p=.04), autism characteristics (ASDm=9.9, TDCm=8.14, F=8.17, p=.005) and total score (ASDm=38.22, TDCm=32.61, F=7.60, p=.007). Comparing the groups, even the subscales of Short Sensory Profile were significant. In particular, 51% of children with ASD fell below two SD from the reference mean, 21% one SD below the reference mean and 28% within one SD from the reference mean than TDC (4%, 4%, 92%; X^2=36.90, p<.001). Finally, concerning the data collected with the Caregiver Feeding Style Questionnaire only the first dimension was significantly different comparing the groups, specifically the Parent Centered-High Control scale (ASDm=2.34, TDCm=1.88; F=6.15, p=.01). To find additional information on all the scores gathered by clinical and control group please see (Table 1).

Correlation analyses

The correlational analyses showed some similar (but not equal) associations between children's sensory sensitivity, GID, parental feeding practices and food selectivity either for children with autism or for the control group see (Table 3). Precisely, the group of children with autism displayed a hypersensitivity to gustatory, smell, movement and visual stimuli connected with food selectivity along with the presence of gastrointestinal symptoms. On the other hand, the control group of children presented a tactile, auditory and taste/smell sensitivity along with a weakness associated with food refusal, displaying a minor influence of GID. Moreover, the analyses indicated an association among the caregiver feeding style and food selectivity scales in both groups, one of these relationships was displayed only in the ASD group (the child-centered strategy). The different educational approaches of mothers to the feeding problems of their children could be described as a diverse reaction to challenging behaviours of the children with autism exhibited at mealtime.

	Children with ASD						Children without ASD					
Variables	**Refusal**		**Limited variety**		**Autism characteristics**		**Refusal**		**Limited variety**		**Autism characteristics**	
Age	0,005	0,970	0,067	0,645	0,065	0,654	-0,064	0,660	0,034	0,812	0,028	0,848
BMI	-0,255	0,074	-0,181	0,209	-0,236	0,099	-0,144	0,320	-0,154	0,287	-0,127	0,380
GID	0,413	0,003*	0,451	0,001*	0,501	0,000*	0,403	0,004*	0,189	0,19	0,124	0,393
Tactile Sensitivity	0,229	0,109	0,025	0,861	0,277	0,052	0,425	0,002*	0,240	0,093	0,414	0,003*
Taste\Smell Sensitivity	0,464	0,001*	0,627	0,000*	0,481	0,000*	0,322	0,023*	0,385	0,006*	0,272	0,056
Movement Sensitivity	0,250	0,080	0,28	0,049*	0,366	0,009*	0,117	0,418	0,168	0,244	0,245	0,086
Under Resp. Seek Sensation	0,049	0,738	-0,056	0,697	0,084	0,561	0,519	0,000*	0,265	0,063	0,104	0,470
Auditory Filtering	0,093	0,521	0,096	0,507	0,307	0,030*	0,461	0,001*	0,251	0,079	0,221	0,122
Low Energy/Weak	0,108	0,455	-0,093	0,521	-0,136	0,346	0,279	0,049*	0,146	0,312	0,009	0,953
Visual Auditory Sensitivity	0,379	0,007*	0,213	0,138	0,335	0,017*	0,325	0,022*	0,298	0,036*	-0,086	0,554
Parent C. High Control	0,577	0,000*	0,133	0,357	0,491	0,000*	0,650	0,000*	0,473	0,001*	0,194	0,176
Parent C. Cont. Management	0,431	0,002*	0,422	0,002*	0,333	0,018*	0,625	0,000*	0,365	0,009*	0,227	0,113
Child Centered	0,447	0,001*	0,517	0,000*	0,455	0,001*	0,146	0,31	0,277	0,051	0,006	0,966
**α<0.05*												

Table 3: Correlation analysis of children with and without ASD: associations between age of children, BMI, GID, sensory anomalies, parental feeding practices and food selectivity scales.

Cluster analyses

The cluster analyses indicated three similar subgroups in both groups of children even if with some differences concerning the prevalence of some input variables within the specific profile. As showed by (Table 4) (cluster means), the cluster 2 (frequency=12%) of children with autism, considered as at high risk, displayed the following features: BMI (-0,74), GID (1,11), Taste/Smell (1,49), Movement (0,96), Visual (0,92), Refusal (1,66), Limited Variety (1,67), Autism Characteristics (1,30), Parent Contingency Management (1,40) and Parent Child Centered Strategy (1,19). Correspondingly, in the control group the cluster 2 (frequency=18%) shared some features with the previous subgroup: GID (1,13), Refusal (1,55), Limited Variety (1,07), Contingency Management (1,44), although exhibited some significant dissimilarities as Tactile (0,98), Seek Sensation (1,26), Auditory Filtering (1,09), Weak (0,71) and Parental High Control (1,34). A "safe subgroup" occurred in both groups of children (the clusters 3), since it presented lower scores of food selectivity than the other clusters studied (third cluster of ASD: Refusal=-0,48, Limited Variety=-0,40; third cluster of Controls: Refusal=-0,40, Limited Variety=-0,34). Finally, the groups of children varied with respect to the first cluster, since the risk of food problems in the children with autism was slightly higher than the controls (first cluster of ASD: Tactile=0,67, Refusal=0,15, Autism Characteristics=0,44, Parental High Control=0,55; first cluster for Controls: Tactile=0,34, Refusal=-0,16, Autism Characteristics=-0,26, Parental High Control=-0,11).

	Children with ASD			Children without ASD		
Variables	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 1**	**Cluster 2**	**Cluster 3**
Age	-0,048	0,384	-0,055	-0,207	-0,213	0,140
BMI	-0,146	-0,744	0,273	-0,073	-0,134	0,067
GID	0,386	1,114	-0,524	0,307	1,132	-0,452
Tactile Sensitivity	0,675	0,332	-0,544	0,345	0,984	-0,422
Taste\Smell Sensitivity	0,090	1,493	-0,407	0,601	0,616	-0,405
Movement Sensitivity	0,294	0,968	-0,427	0,396	0,521	-0,301
Under Responsiveness Seek Sensation	0,423	0,180	-0,334	0,246	1,266	-0,470
Auditory Filtering	0,587	0,285	-0,472	0,097	1,094	-0,364
Low Energy Weak	0,585	0,050	-0,416	0,438	0,715	-0,375
Visual Auditory Sensitivity	0,468	0,922	-0,537	0,897	0,625	-0,517
Refusal	0,151	1,669	-0,489	-0,164	1,550	-0,405
Limited Variety	0,022	1,670	-0,400	0,044	1,079	-0,340
Autism Characteristics	0,443	1,304	-0,607	-0,267	0,700	-0,112
Parent Centered High Control	0,551	0,678	-0,538	-0,112	1,341	-0,361
Parent Centered Contingency Management	0,090	1,403	-0,386	-0,653	1,449	-0,195
Child Centered	0,219	1,198	-0,428	0,033	0,473	-0,154

Note: Children with ASD: Frequency of Clusters/Nearest Cluster: Cluster 1(36% /CL 3); Cluster 2(12% /CL 1); Cluster 3(52% /CL 1); R^2=0.292; Cubic Clustering Criterion=11,788; Solution with four and five clusters: R^2=0.358; Cubic Clustering Criterion=11,075; R^2=0.392; Cubic Clustering Criterion=9,035 Children without ASD: Frequency of Clusters/Nearest Cluster 1(22% /CL 3); Cluster: Cluster 2(18% /CL 1); Cluster 3(60% /CL 1); R^2=0.276; Cubic Clustering Criterion=10,305; Solution with four and five clusters: R^2=0.321; Cubic Clustering Criterion=8,051; R^2=0.359; Cubic Clustering Criterion=6,438

Table 4: Cluster Analysis: comparing three subgroups of children with and without ASD which display similar and different patterns concerning weight, gastrointestinal issues, sensory anomalies, food selectivity and parental feeding practices.

Discussion

This study was aimed at defining the profile of the child at risk of food selectivity in terms of individual and environmental factors. Precisely, we have compared children with and without autism supposing, in the first research question (a), that children with ASD would have showed more levels of food selectivity than neurotypical children. This study confirms this evidence showing more levels of food selectivity in children with autism than controls, in accordance with the percentages of feeding problems found in the literature in children with ASD [4-6,9,10]. Moreover, the relationship between BMI and food selectivity in children's development is of great importance since the lack of variety in the diet could expose children with ASD and TDC to poor nutritional intake [3,20,42]. Although in our study we did not detect biomarkers, through the interviews we revealed that almost half of the clinical sample did not eat vegetables, legumes and fruit. It seems reasonable that the frequent refusal of certain foods, can lead to a preference to specific food categories, and this may change the caloric intake of children with ASD, resulting in a reduction or significant weight gain. In fact, 22% of our sample was found to be overweight or obese, while 17% underweight. These percentages are similar in part to those found by other authors in a larger clinical sample [43] and by a recent survey which indicates lower values of BMI in children with ASD compared to TDC [42]. However, even if in the current study the children with ASD showed more percentages of underweight and obese subclasses than the TDC, these differences didn't overcome the significance criteria (research question b). A limit of our study overall for this variable is certainly the poor numerosity of the sample, since within the cluster 2 of the clinical group, considered at high risk for feeding issues, the levels of BMI was near the 1st SD (-0,74). Another focus of interest in the current study concerned the frequency and the duration of gastrointestinal disorders. Several previous studies have reported a higher incidence of gastrointestinal disorders in children with ASD [16,34,44]. Therefore, since gastrointestinal disorders may affect eating behaviours of typical children, it is recommended investigating these issues during one child's evolution [16]. Our results, while indicating a low incidence of gastrointestinal disorders in general, have shown a relatively high percentage of constipation in children with ASD. This evidence could be the result of atypical eating behaviors characterized by a low intake of fiber, fruits and vegetables [3].

Additionally, the third hypothesis (c) of our study was to demonstrate that children with ASD can display more sensory abnormalities than neurotypical children influencing their feeding behaviors. In fact, we found that 72% of the children with autism exceeded 1SD from the reference mean concerning the SSP versus 8% of the typical children, and in particular the Tactile Sensitivity and Under Responsive/Seek Sensation scales were more representative, as observed by other authors [39-41]. Moreover, sensory processing had an impact on food selectivity in both groups. Particularly, gustatory, movement and visual hypersensitivity were associated with an increase in food selectivity at mealtime for the children with ASD while tactile, auditory, taste/smell and weakness were exhibited by typical children. On a theoretical basis, this evidence would support the hypothesis of an aetiology of food selectivity in children which is secondary to sensory anomalies. According to this hypothesis [45], it is possible that sensory hypersensitivity can make the properties of a wide variety of foods aversive, inducing children to avoid new foods. Such avoidance behavior could have the function to reduce the discomfort caused by the texture and flavour of the food. In addition, the movement and the background noise expected during some meal times, especially at school, could instigate in children with autism dysfunctional behaviors such as throwing food from the table, getting up or running around the room. Likewise, this hypothesis is supported by studies that have recently highlighted the incidence of sensory abnormalities in eating disorders in children with ASD [20,46,45]. In particular, children with ASD seem to refuse food just on the basis of perceiving their sensory characteristics, such as texture, smell and taste, as aversive [4,21,23,26,27]. However, the only hypothesis with regard to hypersensitivity is not sufficient in the explanation of food selectivity in children, since other variables play an important role in the expression of this phenomenon. Mainly, in the current research the gastrointestinal symptoms investigated through the GID dimension (constipation, vomiting and reflux) have been associated with food refusal, limited variety of food and autism characteristics especially for children with autism, as displayed by correlation analyses.

Similarly, food problems in children with autism could also occur simply due to their challenging behaviors (occurrence of sameness, self-injury or aggressive behavior, scarce interests and so on). Finally, education received by caregivers could have an impact on children's feeding routines either through parents' food preferences (children could follow the feeding behaviours of their parents starting to imitate their routines), or through parental feeding practices. In fact, in our sample food refusal and limited variety of diet were associated with parental feeding practices in both groups of children (research question d). For example, a demanding educational style at mealtime (parent centered-high control) appeared to be related to a higher level of food selectivity in both groups. A similar finding was reported in a recent study by Kral et al. (2014) [13] who found that strategies of prompting-encouragement are the most adopted by parents of children with ASD. On the other hand, the correlation analyses also revealed that an educational style more sensitive and responsive to the child's needs during mealtime (child-centered) seemed to be associated with an increase in food refusal only for the group of children with autism. One potential explanation for this last association

could be interpreted as an acceptance by parents that well-known food categories, habitually accepted by the child, in particular when the child displays severe challenging behaviors during mealtimes. Probably, the parent's behaviour could hide the fear of observing a child's regression, if they are authoritative towards the child. According to the previous results, the cluster analyses applied for both groups seem to confirm this multisystemic model in the expression of food selectivity in children. The three clusters examined for each group of children shared either some characteristics or displayed dissimilarities concerning sensory processing, levels of food selectivity, gastrointestinal symptoms and parental feeding practices. For example, the cluster 2 for the children with ASD, described at high risk for feeding issues, included low levels in BMI and high levels in GID, taste/smell, movement and visual hypersensitivity, autism characteristics at mealtimes, parental child-centered and contingency management strategies. Conversely, the corresponding cluster of the control group showed the following features such as normal levels in BMI and high levels in GID, tactile, auditory and weak sensitivity along with a parental high control and contingency management style. Comparing these two clusters, characterized both by food refusal and limited variety of food consumed by children, it is possible to recognize a major impact of feeding issues in the children with autism either in weight loss or with respect to the less authoritative behaviour shown by some mothers, for the reasons reported above. Furthermore, only in the group of children with autism the impact of food selectivity seemed to be distributed in the first two clusters (1 and 2) than controls, displaying a different and cumulative level of feeding risk; moreover, parental feeding style passed from child-centered strategies to high control. It is possible that the mothers of children with autism, comprised in the high-risk cluster 2, coped with children with more severe behavioral profiles, showing "careful" educational strategies during mealtime, while with a slightly less challenging child (cluster 1) could display a more authoritarian educational approach, similar to the mothers of typical children in the cluster 2 exhibited. As a result, from a theoretical point of view the current research contributes to explaining the role of diverse variables in the expression of food selectivity, including parenting styles, for children with and without autism. On the other hand, from an application point of view these results allow us to define prevention and intervention protocols which could be applicable in the context of parent training, in order to promote functional parental styles increasing healthy eating habits in children. Additionally, it would be useful to develop a complete screening protocol for young children considering the following aspects: taste, smell, tactile sensitivity, weight, diet variety and gastrointestinal symptoms in order to detect immediately the corresponding risk profile of the child and preventing potential eating problems and a poor nutritional intake. Nevertheless, a possible limitation of our study could be the absence of longitudinal data, which is useful for understanding the long-term relationships concerning the factors we want to consider. Another possible limitation could be the absence of direct behavior observation [47] together with sample size, as a result the interpretation of our findings should be interpreted with caution. Furthermore, the children with ASD diagnosis came from rehabilitation programs, and although they were not treated for food issues, our group may not be representative of the entire clinical population. To conclude, the current study provides suggestions for therapists operating in clinical settings where the aim of treatment could be to decrease eating problems in children with and without neuropsychiatric issues. Future clinical interventions should not exclude some key variables, considered in the current study, in order to achieve a good treatment efficacy, including specific training for parents.

Conclusions

Food selectivity is a complex phenomenon that involves individual and environmental features, among these, sensory anomalies, distinctive in children with ASD, may be an important risk factor, along with some challenging behaviors and gastrointestinal symptoms.

At the same time, parental feeding styles may contribute to the onset of eating disorders. To explore these key variables may be of interest with the purpose of identifying the causative factors of food selectivity, but at the same time can help to program appropriate interventions for children and parents. Future studies could investigate the effectiveness of these interventions and the impact that caregivers' practices might have on eating health of children with and without developmental disabilities.

Conflict of Interests

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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