AN IDENTIFICATION OF SYNAESTHETIC ABILITY: CONSISTENCY OF SYNAESTHETIC EXPERIENCE TO VOWELS AND DIGITS

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Abstract

The present study investigates the consistency of synaesthetic attribution. By means of a local press campaign we recruited 50 participants reporting synaesthesia. Of those, 19 reported mainly lexical synaesthesia, and 11 reported occasional lexical synaesthesia besides other synaesthetic experiences. By comparing repeated colour selection (RGB-colour space) attributed to alphanumeric signs (vowels and Arabic digits) for synaesthetes and a control group it was found that the mainly lexical synaesthetes showed a high consistency in responding over a short (one week) as well as a long (three month) time span. In comparison, the control group and the occasional lexical synaesthetes demonstrated less consistent responding when retested after one week.

Synaesthesia, which means *syn* = together and *aesthesis* = perception or sensation, is a vivid cross-modal perception, defined as an experience in one modality as a function of stimulation in a different modality (e.g. Baron-Cohen et al., 1987, 1993). A person experiencing synaesthesia is called “synaesthete”, typically experiencing synaesthesia on a daily basis, beginning in early childhood (e.g. Grossenbacher & Lovelance 2001). Synaesthete’s sensory reaction to stimuli like, for instance, letters and numbers is special. By their own description lexical synaesthetes perceive spoken or written letters and numbers always involuntarily and insuppressibly together with colours. These synaesthetic assignments are highly individual, they vary from person to person. Some synaesthetes perceive multidimensional sensations, e.g. coloured shapes elicited by music. These multidimensional sensations are interesting and fascinating, but it is difficult to investigate them objectively. Therefore, we decided to focus on a single and frequent dimension of synaesthetic experience.

The following section we firstly describe a survey of the dimensions of synaesthesia, which was conducted to isolate the major dimensions of synaesthesia for subsequent experiments. Secondly we reported a test of consistency of synaesthetic attributions. The aim of this test was to find an objective measure for the stability of the synaesthetic experience of each individual. The results allow a first differentiation between self-reported synaesthetes and non-synaesthetes by psychophysical methods.

Survey of individual dimensions of synaesthetic ability

In order to find individuals experiencing synaesthesia, the media were informed about our project. Nationwide there was a lot of resonance. Following publications in major local and national newspapers and leading German magazines (e.g. Spiegel and Süddeutsche Zeitung) and interviews on TV and radio (e.g. Arte and Deutschlandfunk), people from all parts of the country got in touch with us. 50 subjects took part in qualitative interviews aimed to identify the dimensions involved in their individual synaesthetic experience. All subjects reported synaesthesia from their early childhood. To investigate the dimensions of synaesthesia systematically we inquired of the participants about their synaesthetic sensations. The aim was to find criteria that would allow us to select a homogeneous group of synaesthetes from all participants. The results of the initial interviews are shown in Figure 1 below.

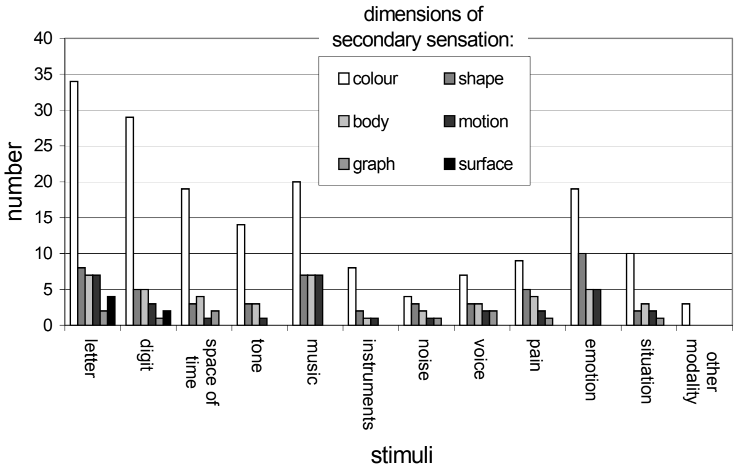

Figure 1. Dimensions of Synaesthesia. Number of synaesthetes reporting a certain secondary sensation elicited by the stimuli shown on the abscissa. Multiple choices of the modality of the secondary sensation were possible.

This diagram shows that the experience of synaesthesia can be triggered by various stimuli (e.g. letters, tones, or even pain). This secondary sensation can involve various dimensions (e.g. colour plus form plus surface). The diagram shows also that a very common form of synaesthesia is coloured hearing, which implies that the subject experiences colours when hearing various kinds of auditory signals, such as spoken letters, music, or instrument sounds (Argelander, 1927; Bleuler & Lehmann, 1881; Marks, 1975). A prominent kind of synaesthetic experience is linked to vowels (Argelander, 1927; Marks, 1975). Argelander as well as the interviewed synaesthetes described vowels as acoustically "clearer" than consonants. If vowels and consonants occur together, the vowel sound is assumed to dominate in the production of synaesthetic photisms. According to our survey, the most frequently experienced synaesthetic link exists between letters (esp. vowels) and digits on the one hand and colours on the other hand. Therefore we designed an experiment investigating this lexical synaesthetic link. Based on their self-report, 19 participants reporting mainly lexical synaesthesia and 11 participants reporting occasional lexical synaesthesia (often in addition to other synaesthetic experiences) were selected to take part in the following test.

Investigation of stability of synaesthetic connection: The correspondence of colour to digits and vowels

The main purpose of this experiment was to measure the assignment of a specific colour to each of 18 alphanumeric signs. The existence of synaesthesia is well documented (Cytowic & Wood, 1982; Marks, 1975), but the degree of consistency in the individual synaesthetic experience has not been adequately investigated. Early investigators were especially interested in common combinations (e.g. red and a). From a short survey among the citizens of Leipzig in 1880 Fechner, a synaesthete by himself, reported some colour-letter associations to be more frequent than others (e.g. yellow and e) (Fechner, 1880, 1883). Francis Galton (1883) was the first who described the experiences of synaesthetes systematically. He found that "seers" , as he called them, are invariable in their description of the precise tint and hue of the colour of their "coloured alphabets". Similar to Fechner's approach, this early study relied on verbal introspective reports of the synaesthetes. Argelander (1927) and Marks (1975) used colour-matching tasks to investigate synaesthetic sensations with a small number of broad colour categories like "yellow", "red", etc., neglecting the highly specific and differentiated character of synaesthetic sensation.

A more recent study confirmed the high consistency of synaesthetic associations between primary perception and secondary synaesthetic sensations (Baron-Cohen et al., 1993). To specify the degree of consistency, 13 synaesthetes and 13 non-synaesthetes were compared. The participants had to attach a colour word to over one hundred items (e.g. days of the week, months, seasons) and it was found that in a retest one year later the synaesthetes had chosen nearly the same colours for all one hundred items (consistency 92%). Consistency in non-synaesthetes retested after one week was only 25%. Like most other studies this study employed methods of verbal colour report, which are constrained by the limitations of the subject's language to accurately describe a synaesthetic episode. Additional evidence of the high consistency of synaesthetic experience was given by a test of Svartdal & Iversen (1989). They tested the assignment of colours to vowels and consonants. Their subjects could respond within a given set of choices by Munsell colour chips. Using colour-matching tasks to investigate the synaesthetic assignments, Cytowic & Wood (1982) found the answers of synaesthetes are more stable over a long time span.

One of the weaknesses of the studies reported above is the restricted range of colour responses subjects can choose from. Head (1995) conducted initial work to provide a more precise measurement of colour matching. He used a continuous printed colour pallet on which subjects marked their responses with a pen. The palette was taken from Bouma (1971) and did not contain all possible colours. In line with this idea we wanted to develop a test with a finely-graded response domain. The aim of the study was to expand and further improve the response quality, by allowing participants to indicate colour matches on a continuous and complete three-dimensional colour palette. These include the greys, browns, and black omitted in the Head (1995) palette. The palette was implemented by using a colour-preference tuning program on a computer. Thus, the data would directly be available for further experiments with the same subjects.

Hypothesis. We expected synaesthetes to prove higher degrees of consistency than control subjects. Furthermore, the results of the test should confirm the self-reports of the participants: If they assigned themselves to the mainly lexical synaesthetes they should show better results in the test of consistency compared to participants calling themselves occasional lexical synaesthetes or the control group of non-synaesthetes.

Methods

Participants. Synaesthetic participants (n=30, 23 female and 7 male; age range 16 to 75) were selected on the grounds of self-reported sign-colour synaesthesia in the initial interview (19 reporting mainly lexical and 11 reporting occasional lexical synaesthesia). A comparison group of non-synaesthetes was included. Control participants without synaesthesia were found locally and comprised 30 undergraduates (23 female and 7 male; age range 17to 35).

Procedure/Stimuli. The synaesthetes were asked to express their inner colours with the help of a computer colour-preference tuning program. The control subjects were asked to mix a colour that fits best to the vowel or digit. The stimulus set comprised 18 alphanumeric signs: 10 digits, 5 vowels, and 3 diphthongs. These stimuli were randomly chosen in terms of colour and sequence. They appeared on a light-grey monitor (size approximately 10 x 5cm). The monitor was placed in a darkened room with controlled soft background illumination. The colour of the letter or digit was continuously adjustable by three pairs of keys for the dimensions saturation, brightness and hue. In order to support subject's orientation in colour space a coloured ruler for every dimension was located on the right side of the monitor. A pointer indicated the respective value. In addition to that the ruler indicated which colours would emerge by manipulation of this dimension. The experimental screen is shown in Figure 2 below. There was no time limit for this test. During the first test, subjects were not aware that there would follow a retest. Subjects were retested after one week. A further unannounced retest was performed after three months.

Figure 2. Screen shot of colour-preference tuning program. A colour version of this screen shot can be found at www.uni-leipzig.de/cognition/synaesthesia/screenshot.gif

Data Analysis. Each session yielded for each subject 18 RGB vectors corresponding to their colour responses to the 18 stimuli. Comparing two sessions, the Euclidic distance for each of 18 pairs of RGB vectors was computed and averaged. The results come out in percent, with 100% corresponding to the maximal distance varying one dimension alone (R, G or B-colour). Due to the number of dimensions, a maximal distance of 173% (100% x $\sqrt{3}$) is possible. Pairs of randomly distributed values in the RGB colour cube result in a mean distance of 67%. The distribution of such random distances is indicated in Figure 3 by the white bars: random performance (Monte-Carlo simulation). "Genuine" synaesthetes in our sense are subjects with a small average distance. This indicates that they mixed similar colours for the same alphanumeric sign in both experimental sessions.

Results and Discussion

The results of the test of consistency are shown in Figure 3. Figure 3a shows the consistency after one week. Apparently, mainly lexical synaesthetes show a much higher degree of consistency than both occasional lexical synaesthetes and control subjects. The mean value of all synaesthetes taken together (n=30) is 37,5%±20,4%, the mean value of the control group (n=30) is significantly higher 59,0±11,8% (2-tailed t-test: $t(29) = -4,8$; $p < 0.001$). Would the mean have been calculated only across mainly lexical synaesthetes, the difference would have been even more significant.

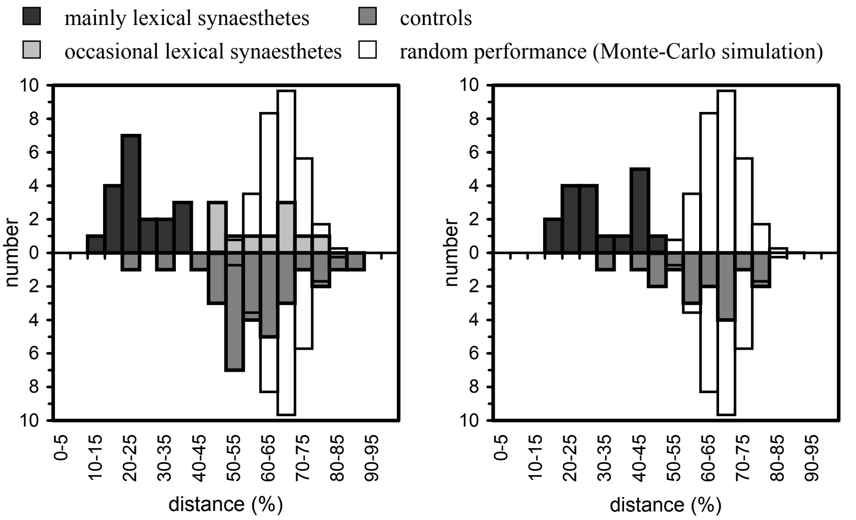

Figure 3.a. Consistency measure based on retesting after one week: Distribution of distances in the RGB colour cube for repeated sign-colour matching for mainly (N=19) and occasional (N=11) lexical synaesthetes and control subjects (N=30). Simulation see text.

Figure 3. b. Consistency measure based on retesting after three months: Distribution of distances in the RGB colour cube for repeated sign-colour matching for synaesthetes (N=17) and control subjects (N=17). Data for occasional lexical synaesthetes can not be shown because of subject drop-out.

Figure 3b shows the consistency after three months. Only 17 synaesthetes took part in this second retest. It is remarkable that these are exclusively from the group of the mainly lexical synaesthetes. All synaesthetes had been invited without prior warning, and none of them knew the outcome of the first consistency test. Nonetheless, occasional lexical synaesthetes showed no interest in a further lexical retest, some of them stating that this test didn't fit their kind of sensations. After three months, the mean value of the synaesthetes (n=17) is 33,6±12,5%, (note: after one week the mean value for these 17 subjects is 29.4%). We restricted the number of control subjects equally to 17. The mean value of the control group after three months is 61,0±12,1% ($t(16) = -5,4$; $p < 0,001$) (note: after one week the mean value for these 17 subjects is 56.9%). Apparently, synaesthetes were significantly better at repeating a colour response for the same alphanumeric sign on an unannounced retest.

The consistency of occasional lexical synaesthetes after one week did not differ much from that of controls. Both groups exhibit performance slightly above randomness. This indicates that their assignments of colour values to the items was not carried out in a random manner. We assume that they followed general assignment trends or memory effects after the one-week period. Only two subjects of the control group stand out of the distribution. For these individuals the classification as non-synaesthetes is questionable. In these cases additional tests may provide further information.

Those of the synaesthetes that classified themselves as mainly lexical synaesthetes (n=19) showed very stable sign-colour correspondences (mean value after one week: 25%). These results confirm nicely the self-report of the participants. The low consistency of occasional lexical synaesthetes does not contradict their synaesthetic disposition, but reveals the different focus of their synaesthesia. Although classified as synaesthetes this subgroup was excluded from further experiments in the lexical domain, as here a stable assignment is the precondition. The results of this study are encouraging. At present 19 synaesthetes with stable sign-colour correspondences are available. The number of subjects is still increasing.

Conclusion

The aim of this study was to investigate synaesthetic ability. While the latter can be highly complex and multidimensional, we focussed on a single dimension which was found frequently in our group of synaesthetes in order to facilitate the design of future group experiments. We intended to establish a measure of the stability of synaesthetic experience in order to recruit a homogeneous test group for further cognitive experiments. In our interviews, vowels and digits were found to be the most common stimulus domains whereas colour was the most frequented response domain. These assignments were reported to be very stable over time. Based on this survey a new computer test with a continuous three-dimensional response domain was designed to measure the degree of the stability of sign-colour synaesthesia. The results of the test confirm the self-report of the participants: When they assigned themselves as mainly lexical synaesthetes they showed better results in the test of consistency compared to participants calling themselves occasional lexical synaesthetes.

Classical studies on synaesthesia rely on self-report/introspection. Future research might be advanced by defining synaesthetic ability by objective measures. A first step in this direction is the investigation of stability we presented. More progress should result from developing further objective methods to assess synaesthetic sensations offering additional evidence for the reality of synaesthesia as a phenomenon above memory, metaphor or imagery.

The test of stability presented in our study is useful as an indication of how genuine the subject's synaesthesia is, but as Cytowic (1989) observes, "these studies do little to clarify the underlying mechanisms of synaesthesia itself". They can, however, provide a basis to build up a homogeneous group of approved synaesthetes as a precondition to further studies.

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