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Research report

Identifying flavor preference subgroups. Genetic basis and related eating behavior traits ☆

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ABSTRACT

Subgroups based on flavor preferences were identified and their genetic and behavior related characteristics investigated using extensive data from 331 Finnish twins (21–25 years, 146 men) including 47 monozygotic (MZ) and 93 dizygotic (DZ) pairs, and 51 twin individuals. The subgroup identification (hierarchical and K-means clustering) was based on liking responses to food names representing sour, umami, and spicy flavor qualities. Furthermore, sensory tests were conducted, a questionnaire on food likes completed, and various eating behavior related traits measured with validated scales. Sensory data included intensity ratings of PROP (6-*n*-propylthiouracil-impregnated filter paper), hedonic and intensity responses to sourness (orange juice with and without added citric acid, 0.42%), pungency (strawberry jelly with and without added capsaicin 0.00013%) and umami ('mouthfeel flavor' taste solution). Ratings of liking of 41 general food names were categorized into *salty-and-fatty, sweet-and-fatty, fruits and vegetables* and *fish* foods. Subgroup differences (complex samples procedure) and the genetics underlying the subgroups (structural equation modeling) were investigated. Of the resulting two groups (basic, $n = 140$, adventurous $n = 152$; non-grouped $n = 39$), the adventurous expressed higher liking for sour and spicy foods, and had more tolerance for capsaicin burn in the sensory-hedonic test. The adventurous were also less *food neophobic* (25.9 ± 9.1 vs. 32.5 ± 10.6, respectively) and expressed higher liking for *fruits and vegetables* compared to the basic group. Genetic effects were shown to underlie the subgroups (heritability 72%, CI: 36–92%). Linkage analysis for 27 candidate gene regions revealed suggestively that being adventurous is linked to TAS1R1 and PKD1L3 genes. These results indicate that food neophobia and genetic differences may form a barrier through which individual flavor preferences are generated.

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Abbreviations: A, additive genetic variance component; C, common environment variance component; CA, citric acid; CP, capsaicin; CR, cognitive restraint; CSF, Craving for Sweet Foods; D, genetic dominant variance component; DZ, dizygotic; E, unique environment variance component; EE, emotional eating; FNS, Food Neophobia Scale; G1, subgroup 1, the basic; G2, subgroup 2, the adventurous; GF, General Food questionnaire; GHI, General Health Interest ; GWA, Genome Wide Association; HTAS, Health and Taste Attitude Scales; HWE, Hardy Weinberg Equilibrium; LMS, Labeled Magnitude Scale; MAF, minor allele frequency; MZ, monozygotic; PKD1L3, polycystic kidney disease 1-like 3 protein coding gene; PROP, 6-*n*-propylthiouracil; RSE, the Rosenberg Self-Esteem Scale; SF, Specific Food questionnaire; SNP, single nucleotide polymorphism; TAS1R1, taste receptor type 1 member 1 protein coding gene; TFEQ, Three-Factor Eating questionnaire; UE, Uncontrolled Eating.

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Introduction

Food preferences are formed due to the effects of environment (exposure and experience) and genetic predispositions (e.g. taste, preferences and neophobic reaction to foods) which together play a central role in determining food selection and diet quality (Birch, 1999; Story, Neumark-Sztainer, & French, 2002). Although individual diversity exists in flavor responses to foods, individuals tend to differ more dramatically in terms of what they like or dislike, than they differ in their sensory perceptions (Moskowitz, 1985). Surprisingly, flavor preferences have been rarely used in market research in identification of consumer clusters, while more attention has been paid to demographics, attitudinal and food-related motivations (Gao et al., 2011; Logue & Smith, 1986; Contento, Michela, & Goldberg, 1988; Verdurme & Viaene, 2003).

Honkanen, Olsen, and Myrland (2004) demonstrated the applicability of preference data on segmenting consumers, using 1168 Norwegian teenagers. They identified four distinctive subgroups varying in general liking of foods, particularly fish. Later on, Honkanen (2010) found six preference based subgroups in 1081 Russian adults from which the largest group (*various food lovers*) showed high preference for all foods. Another valuable approach in consumer studies have been the use of psychographic measures such as food related lifestyles (Wycherley, McCarthy, & Cowan, 2008) and personality dimensions, e.g. food neophobia (Henriques, King, & Meiselman, 2009). Among 1037 British consumers, Wycherley and others identified six distinct life-style groups from which two (*adventurous* and *rational*) together accounted for nearly half of the population. Both groups showed interest and reacted positively to the attributes such as taste and quality of *specialty foods* (special, exclusive and quality products). Henriques and others used food neophobia (reluctance to/avoidance of novel foods) as the basis of subgrouping and studied its effect on acceptability of novel food items in 389 North American consumers. They concluded that neophobics and neophilics perceived sensory characteristics similarly, but showed a different degree of liking for a food. As many studies have shown, clustering is a major improvement over undifferentiated approaches to 'the consumer' (MacFie, 2007). In addition, it can be helpful for nutrition educators who need understanding of food choice motives to better tackle unhealthy eating behaviors.

In the context of the FinnTwin12 study (Kaprio, 2006; Kaprio, Pulkkinen, & Rose, 2002), investigating genetic and environmental determinants of young adults' health, a data set including flavor preferences as well as behavioral and personality related traits was collected. From these data, the heritability of food neophobia (Knaapila et al., 2007, 2011), astringency perception (Törnwall et al., 2011) and the preference for sourness and pungency (oral sensory burn) (Törnwall et al., 2012; Törnwall, Silventoinen, Kaprio, & Tuorila, 2012) have previously been investigated. The evidence for the role of genes in less well-studied traits such as umami, sourness and pungency is limited (Dotson, Babich, & Steinle, 2012). At present, the objective was to obtain a coherent picture of flavor preferences among young adults to the extent that the present data allowed. Subgroups were identified based on available preference data (sour, umami and pungency), and subsequently, the sensory, genetic and behavior related characteristics were explored among the obtained subgroups.

Methods

Respondents

A total of 331 adult Finnish twins (146 men and 185 women, mean age 22.0 years, range from 21 to 25 years) participated in the study, including 47 monozygotic (MZ) and 93 dizygotic (DZ) complete twin pairs and 51 twin individuals without their co-twin. The data were collected during 2008–2009 as part of the fourth wave of the longitudinal FinnTwin12-study (Kaprio, 2006; Kaprio et al., 2002). A total of sixteen participants were excluded from performing a specific sensory test as they were or had been using thyroid medication (6-*n*-propylthiouracil, PROP), or reported allergy to citrus fruits (sourness), strawberries or chili (pungency). The study protocol was approved by the Ethics Committee of Helsinki University Hospital District. The respondents gave their written informed consent in the beginning of testing.

Sensory stimuli

PROP-impregnated filter paper was used for PROP-testing as described earlier (Keskitalo et al., 2007; Zhao, Kirkmeyer, & Tepper, 2003). Umami sample was prepared on the preceeding or the day of testing by adding 0.5 g of Mouthfeel Flavor aroma powder (0.1–0.5% p137074, Givaudan, Switzerland) to 250 ml of tap water. The umami aroma was stirred well with water allowing the aroma powder to dissolve properly. Orange juice spiked with 4.20 g/L citric acid (CA) vs orange juice without CA were used for sourness testing. For pungency, strawberry flavored jelly spiked with 0.0013 g/L capsaicin (CP) vs jelly without capsaicin were used. Samples were prepared as described previously (Törnwall, Silventoinen, Keskitalo-Vuokko, et al., 2012; Törnwall, Silventoinen, Kaprio, et al., 2012). All samples were served at room temperature.

Overview of data collection

Respondents were invited to the twin research unit located in Helsinki, Finland, for a 1-day assessment. The day started with sensory testing followed by other health related assessments (e.g. interview and neuropsychological tests) according to the FinnTwin12 study protocol (Kaprio, 2006; Kaprio et al., 2002). Data collection scheme related to the present study is presented in Fig. 1. Upon arrival to the research unit, a "Home questionnaire" was returned and the participants were given both written and oral instructions concerning the sensory tests. Sensory evaluations (4 tests: PROP, umami, sourness and pungency) were performed in the morning after an overnight fast (12 h) in an undisturbed classroom-type environment with divider screens for privacy. The order for sensory tests (Fig. 1) was chosen to minimize the interaction effects between the tests (e.g. pungency test was completed last due to the long lasting perception). For blood collection and weight and height measurements, performed by a research nurse, the participants were divided into two groups to streamline the testing protocol. The blood was drawn (2×10 ml) from the first group in between the PROP and umami tests and from the second group after the pungency test. Other questionnaires; Specific Food questionnaire (SF) and General Food questionnaire (GF) were completed depending on available time, in between and after the sensory testing.

Sensory procedure

PROP intensity was evaluated in the beginning of sensory testing. To distinguish the taste of PROP from that of the filter paper, respondents first tasted pure filter paper and after this PROP-impregnated filter paper. Before and in between the stimulations, subjects rinsed their mouths with tap water. Both filter papers were held in the mouth for 10 s. The rating was done after a short break (PROP intensity builds up after a short delay) using a Labeled Magnitude Scale (LMS) by Green et al. (1996). The verbal labels and their positions in the line from bottom to up were: "barely detectable" (2 mm), "weak" (7 mm), "moderate" (20 mm), "strong"

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