Short Communication

# Grapheme-color synaesthesia benefits rule-based Category learning

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followed by a consonant has a short pronunciation, unless the consonant is immediately followed by the letter ‘e’, in which

Three groups participated in the study. A Synaesthete group viewing achromatic stimuli was compared with non-synaesthetes viewing either the same achromatic stimuli (Control-Achromatic) or stimuli that were colored according to synaesthetic color assignments (Control-Color). Thus if synaesthetic colors can be used in rule-based categorization tasks, we expect the Synaesthete group to perform better than the Control-Achromatic group on the Category learning task and the Transfer Test, but worse on the Recognition Test. Comparing the Synaesthete and Control-Color groups allows us to infer further similarities and differences between synaesthetic and normal color perception.

## 2. Experiment 1

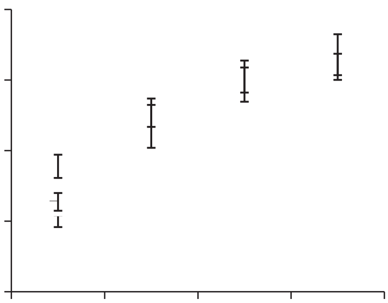
### *2.1.*

Ten grapheme-color synaesthetes participated in the study and were rewarded with $10 (CAN). All synaesthetes' grapheme-color associations were verified as consistent by the online Synaesthesia Battery (Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007), with a mean consistency score of .70, and a mean accuracy score of 89% on the Speed-Congruency Test. Eighty-six non-synaesthetes were recruited from undergraduate psychology classes at the University of British Columbia. Six of these participants were removed from all analyses for performing at chance, leaving 80 non-synaesthetic participants. Eight and ‘‘No’’, and were not given any feedback. The stimuli presented in this phase consisted of all 16 original stimuli, the 10 Foil Stimuli that had not been used in the Transfer Test, and six new grapheme pairs unrelated to any of the other stimuli in the experiment. Thus, half of the stimuli in the Recognition Test had been seen previously and half had not. We were particularly interested in participants’ responses for the 10 Foil Stimuli, as someone paying attention to color might be expected to make False Recognition errors on these trials.

Finally, participants were asked to write down any strategies they used during the Category learning phase of the experiment.

*2.0.*

For each participant, we computed four scores. Categorization Accuracy was the mean accuracy over each block of the Category learning task, and response times (RTs) were also recorded during these blocks. Transfer Accuracy was the mean accuracy over the 10 Transfer Test trials. False Recognition was the inverse of the mean accuracy over the 10 Recognition Test trials that used the Foil Stimuli. (Recognition Test accuracy for the other stimuli was over 95% for all groups, and so was not analyzed further.)



The results were qualitatively very simple. First, accuracy on the Category learning task was higher for those with access to color information, whether these colors were synaesthetic or real (see Fig. 2a), although synaesthetes learned somewhat more slowly than controls viewing real colors. Second, participants looking at achromatic letters were slower to make decisions, whether they were synaesthetes or controls, and the synaesthetes were generally slowest of all. Third, access to color information also improved participants' ability to generalize to novel stimuli on the Transfer Test, although real colors provided more of an advantage than synaesthetic colors (see Fig. 2b). Finally, participants with access to color information were prone to False Recognition of the Foil Stimuli during the Recognition Test, but those without color were able to correctly reject most of these stimuli (see Fig. 2c).

These qualitative descriptions are supported by analyses of variances (ANOVAs) and post hoc group comparisons. To begin with, Categorization Accuracy and RT were the dependent measures in two-way ANOVAs using Group as a between-subjects factor with three levels (Synaesthete, Control-Achromatic, and Control-Color), and Epoch (1–4, each composed of two experimental blocks) as a within-subjects factor. In both cases, there were significant main effects of Group (Categorization Accuracy: $_{2,87}$ = 12.1, $\eta^2$

$\eta^2$ = .61, .26,(factor.)11025.02845 a betwee4o54259un-Fsub1.244.5(.01,)-482.5(.42,)-485.3(respectivel)11.5(y;)245.621(both)factor $_{6,261}$ = 3.6

$\eta^2$

Second, synaesthetes were not as successful in transferring their learning to novel stimuli. This might also be explained by less vivid synaesthetic experiences. Alternatively, a comment made by a synaesthetic participant may shed light on this result. He indicated that when viewing the stimuli, he did not experience two different colors, but saw a single color for the pair as a whole, typically the color of the grapheme that seemed more "dominant" than the other. Indeed, many grapheme-color synaesthetes experience single colors for words, often determined by the color of an individual letter (Simner, Glover, & Mowat, 2006; Ward, Simner, & Auyeung, 2005). This may account for the lower accuracy of synaesthetes on the transfer task, although it does not mitigate the critical finding that their accuracy was almost twice that of non-synaesthetes viewing achromatic grapheme pairs.

Third, synaesthetes were slower to respond than participants viewing real colors. There are at least two ways of accounting for this result. First several researchers argue that synaesthetic colors cannot be induced without the conscious recognition of the grapheme (e.g. Laeng 2009). This would imply that the Synaesthete group ought to respond at least as slowly as the Control-Achromatic group, which is what we find. An alternative is that the process of establishing which letter in a pair is dominant, as described in the previous paragraph, may take some time to resolve itself. The present data does not provide

## References

Ashby, F. G., & Maddox, W. T. (2005). Human category learning. [illegible], [illegible], 149–178.