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Article

Do People with Lower IQ Have Weaker Taste Perception? A Hidden Supplementary Table in 'Is the Association Between Sweet and Bitter Perception Due to Genetic Variation?'

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Abstract

This paper is about Nick's contribution to the field of taste genetics, how I became involved and how a study on the genetic association between the perception of sweetness and bitterness ended up examining the influence of intelligence on taste perception.

Keywords: Taste perception; genetics; intelligence; sweet; bitter; twin; genetic correlation

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The story started from a chat between Nick Martin and Danielle Reed at the 2001 American Society of Human Genetics Annual Meeting. The two scientists had mutual interest in taste perception and decided to build an international collaboration, together with Margie Wright and Paul Breslin, to collect taste and smell data from twins in the Australia and the USA to explore the human genetics of chemical senses. The first study from this collaboration employed structural equation modeling to quantify the heritability of the perceived intensity of four bitter substances — propylthiouracil ($h^2 = .72$), caffeine ($h^2 = .30$), quinine ($h^2 = .34$) and sucrose octaacetate ($h^2 = .28$) — in a sample of 62 monozygotic (MZ) and 131 dizygotic (DZ) twin pairs and 237 sib pairs (Hansen et al., 2006). It was the study that brought quantitative genetics to chemosensory science and is one of the most highly cited papers in *Chemical Senses* (84 cites, Google Scholar, assessed March 26, 2020).

In 2010, I joined the collaboration as a research technician working with Danielle at the Monell Chemical Senses Center (Philadelphia, USA). I was responsible for collecting sensory data and saliva samples at the annual Twins Days Festival in a city named Twinsburg in Ohio. I also prepared taste solutions and shipped them to Australia for taste tests, without knowing it was going to my next stop. In 2014, I moved to Brisbane to do my PhD at the QIMR Berghofer Medical Research Institute under the supervision of Nick and Margie. By the time, the sample size of the Australian taste cohort had grown to 1901, including 243 MZ and 452 DZ twin pairs and 511 unpaired individuals. Using this dataset, my first project established the heritability of the perception of sugars and artificial sweeteners ($h^2 = .30$–.34) and identified a common genetic factor (Hwang et al., 2015).

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It had been known for more than one decade that human sweet and bitter taste receptors were both from the G protein-coupled receptor family (Margolskee, 2002); however, no one had ever been able to prove a shared molecular mechanism. This question became my second project, which aimed to investigate the genetic correlation between sweet and bitter taste perception. In August 2015, I presented results from bivariate and multivariate modeling to Nick and Margie. In the meeting, Nick was suspicious about whether the moderate genetic correlation ($r_g = .46$–$.51$) was due to confounding and hypothesized that people with lower intelligent quotient (IQ) might have weaker taste perception. 'Why don't you have a look at the IQ in our 19UP study?' Nick said to me. This suggestion gave IQ a place in the paper.

Surprisingly, IQ was correlated with taste perception but in an opposite direction as Nick thought. People with lower IQ actually rated both sweet and bitter solutions as more intense (Table 1). Nevertheless, including IQ, as well as the Big 5 personality traits, did not change the genetic correlation between sweet and bitter taste perception. These results to some extent convinced Nick that the genetic correlation we found was likely due to a shared molecular mechanism rather than cofounding. The paper was published in 2016 (Hwang, Breslin et al., 2016) and later recommended in F1000Prime (Finger, 2017) due to its significance in solving a decade-long question in chemosensory science. However, the association between IQ and taste was only briefly discussed as 'higher IQ is associated with less extreme rating styles' and hidden in the supplementary materials. While we believe that people who like to complain that foods are too sweet or too bitter do not necessarily have lower intelligence, whether intelligence affects how we taste remains a puzzle.

Many people may not know that taste perception is one of Nick's earliest research topics (Martin, 1975) and a part of his doctoral dissertation. I still remember that he was very excited to share with me a paper about the super taste acuity of aboriginal people in Taiwan (Lugg, 1970) from his 'hard copy' collection after knowing where I came from. Taste perception may just be one of Nick's

Table 1. Phenotypic correlations between taste intensities and IQ, personality and emphasis scores estimated from bivariate ACE models

	IQ	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness	Emphasis
PROP	−.11*	.04	.02	−.05	−.07*	−.03	−.02
SOA	−.15*	.07*	.03	−.07*[a]	−.06*[a]	−.04	−.02
Quinine	−.14*	.07*	.05	−.05	−.04	−.05	0
Caffeine	−.13*	.07*	.02	−.04	−.06*[a]	−.04	−.02
gSweet	−.07*	.05	.02	.00	−.03	−.05	0

Note: $n = 1244–1256$. $^*p < .05$ before correction for multiple testing.
[a]Insignificant after adjusting for IQ. PROP, propylthioracil; SOA, sucrose octaacetate; gSweet, a general sweetness factor. This table was modified from the Supplementary Table 8 in Hwang, Breslin et al. (2016).

(tons of) traits of interest, but his genuine passion for science plus wild ideas have led to important breakthroughs and driven the field of taste genetics many steps forward. These include the identification of novel genes for bitter (Hwang et al., 2018; Reed et al., 2010) and sweet (Hwang, Lin et al., 2019) taste perception, correlations between taste, BMI (Hwang, Cuellar-Partida et al., 2016) and brain structure (Hwang, Strike et al., 2019) and how taste perception affects our dietary intake (Ong et al., 2018). Building on Nick's contributions, we are expecting many more interesting and exciting scientific discoveries to come.

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