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The role of sensory sensitivity in predicting food selectivity and food preferences in children with Tourette syndrome

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1	Running title: Sensory sensitivity and food selectivity in Tourette syndrome
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4	children with Tourette syndrome
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27 Abstract

Tourette syndrome (TS) is a neurodevelopmental disorder characterised by involuntary, repetitive and non-rhythmic motor and vocal tics. Despite suggestion that diet may affect tics, and the substantial research into children's diet, eating behaviours and sensory processing in comorbid disorders (e.g. ASD), research in TS is lacking. The present study examined differences between children with and without TS in parental reports of child selective eating, food preferences and sensitivity, and aimed to examine sensory sensitivity as a predictor of food selectivity outcomes in children with and without TS. Thirty caregivers of children with TS (M=10 years 8 months [SD=2.40]) and the caregivers of 30 age- and sex-matched typically developing (TD) children (M=9 years 9 months [SD=2.50]) completed the following measures online: Short Sensory Profile, Food Preference Questionnaire for Children, Child Eating Behaviour Questionnaire. Children with TS were reported to have significantly higher levels of food selectivity and sensory sensitivity, and less preference for fruit and vegetables than TD children. Importantly, while higher levels of overall sensory sensitivity predicted eating outcomes in the TS group, only sensitivity to taste/smell was found to be a predictor of food selectivity and preference for vegetables for both groups of children. The findings suggest that efforts to address food selectivity in children with TS may be enhanced by including strategies that address atypical sensory processing.

48 Keywords: Tourette syndrome, food selectivity, sensory sensitivity, food preferences

62 **1. Introduction**

63 Tourette Syndrome (TS) is a neurodevelopmental disorder characterised by 64 involuntary, repetitive and non-rhythmic motor and vocal tics, with a typical onset between 7 and 12 years (American Psychiatric Association, 2013). Prevalence figures 65 66 of TS vary depending on the methods adopted, the diagnostic criteria employed and 67 whether the sample was a community or clinical sample. However, the international 68 incidence of TS is reported to be around 1% (Robertson, Eapen & Cavanna, 2009). 69 Anecdotal and case reports have suggested that many individuals with TS are more 70 likely to consume an unhealthy diet, and overeat energy dense foods (Liang, Sun, Ma 71 & Liu, 2015; Ludlow & Rogers, 2017). This increases the risk of children with TS 72 becoming overweight, along with the associated health complications and nutritional 73 deficiencies with being overweight (Liang et al., 2015; Degrauw, Li & Gilbert, 2014). 74 The lack of a balanced and varied diet consumed by children with TS may also 75 contribute to the increased levels of supplements, including vitamin B and C, being 76 given to these children (Mantel, Meyers, Tran, Rogers & Jacobson, 2004). Despite 77 anecdotal reports suggesting that eating behaviours are a substantial concern in 78 individuals with TS, there is no empirical evidence comparing eating behaviours 79 between children with TS and TD children (Ludlow & Rogers, 2017). The current 80 study investigates differences in food selectivity and food preferences between 81 children with and without TS, and determines whether sensory sensitivity is a 82 predictor of food selectivity in these groups of children.

Food selectivity, also termed food fussiness and selective eating, can be defined as 83 84 consuming "an inadequate variety of foods" (Galloway, Fiorito, Lee & Birch, 2005, 85 p.542). Caregivers often report children's food selectivity as a common problem 86 (Mascola, Bryson & Argas, 2010), which can have several adverse consequences for 87 general health and well-being (Jacobi, Schmitz & Agras, 2008). While food 88 selectivity has been found to be frequently observed in pre-schoolers, it is less common in older TD children, suggesting it is something children will often 89 90 eventually grow out of (Cardona Cano et al., 2015). Food selectivity has been found 91 to be more common and more likely to continue beyond early childhood in children 92 with developmental disorders, such as Autism Spectrum Disorders (ASD; Legge, 93 2002) and Attention Deficit Hyperactivity Disorder (ADHD; Leventakou et al., 2016)

both of which are highly comorbid with TS (Kadesjö & Gillberg, 2000; Freeman etal., 2000).

96 Maladaptive patterns of eating are reported in more than 75% of children with ASD 97 (Cermak, Curtin & Bandini, 2010) and include adherence to specific dietary habits 98 and preferences as well as difficult mealtime behaviours, such as a need for a routine or throwing food (Rogers, Magill-Evans & Rempel, 2012; Curtin et al., 2015). 99 100 Children with ASD have also been shown to display a range of food selectivity 101 behaviours, including lack of dietary variety (Zimmer et al., 2012), preferences for 102 energy-dense/nutrient-poor foods, consumption of fewer fruits and vegetables 103 (Schreck & Williams 2006), and higher consumption of sugar-sweetened beverages 104 (Evans et al., 2012). In addition, problematic eating behaviours are common in both 105 children with ASD (Ledford & Gast, 2006) and ADHD (Bennett & Blissett, 2017; Farrow, 2012). Given the high level of comorbidity of these disorders with TS, the 106 107 underlying mechanisms for food selectivity in TS require further examination.

108 One explanation for food selectivity is the perceived sensory properties of food which 109 are suggested to underlie children's reasons for rejecting food in both typical and 110 atypical development (Nicholls, Christie, Randall & Lask, 2001; Martins & Pliner, 111 2005). The process of eating involves integration of various sensory aspects, which have been found to influence individuals' preferences for particular food groups. For 112 113 instance, individuals with an increased sensitivity to bitter compounds tend to have a 114 reduced intake of vegetables, especially those that are bitter-tasting (Duffy et al., 115 2010). However, sensory influences on eating behaviour are not limited to taste; sensory sensitivity, as defined by one's over-responsiveness to sensory information 116 117 (Reynolds & Lane, 2009), has been identified as an inherent characteristic that makes 118 one particularly vulnerable to becoming a picky eater. For example, children's 119 reluctance to eat new foods and/or eat fruit and vegetables has been associated with higher levels of tactile and taste/smell sensitivity (Coulthard & Blissett, 2009). 120

121 Compared to TD children, there is a greater prevalence of food refusal based on 122 texture, taste and smell of food, in children with ASD (Hubbard, Anderson, Curtin, 123 Must & Bandini, 2014). This food refusal has been shown to be associated with 124 increased sensory impairment and behavioural rigidity. Furthermore, sensory 125 impairment has been associated with an increased number of eating problems, such as

food refusal and limited variety (Nadon, Feldman, Dunn & Gisel, 2011; Shmaya, 126 127 Eilat-Adar, Leitner, Reif & Gabis, 2017), and has been found to surpass repetitive and 128 ritualistic behaviour in predicting food selectivity in children with ASD (Suarez, 129 Atchison & Lagerwey, 2014). Despite the paucity of research addressing eating 130 behaviours in TS, an important symptom of TS is sensory over-responsivity. For 131 example, heightened sensory sensitivity to external stimuli has been reported in 80% 132 of TS patients, compared to 35% of TD children (Belluscio, Jin, Watters, Lee & 133 Hallett, 2011). More recently, Ludlow and Wilkins (2016) identified similar levels of 134 atypical sensory behaviour in ASD and TS participants whereby both groups exhibit 135 higher levels of sensory sensitivity. Thus, sensory sensitivity is a plausible mechanism 136 by which children with TS might be at greater risk of problematic eating behaviour.

There were two main aims of the current investigation: 1) To determine whether 137 children with TS are reported to show more food selectivity, show less preference for 138 139 fruit and vegetables, and have greater sensory sensitivity compared to a group of age-140 and sex-matched TD children; 2) To address whether sensory sensitivity would be a 141 predictor of food selectivity and preference for fruit and vegetables in both groups of 142 children. Based on previous research in children with other developmental disorders, 143 it was hypothesized that children with TS would show more food selectivity and show 144 less preference for fruit and vegetables compared to TD children. It was also 145 predicted that children with TS would show significantly higher levels of sensory sensitivity than TD children, and that sensory sensitivity would be a predictor of 146 147 eating outcomes for both groups of children.

148

149 **2. Method**

150 **2.1 Participants**

Sixty caregivers (aged 26-66 years [M = 39 years, SD = 7.19]) reported information on their child. All of the caregivers were mothers. Fifty-eight caregivers described their nationality as British and 2 as American. Thirty children with TS (25 male and 5 female; aged between 7 years 4 months- 15 years 10 months; M= 10 years 8 months, SD = 2.40) were matched to a group of 30 TD children (25 male, 5 female; aged between 7 years 0 months- 16 years 3 months; M= 9 years 9 months, SD=2.50). The groups did not differ in age (t (60) = 1.56, p= .12). Caregiver report of a TS diagnosis

158 and the Premonitory Urge for Tics Scale (PUTS; Woods, Piacentini, Himle & Chang, 159 2005) were used to confirm children's status in the TS group only. This measure 160 reflects the presence and frequency of premonitory urges, along with the relief that may be experienced after tics have been performed. A score above 31 indicates 161 162 extremely high intensity with probable severe impairments. In the current sample 163 scores ranged from 9 to 31 (M=24.88, SD = 6.00). Twenty-five of the children with 164 Tourette syndrome had a comorbid disorder: ADHD (n = 4), ASD (n = 10), Anxiety 165 (n = 6), PTSD (n = 1), OCD (n = 10), Dyspraxia (n = 4) and Dyslexia (n = 1). None of the parents reported any of the TD children to have any known clinical diagnosis. Of 166 the children with TS taking medication (n = 15), the most commonly reported was 167 melatonin (n = 6). Other prescription drugs recorded were sertraline (n = 4) and 168 clonidine (n = 2). Participants were recruited through Tourette's Action charity online 169 170 website in addition to online forums and local organisations who agreed to advertise 171 the study.

172 **2.2 Measures**

173 Demographic variables collected included: child's sex, birth date, any clinical 174 diagnosis including comorbid disorders, age at which the child was diagnosed with TS (M = 7 years 9 months, SD = 2.09). Parents were asked to provide a measurement 175 176 of their child's weight and height, which was then converted to a BMI standard deviation score (SDS). The Child Growth Foundation Package (1996) was used to 177 178 standardise the measurements for age and sex according to standardised norms for a 179 UK sample. Caregivers were also asked to describe their age, ethnicity and their 180 relation to the child. Finally, parents were asked to complete the following 181 questionnaires:

182 2.2.1 The Short Sensory Profile (SSP; Dunn, 1999)

The SSP is a 38-item caregiver questionnaire designed to assess children's responses to sensory stimuli. Three subscales from the questionnaire were used to assess children's tactile sensitivity (e.g. avoids going barefoot, especially in grass and sand), taste/smell sensitivity (e.g. avoids tastes or food smells that are typically part of a child's diet), and visual/auditory sensitivity (e.g. covers eyes, or squints to protect eyes from light). The total scores from all seven subscales of the questionnaire, which included Auditory Filtering, Low Energy/Weak, Movement Sensitivity, were also

190 computed to provide a total sensory sensitivity score. Caregivers responded to items 191 on a 5-point Likert scale ranging from 1 (always) to 5 (never) with lower scores 192 indicating higher sensory impairment. The subscales range from weak to strong 193 internal consistency (Cronbach α =.47 to α =.91; Dunn, 1999). In the current study 194 good to excellent internal reliability was found for the subscales used; tactile 195 sensitivity (Cronbach α =.88), taste/smell sensitivity (Cronbach α =.95), visual/auditory 196 sensitivity (Cronbach α =.90) and overall sensory sensitivity (Cronbach α =.96).

197 2.2.2 The Food Preference Questionnaire for children (FPQ; Fildes et al., 2015)

198 The FPQ requires caregivers to rate their child's liking for 75 commonly consumed 199 individual foods from 6 food groups: fruit, vegetables, meat/fish, dairy, snacks and 200 starches. The items are rated on a 5-point Likert scale, ranging from 1 (dislikes a lot) 201 to 5 (like a lot), with an option of 'never tried' which is scored as a missing response. 202 The mean score of items pertaining to each subscale was calculated, with the higher 203 the score indicating an increased like towards the given food category. In terms of 204 psychometric properties, the current study found a good to excellent internal reliability for the food groups; fruit (Cronbach α =.95), vegetables (Cronbach α =.93), 205 206 meat/fish (Cronbach α =.92), snacks (Cronbach α =.82), dairy (Cronbach α =.74), 207 however the reliability for the starch subscale was lower (Cronbach α =.66).

208 2.2.3 The Child Eating Behaviour Questionnaire (CEBQ: Wardle, Guthrie, Sanderson 209 & Rapoport, 2001)

210 The 'food fussiness' subscale from the CEBQ was used to assess parental perceptions 211 of their child's food selectivity behaviour. This subscale consists of six items and 212 includes how difficult the child is to please with meals; how often the child refuses to 213 taste new foods and the variety of foods the child will eat. Caregivers rated the 214 frequency of which the child exhibits the behaviour on a 5-point Likert scale ranging 215 from 1 (never) to 5 (always). Development of the questionnaire revealed good internal 216 reliability coefficients (Cronbach's alpha) for all the subscales, ranging from 0.74 to 217 0.91 (Wardle et al., 2001). In the present study Cronbach's alpha for food selectivity 218 was 0.68.

219 **2.3** *Procedure*

220 Ethical approval for this research was obtained from the University of Hertfordshire

221 University Ethical Advisory Committee Protocol Number: LMS/PGT/UH/02784 and

222 the research was performed in accordance with the Declaration of Helsinki. Informed 223 consent was given by all participants prior to their participation in the research. The 224 study was advertised on Tourette's Action charity website, which aided the recruitment of caregivers of children with TS. Additionally, local organisations and 225 226 online parenting forums were contacted and with their permission the advertisement 227 was distributed. Participants volunteered to participate in the study by clicking on the 228 given link, which directed them to the online survey. Following this, every participant 229 was presented with the questionnaires in the same order. Information on how to seek 230 further advice if the parents had any concerns regarding their child's eating 231 behaviours was also provided. The survey took approximately 25 minutes to complete 232 and was active for two months. Families were provided no incentive to participate. 233 Approximately 177 parents were sent the link to the survey (123 parents of TS, and 234 54 parents of TD) and 79 completed (32 TS and 47 TD) the survey, rendering a response rate of approximately 46%. Two children with TS were removed due to 235 236 being much older than the TD children, and then 30 TD children were selected from 237 the 47 to be nearest in both age- and sex- of the 30 children with TS. Where single items were missing from the data and equated to less than 10% of a participant's 238 239 questionnaire data, the means substitution method was adopted (*N*=6 participants).

240 **2.4.** Analysis

Independent t-tests were first computed to compare differences in BMI SDS between groups and to examine whether there were sex differences in outcome measures. The data was then analysed using Two-tailed Pearson's correlations establish whether child age or BMI SDS were related to food selectivity.

To investigate differences between the children with and without TS, a series of independent t-tests were conducted for each of the questionnaires (SSP, FPQ, CEBQ). To examine whether sensory sensitivity was a predictor of eating outcomes in the two groups (TS and TD), a series of simple Multiple Linear Regressions were carried out. This included the overall sensory sensitivity score as well as Taste/smell, Tactile and Visual/Auditory subscales as a predictors of food selectivity and preference for fruit and vegetables.

252 **3. Results**

253 **3.1.** Descriptive Statistics

254 Independent t-tests revealed no significant differences between BMI SDS for children 255 with TS (M= -1.59: SD= 4.17) compared to TD children (M= -.36: SD= 1.95), t (45) = 256 1.28, p = .21. Furthermore, BMI SDS did not significantly differ between children 257 with TS taking medication (M= -.36: SD= 2.90) and children with TS not taking medication (M= -2.82: SD= 4.96), t (22) =1.48, p = .15. The data were then analysed 258 to establish whether child age, BMI SDS, or sex were related to food selectivity. Two-259 260 tailed Pearson's correlations indicated that child food selectivity was not significantly associated with child age (r = -.02, p = .94) or BMI SDS (r = .09, p = .67) in TD 261 262 children. For the children with TS, food selectivity was also not correlated with age (r = -.29, p = .11) or BMI SDS (r = -.25, p = .24). Therefore, these measures were not 263 264 controlled for in further analyses. While an independent samples t-test revealed a significant difference in food selectivity between males and females in the TD 265 children, t = (28) = 2.48, p=.02, with males showing higher levels of food selectivity 266 267 (Males, M = 2.90 SD= .96; Females M = 1.80: SD= .36), no significant difference in 268 food selectivity between males and females was found in the children with TS, t =(4.52) = -.12, p = .91, (Males, M = 3.46 SD= 1.07; Females M = 3.53: SD= 1.89). 269

270 **3.2.** Differences in food selectivity, food preference and sensory sensitivity

To examine whether there were group differences in food selectivity between the two groups, an independent t-test was conducted to examine differences in the food fussiness subscale of the CEBQ. This revealed a significant effect of group on food selectivity, t(77) = -2.32, p = .02. Parents reported children with TS had significantly higher levels of food selectivity (M = 3.47: SD = 1.20) compared to TD children (M =2.71: SD = .98).

Further t-tests were carried out to address differences between the groups in the six individual subscales of the Food Preference Questionnaire. Results revealed children with TS had significantly lower preferences for meat, t (58) = 2.31, p = .02; fruit, t(58) = 4.20, p < .001 and vegetables, t (58) = 2.03, p = .04 than TD children. There were no differences in preference for snacks, t (58) = .87 p = .08; starches, t (58) = 1.76, p = .39 and dairy, t (58) = 1.78, p = .08.

283 Finally, to examine whether there were differences in sensory sensitivity between the 284 two groups, differences between the groups in the overall total score on the sensory 285 profile and the three selected scales of the sensory profile were analysed using 286 independent samples t-tests. Results revealed children with TS were significantly 287 more sensory sensitive overall, t (58) = 717, p < .001; and were significantly more sensitive to tactile, t (58) = 7.06, p < .001; taste/smell, F (58) = 2.61, p < .01, and 288 visual/auditory information, F(58) = 5.86, p < .001 than TD children. Total scores 289 290 and standard deviations are shown in Table 1.

291 Table 1: Mean scores (standard deviation) for each of the questionnaires for children

292	with Tourette	syndrome a	<i>ind typically</i>	developing	children.
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	Typically Developing		Tourette Syndrome	
_	Mean	SD	Mean	SD
Demographics				
Age in Months	154.36	12.92	155.73	17.74
Height	144.96	16.23	149.09	17.75
Weight	37.57	18.96	38.84	17.25
BMI SDS kg/m ²	36	1.94	-1.59	4.17
Sensory Profile				
Tactile	31.73	3.96	22.13***	6.31
Taste/Smell	16.80	3.90	12.73**	7.57
Visual/Auditory	22.67	2.96	15.70***	5.80
Total	163.60	20.91	115.20***	30.47
CEBQ				
Fussiness	16.45	5.86	20.72**	7.12
FPQ				
Meat/Fish	48.13	1005	40.17*	15.89
Dairy	30.20	6.01	27.00	7.78
Starches	22.87	4.11	21.93	4.24
Snacks	50.10	7.98	46.43	8.810
Fruit	64.63	11.52	46.57**	19.05
Vegetables	61.13	18.68	50.27*	22.65

293 *Note:* *** = *p* < .001, ** = *p* < .01, * = *p* < .05

294

295 **3.3. Multiple Regressions**

Multiple linear regression analyses were first carried out exploring total levels of sensory sensitivity as predictors of food selectivity, preference for meat/fish and preference for fruit and vegetables. Results revealed a significant overall model of sensory sensitivity as a predictor of food selectivity for the TS children F(1, 29) =9.35, p < .01, with an $R^2 = .25$, but not for the TD children, F(1, 29) = 1.77, p = .19, with an $R^2 = .06$. Overall levels of sensory sensitivity were also found to predict

302 preference for fruit (F (1, 29) = 13.69, p < .001, R^2 =.33) and vegetables in the TS 303 group (F (1, 29) = 4.15, p < .05, R^2 =.13). However, overall levels of sensory 304 sensitivity was not found to be a significant predictor for fruit (F (1, 29) = 1.48, p = 305 .23, R^2 =.05) or vegetables (F (1, 29) = .51, p = .48, R^2 =13) in the TD group. Sensory 306 sensitivity was not predictor of preference for meat/fish in either group.

307 Multiple linear regression analyses were then carried out to explore the relationship 308 between the three sensory subscales as predictors of food selectivity, preference for 309 meat/fish and preference for fruit and vegetables. Tactile, taste/smell and 310 visual/auditory sensory subscales were all entered into the model in the same step. 311 Results revealed that no sensory subscales were significant predictors for preference 312 for meat. Taste/smell sensitivity was the only significant predictor for food selectivity 313 and preference for vegetables in both groups of children. While Taste/smell predicted 314 preference for fruit in TD, it was not a significant predictor for TS. Table 2 shows the 315 models accounted for a large variance of both food selectivity and preference for fruit and vegetables. Taste/smell sensitivity accounted for a greater variance in food 316 317 selectivity, compared to preference for fruit and vegetables in both groups.

318 Table 2: Standard Coefficients of the three sensory profile subscales predicting eating

319 outcomes.

	Tactile	Taste/ Smell	Visual/ Auditory	R ²	F(3,29)
TD		Y	. <u> </u>		
Food Selectivity	.02	85***	.14	.65	15.21**
Preference Fruit	08	.67***	17	.41	5.93**
Preference Veg	21	.84**	02	.61	13.47**
TS					
Food Selectivity	002	74**	01	.55	10.75**
Preference Fruit	.24	.33	.28	.47	7.76***
Preference Veg	.04	.60**	.76	.35	4.65**

320 Note: *** = p < .001, ** = p < .01, * = p < .05

322 4. Discussion

The current research found significant differences in the eating behaviours of children with TS compared to an age- and sex-matched group of TD children. Children with TS reported more food selectivity and showed less preference for several food categories, namely meat, fruit and vegetables compared to TD children. Children with

³²¹

TS showed higher overall levels of sensory sensitivity and were also more sensitive to tactile, taste/smell and visual/auditory information than TD children. Higher overall sensory sensitivity was found to be a significant predictor of food selectivity and lower preferences for fruit and vegetables for the TS group only. However across the individual subscales, taste/smell sensitivity was found to be an independent predictor of food selectivity and preference for vegetables in both groups of children.

333 Differences in food preferences of children with TS, compared to TD children, 334 showed children with TS to display less preference for meat, fruit and vegetables 335 overall. Research has found iron deficiencies are frequently identified in individuals 336 with TS, the decreased level of iron has been suggested to exacerbate tic severity 337 (Gorman, Zhu, Anderson, Davies & Peterson, 2006). This iron deficiency may be 338 partially explained by the lack of preference for meat and vegetables in children with 339 TS as found in the current study. However, it was not known if any of children with 340 TS included in this study were iron deficient. In previous research, a reduced 341 consumption of a variety of food groups has been consistently associated with poor 342 nutrition (Sharp et al., 2013), and intakes of dairy, grains and total fruits and 343 vegetables are inversely associated with central obesity among adolescents (Bradlee, 344 Singer, Qureshi & Moore, 2010). However, in this sample, no difference was found between TS and TD in their preference for snacks, starches & dairy, and no 345 346 significant differences were found in BMI SDS between the two groups. However, 347 parents provided this information via self-report, and future studies need to collect a 348 direct measure of height and weight of participants to ensure an accurate comparison 349 across samples.

In addition, children with TS were shown to have higher levels of food selectivity 350 351 than TD children. Not only does greater food selectivity increase the health risk for 352 the child, it has also been suggested that food selectivity can contribute to elevated 353 anxiety for the child and their family (Farrow & Coulthard, 2012). Children who are 354 selective eaters have been shown to have an adverse impact on their family's quality 355 of life (Rogers et al., 2012) by increasing stress (Curtin et al., 2015), frustration 356 (Rogers et al., 2012) and difficulty eating in social environments (Twachtman-Reilly, 357 Amaral & Zebrowski, 2008; Nadon et al., 2011). The wide impact of food selectivity 358 highlights the importance of early intervention and the need to understand the origin 359 of this maladaptive behaviour.

360 Children with TS displayed greater overall, tactile, visual/auditory and taste/smell 361 sensitivity compared to TD children. The finding of increased sensory sensitivity in 362 the TS group is consistent with previous research and the symptomology of TS 363 (Belluscio et al., 2011). In the current study, higher levels of overall sensory 364 sensitivity was able to account for significant variance in both food selectivity and a 365 reduced preference for fruit and vegetables in the TS group. Importantly, the present 366 findings are similar to those found in children with comorbid disorders. Within the 367 ASD literature, food refusal has been found to have a sensory basis (Hubbard et al., 368 2014) and increased sensory processing impairments predict maladaptive eating behaviours (Johnson et al., 2014). The role of sensory sensitivity identified in the 369 370 current study highlights the need to further investigate this across comorbid disorders, 371 where sensory-oversensitivity is a transdiagnostic feature. Overall, the findings 372 suggest that efforts to address food selectivity in children with TS may be enhanced 373 by understanding the sensory basis of mealtime behaviour difficulties. This may be an 374 important part of developing effective treatment and intervention for both the child 375 and their family (Shmaya et al., 2017).

376 Findings also revealed that taste/smell sensitivity predicted preference for vegetables 377 in both groups. This is consistent with the majority of studies addressing food consumption in children with ASD, which have indicated that children with ASD 378 379 consume fewer fruits and vegetables compared to current recommendations (Emond, 380 Emmett, Steer & Golding, 2010; Lukens & Linscheid, 2008). It is likely the lack of 381 preference for fruit and vegetables when a greater level of taste/smell sensitivity is 382 present, is due to the susceptibility of fruit and vegetables to have greater potential 383 differences and changes to their sensory properties, compared to other food groups. 384 Therefore, the unpredictable sensory properties of fruit and vegetables may decrease 385 preference for these specific food groups (Coulthard & Blissett, 2009). However, it is 386 important to note that despite being a predictor of vegetable preference in children 387 with TS, taste/smell sensitivity did not predict preference for fruit in this group. It is likely that there other sensory factors aside from taste/smell sensitivity that will also 388 389 influence food preferences in this group of children, as evidenced by higher overall 390 levels of sensory sensitivity being a significant predictor. However, increased parental 391 fruit and vegetable consumption (Patrick, Nicklas, Hughes & Morales, 2005) and 392 reoffering various foods within the food group (Birch, Gunder, Grimm-Thomas &

Laing, 1998) can increase the acceptance of fruit and vegetables in typically
developing children, and the potential for these kinds of intervention strategies now
needs to be examined in children with TS.

396 The present study is not without limitations. First, the measures were based on 397 parental self-report rather than direct observations of children's food choices. Parents 398 may make assumptions about their children's food choices and sensory problems. 399 Second, the forced choice aspect of the questionnaires may not have identified 400 important aspects of the children's eating behaviours, and therefore limited the 401 responses the parents gave. For example, in the SSP, taste and smell are combined 402 into a single subscale precluding the ability to separate these characteristics (Hubbard 403 et al., 2014). Third, while the food preference questionnaire showed a lower preference for fruit and vegetables in the children with TS, the exclusion of a food 404 405 frequency questionnaire prevented detail about the frequency of consumption and 406 portion size of these food groups. Therefore, this would be an important direction for 407 future research to address. Last, the small sample size limited the ability to compare 408 whether there were significant differences between TS with and without comorbid 409 disorders. Given the high comorbidity between ASD and ADHD in TS, it is important 410 for future studies to examine the eating behaviours of TS in comparison to groups 411 with ASD without TS, and ADHD without TS. In addition, it will be important to 412 screen for comorbid ADHD in all groups, to identify the degree to which eating problems are syndrome specific. 413

This is the first exploratory study addressing the relationship between sensory sensitivity and child eating behaviours in TS. It is clinically important for future research to understand the origin and nature of these differences in eating behaviours. Not only can feeding problems lead to growth delay, but they can also cause significant family stress, with parents worried about the child's nutritional intake and troublesome mealtime behaviours (Reynolds, Kreider, Meeley & Bendixen, 2015).

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	ACCEPTED MANUSCRIPT
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427	5. Acknowledgements
428	We wish to thank Tourettes action for their support with recruitment, and all the
429	parents who kindly gave up their time to participate in this research.
430	
431	6. Declarations
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434	
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