Review TRENDS in Cognitive Sciences Vol.11 No.1

Beyond perception: synaesthesia as a psycholinguistic phenomenon

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Synaesthesia has been described as a perceptual phenomenon that creates a 'merging of senses'. Therefore, academic treatments have focused primarily on its sensory characteristics and similarities with veridical perception. This approach has dominated, despite parallel work that has suggested conceptual influences are involved, including data that show a large number of synaesthetic variants are triggered by linguistic symbols (e.g. words). These variants are the focus of a novel subfield that applies psycholinguistic methodology to the study of linguistic synaesthesias. This approach is redefining notions of synaesthesia and of the interplay between perceptual and non-perceptual systems, in addition to informing general theories of language. This review examines the emergent field of linguistic synaesthesia research and the broad range of linguistic mechanisms that are implicated.

Introduction

Synaesthesia is a familial condition [1,2] in which ordinary activities (e.g. listening to music or reading) trigger consistent, extraordinary experiences (e.g. colours or tastes). For example, for synaesthete ES, hearing a major-sixth tone interval produces the taste of low-fat cream, and hearing F-sharp produces a purple colour experience [3]. The condition affects approximately 4% of the population [4] and is thought to stem from neurodevelopmental differences in the maturation of the brain among synaesthetes, which give rise to atypical 'cross-talk' between areas of the brain that would not normally interact. This interaction between brain regions is thought to arise either from incomplete pruning during development (which leads to a greater retention of connections that would normally be eliminated) [5] or from the disinhibition of pathways that are inhibited in the normal adult brain [6–8]. In addition to providing evidence of genuineness (fMRI studies are discussed later in this article), the central focus of research to date has been the perceptual basis of synaesthesia (e.g. Refs [5,9,10]). For example, experiments have shown that synaesthetic colours can be advantageous in the perception of difficult-to-see stimuli (e.g. hidden or crowded graphemes [5,9,11,12]; see Glossary) and that synaesthetic colours can interact with veridical colours in visual phenomena such as apparent motion [13]. Other studies have focused on mappings across sensory domains and have shown correlations between pitch and brightness, and timbre and chroma in music–colour synaesthesia (e.g. Ref. [14]).

Although synaesthetic triggers ('inducers') and experiences ('concurrents') [6,7] occur across a range of perceptual domains (for a review, see Ref. [7]), they are not limited to these dimensions. The most common synaesthesias (approximately 88% [4]) are those triggered by linguistic units such as words, graphemes (letters or numerals) and phonemes; these generate concurrents in the visual domain (e.g. colours and shapes [4,7,15]), taste modality [16,17], other senses (e.g. smell [4,17]) or even in non-sensory dimensions (e.g. personality types and gender [18,19]). Moreover, the brains of linguistic synaesthetes respond differently when exposed to language (reviewed in Ref. [20]): when processing words or graphemes, language–colour synaesthetes show fMRI activation in areas that are normally associated with colour perception for external stimuli (i.e. V1 [21], (left) V4 and/or V8 [22–24]) and synaesthetic tastes appear as word-triggered activations in the primary gustatory cortex [16].

By examining the relationship between inducers and concurrents, studies have revealed the complexity of the psycholinguistic system that drives the synaesthetic experience. These studies provide information not only about synaesthesia but also about normal language processing; these are the dual goals of this emerging field. This review assembles, for the first time within a single paper, the findings from the synaesthesia literature that pertain to the psycholinguistic nature of the condition. By illustrating the range of linguistic entities involved, I will

Glossary

Allophones: phonetic variants of a phoneme; substituting one allophone for another does not change the meaning of a word (e.g. [bat^h] does not differ in meaning to [bat]; [t^h] is an aspirated /t/ and [t] is an unaspirated /t/).
Graphemes: the minimal contrastive units in the writing system of a language (e.g. *t* versus *d*).
Lexical access: the cognitive process of retrieving words from the mental lexicon.
Lexical semantics: pertaining to word meaning.
Lexical stress: describes the relative force with which syllables are produced (e.g. '*ca*-*non* has first-syllable stress; *ca*-'*det* has second-syllable stress).
Mental lexicon: mental storehouse of words in long-term memory.
Morphemes: the smallest meaningful units in the composition of words (e.g. *blackbird* has two morphemes).
Phonemes: the minimal contrastive units in the sound system of a language; substituting one phoneme for another changes the meaning of a word (e.g. /t/ versus /d/ because /bat/ differs in meaning to /bad/).
Stress homographs: words in which pronunciations differ according to lexical stress (e.g. '*con*-*vict* versus *con*-'*vict*).

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Available online 29 November 2006.

Box 1. Terminological variations

In this article, synaesthesia terminology is based on synaesthetic and psycholinguistic usage and follows the convention of placing inducer before concurrent. There are alternatives but, in most cases, the referent remains clear (e.g. 'grapheme–colour' synaesthesia is also known as 'colour–graphemic' [23], 'chromatic–graphemic' [18,53] and 'chromatic–graphemical' [69]). However, other alternatives present confusion; for example, 'grapheme–colour' versus 'phoneme–colour' synaesthesia has been interpreted as synaesthesia that is triggered by written language only versus spoken language only. This interpretation rests on the incorrect assumption that graphemes are processed only when reading text, and phonemes are processed only when hearing speech (but see Refs [33–35,70]). This interpretation also fails to reflect the widely attested finding that graphemes, for example, trigger colours across both spoken and written modalities (e.g. Ref. [48]). Elsewhere, linguistic synaesthesias (i.e. denoting all or any language-triggered variants) have been termed 'lexical synaesthesias', although 'lexical' usually denotes word-level processing. Finally, the term 'coloured hearing' has been applied to linguistic synaesthesias, even though this incorrectly implies that associations are triggered by heard language only; it also incorrectly conflates linguistic synaesthesias with manifestly different forms (e.g. music–colour synaesthesia).

Box 2. Cross-linguistic investigations

Studies illustrate that German (like English) synaesthetes show high consistency over time for language–colour associations [67], have significant group preferences for letter colours [68] and have word colouring that can be modulated by serial letter position and lexical stress, in addition to morphology and lexical frequency (see 'Linguistic inducers of visual concurrents'). Other studies have revealed cross-linguistic transfer from a first language (L1) to a second language (L2). For English–Russian [32,37] and English–Greek [25] bilingual individuals, the L2 (Cyrillic and Greek) letters tended to adopt the hue of the L1 letter that they resembled visually (e.g. English *R* and Cyrillic *Я* were both purple [32]) or, if there was no visual counterpart, L2 letters adopted the hue of the L1 letter they resembled phonetically [English *P* and Cyrillic *П* (/p/) were both green]. Moreover, L1–L2 visual counterparts correlated in both hue and saturation, whereas phonetic-only counterparts shared hue only [32]. All three reported cases showed similar mechanisms, even though L2 was acquired at the age of three for one synaesthete but after puberty for the others, which suggests that early-acquired synaesthetic associations can generalize to linguistic symbols learned considerably later. However, in a case where L2 Russian was learned both late and superficially, L1 colours did not transfer (participant JM [18]; see also Ref. [37]), although L2 words became coloured if they were mentally transliterated to L1 spelling (see also Ref. [57] for English–Chinese). Although one study has shown a tendency for synaesthesia to occur more often in a fluent L2 (88%) than in a non-fluent L2 (73%) [25], depth of familiarity is not an absolute predictor of cross-linguistic transference: some bilinguals have colour in only one language [10] and some monolinguals have colour for languages they do not understand [25].

demonstrate the extent to which inducer–concurrent mappings can be conceptually mediated by linguistic information acquired through learned experience.

The sub-sections in this article reflect a primary focus on the synaesthetic variants whose linguistic roots have been examined in most detail (i.e. those triggering vision and taste; but see also Refs [4,16–18,25]) and those that provide insight into both synaesthetic and normal language function. For each type of synaesthesia, the review addresses the linguistic features that have been shown to have a key role (e.g. graphemes and phonemes). The discussion also examines terminological variations (Box 1), cross-linguistic manifestations (Box 2) and questions for future research (Box 3).

Linguistic inducers of visual concurrents

Graphemes and phonemes

One of the most common variants of synaesthesia is the triggering of colours by letters and/or numerals, known as grapheme–colour synaesthesia, which is experienced by 1–2% of the population [4]. Here, 'grapheme' denotes the minimal distinctive unit of a writing system [26] (rather than the phoneme-representing segment described by Coltheart [27]) and in some cases extends to coloured punctuation [18] (although not necessarily for all punctuation marks [13] or all synaesthetes [9]). Colours can be triggered by some or all letters and/or numerals, or sometimes only by vowels [28] or consonants [29]. These colours are experienced in the 'mind's eye' (in 'associator synaesthesias') or projected into space (in 'projector synaesthesias') [30]. In the latter case, colour is sometimes experienced as externally visualized text [18] (Figure 1) or it might be superimposed onto the typeface when reading [8,31,32]. Grapheme colours can be triggered by spoken and/or written language; this is consistent with psycholinguistic studies that show that graphemes are processed even during speech comprehension [33–35]. Because colours are tied to orthographical rather than phonological properties, the initial constituent of words such as *cat* and *cite* would be the same colour, whereas the initial constituent of *site* and *cite* would be different colours [17,36,37]. Phoneme–colour synaesthesia (where colours are triggered by phonemes independent of orthography) has also been reported but this is less common [19] and under-explored.

Although a small number of grapheme–colour synaesthetes are sensitive to low-level features of the grapheme [20,22], most are triggered by its conceptual notion or categorization. Hence, an ambiguous symbol (e.g. I) can induce different colours depending on context (e.g. long versus I2345) [38,39] and thinking of a grapheme might even suffice to trigger colour [31,37]. Similarly, visually distinct forms can induce the same colour if they are members of the same linguistic category (e.g. *4*, 4 and **4** are all experienced as blue [7,8]). However, despite this categorial effect, font differences might influence the intensity of colouring, with 'typical' high-frequency fonts (e.g. *Times*) sometimes eliciting more saturated [32] or subjectively more vivid [10] colouring. Finally, in approximately 30% of cases [25], conceptual triggering occurs within just one symbolic system, producing a different colour for Arabic numerals versus number terms (e.g. *2*, 2 and **2** are all experienced as orange, but *two* is experienced as green) [9].

Two grapheme–colour synaesthetes will often disagree on synaesthetic colours, even if they are family members or identical twins [18,25]. This led to the view that graphemes were coloured idiosyncratically from one synaesthete to the next [7,37,40]. However, recent work that examines large numbers of grapheme–colour synaesthetes [19,25,41] shows that they share significant letter–colour preferences (e.g. *a* tends to be red; see also Refs [42,43]). Amassing these significant preferences for each letter produces the 'prototypical' synaesthetic alphabet [41], shown in Figure 2. Statistical and linguistic analyses have uncov-

Figure 1. A graphic artist's interpretation of the reports of projector synaesthete DL, for whom speech produces visualized coloured text that is projected into space. Reproduced, with permission of BBC Horizon documentary (Derek Tastes of Earwax; September 2004).

ered a series of implicit linguistic 'rules' that govern these preferences: (i) higher-frequency graphemes tend to pair with higher-frequency colour terms (e.g. *a* is red, whereas *q* is purple) [41]; (ii) associations tend to reflect initial-letter priming (e.g. *b* tends to be blue and *y* tends to be yellow) [25,41]; and (iii) low numbers [44] and high-frequency letters [41] tend to pair with colours that appear early in the Berlin and Kay [45] typology. This typology (black and white; red; green and yellow; blue; brown; and orange, purple, grey and pink) reflects the order in which colours arise in the vocabularies of languages with few colour terms versus those with many colour terms (i.e. those with two colour terms tend to have black and white; those with three colour terms tend to have black, white and red, etc.). However, this typology has failed to prove itself as psychologically meaningful in the acquisition of colour terms within a language [46]. Therefore, it is possible that its apparent role in synaesthetic colouring is nothing more than the influence of colour-term frequency in English [41].

Figure 2. Representation of the 'prototypical' coloured alphabet of 70 grapheme–colour synaesthetes [41]. Letters in two or more colours represent those with more than one significant shared colour preference; reported colour terms (e.g. *red*) are represented here as focal colours. (Please note that there is no significance in the positioning of line breaks within this figure and that *k* is omitted because it has no significant colour preference.)

Words and morphemes

Mechanisms for word colouring vary across synaesthetic manifestations. Lexical–chromatic synaesthetes colour words holistically, independent of constituent letters (although, in isolation, constituent letters might also induce colour) [47]. However, among grapheme–colour synaesthetes, constituent letters compete [37,48], which results in the colour of one letter dominating the whole word. This is usually the initial letter (e.g. *mother* takes the colour of *m*) or initial vowel (e.g. *mother* takes the colour of *o*) [17,36,37,43,47,49]. Evidence of this competition comes from the fact that when downstream letters in a word reinforce the dominant colour (e.g. *ether*) rather than conflict with it (e.g. *ethos*), there is faster colour naming of the synaesthetic experience [48]. Prosodic features also influence this competition. Although initial letters in English appear most often in stressed syllables (e.g. Ref. [50]), lexical stress and serial letter position can be isolated by studying stress homographs; studies of these in synaesthesia have shown that word colouring is dictated by a stressed letter, rather than by an initial letter (e.g. *'con-vict* is the same colour as *o*, but *con-'vict* is the same colour as *i*) [48]. (However, this effect is slightly greater for stressed letters that are also initial letters and is stronger for synaesthetes whose words are coloured by vowels rather than by consonants [48]). Finally, word colouring in grapheme–colour synaesthesia is also influenced by morphology and lexical frequency. Hence, German words that comprise two morphemes, such as the compound *Fährmann* (= ferry + man; *ferryman*), are more likely to have two dominant colours than words that comprise one morpheme (e.g. *Stöckel* = *heel*). However, two colours are less likely to be experienced if the compound is high frequency (e.g. *Bahnhof* = train + yard; *station*), which suggests that these compounds might become lexicalized as single units among German speakers [see 'Word frequency effect for synaesthetic word colour in German NN-compounds (case study)' (http://www.uni-erfurt.de/psycholinguistik/Kubitza.html); also see later in this article].

Semantics

Synaesthetic word colouring is influenced by several semantic factors. In lexical–chromatic synaesthesia, inherent real-world colouring (e.g. cherry = red) can interfere with the generation of synaesthetic colours [47], and in grapheme–colour synaesthesia, the lexical semantics of colour terms tend to override graphemic rules of word colouring (e.g. *red* is experienced as red, even when none of its constituent letters is red) [25]. However, some synaesthetes experience an 'alien colour effect' (e.g. *red* is experienced as blue) [51,52]. In other variants, synaesthesia is triggered only, or particularly, by proper names [4,53,54] (although this could derive from the emotional or affective quality of the person, rather than the lexical-semantic class [18,54]). Perhaps the most apparent influence of semantic class is seen in linguistic sequences (e.g. days and months), which represent the most common inducers of synaesthesia [4,25]. Members of linguistic sequences (e.g. Monday) tend to take their own lexically specified colouring, even in grapheme–colour synaesthesia (e.g. although *mother* and *Molly* might be coloured by *m*,

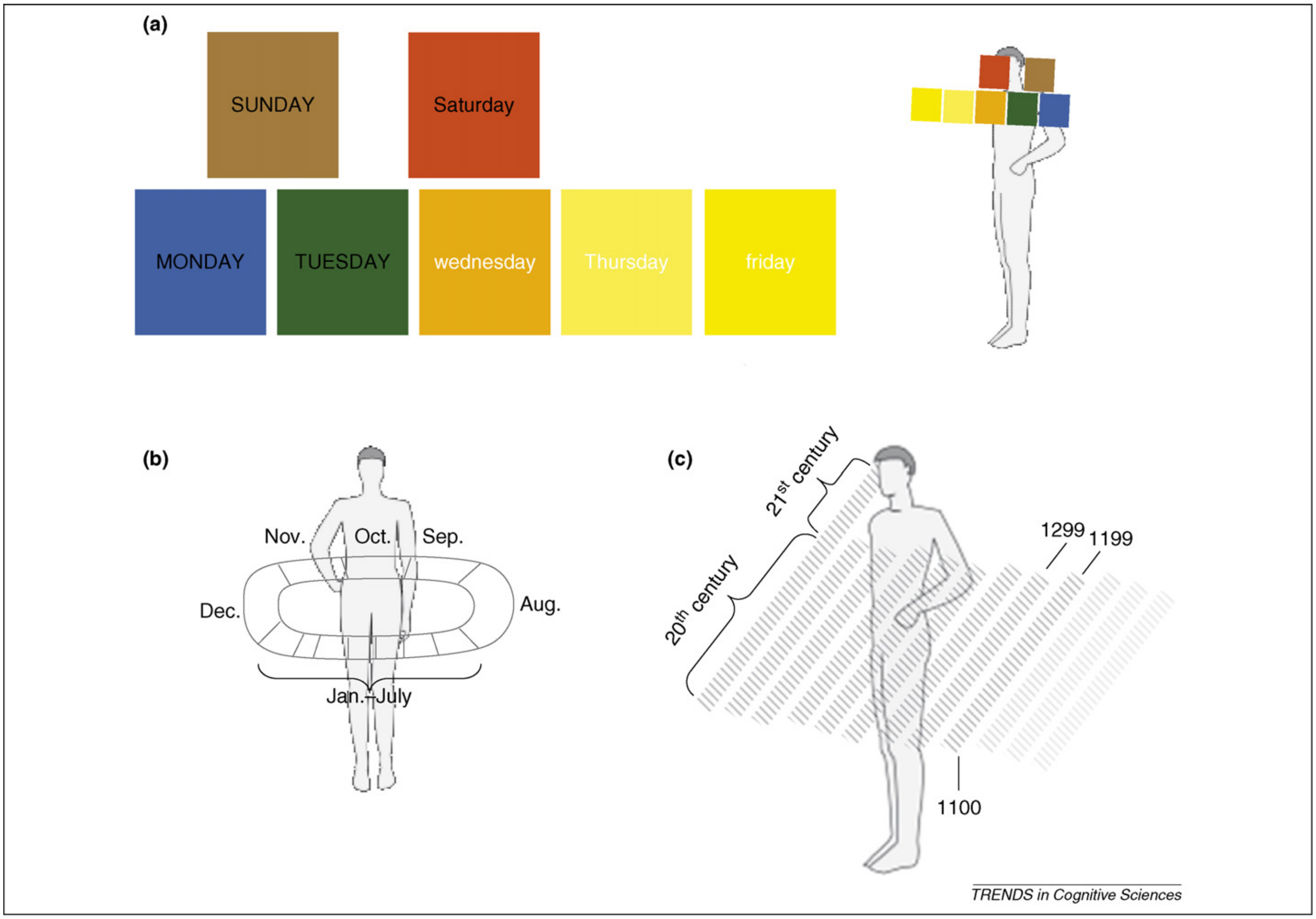

Figure 3. The visuospatial forms of synaesthete IB. **(a)** Days are seen as white or black text against coloured blocks and are projected into peripersonal space onto a vertical plane approximately 50 cm from the face. **(b)** Months are colourless and run anti-clockwise at hip level on a horizontal plane, which IB views from any positional perspective. **(c)** Years group into centuries and form columns on an inclined plane. Each turn of the century starts at arm's length and moves up towards the body. The exception is for the year 2000 onwards, which (as IB noticed in 2001) did not return to arm's length as expected, but continued over his right shoulder. All forms are involuntarily evoked when IB hears, says or thinks about time units. All arrangements (for example, the slight off-centring of Sunday above Monday and the permutations of upper- and lower-case text on day names) are precise, automatically generated and have existed (without conscious construction) for as long as IB can remember.

Monday would not [17,25]). These ordered units are also the key inducers of visuospatial forms [7,15,55–57] in which such sequences are seen in particular spatial orientations (Figure 3) and where their spatial connotations are retrieved in the early stages of lexical processing [56]. The special status of sequences might relate to their early acquisition; this is supported by the finding that days are more likely to colour idiosyncratically than months, which are acquired later [25]. However, age of acquisition provides only a partial explanation because other words that are acquired at the same age show no idiosyncratic colouring. Other accounts trace the special status of sequences to neurological roots, suggesting that visuospatial forms arise from the proximity of neighbouring parietal regions that encode ordinal sequences and spatial knowledge [5,15].

This section has illustrated that visual synaesthetic experiences can be triggered by a range of linguistic mechanisms, but the relationship between colours and graphemes might be particularly important given the high frequency with which this variant arises. Next, we review studies of synaesthesias that generate taste; in these cases, the primary sublexical determinant seems to be the phoneme.

Linguistic inducers of taste concurrents

In lexical–gustatory synaesthesia, spoken or written words trigger perceptual taste sensations of complex food experiences (e.g. for synaesthete JIW, *jail* tastes of cold, hard bacon [16]); JIW describes these experiences as being identical to veridical perception, apart from having no substance on the tongue. This variant was identified in 1907 [58,59] and reports remain remarkably similar across centuries and across continents. In all reported cases, the condition has phonological roots – each taste can be traced to a particular phoneme (or phonemes), whose presence in a word endows a significant likelihood of generating that particular taste (e.g. for JIW, words containing /k/ tend to taste of egg) [16,17]. Some phoneme triggers seem to derive from food names (e.g. /ɪ/, /n/ and /s/ trigger JIW's taste of mince), whereas others have less obvious roots (e.g. /f/ triggers sherbet). These associations seem to be largely independent of orthographic properties; hence JIW's taste of egg is associated with the phoneme /k/ whether the phoneme is spelled with a *c* (e.g. *accept*), *k* (e.g. *York*), *ck* (e.g. *chuck*) or *x* (e.g. *fax*) [16].

This variant of synaesthesia shows a sensitivity to fine-grained phonological constructs of which the synaesthete has no conscious awareness. For example, different tastes can be triggered by different allophones (i.e. acoustic and articulatory variants) of the same phoneme. Hence, JIW tastes both fingernails and potato from the phoneme l; however, the taste of fingernails is triggered specifically by the dark allophone (which has a secondary articulation in which the back of the tongue is raised towards the velum, as in *deal*) whereas the potato taste is triggered by the clear (unvelarized) allophone (as in *like*) [16]. JIW's synaesthesia also responds to further distinctions within the class of dark /l/s. Hence, a syllabic dark /l/ (i.e. one that fills the peak of an unstressed syllable, as in *bottle*) is significantly associated with the taste of Rice Krispies®, whereas a non-syllabic dark /l/ (as in *deal*) is associated with the taste of fingernails [16]. Finally, instances where similar phonemes trigger the same taste reveal a sensitivity to the defining features of phonemes. For example, JIW's taste of milk is triggered by words that contain the phonemes /sk/ (e.g. *a<u>sk</u>*) or /zg/ (e.g. *Gla<u>sg</u>ow*); these pairs are articulated in the same way, except for the feature of voicing (i.e. /zg/ in *Glasgow* involves vocal-fold vibration). Hence, the most parsimonious model would describe the phonological trigger for milk as underspecified for voicing [16].

Although phonological processing might be important during development to associate words with tastes, the triggering of taste in adulthood might arise from lexical access (i.e. retrieving words from long-term memory) [16]. This notion is supported by evidence that associations between phonemes and tastes are not entirely productive (e.g. /s/ significantly associates with lettuce, but some words that contain /s/ are tasteless) [16]; if processing a phoneme was enough to trigger taste, association would be consistent among all words that contained that phoneme. The presence of lexical gaps suggests a role for the mental lexicon, where gustatory pathways could target selectively some words but not others. This view is compatible with the presence of other word-level influences (e.g. tastes are more likely to be triggered by high-frequency than by low-frequency words and by real words than by non-words) and with the influence of lexical semantics (e.g. food names tend to taste of the foods they represent) [17].

In summary, synaesthetic tastes seem intimately tied to the level of the phoneme (and perhaps also the word), unlike colours, which seem to be more closely associated with graphemes. Although the reason for these different linguistic–sensory pairings is not yet clear, it might relate to the observation that the colour-perception region V4 is situated close to grapheme-processing areas [5,11], whereas gustatory centres are situated close to regions that are involved with phonology and lexical semantics [17]. The discussion now turns to the second aim of this subfield and examines what linguistic synaesthesias might tell us about normal language function.

What can synaesthesias tell us about normal language function?

The complex phonological roots that underpin lexical–gustatory synaesthesia add to evidence for the psychological reality of phonemes, allophones, syllabic variants and phonological features (in whatever guise these might be interpreted) because synaesthetes discriminate along these dimensions, even if they cannot describe them explicitly [16,17]. Examinations of lexical–gustatory synaesthesia, therefore, follow in the steps of psycholinguistic investigations by showing how human behaviour can be influenced by posited linguistic constructs. The influence of lexical stress and initial letters in word colouring [48] reinforces previous evidence that suggested the importance of these features in general word processing [60–63]. Moreover, the role of vowels versus consonants (see earlier in this article) suggests that vowel–consonant differentiation might be an intrinsic property of graphemic coding [64]. Grapheme–colour synaesthetes are also sensitive to grapheme and colour-term frequencies [41], which supports the importance of frequency in the processing, storage and acquisition of language more generally (reviewed in Ref. [65]). Similarly, as mentioned earlier, high-frequency German compounds are more likely to have only one colour, which suggests that these compounds might be lexicalized as single units. Finally, second-language studies (Box 2) show that the letters from a speaker's second language (L2) adopt colours from their visual or phonetic counterparts in the first language (L1), which suggests that L2 letter acquisition might be 'scaffolded' (i.e. mapped) onto existing L1 structures.

A key aim of this field is to use linguistic synaesthesias to infer information about normal language function. However, research of this kind is in its earliest stages, perhaps because only a small number of psycholinguists are familiar with the condition or are aware of its psycholinguistic features. It is hoped that the growing number of studies on synaesthesia will expose the condition to a wider range of specialists, and the current review aims to contribute to this. There have been approximately 157 peer-reviewed synaesthesia papers published in the past 25 years; of these, 75% have been published within the past five years and 35% within the past 18 months. This rapid growth not only shows the extent of current interest in this field but it illustrates how much has been learned in a short space of time. It is hoped that the findings that relate to linguistic synaesthesias might now form the basis of future research on general language function.

Concluding remarks

This review illustrates that synaesthetic experiences can be triggered by a range of linguistic entities, including phonemes, graphemes, morphemes, words, lexical stress and lexical semantics. It shows how inducer–concurrent mappings can be conceptually mediated, rather than seen as extending directly between sensory systems. Linguistic symbols are acquired through experience, which shows that learning has a key role in the development of these synaesthetic variants (see also Refs [16,17,25,41,66]). Indeed, some have likened the development of linguistic synaesthesia to the acquisition of language generally [25]: humans have an innate predisposition to acquire language, but this depends on exposure to experiential factors during development; the same might be said of synaesthesia. The protracted nature of this synaesthetic 'acquisition' (which necessarily relies on stages of language learning) raises questions about the ways in which an (assumed) inherited

Box 3. Outstanding questions

- Why is language 'special' in synaesthesia? Why do linguistic inducers dominate?
- Why do certain linguistic inducers (e.g. graphemes) pair with some concurrents (e.g. colour) more than others (e.g. taste)?
- How can neurodevelopmental theories of synaesthesia incorporate the different time courses for acquiring various linguistic inducers (e.g. phonemes before graphemes)?
- What form do linguistic synaesthesias take before language acquisition? For example, is there a progression from sound–colour, to phoneme–colour, to grapheme–colour synaesthesia during language and literacy acquisition?
- What might synaesthesia tell us about the mapping of graphemes to phonemes during literacy acquisition? For example, are grapheme–colour correspondences qualitatively different for graphemes with a one-to-many relationship to phonemes (e.g. *c* = /k/ or /s/ or /č/) versus a one-to-few relationship to phonemes (e.g. *b* = /b/)?
- Does synaesthesia recognize lexical-class differences beyond the semantic groupings noted in this article (e.g. grammatical word classes or tone groups)?
- Can synaesthetic mechanisms hold above the word level (e.g. through syntax, intonation or discourse focus)?
- Are any variants limited to production versus comprehension, or hearing versus reading? How might these be incorporated into existing models?

condition [1,2,4,7,17,18,25] can be modulated by environmental factors.

Synaesthesia is now known to occur in greater numbers than had previously been assumed [4], which suggests that information gained from linguistic variants could shed light not only on synaesthesia but also on language processing more generally. This summary is aimed at researchers of synaesthesia and researchers of language, and shows the range of normal and extended linguistic mechanisms that influence synaesthetic experiences. This emergent field reflects an exciting step in the evolution of synaesthesia research. After early studies that demonstrated the genuineness of synaesthetes' reports and the 'psychological reality' of their sensory experiences, researchers are now turning their attention to examining the exact relationship between inducers and concurrents. Future collaborations between psycholinguists, perceptual psychologists and neuroscientists should present promising avenues for research, by bridging the gap between the linguistic and cognitive phenomena that trigger synaesthesia and the resulting perceptual concurrents (Box 3).

Acknowledgements

This work was supported by a Leverhulme Early Career Fellowship (ECF/41066).

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