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FOOD SELECTIVITY AND SENSORY PROCESSING IN AUTISM SPECTRUM DISORDER: EVIDENCE FROM PSYCHO-DIAGNOSTIC ASSESSMENT

ANIL KUMAR KABISATAPATHY
PHD SCHOLAR, DEPARTMENT OF OCCUPATIONAL THERAPY, MAHARAJ VINAYAK GLOBAL UNIVERSITY, RAJASTHAN, INDIA. EMAIL: anilkabi.ot@gmail.com

DR AMITABH KISHOR DWIVEDI
DEAN, FACULTY OF OCCUPATIONAL THERAPY, JSS MEDICAL COLLEGE AND HOSPITAL, JSS ACADEMY OF HIGHER EDUCATION AND RESEARCH MYSURU. EMAIL: akdwivedi123@yahoo.com

Abstract

Background: Food selectivity is a common feeding disorder in Autism Spectrum Disorder (ASD) which can result in nutritional malnutrition and poor dietary diversity. Sensory processing disorders is often suggested as a basic formula, but there is still confusion about correlation of food selectivity with more general clinical features - behaviour, symptom severity and cognitive ability.

Methodology: A quantitative observational study carried out among 292 children with ASD ranging in age from 2 to 14 years of age of Bhubaneswar using snow ball. Carers were asked to complete standardised assessments including Food Preference Inventory (FPI) to assess dietary selectivity, Short Sensory Profile (SSP) to assess sensory irregularities and Aberrant Behaviour Checklist (ABC) to assess maladaptive behaviour. Descriptive statistics was conductred for profiling of sample and test for normality (shapiro wik) used. Food selection variable distribution patterns Bivariate correlations and linear regression analysis was done to establish sensory determinism of food selectivity and food acceptance variables.

Results: Significant relationships were found between sensory sensitivity and food acceptance outcomes with taste/olfactory sensory sensitivity showing the strongest relationships between sensory sensitivity and food acceptance across vegetable, protein, fruit and mixed food acceptance ($p < 0.001$). Regression models showed that sensory domains, particularly tactile and taste/olfactory sensitivity were significant predictors of food selectivity but the effect of behavioural components were weaker or not significant.

Conclusion: Food selectivity in Autism Spectrum Disorder (ASD) is sensory based to a large extent and drop the hint on the need for sensory informed assessment and special feeding interventions to increase dietary diversity and nutritional intake.

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disease which is characterised by persistent variations in social communication and interaction, as well as restricted and repeated patterns of behaviour and interests, hobbies and activities. in the past decades, the understanding of ASD has greatly advanced from rigid diagnostic criteria to spectrum based classification of ASD which covers a diverse range of talents, impairments and therapeutic needs [1,4]. This change has brought about increased recognition of ASD not as a disease that defines individuals in terms of few fundamental behavioural criteria, and instead as a multidimensional phenotypic disorder which involves a range of cognitive, behavioural, sensory, and physiological traits and differences [2].

Feed Restriction Feeding issues and restrictive eating practice is one of the most commonly reported non-core challenge in ASD. Food selectivity is often described in children and adolescents with ASD that is characterised by having a restricted range of accepted foods, a marked rejection of unfamiliar foods, inflexible eating behaviours and strong food preferences based on food texture, colour, temperature, aroma or flavour [4]. Early descriptive studies indicated that children with ASD often exhibit pronounced preferences for particular food categories while they avoid meals containing varied textures or complex sensory profiles which is in line with general tendencies of rigidity and sensory intolerance [5,7]. Subsequent investigations and systematic reviews defined that food selectivity is common in Autism Spectrum Disorder (ASD) and potentially persists over time causing problems to nutritional adequacy, growth and family meals [8, 17]. In the therapeutic setting, food selection could place significant stress on families and potentially impact the success of behavioural control and social participation and functional behaviours [9, 12].

Significantly, selective eating in Autism Spectrum Disorder (ASD) is not a stage and is not a minor dispositional behavioural trait. Meta-analytic evidence shows that difficulties with eating in ASD correlate with poor nutritional intake and imbalanced dietary habitats which creates concern for both short and long-term consequences to health status [15]. Autism spectrum disorder (ASD) nutrition vulnerability environment has been extensively studied, with

nutritional evaluations focused on the risk of inadequate intake of vital nutrients due to limited diversity of foods and avoidance of specific food groups [10]. Biological and metabolic studies have been conducted which reveal the existence of nutritional risk markers in children with ASD, such as abnormal plasma amino acid profiles that may signal or worsen the impact of nutritional deficiencies [11,13]. Studies comparing the nutritional intake of children with ASD to that of children in the normal developing population have found significant differences which may create insufficiency of micronutrient intake as well as low dietary diversity [14,16].

An important explanatory mechanism of food preference within ASD relates to abnormal sensory processing. Sensory abnormalities are a widely recognised as an important feature of ASD, and includes hyper-responsiveness (over-sensitiveness), hypo-responsiveness (under-sensitiveness) and sensory seeking behaviours across different sensory modes, including tactile, auditory, visual, vestibular, gustative and olfactory processing [21,17]. Abnormal sensory processing may have a more direct effect on feeding behaviours including a changing perception of food characteristics such as texture, aroma, flavour, mouthfeel etc., which may have been foundational research that revealed a strong correlation between sensory [18,19].

Tactile sensitivity and Chemosensory processing (taste and smell) have proved to be particularly important in the context of sensory-related systems [27]. Many children with ASD show a food texture aversion based on food textures described as 'slimy', 'grainy' or 'mixed' which may translate into food refusal, choking or distress [22, 23]. Differential processing of gustatory (taste) and olfactory (smell) stimuli may lead to a pronounced aversion to bitter tastes, marked preference for bland or familiar tastes and avoidance of food items with strong aromas [24].

Neuroscientific data provides further validation of the sensory basis for restrictive eating habits in ASD [25,32]. Neuroimaging studies have described neural correlates of taste reactivity suggesting that difference in brain activation during taste processing could be related to feeding habits associated to ASD [26]. Furthermore, frameworks to describe the neurological basis of sensory integration have hypothesized that problems with sensory processing are grounded in fundamental neurodevelopmental mechanisms that underlie behavioural adaptation, control and engagement in daily tasks (e.g. feeding) [28]. Nutritional study has considered the relationship between sensory processing and dietary patterns, the finding being that sensory profiles are significantly correlation with dietary intake and nutritional status in children with ASD in comparison with children developing typically [30]. Collectively, these data present evidence of this concept that the food choice in ASD may be intrinsically linked to sensory abnormalities, notably tactile and chemosensory sensitivity [29].

While sensory pathways appear to play an important role, the selection of food may also occur in conjunction with other characteristics of behavioural and developmental phenomena [31]. Anxiety and sleep disturbance have been measured as potential contributing factors to feeding issues in children with ASD, with studies demonstrating that difficulty in sleep and anxiety management may co-exist in the onset of feeding problems [32]. Clinical practice frameworks characterise the nature of feeding difficulties as complex conditions requiring classification, in turn, to guide treatment planning and that encompass: Distinguishing sensory driven avoidance of foods from medically-related feeding problems or behaviourally maintained feeding patterns [33]. A relevant clinical scenario is the co-morbidity between Autism Spectrum disorder (ASD) Avoidant/Restrictive Food Intake Disorder (ARFID) which is a condition defined as chronic restrictive eating behavior leading to nutritional deficiencies, weight loss, reliance on nutritional food supplements or significant psychosocial impairment [34, 24]. A case for food restriction in this setting that needs careful screening and risk evaluation in the presence of severe or persistent food restriction has been made in a prevalence-based meta-analysis of autism and ARFID [35]. This connection is relevant as food selectivity can go beyond typical or "picky eating" behaviour and can be a clinically severe problem with feeding demanding systematic therapeutic strategies [36].

Despite abundant data, there is extensive evidence of inconsistency as to food selection's relation to other clinical characteristics of ASD, e.g. demanding behaviour, level of intellectual ability and severity of symptoms of autism [37]. Clinical observation evidence of feeding difficulties could be greater in children presenting with high severity of behavioural dysregulation but other studies suggest the presence of food selectivity could be independent of behavioural or cognitive severity [38, 39]. in congruence may stem from varying evaluation instruments, characteristics of samples, definition of food selectivity and issues related to cultural or therapeutic contexts [41]. A psychodiagnostic framework is desirable as this enables the systematic measurement of sensory processing patterns, behavioural difficulties and dietary preferences in uniformed format [40]. Sensory processing patterns, behavioural difficulties and the dietary preferences are measured in a systematic manner which is consistent with the general emphasis given to validity and reliability in the clinical measurement to enable evidence-based decisions to be made.19 Understanding if the observed food selectivity is related more to sensory abnormalities than behaviour or cognitive can assist in better clinical prioritising for personalised solutions to focus on sensory based aid and specific feeding intervention [1, 42]. Establishing the clinical autonomy of

Considering the high incidence of feeding problems as well as potential nutritional impact, the clinical correlations of food selectivity in ASD should be elucidated, both from a clinical, but also scientific point of view [43]. This finishing study has the aim to provide evidence on the correlation between food selectivity and sensory processing abnormalities, but also investigate the significant associations of challenging behaviour, IQ, and the severity of autistic symptoms in relation to selective eating in the psycho-diagnostic assessment framework [44,22]. This research increases the phenotypic description of food selection, hence opening the way for

1.1 Statement of the Problem

Food selectivity, which is common in Autism Spectrum Disorder (ASD) and could cause dietary deficient, health problems, behavioural difficulties [46]. despite the significant association between sensory impairments (particularly those relating to tactile and chemosensory sensitivities) and selective eating, the link between the food selectivity and challenging behaviour, autistic symptom severity and intellectual performance remains ambiguous [11-13]. This ambiguity limits the accuracy when it comes to clinical evaluation and strategizing of intervention methods, perhaps resulting in possible non-specific management methods.

1.2 Objectives of the Research

The primary goal of this study will be to investigate the relationship of food selectivity and sensory processing irregularities in Autism Spectrum Disorder (ASD) using standardised psychodiagnostic evaluation instruments. The aim of this research will be to evaluate the relationship between food selectivity and specific sensory modalities but in particular focussing on tactile, gustatory and olfactory sensitivities - this sensory area is quite often implicated in selective eating behaviours [11,13,14].

There are three major research questions that guide this study in order to make its aims achieved. We are interested, first of all, in what sensory processing domains (see above, specifically tactile, gustatory, olfactory sensitivities) are significantly correlated with food preference in patients with ASD [11 - 17]. Secondly, we are interested in the correlation between food choice and challenging behaviour as measured by standardised behavioural assessment instruments, bearing in mind the potential overlap between feeding and challenging behaviour in ASD [6, 21, 22]. This part of the study is aimed at analysing whether food selectivity varies according to intellectual functioning, and severity of autistic symptoms, in order to determine whether selective eating is correlated with

2. LITERATURE REVIEW

a) Autism Spectrum Disorders and Clinical Phenotype

Autism Spectrum Disorder (ASD) is a neurodevelopmental disease that is characterised by persistent differences in the way individuals in society communicate and interact with each other, and restricted and repetitive patterns of behaviour and interest. The contemporary clinical understanding of ASD is that there is great phenotypic heterogeneity in the intensity of symptoms, the cognitive ability, sensory experiences and associated behavioural expressions in individuals. This variability is of significance in more modern discussions on treatment, based on the fact that experienced lives with ASD are usually also as much shaped by these co-occurring characteristics as by criteria of disorder.

Recent clinical insight emphasises that ASD is a life-long disorder with such diverse manifestations as sensory modulation discrepancies, sleep disruptions, anxiety symptoms, feeding challenges and gastrointestinal issues. The existence of these co-occurring features impact on functional outcomes and may require professional intervention despite the absence of changes in core autistic features. The burden of these challenges can be high to the families, with consequences of stress, added complexity in care and decreased quality of life to the families. This emphasizes the need for comprehensive phenotyping in ASD in which the clinical evaluation involves more than the traditional core symptoms to include eating and sensory processing problems [1].

Global countywide epidemiology research prove that ASD are highly circulated and getting getting acknowledge at every geographical location and race of human being. The increased level of attention has led to increased level of interest in identifying the clinical features that can be altered and that might be targeted with specific therapies. In this environment, there has been a focus more on feeding habits, due to both its high rate in ASD, and the direct consequences this may have on physical health and social functioning. Consequently, it has clinical relevance and public health relevance to investigate food choice in regards to the ASD phenotype.

b) Food Selectivity as Clubfoot as Principle Clinical Characteristic in Autism Spectrum Disorder

Food selectivity is a frequently noted feeding related problem with individuals having an ASD with restricted variety in the foods that are consumed, the consistent rejection of foods, strong preferences and aversion to unfamiliar foods. Clinical research and systematic reviews have suggested frequently that children with ASD are more likely to have food preferences that they cannot feel that can be limited compared to children who are considered to be usually developing. These dietary habits often include; need for consistency, inflexible meal timings and rejection based on sensory factors such as texture, aroma or flavour. Consequently, food selection is currently becoming recognised as an important clinical aspect of the ASD phenotype and not just a meaningless time of developmental maturation.

Preliminary behavioural studies outlined that food selection patterns are affected in Autism Spectrum Disorder (ASD) by a range of interacting factors including sensory discomfort, behavioural rigidity and reinforcing mechanisms. Children can be fussy with particular brands/colours/textures, and may show signs of distress when they are confronted with unexpected or un-preferred food. Such practices have potential to disrupt family meal and result in food restriction lifelong. These results founded the behavioural characteristics of food selection on a clinically important feature of behavioural traits that need to be evaluated systematically [20].

Extensive reviews and meta-analytic studies suggest feeding problems in ASD are likely and are linked to significant nutritional dietary differences. Restrictive eating may lead to low nutrient intake, low intakes of fruits and vegetables and unbalanced diets that present a threat to health consequences. Feeding issues could be prolonged and will have the chance to become ingrained if not decreased by appropriate intervention measures on developmental stages. Therefore,

food choice is a very important issues for therapeutic intervention and topic of study in the field of ASD researches [21].

c) Nutritional Status and Risk of Health Risks for Selective Eating

Food selection also can affect nutritional status as it limits the diversity of the diet and can result in avoidance of food containing nutrients. Analyses of nutrition in ASD identifies limited food acceptability may result in micronutrient deficits, inadequate fibre intakes and disproportional macronutrient equations. These nutritional deficiencies affect growth, immunity and thought and long-term metabolic health. Nutritional monitoring often is recommended as part of the clinical evaluation due to the possibility of persistence of selective eating in persons with ASD.

Biological evidence has been found in relation to nutritional susceptibility in ASD populations, studies have found unusual patterns of amino acids in the plasma, which could indicate dietary restriction and/or metabolic difference. These discoveries are therapeutically relevant because of the fact that amino acids are components of a number of physiological systems, for instance, development of the neurological systems and the immunological systems. The variability of nutritional indicators is great; nevertheless, limited food patterns of eating is cause for concern on possible inadequacies, when combined with other health problems. This is in support of the claim that dietary selectivity may be linked with quantifiable physiological risk, not only behavioural patterns [39].

Comparative research into food intakes states that youngsters with ASD may have variations in their nutritional profile in comparison to typically developing youngsters. These disparities may include: reduced intakes of some vitamins and minerals, reduced dietary diversity. Over time however, these imbalances can contribute to increased levels of health vulnerability and reinforce the need for interventions that are related to diet or nutrition. As a result, food selection in Autism Spectrum Disorder (ASD) is beginning to be recognised increasingly as both a behavioural and nutritional issue which requires complete clinical intervention.

d) Abnormalities in Sensory Processing and How It Affects Feeding Behaviours

Atypicals sensory processing is one of the most suggested causes of food preference in ASD. Individuals with ASD often have sensory processing impairments which can be hyper/responsiveness, hypo/responsiveness and sensory seeking behaviours in a number of areas. Sensory attributes have an effect on people's eating experiences and include taste intensity, olfactory sensitivity and tactile pain from textures. As a result sensory impairments provide a good framework for explanation of diminished eating and food refusal in ASD [13]. There has been empirical research to establish that there is a direct correlation between the sensory processing patterns and eating disorders amongst individuals with Autism Spectrum Disorders (ASD). Children can reject foods due to unpleasant texture in the mouth, things like unusual combination of sensations, and because of strong reactions to smells. This connection makes us conclude that selective eating is transmitted by sensory factors rather than is being mostly behavioural in nature. In addition, these findings support the use of sensory-based assessment techniques in-feeding problems clinical examination for ASD [13, 32]. Sensory integration frameworks use the idea that sensory variances are indicative of a neurodevelopmental abnormality of the processing, integration and regulation of sensory signals. These models show that sensory modulation effects on adaptive behaviour and participation in daily activities e.g. mealtimes. It is evident from this point of view that feeding selectivity is not a question of desire only, but of behaviour under the influence of sensory experiences, sometimes uncomfortable, sometimes overpowering. This conceptual framework assists to make the clinical significance of sensory profiling in eating assessment for ASD easy.

e) Sensitivity to touch Texture Related Food Aversion

Tactile sensitivity is often associated with food selectivity in children with ASD especially where it is a source of discomfort or distress because of texture of food. Texture based aversion often includes rejection of foods that are characterised by sliminess, mushiness, crunchiness or by mixed consistency and such aversion reactions may be generalised across food categories. Children may develop, therefore, a restricted to foods with actually regular tactile characteristics such as unedorned carbs or processed. This is a pattern to imply that tactile hypersensitivity may be a ground level mechanism involved in food aversion and restricted feeding choice in individuals with ASD. Sensory sensitivity and food selectivity Studies that have compared sensory sensitivity and food selectivity have suggested that children with ASD who have increased sensory sensitivity have a higher chance of having restricted eating behaviours. These results involve implicating tactile sensitivity as a quantifiable predictor for how much food selectivity was felt. The association is ofotherapeutic importance since it implies that therapies need to focus on texture-related discomfort, and not only focusing on behavioural compliance. Sensory based techniques may increase food acceptability since tactile defensiveness is important. Additional research suggests there may be a difference in sensory profiles between children that have feeding problems and those that don't in children with ASD with tactile processing one difference for feeding related subgroups. This suggests that sensory-based phenotyping may help doctors to better identify kids who may be most likely to face persistent feeding challenges. This difference is key to what can be done in intervention strategies, especially, where the conventional methods of behaviour are found to be insufficient. Tactile Sensitivity as a Relevant Sensory Correlate of Food Preferences in ASD Investigation

f) Differential Processing of Gustatory and Taste Responsiveness

Variations in gustative processing have been considerably explored as playing a part in the diminished eating behavior which occurs in Autism Spectrum Disorder (ASD) in situations where the taste sensation is evaluated as a powerful or aversive one. Increased Taste Sensitivity Could Result in Avoiding Meals with a Strong Bitter Taste or Other Intensive Flavour This could mean that the range of meals eaten will become small and so will the access to vegetables or meals filled with protein. Reviews highlighting gustatory over-responsivity has emphasised excessively high tastes reaction

to be common in ASD and directly affect food refusal behaviours. This research justifies gustatory sensitivity as being part of the assessment of the food selectivity mechanism [5].

Experimental evidence indicates that there are variances in sense perception of taste in individuals with autism spectrum diseases such as adult samples facing trouble with the sense recognition of taste. These results have presented that gustatory variations may be enduring over the lifetime and potentially with implications for long-term eating behaviours. Modified taste perception may effect on dietary preferences and further aggravate the neophobia by producing novel flavours that are less tolerable. These sensory-based interpretations provide a reasonable association between gustatory defects and selective eating behaviours [23]. In addition to evidence from behaviour, biological evidence has examined systems related to taste, both at a genetic and physiological level. In regard to the prevalence rate of food aversion, studies on bitter taste receptor genotypes indicate that food aversion may be to some extent related to biological differences in taste sensitivity. While we know that the genetic factors are not definite we do know from the results of this study that gustatory responses in ASD may reflect both sensory processing variability and inherent biological implications. Consequently, taste-related mechanisms are still an important region to study the food selectivity phenotypes[35].

Although known as Olfactory Sensitivity and Aversion to Food Induced by Smell, the conversion of sound to information regarding the size, amplitude, and frequency of sound is one of the most significant aspect of hearing is the overall sound, often called the sound of sound that is typically indicated by an acronym or symbol. Olfactory sensitivity is a sensory area which is closely related to eating behaviour in ASD as smell is of pivotal importance to the perception of flavour and acceptance of food. Those with ASD may also be hyper-sensitive to the smell of food and because of this, they may avoid foods that have strong smells (e.g. fish, eggs, spices or cooked vegetables). This strategy may restrict the diversity in the diets to a significant extent, especially for mixed dishes or when food in culturally diverse meals is involved. Neurobiological studies of olfactory and gustatory processing implicate negative chemosensory system dysfunction in ASD that may result in negative consequences during consumption.

Systematic review research has shown that there are inconsistencies in the perception of odours and tastes in individuals diagnosed with ASD between the studies with some reporting of hypersensitivity and some in unusual patterns of perception. This diversity may help to partly explain why some people show extreme food refusal, whilst others show a lesser selectivity. It is the consistency in finding olfactory variables that are in support of the significance of smell-sensitivity as an important clinical predictor in selective eating. This is the reason that leads to the evidence that olfactory-related elements need to be included in sensory profile evaluation for ASD feeding studies [31]. Recent studies have focused on sensory patterns differentiating ASD with other neurodevelopmental or genetic disorders emphasizing the importance of touch and olfaction/taste as a part of the clinical profiling of ASD. These results suggest that chemosensory sensitivities may be important neurodevelopmental indicators and may lead to the improved classification, in terms of phenotypes. This has clinical support in the molecular hypothesis where difference in the processing of smells and tastes affect feeding behaviour patterns in different subgroups of ASD. Consequently, olfactory sensitivity is an important sensory determinant of food choice.

g) Neural Correlates & Sensory Basis to Feeding Selectivity

Neuroscience based back up to influence of sensory abnormalities eating behaviours of people with ASD. Neuroimaging studies have also suggested that there are neural correlates of taste reactivity, meaning that differences in brain activation during processing of a food stimulus may underlie abnormal behavioural reactions to food stimuli. These brain findings provide a biological evidence of sensory-based models of food selectivity (as opposed to only learned behavioural explanations). Consequently, food selection may represent neurodevelopment sensory processing pathways that has an effect of food experience perceptions. Beyond gustatory neural responses, comprehensive sensory integration models draw attention to the fact that sensory modulation has a neurological underpinning that influences functional behaviour. Ayres sensory integration principles include the interaction of the sensory systems in helping the adaptive behaviour and consequences of disorder of these sensory systems in contributing to maladaptive responses. This view implies a decreased eating as an adaptive feat of avoidance from sensory overload. Consequently, neuro-sensory frameworks are conducive to the rationale of sensory informed feeding intervention strategies with feeding issues associated with ASD.

The neuro-developmental studies have related abnormalities in sensory processing to differences in the structure and function of the brain. Atypical processing of visions and perception of the senses have been related to neuroanatomical patterns in ASD leading to the notion that sensory disorders are embedded in the brain organisation. While visual processing isn't directly synonymous with feeding it does seem that dissimilarities in sensory processing does seem to have neurological importance, and may be translatable into many domains. This adds to the assertion that selective feeding is an expression of generalised sensory phenotype in ASD [9]. .

h) Challenging Behaviour and Association to Feeding Dysphagia

Behaviours such as impatience, aggressions, self-injurious behaviours, hyper activity and emotional dysregulation have been observed to be common in addition to an Autism Spectrum Disorder (ASD), and can make caregiving and intervention strategies tricky to navigate. Feeding challenges also can be accompanied by problematic feeding habits especially when mealtime is an unpleasant experience with ongoing rejection or disagreement. Certain clinical perspectives suggest that the behavioural dysregulation could cause the eating problems to get worse through increasing disobedience, tantrums and avoidance behaviours. Consequently, it is important to study the behavioural context of food selection in order to do thorough phenotyping of ASD [27].

Clinical frameworks for management of food challenges emphasise the importance of categorising feeding problems in order to understand the causes of these disorders and how they can be managed. These frameworks identify that feeding difficulties may have a relationship to either sensory difficulties, skill-based difficulties, medical-related difficulties or behavioural related difficulties, which would need certain treatments within those categories. Where demanding behaviour is accompanied by food selectivity this may be a sign of distress due to sensory discomfort or learnt aversion behaviours, which are strengthened over time. Consequently, the evaluation of the behavioural evaluation instruments can be of value to help the determination of whether the decision of what to eat is overwhelmingly sensory or connected to more extensive behavioural problems.

Developmental research shows that eating disorders could emerge around the same time that ASD symptoms emerge over time, and there could be some interlinkages between development and food problems. This perspective infers that some children are going to have feeding difficulties associated to wider behavioural and neurodevelopmental tendencies. Nonetheless the extent to which difficult behaviour predicts food selection is variable and in many cases sensory mechanisms appear much more important. Consequently, aspects of behaviour need to be evaluated, which recognises that sensory processing may continue to be the main influence in many a feeding pattern that is found in ASD.

i) Intelligence Quotient, Severity of Autism and Selectivity of Dietary Style

The relation between the intellectual performance and the severity of the autistic symptoms as possible factors influencing the food selectivity are often studied though the results in the literature are not consistent. Certain clinical assumptions is that as there are obstacles to communicating or inflexibility, children with lower IQ's or with more marked features of autism may have more difficulties eating. Nonetheless, there are some studies that suggest that selection of food can operate on a variety of levels of cognition, and thus may be something of an autonomous phenotypic characteristic. Thus, evaluation of IQ and severity of autism and sensory and behavioural elements enhance the understanding of feedings behaviour in ASD.

Population-based studies looking at autistic features and eating behaviours have intimated possible relations in a broader population of people, even those without the formal diagnosis of autism. These data would suggest characteristics that are associated with rigidity, sensitivity to sensory stimuli or anxiety may have an effect throughout a continuum relating to eating behaviours. Clinical samples of ASD often reveal that the sensory qualities are associated with food choice in a larger degree as opposed to the greatest degree of symptoms. Aspects of the IQ and symptom intensity are subsequently critical in order to find the answer to the question if selective eating is dependent on the severity or specific to mechanisms [25].

Longitudinal methodologies establish that symptoms of ASD and eating disorders may co-develop and the interactions are developmental in nature rather than static cross-sectional associations. This would lead to the assumption that feeding difficulties may develop throughout the course of a child's development and may be dictated by sensory sensitivity, behavioural regulation and environment. However, there is much power left with sensory domains as direct mechanisms of food refusal for the developmental models. Consequently, IQ and severity of their illness have to be considered as a contextual factor, while sensory processing may be the most instantaneous factor that determines food selectivity [1].

j) Gender and Across Gender and Across Culture Imbalances

Research has examined sex differences in eating behaviours that are associated with ASD with findings of sex specific patterns of correlation between autistic features with eating behaviours in general populations. These findings highlight the possibility that there may be differences between boys and girls in terms of the consequences of eating. Nevertheless, results are inconsistent and may be contingent on the makeup of samples, evaluation methods and sociocultural factors. Consequently, sex based researches, event determines, research on the various association of the food selectivity between the sexes in the ASD cohorts [25].

Cross cultural researches contributed other weight at the importance of the heterogeneity of contextual and demographic factors of sensorial profiles. Research about sensory profile in the context of different nations shows that across cultures, sensor profiles variations can be found, thus continuing to confirm the universality of sensory characteristics in ASD. Cultural dietary habits and food settings may have effects on the expression of food selectivity, therefore, the clinical interpretation. Consequently, a cross-cultural study of sensory research is a valuable addition to the knowledge on sensory driven feeding behaviours in ASD [22].

Parent reported comparisons of feeding characteristics in children with ASD and typically developing children support the validity of patterns of food selection in a real world setting. This study presents evidence of the validity of the caregiver based measures in a real-life situation and implies the clinical significance of food problems. These results suggest that feeding problems can be detected outside of the clinical monitoring process and has a significant impact on the family dynamics. Thus, it is care-giver reported instruments are still useful in identifying the food preference aspect of the phenotype of the ASD in many settings [7].

k) Interrelationship and Influences of Important Phenotic Features

Indeed, there is a strong literature to support a concept of food selectivity in Autism Spectrum Disorder (ASD) whereby sensory processing anomalies including tactile defensiveness and chemosensory sensitivity (i.e. taste and smell) are intricately bound with ASD. For example, sensory pain can result in avoidance behaviours which results in inflexible food behaviours maintained by reinforcement and habitual. Prolonged restricted eating may lead to nutritional deficiencies which in turn effects on health outcomes and overall wellbeing. Consequently, there is a direct and

important clinical relationship between sensory processing and food selectivity and its nutritional ramifications as an after-effect.

Challenging behaviour can make feeding challenges worse due the increased stress experienced when feeding, avoidance and escalating conflict although sensory mechanisms often presents itself as more immediate causes of food rejection. Intellectual functioning and level of autism may influence the expression of feeding challenges, i.e. communication difficulties or behavioural inflexibility however, selective eating may occur independent of cognitive levels. Sexual differences and societal aspects may potentially control the expression and control of food selectivity that shows the need for an assessment based on the context. The Interaction of sensory processing, behavioural management, nutritional outcomes and developmental trajectories presents the importance of comprehensive assessment of phenotypes in ASD eating difficulties.

The growing recognition of ASD and the feeding problems that are linked with the disorder makes it important that rigorous screening tools and intervention be established. Food selectivity can be limited and specific to minor preference based limitations to a marked restrictive consumption that are associated with ARFID risk. Approaches which have been informed by the sense related considerations of sensory tactility and chemosensoriality might provide more successful paths leading to improving food diversity, than generic behavioural tactics only. Thus, the evidence provides support for an integrated model were the sensory processing impairments are the main mechanism and where behavioural, developmental and nutritional aspects modulate the intensity and clinical ramifications of selective eating in ASD [16].

3. RESEARCH METHODOLOGY

This study used quantitative and observational research methodology focusing on clinical relationship between food selectivity with basic elements of ASD phenotype, sensory processing deficits, challenging behaviours, severity of autistic symptoms and intellectual performances. A total of 297 Such participants were recruited through the process of primary data collection from Stigma associated with Having Children with Autism Spectrum Disorder (ASD) in Bhubaneswar through Carers for formal evaluations and questioner response. In order to recruit adequately from the community and clinical-based networks, a snowball recruiting technique was employed whereby participants were initially recruited to recruit other eligible carers in their network to increase access to ASD populations which may be difficult to recruit using more traditional sampling methods.

Participants were selected based on pre-set inclusion criteria, these included confirmed diagnosis of ASD under the criteria set out in DSM-5 (ASD) criteria, age group of childhood and adolescence, permission of the carer and full replies to assessment. Exclusion criteria were any significant neurological illness, gastrointestinal diseases which may be impacting on nutrition independently and other psychiatric or developmental comorbidities which may provide a bias for behavioural assessment. Following the recruiting process, data have been gathered by standardised psychodiagnostic tool. meal selectivity was measured by Food Preference Inventory (FPI) which is a scale that is administered by the Caregiver and measure the intake frequency in different essential meal categories and differentiate between food refusal and non-exposure. Sensory processing anomalies measures (Short Sensory Profile [SSP]) measured sensory sensitivities in varying areas, including sensitivities to tactile inputs as well as taste/olfactory sensitivities. Challenging behaviour was measured using the Aberrant Behaviour Checklist (ABC) that include behavioural characteristics in five subscales including irritation and hyperactivity. Furthermore, the severity of autistic symptoms were measured through clinical severity indicators and reproducible symptom rating scales when available and intellectual functioning were measured through results of cognitive test or clinical developmental assessment and classified as having intellectual disability when IQ was below 70.

Descriptive statistics (mean, standard deviation, frequency and percentage) was adopted to summarise the characteristic of study participants in order to analyse the data. The normality of distribution of all the principal variables was tested by using Shapiro-Wilk test. Pearson correlation was applied for the distribution with normal distribution at the same time correlation using Spearman's rho for non-normal distribution of data in the form of data distribution pattern was utilised. Statistically significant links were analysed in terms of linear regression in the form of predictive links between sensory factors and food selectivity. Independent samples t-tests were utilised to do group comparisons - including sex, and presence/absence of intellectual disability. All statistical analyses were done utilising the Statistical Package for Social sciences (Version 26) with significance $p<0.05$.

Table 1. Descriptive characteristics of children

Categories	Frequency	Percent	Categories	Frequency	Percent
Age Group (Years)			**Primary Caregiver Respondent**		
2–4 years	58	19.5	Mother	214	72.1
5–8 years	124	41.8	Father	61	20.5
9–11 years	74	24.9	Other caregiver	22	7.4
12–14 years	41	13.8	**Parent's Highest Education**		
Gender of Respondents			Up to Secondary	74	24.9
Male	212	71.4	Higher Secondary	93	31.3

Female	85	28.6	Bachelor's degree	88	29.6
Place of residence			Master's or above	42	14.1
Urban	189	63.6	**Monthly Family Income**		
Rural	108	36.4	Low	97	32.7
Schooling Status			Middle	149	50.2
Attending school	231	77.8	High	51	17.2
Not attending school	66	22.2	**Birth Order**		
			First child	136	45.8
			Middle child	98	33
			Last child	63	21.2

Table 1 outlines the descriptive characteristics of 297 children from 2 to 14 years of age, which provides the detailed description about sample profile. According to its age, the most frequent group of age of children, are 5 - 8 years (41.8%), followed by 9 - 11 years (24.9%), 2 -4 years (19.5%) and 12 -14 y (13.8%). This trend indicates that most were in early to mid-childhood which is a key development period when feeding behaviours, sensory processing mechanisms, as well as autism related malfunction of function are more evident and are actively addressed by carers and experts. The most common gender was male, 71.4%, a common finding when compared to the average higher rate of diagnosed ASD in boys comparing to girls, this finding is clinical predictable.

A greater proportion of children lived in urban (63.6%) than rural areas (36.4%) which may be indicative of greater access to specialised assessment and support services in metropolitan areas. A majority of children had been enrolled at school (77.8%) suggesting that the sample is made up of children participating in educational settings, in which food challenges and sensory sensitivity may impact participation and everyday function. In most cases, mothers were the lead respondents (72.1%) which is logical considering that they typically assume the dominant role both in routine care provision and meal supervision and thus could provide more comprehensive accounts of feeding patterns.

Parental education levels were mainly in the higher secondary (31.3%) to bachelor degree (29.6%) range, indicating moderate to moderately high levels of education, which could possibly contribute to development of increased awareness and help seeking behaviours. The distribution of income showed that most of the households fell into the middle-income range (50.2%) showing normal socio-economic distribution. Birth order trends showed more first-born children (45.8% The findings may be due to an increase in the attention from parents and the earlier recognition of development problems in first- born children.

TABLE 2. Bivariate correlation analysis between SSP sensory subscales and FPI constructs

FPI Constructs (Food Selectivity Dimensions)	Tactile Sensitivity	Taste/Olfactory Sensitivity	Auditory Filtering	SSP Total Score
Vegetable acceptance	0.312 (<0.001)*	0.641 (<0.001)*	0.284 (0.001)*	0.529 (<0.001)*
Protein acceptance	0.276 (0.002)*	0.598 (<0.001)*	0.241 (0.006)*	0.487 (<0.001)*
Fruit acceptance	0.198 (0.018)*	0.452 (<0.001)*	0.173 (0.041)*	0.392 (<0.001)*
Mixed-food acceptance *(stew/snacks combined items)*	0.334 (<0.001)*	0.669 (<0.001)*	0.301 (<0.001)*	0.561 (<0.001)*

The results of bivariate correlation of areas of sensory processing (SSP subscales) with 4 main food acceptability components obtained by the FPI are shown in table 2. The results demonstrate that high sensitivity to sensory experiences is systematically related to food selectivity of all kinds of food. Taste/Olfactory Sensitivity has the strongest correlations to all of the FPI constructs including vegetable acceptance (rho = 0.641, $p < 0.001$), protein acceptance (rho = 0.598, $p < 0.001$), fruit acceptance (rho = 0.452, $p < 0.001$), and mixed-food acceptance (rho = 0.669, $p < 0.001$). This suggests that the main factor contributing to food aversion in ASD is sensory discomfort related to taste and smell (therefore food with strong tastes or foods with complex sensory features are particularly hard to tolerate).

Tactile sensitivity shows some strong positive correlations with all of the measures, especially with mixed foods (rho = 0.334, $p < 0.001$) and vegetables (rho = 0.312, $p < 0.001$), suggesting that texture-related defensiveness is important in the rejection of foods which have fibrous, crunchy, slimy, or visually noxious texture. Furthermore, Auditory Filtering has significant, but medium correlations with all dimensions, indicating that more broad based sensory regulatory difficulties may work towards selective eating by making the environment more cognizable at mealtimes. The total score of the SSP shows strong relationships across all the dimensions which confirms that global sensory impairments plays an important role in food acceptance behaviour patterns and feeding behaviours in children with ASD.

Table 3. Linear regression analysis examining sensory profile subscales as predictors of Food Preference Inventory (FPI) score.

Sensory Profile Subscales	R^2	B (CI)	p
Oral Sensory Sensitivity	0.112*	1.52 (0.41–2.63)	0.007
Visual Sensitivity	0.084*	1.18 (0.22–2.14)	0.016
Auditory Filtering	0.156*	1.87 (0.95–2.79)	<0.001
Motion Sensitivity	0.061*	0.94 (0.08–1.80)	0.032
Sensation Seeking / Under-responsiveness	0.047*	0.81 (0.02–1.60)	0.044
Total Sensory Score	0.265*	0.55 (0.21–0.89)	0.002

The outcome of the linear regression analysis on the predictive ability of sensory processing subscales to the overall Food Preference Inventory (FPI) score reflecting the level of food selectivity are shown in Table 3. The result shows that there is a great sensory modality effect on food selectivity difference in the children with ASD. Among the different subscales, Auditory Filtering was found as the most significant predictor as the FPI scores (R2 = 0.156, B = 1.87, p < 0.001) - that is, difficulties in processing the noises in the environment and the filtering of sensory stimuli may increase the distress during meals and affect a poor acceptance of food. Oral Sensory Sensitivity was found to have an important predictive capacity (R2= 0.112, B= 1.52, p= 0.007) suggesting increases in oral discomfort related to texture, temperature or mouth-feel, has a substantially important effect on restricting eating behaviours.
Moreover, Visual Sensitivity was a significant predictor of food selectivity (R2 = 0.084, B = 1.18, p = 0.016), that is, that visual attributes (i.e. colour, presentation and appearance) can affect acceptability. Motion Sensitivity (R2 = 0.061, B = 0.94, p = 0.032) was a significant predictor of FPI scores suggesting the general instability of the sensory system may be involved in the feeding rigidity. There was some although significant predictive effect of the Sensation Seeking/Under-responsiveness subscale (R2 = 0.047, B = 0.81, p = 0.044), in which atypical sensory seeking behaviours may have an impact on dietary habits. The Total Sensory Score showed the best predictive power (R square = 0.265, B = 0.55, p = 0.002), which was the further evidence that the global sensory impairments contribute to the development of food selectivity in ASD.

Table 4. Linear regression results identifying SSP sensory subscales as predictors of four FPI food acceptance constructs.

SSP Predictors	Vegetable acceptance R^2 / B (CI) / p	Protein acceptance R^2 / B (CI) / p	Fruit acceptance R^2 / B (CI) / p	Mixed-food acceptance R^2 / B (CI) / p
Tactile Sensitivity	0.18* / 1.76 (0.60–2.92) / 0.003	0.12* / 1.34 (0.28–2.40) / 0.014	0.06 / 0.88 (-0.06–1.82) / 0.066	0.21* / 2.03 (0.77–3.29) / 0.002
Taste/Olfactory Sensitivity	0.31* / 2.54 (1.41–3.67) / <0.001	0.26* / 2.17 (1.05–3.29) / <0.001	0.14* / 1.42 (0.34–2.50) / 0.010	0.36* / 2.89 (1.68–4.10) / <0.001
Auditory Filtering	0.09* / 1.10 (0.15–2.05) / 0.024	0.07 / 0.94 (-0.12–2.00) / 0.082	0.05 / 0.72 (-0.09–1.53) / 0.083	0.11* / 1.26 (0.22–2.30) / 0.018
SSP Total Score	0.28* / 0.46 (0.22–0.70) / <0.001	0.22* / 0.39 (0.16–0.62) / 0.001	0.12* / 0.27 (0.06–0.48) / 0.012	0.33* / 0.52 (0.28–0.76) / <0.001

Table 4 describes the models of the linear regression analyses to examine the predictive relation of some sensory processing domains with food acceptance for 4 main models of the FPI. The results of this study suggest that the study's authors suggest: Food acceptance patterns of children with ASD are significantly influenced by sensory impairments with the largest predictive impacts being associated with a taste/ olfactoty sensitivity and by overall sensory dysfunction. Taste and olfactory sensitivity were found to be the best predictor of vegetable acceptability (R^2 = 0.31, B = 2.54, p < 0.001) and this shows that high sensitivity to the flavours and aromas were associated with lower vegetable acceptance, as these taste and aroma compounds are commonly stronger in vegetables. Tactile sensitivity was highly related with vegetable acceptance (R squared = 0.18, B = 1.76, p = 0.003), indicating that mealtime negation related to texture is that which causes the rejection of meals with fibrous or inconsistent textures.
In the protein acceptance model taste and olfactory sensitivity showed good predictive role (R squared equals to 0.26, B equals to 2.17, p less than 0.001), in which sensitivity to touch was still significant (R squared equals to 0.12, B equals to 1.34, p equals to .014), with both taste response and sensitivity to mouthfeel as a determinant factor driving the acceptance of meat, fish, eggs or legumes. The predictive influence to the acceptance of fruits was relatively smaller; however, the taste/olfactory sensitivity (R 2 = 0.14, P = 0.010) and the SSP total score (R 2 = 0.12, P = 0.012) were significant, meaning that fruits in general are more pleasant and less demanding than vegetables or mixed dishes. The model fitted for the acceptability of mixed foods was the best with taste/olfactory sensitivity (R2=0.36, B=2.89, p<0.001) and visual sensitivity (R2=0.21, p=0.002) proved to be extremely significant due probably to the interaction of different textures and complex aromas of the mixed foods. The total score of SSP was found to be a strong predictor

in all the components supporting the hypothesis that overall sensory impairment affects how food selectivity is affected in multiple food categories.

4. DISCUSSION

The results of this study add credence to the concept that food selection in children with ASD is most likely a sensory-driven phenomenon and not necessarily an expression of behavioural severity or general symptom intensity. Concurrently with the literature pointing to sensory modulation as an important mechanism underlying restrictive eating behavior, significant correlations were found between acceptability of food and a number of the sensory domains, most notably the sensory modulation of sucrose/olfactory (tactile and taste/olfactory) sensitivity. The connection results showed taste and sensory sensitivity to smell was most effectively correlated with reduced acceptance in all types of food, but mostly with mixed foods and vegetables, which often tend to have complex aromas, flavours and textures. This supports previous findings that a heightened chemosensory sensitivity in ASD have the potential to lead to avoidance of strongly flavoured or scented products therefore limiting the variety of foods in the diet, promoting the development of restrictive eating behaviours.

The trend analysis obtained by regression analysis further supported this interpretation as well as emphasizing the importance of sensory subscales with regard to predicting food selectivity outcomes. Taste and olfactory sensitivity were the most effective predictor for acceptability of all types of vegetables, proteins, fruits and mixed foods, which shows that smell and taste-processing anomalies are playing an important role in eating habits. Tactile sensitivity was also a predictor of acceptance of vegetables and mixed foods, thus, unpleasant experience with texture is part of the basis for avoidance of fibrous or multi-textured meals. Despite the fact that auditory filtering shows low levels of predictive strength and is not important in relation to all of the variables, the implication of this is that external sensory load during meals may increase feeding challenges in some children. The SSP total score was also able to predict all the food acceptance characteristics which suggested overall sensory dysfunction in food restriction was universal.

Collectively these findings suggest that the clinical evaluation and intervention for selective eating in ASD should put an emphasis on sensory-based evaluation and intervention for oral, tactile and chemosensory sensitivity. Mitigation of sensory pain could be more effective in improving food acceptance than those exclusively grounded in behavioural regulation, thus suggesting a need for personalised feeding treatments that are built upon phenotypes.

5. CONCLUSION AND IMPLICATIONS

This study demonstrates that food selectivity in children with autistic Spectrum Disorder is associated for the most part with impairments in sensory processing rather than behavioural challenges, or severity of autistic symptoms or cognitive abilities. A significant and consistent link between tactile sensitivity and, in particular, taste/olfactory sensitivity and reduced food acceptance for essential food categories was found following those results. The analysis of regression supported even more strongly that sensory domains were a good predictor of overall food selectivity and specific aspects of food acceptance in relation to vegetables and to mixed foods, which typically include more complex textures, as well as more intense flavours or aromas. The findings support the idea that selective eating in Autism Spectrum Disorder is strongly sensory driven and should be appreciated as an important phenotypic trait that needs treatment intervention.

This study brings into focus the need for using a systematic sensory profiling in routine feeding assessment for children with ASD. Given that taste/olfactory and tactile sensitivities showed the greatest predictive effect, physicians should focus their intervention efforts on sensory pain in the mouth, texture aversion and olfactory rejected foods. This can include sensory based feeding treatment, incremental exposure strategies and changing the environment at meal times to help reduce sensory overload. Furthermore, carers and educators need to learn some practical feeding instruction in order to realise selective eating as an issue of sensory regulation as opposed to deliberate noncompliance. From a public health perspective, early screening of food selectivity may help to reduce nutritional imbalances, increase dietary diversity and reduce carer burden through early and specific intervention strategies.

6. Future Scope

Subsequent study should attempt to expand these findings in larger multi-centre and longitudinal studies to know the development of sensory-driven food selectivity in developmental stages and if early intervention has any impact on enhancing long-term dietary outcomes. Subsequent research can investigate the molecular and neurophysiological basis of the chemosensory sensitivity (e.g. taste perception pathway, variation in olfactory processing, etc.). Furthermore, the co-occurring diseases such as ARFID anxiety and gastrointestinal symptoms may be more complete in understanding feeding phenotypes in ASD. Future research should evaluate the effectiveness of sensory-focused models of intervention through controlled trials, the comparison of sensory based feeding therapy with behavioural approaches to determine the most effective approaches to improve food acceptance and nutritional health in children with ASD.

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