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The linguistic and cognitive factors associated with lexical-gustatory synesthesia: A case study

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ABSTRACT

Past research on lexical-gustatory synesthesia (people who associate words with tastes) has shown that linguistic factors underlie the inducer (word)–concurrent (taste) mappings in these individuals. The developmental cognitive model envisioned by Simner and Haywood (2009), and an extension of it proposed in this paper can be used to understand these linguistic associations. The first aim of the current case study was to test these models by examining the linguistic factors associated with this type of synesthesia. The influence of lexical-gustatory synesthesia on memory was investigated using a paired-associate learning task. Further, the present case study also examined if word-pairs with same or similar tastes and word-pairs with dissimilar tastes enhanced learning relative to word pairs that had no tastes. As predicted, the findings revealed possible phonological, phonological–lexical, and lexical–semantic factors linking the inducer–concurrent pairings. These findings are in line with the developmental cognitive models of LG synesthesia. There were no effects of synesthesia on memory as demonstrated by the lack of any significant difference between the synesthete and non-synesthete controls on a paired-associate learning task. Moreover, no significant differences emerged between the "no taste" and "taste" conditions (although she performed slightly better on the "no taste" condition). Interestingly, a metamemory task (judgment-of-learning) revealed the opposite. That is, the synesthete predicted that her learning would be better in the "taste" condition when compared to the "no taste" condition. This indicates that the word-pairs, which produced tastes, could have created a "foresight bias". This is attributed to the unidirectional nature of this individual's LG synesthesia. This finding should, however, be treated with caution because it is a preliminary finding based on a single subject and needs to be corroborated with future studies on other lexical-gustatory synesthetes.

1. Introduction

Synesthesia refers to a condition in which otherwise normal individuals involuntarily experience sensation in a certain unstimulated sensory modality when some other modality is stimulated. The modality in which the stimulation occurs is called the 'inducer' and the modality in which the sensation is experienced is referred to as the 'concurrent' (Grossenbacher & Lovelace, 2001). For example, a person with grapheme-color synesthesia may see the color "red" when presented with the letter *L* or the number *5*. Lexical-gustatory (LG) synesthesia, which is the focus of the present study, is a very rare form of synesthesia in which individuals typically experience tastes in their mouth (sometimes smell odors) when they see or hear words. For example, the LG synesthete who participated in the current study tastes "cherry coke" when presented (reading or hearing) with the word *chair*, and when presented with the proper name *Ian*, she experiences the taste of "bread with marinara sauce and locatelli cheese".

Synesthesia was first clearly described by Sir Francis Galton in 1880. He reported the experiences of several individuals who visualized numbers as being represented in a fixed order in space. Some individuals felt that the numbers had certain shapes and these shapes in turn had specific colors. He described these experiences as idiosyncratic, familial, and varied from one individual to another (Galton, 1880). Synesthesia is not listed in the DSM or ICD classification systems as it generally does not adversely affect the daily activities of a person having this neurological condition (Hubbard, 2007). It runs in families and it could be polygenic in origin (Brang & Ramachandran, 2011).

1.1. Synesthesia related to taste

There have been several reports in synesthesia literature where taste has been the 'inducer' rather than the 'concurrent' (e.g. Cytowic, 1993; Downey, 1911; Myers, 1911). There are 3 published

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studies in historical literature that have described individuals who experience taste (concurrent) when some other sensory modality is stimulated (Ferrari, 1907, 1910; Pierce, 1907). Eleven papers on LG synesthesia have been published in the contemporary literature (Bankieris & Simner, 2014; Cytowic, 1989; Gendle, 2007; Gray & Simner, 2015; Jones et al., 2011; Richer, Beaufils, & Poirier, 2011; Simner & Haywood, 2009; Simner & Logie, 2007; Simner & Ward, 2006; Ward & Simner, 2003; Ward, Simner, & Auyeung, 2005). Some of these studies, however, have been conducted on the same subjects, which is an indication of the rarity of this form of synesthesia.

More recently, several studies on LG synesthesia have revealed the influence of linguistic and conceptual factors on synesthetic experiences. Studies on LG synesthesia have clearly shown the connection between phonology of the words and the tastes triggered by them. For example, words such as *prince* and *cinema* elicit the taste of "mince" (the critical phonemes in this word–taste association are /I/, /n/, and /s/). Orthography does not seem to have much effect on the taste experience. For example, /g/ resulted in the taste of "yogurt" not only in words with a phoneme and grapheme match such as "g" in begin but also when there was a mismatch as in "x" in exactly. The studies also showed that "fine-grained phonological distinctions" were important. For instance, the syllabic dark /l/ (as in bottle) produced the taste of "Rice Krispies" while the nonsyllabic dark /l/ (as in deal) resulted in the taste of "fingernails". The word–taste associations are not always phonological in nature. The words *post*, *past*, *coast*, *most* and *must* led to the taste of "toast" but the words *host* and *boast* on the other hand which are phonologically similar to the words that induced "toast" resulted in totally different tastes. Further investigation has clearly demonstrated the role of learned lexical knowledge in synesthetic experiences. For example, the word *blue* tasted "inky" and the word *bar* tasted like "milk chocolate" (see Ward & Simner, 2003 for a detailed description of their case JIW). The lexical influence is also evident from findings that suggest that tastes are triggered by high frequency rather than low frequency words, and by real words rather than nonwords. The frequency of words is also important in determining the intensity of the synesthesia experience (Gendle, 2007; Simner & Haywood, 2009; Ward et al., 2005). Functional brain imaging studies have shown that the brain activation in individuals with LG synesthesia is different from that of non-synesthetes. The insula is highly active in response to the valence (pleasant/unpleasantness) of the tastes, and the medial parietal regions are active in response to the intensity of these experiences (Jones et al., 2011). It has also been noted that the primary gustatory cortex is activated in response to listening to words but not tones in a person with LG synesthesia (cited in Ward et al., 2005).

1.2. Purpose of the study

Synesthesia is not purely a sensory-perceptual phenomenon; higher-level cognitive processes are involved in these experiences. For example, variations of a letter (change in font, size, etc.) do not change the resultant colors experienced by most grapheme-color synesthetes (Simner, 2012). The components of language such as numbers, letters, days, and months are associated with different personality types and gender by some individuals with synesthesia (Simner & Holenstein, 2007). Interestingly, one of the earliest publications on synesthesia by Galton described a man who associated different numbers with different personifications. To this individual, the number 7 was "masculine", *6* was of "no particular gender but gentle and straightforward", *2* was "young and sprightly", etc. (see Galton, 1880 for a detailed description). These are just a few illustrations to indicate that in most cases of synesthesia, the association is not a simple and straightforward "merging of the senses" as defined in the synesthesia literature (Simner, 2012). Like most types, LG synesthesia is also not a result of a direct association between two sensory centers in the brain (crosstalk). It is influenced by linguistic factors such as phonology and lexical–semantics (Gendle, 2007; Ward & Simner, 2003; Ward et al., 2005). Simner and Haywood (2009) have used a cognitive model to explain these complex word–taste associations. They have proposed that the word–taste mappings may not be formed during infancy but may occur during early childhood as a consequence of language acquisition. At the early stages of LG synesthesia development, food words get mapped onto the lemma (abstract concept associated with words) of food names and this in turn is linked to gustatory sensations (see Fig. 1). This can explain some of the direct lexical connections between words and tastes (chocolate evokes the taste of chocolate/chocolate milk shake). During later stages, words that are phonological neighbors of food words may start eliciting gustatory sensations by activating the lemmas associated with these food words. This can explain some of the phonological–lexical associations between inducers and concurrents (for example, *tickle* can elicit the taste of "pickle" by activating the food word "pickle" (or the lemma associated with it)). By extending the model proposed by Simner and Haywood (2009), it is reasonable to suggest that during the later stages of synesthesia development, words that share other linguistic associations (e.g. phonological and indirect lexical–semantic or conceptual) with food items produce gustatory sensations by triggering the lemma associated with those food items (see Fig. 2). For example, words that share certain phonemes with a food word can produce the taste of that food item (*stroll* producing the taste of *strudel*) and words that are conceptually linked to a food item can elicit the taste of that food (*pantene* producing the taste of *vanilla pudding* perhaps because of their similarity in consistency). Words that evoke thoughts

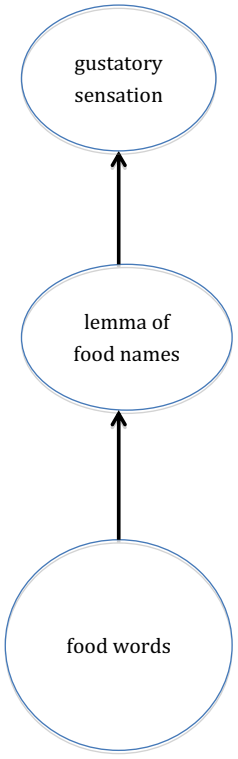

Fig. 1. Lexical-gustatory synesthesia acquisition during the initial stages based on the cognitive model envisioned by Simner and Haywood (2009).