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Prevalence of Synesthesia in College Students

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Abstract

Synesthesia is a rare neurological phenomena that when triggered causes two senses to be presented simultaneously, usually occurring because the senses are abnormally linked. We studied the prevalence of grapheme to color synesthesia in college students, and found a prevalence of 4.2% among test subjects, higher then the previously estimated prevalence of the condition. We estimated prevalence in college students using three different styles of testing. Two tests to produce a consistency score for graphemes, a memory test as a latency period between the consistency tests, and a survey that participants rated themselves on their synesthetic perceptions.

Introduction

Synesthesia is a union of the senses, where stimulation of one sense causes another sense to be automatically evoked. Any type of synesthesia is represented as an inducer to a concurrent (Hubbard, Arman, Ramachandran, & Boynton, 2005). The inducer is the sensation present to all people. This can be a color, grapheme (numbers or letters), sound, taste, or object. The concurrent is the sensation evoked in the synesthetes alone, and can be a specific sensation on the skin, a taste, a color, a shape, an object seen in space, or even a personality. For example, a synesthete may see the number four in black ink, and concurrently see a pink four. Synesthesia types are then referred in the form of inducer to concurrent, so the example used above, the synesthete would have grapheme to color synesthesia.

Synesthetes can remember their percepts as soon as they are introduced to their inducer. For grapheme-color synesthetes, their numbers and letters have had a color since they've learned them. Synesthetes have very good memory recall for their inducer, because every time the same

inducer is encountered, the same concurrent is produced. Synesthetes have an 80% to 100% recall in test-retest consistency, where controls have only 30% to 50% consistency (Mattingley, Rich, Yelland, & Bradshaw, 2001).

Many different forms of synesthesia are possible, with the prevalence of the disorder as a whole changing constantly. Simner et al. (2006) has given a prevalence of approximately 1 in 25, but Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton (1996) have given a 1 in 2000 prevalence of the disease. Prevalence of synesthesia has been hard to determine, because many synesthetes do not realize that they have synesthesia. Synesthesia has no visible signs and symptoms, and it is not realized by synesthetes as different until they have a conflict in the actual object with their synesthetic percept. For people with grapheme-color synesthesia if letters and words are in colored font, the conflict may bother them.

For this study, the prevalence of synesthesia in college students at Grand Valley State University is determined by using cued recall tests, and a survey to see if the participants rated themselves as synesthetic for grapheme to color synesthesia.

Materials and Methods

We recruited 168 English-speaking participants through Grand Valley State University's Psychology 101 study scheduling system. A computerized test individually presented 54 randomized graphemes[1] in three sets with 18 graphemes for each set, with each presentation accompanied by a palette of 27 colors[2] generated from the 255 RGB color system. All participants were asked to write down the color they felt was associated to a grapheme presented

[1] a-z, 0-9, @, #, %, *, =, +, ?, ^, -, ~, ♦, ✓, ▲, ●, ■, ©, 𝄢, 𝄞

[2] red, maroon, salmon, coral, pink, light pink, light purple, violet, purple, beige, orange, tan, brown, olive, dark green, green, lime, light green, gold, yellow, white, gray, black, navy, blue, teal, aqua

on a screen on a sheet of paper with three columns on 18 blank spaces each. If participants had no association to the symbol they were asked to place a diagonal slash in the space provided for the grapheme.

After one round of testing for associations, subjects underwent a cued recall memory test. Subjects were read aloud 27 randomized word color pairs, with the 27 colors they were presented on the screen. After the complete list was read, the subjects were given a sheet with 27 blank spaces and asked to recall the color paired to the cued word, and if they could not recall the color paired to the word to place a diagonal slash in the space for that word. The cued word was given in a new re-randomized order than the order of the word color pairs. Subject were given approximately 5 seconds to recall and write down the color associated to the word.

After the cued recall test subjects were given a second sheet with 54 spaces, and asked to repeat the first test with the same instructions as before. Graphemes were re-randomized and presented again in 3 sets. The presentation of the colors was identical to the first test.

Once the re-test was completed subjects were given a survey of 7 statements to see how they rated their own experience of synesthesia. These statements were:

1. When performing the experiment, I felt that I knew for certain what the color for a letter or number should be.
2. When performing the experiment, I felt as if I was guessing what the color for a letter or number should be.
3. Whenever I see or think about letters of numbers (printed black on white), I automatically experience the symbol as having another color (eg. red).

4. Whenever I see of think about letters of numbers (printed black on white), I would never naturally experience the symbol as having another color (eg. red).
5. Letters and numbers always evoke very precise colors (other than the color they are printed in) and there were not enough colors for me to choose from.
6. I have always associated the same particular colors with letter and numbers, and they never seen to change.
7. I have on or more family members who experience colors when they see or think about letters or numbers.

Responses were given on a 6-point Likert scale from "strongly disagree" to "strongly agree," and were coded from 1 to 6. For high scores to consistently reflect typical synesthetic responses "strongly agree" was given the highest score for questions 1, 3, 5, 6, and 7; and to "strongly disagree" for questions 2 and 4. Procedure and survey questions 1 through 6 were based off of Simner et al. (2006), but were adapted for this study. Synesthetes were identified as those scoring within a typical synesthetic range, on both consistency of perceived colors to the symbols and survey. Synesthetic range for recall were established using Simner et al. (2006), where recall for grapheme to color synesthetes is approximately 54%, or 29 out of 54 symbols, or 19 out of 36 letters and numbers (mean = 28.7; SD = 2.64; mean minus two standard deviations). Synesthetic range for survey responses were established using the Simner et al. (2006), mean minus two standard deviations (mean = 26.4; SD = 4.64; synesthetic range = 57% or 24 points of 42 total).

Results

For this study 168 participants were tested, and five grapheme to color synesthetes (using only letter and numbers) were identified. Giving a prevalence of grapheme to color synesthesia at 3.0%. Of the same 168 participants, three grapheme to color synesthetes were found using all symbols. The prevalence of grapheme to color synesthesia, using all symbols, is 1.8%. Figures 1 and 2 show the frequency distribution for participants' scores in consistency for letter and number graphemes and all graphemes respectively, and indicate the lower range to satisfy the scale of synesthesia. Figure 3 shows the frequency distribution for participants' scores in survey, and indicate the lower range to satisfy the scale of synesthesia.

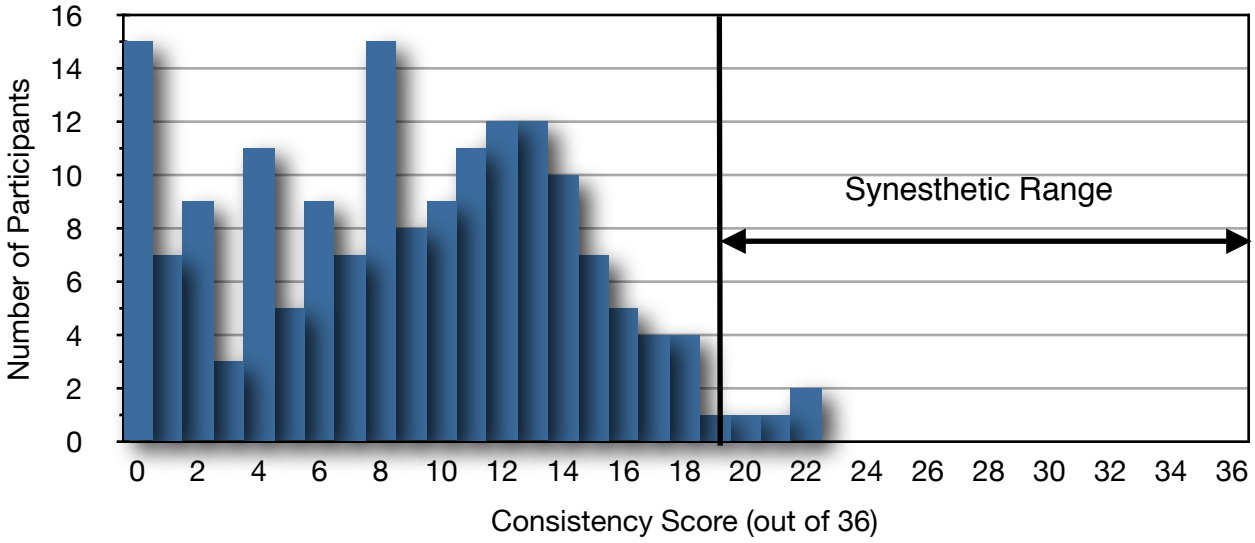

Figure 1: Distribution of consistency scores for letter and number graphemes (out of 36; mean = 8.80, SD = 5.51) for 168 participants. Range satisfying the criterion for synesthetic range (2 SDs from the mean for control synesthetes in Simner et al. 2006 study) is as shown.

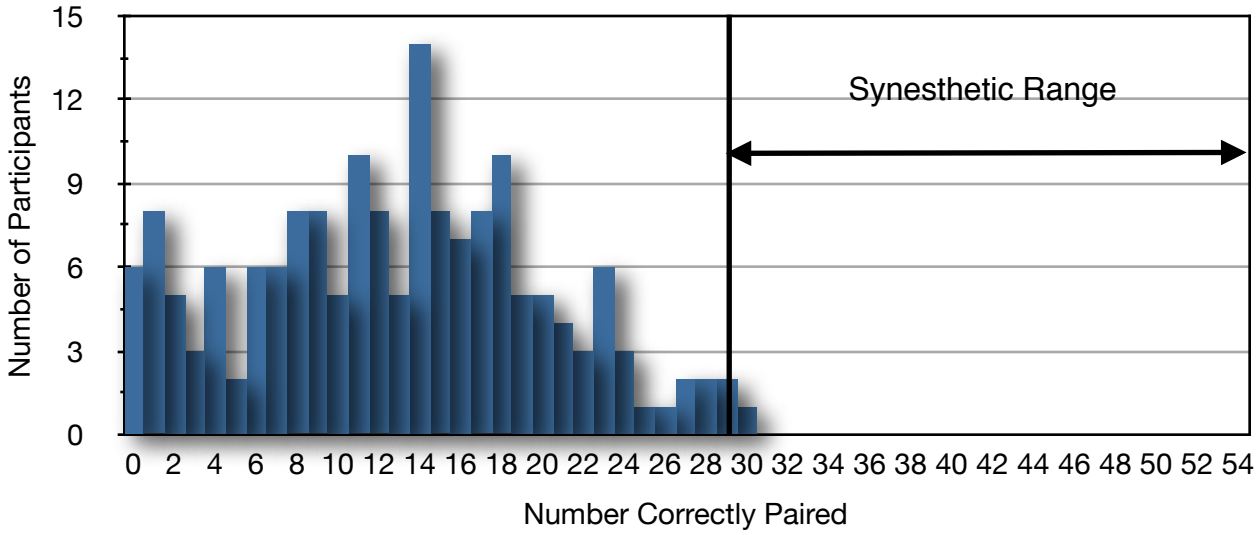

Figure 2: Distribution of consistency scores for all graphemes (out of 54; mean = 12.76, SD = 7.32) for 168 participants. Range satisfying the criterion for synesthetic range (2 SDs from the mean for control synesthetes in Simner et al.'s 2006 study) is as shown.

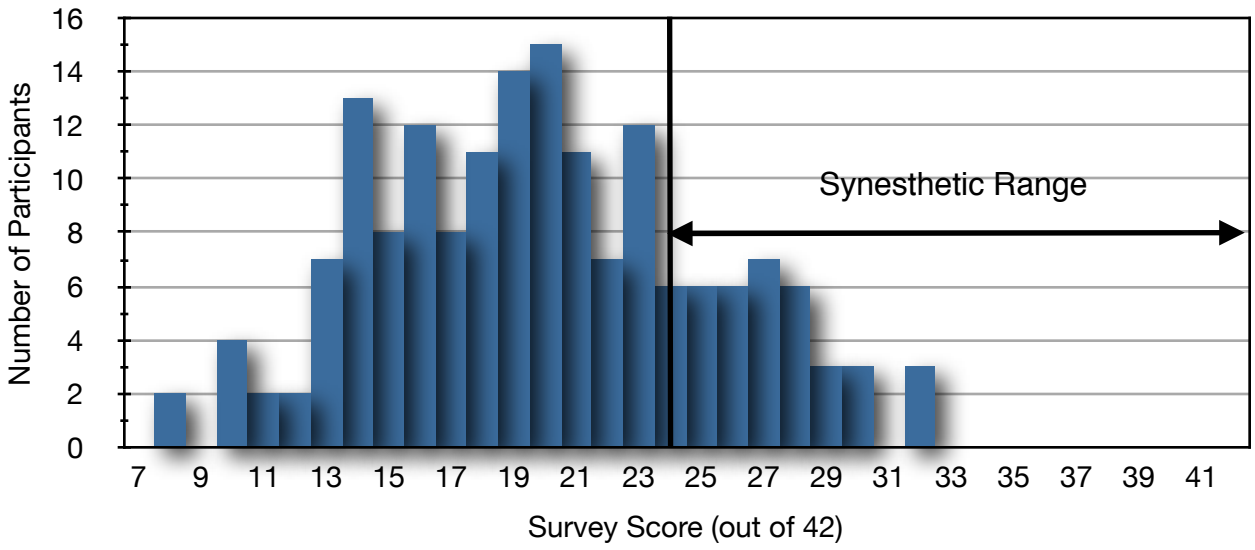

Figure 3: Distribution of survey scores (range of 7 to 42; mean = 19.8, SD = 5.26) for 168 participants. Range satisfying the criterion for synesthetic range (2 SDs from the mean for control synesthetes in Simner et al.'s 2006 study) is as shown.

Individuals who scored within the synesthetic range on consistency were slightly more likely to report synesthesia in the survey compared to individuals who did not ($\chi^2 = 0.1012$, $p < 0.43$). This suggests our two measures are slightly correlated and that our results do not reflect coincidental sampling from two different populations. Individuals who scored within the synesthetic range on consistency did not differ significantly in performance on memory than those who were not scored as synesthetic ($\chi^2 = 0$, $p < 0.01$). This suggests that the two measures are not related.

Of the 168 participants, 40 claimed to have associations between graphemes and colors, but 38 did not score highly on either consistency test. Of the 38, 30 participants appeared to to be more suggestible then the remainder of the sample, in that they were more likely to agree to survey statements, even though the statements were contradictory (eg. that they automatically experience colors, and that they never experience colors). A small number of participants (n = 4) who rated themselves as synesthetes were more likely to generate colors based on the initial letters (eg. o = orange; n = navy - Simner et al, 2005). Another small portion of participants (n = 4) rated themselves as synesthetic for one set of contradictory statements (they knew for certain a color and they were guessing the color), but not for the other (they automatically associate a color and they never naturally experience a color). Conversely, four of the five in the synesthetic range for the letter and number consistency test, and one of the three in the synesthetic range for all symbols were below synesthetic range for the survey. All participants who are evaluated to be synesthetic, for both letters and numbers and for all symbols, a total of seven participants were identified (four for letters and numbers, two for all graphemes, and one identified in both categories). This data gives an overall prevalence of grapheme to color synesthesia as 4.2%.

Conclusion

In this study we found a prevalence of synesthesia to be in the middle of many studies estimates, but closer to subjective studies. Baron-Cohen (1996) and Rich (2005) used self reported data and had ranges of synesthesia of less then 0.5%. Domino (1989) and Simner (2006) used subjective data collection to achieve an estimate of the prevalence of synesthesia of 4.4%-23%. We consider our calculations for the prevalence of synesthesia to be accurate, given the methods of sampling, objective tests, and the evidence based on both consistency tests and survey results. Our study shows a prevalence much higher than the most widely cited estimate of 0.05% (Baron-Cohen et al., 1996), but under the quoted prevalence of the most recent subjective study (Simner et al., 2006). Our study does not take into account any other forms of synesthesia, such as sound to color or taste to color synesthesia, which may account for the low prevalence of synesthesia.

Our study's rate of synesthesia is higher than Baron-Cohen et al.'s (1996) due to the possibility that college students are more likely to have synesthesia then the general public, but there has been no scientific data to prove that people with some college education are more likely to have synesthesia. Our rate of synesthesia may also be high due to the short time period, approximately five minutes for the memory test, between the two consistency tests. Conversely, our prevalence may also be low due to the elimination of participants when their consistency was considered in synesthetic range, but their survey scores were not.

One problem encountered in our study was the amount of participants who selected the name of the color that shared the first letter with the grapheme presented (eg. c = coral, a = aqua). There was also a large amount of participants in our study who wrote black for all

symbols, instead of a dash when they associated no color. To remedy these problems in future studies, responses should be done on a computer with more color options, without color names written next to the color, and they should be instructed to select the color they associate to the symbol and skip to the next grapheme if they associate no color.

Our study also had many participants who did well in consistency ratings, but were not in the synesthetic range, and did not rate themselves as synesthetic. This problem could be remedied by having a longer latency period between tests, which would then decrease the number of participants who were counted as synesthetic due to their good memory.

The memory test results were also hard to compare to other study results for synesthetes. In Mills, Innis, Westendorf, Owsianiecki, & McDonald (2005) and Smilek et al. (2002) both studies found that synesthetes do well on memory tests that involve their synesthesia, for example grapheme to color synesthetes do well on word recall tests when the words are presented to them and they are asked to recall them. Our study used an auditory memory test, when they were read word color pairs and then cued with the word to recall the color. Using an auditory test on memory for a study of grapheme to color synesthesia made the two hard to relate. Using a grapheme memory test, possibly presenting the word color pairs then asking participants to recall the color when cued with the word audibly.

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