CHARACTERISTICS/RELATED CONDITIONS

MONOZYGOTIC TWINS' COLOUR-NUMBER ASSOCIATION: A CASE STUDY

Peter Hancock

(Department of Psychology, University of Stirling, Stirling, UK)

Abstract

A case study of a pair of monozygotic twins, both of whom show a strong and enduring colour-number association, is reported. The origin of the colours, in a jigsaw puzzle, is known. Neither reports conscious photisms typical of synaesthesia, but a Stroop task of naming the colours of digits shows an interference effect with incongruent colours.

Key words: synaesthesia, number colour association, twins, Stroop test

Introduction

This paper concerns an investigation of the colour-number associations of a pair of monozygotic twins, R and T, aged 12 at the time of testing. An unusual aspect of this association is that the origin of it, in a coloured number jigsaw, is known. The association was first noticed by the boys' playgroup leader, when they were aged 3. R was playing a computerised number naming game. Shown the number 8, he answered "orange". The playgroup leader reminded him that the task was naming numbers, but he persisted in reporting colour names. For him, it seemed, the numbers simply were synonymous with colours. Observation of his responses quickly indicated that the colours he was reporting were those shown on an "Early Learning Centre" number jigsaw that he regularly played with. His brother, T, could happily provide the same pairings, but did not appear to show such a strong association.

Now aged 12, both boys will readily report what colour a digit is. They will also report colours for most letters. They do not report the "photisms" sometimes described by those with synaesthesia. However, given that the origin of the association seems clear, it is of interest to see whether they show the Stroop-like interference effects that are often used, along with the enduring associations, to attempt objective assessment of synaesthesia (Stroop, 1935; Wollen and Ruggerio, 1983; Odgaard et al., 1999; Mills et al., 1999).

The boys' reported colour associations have been recorded on two other occasions since it was first observed (see Table I). Note that they were themselves unaware of the origin of their number colours, until after the experiment reported here. Their letter – colour associations are less stable and the origin is not known (they also played with an equivalent letter jigsaw, but the colours did not appear to match). Over nearly 6 years, T gave the same colour (allowing e.g., green and light green as the same) for 12 letters (46%), R for 11 (42%). Although the origin is not known, there would appear to be some commonality, since at age 6 they agreed on 10 (38%), rising to 14 (54%) at age 12. Given that they are using about 10 colour names, chance agreement would be around 3.

Method

The task is to name the colour in which a digit is displayed. The expectation is that, if the digit is coloured "correctly" naming will be quicker than if coloured "incorrectly".

Participants

R and T were aged 12 years and 2 months at the time of testing. They are physically and intellectually very similar and were reported by the hospital (to the author) to be monozygotic, based on an examination of the placenta. No genetic analysis has been undertaken.

Materials

R and T separately selected colours for each of the digits from 0-9, using the Adobe Photoshop colour picker. The numbers were displayed in 200 point font, which during the experiment measured about 6 cm high on the screen. These selections were saved as the congruent colours and are shown in Figure 1, along with a reproduction of the colours used by the jigsaw thought to be the origin of the association. Incongruent versions were created, without their knowledge, by swapping the colours of discordant pairs, e.g. 2 became pink and 1 became blue. The swaps were all for adjacent numbers (1 and 2, 3 and 4 etc., except 3 and 5 and 4 and 6 for T, since 3 and 4 have similar colours for him). Backgrounds were white.

TABLE I

Reported colours for letters and numbers from R and T at age: 6 years and 7 months, 11 and 3, 12 and 2

	T 6, 7	T 11, 3	T 12, 2	R 6, 7	R 11, 3	R 12, 2
1	Pink	Pink	Pink	Dark green	Pink	Red
2	Dark blue	Light blue	Blue	Light blue	Light blue	Blue
3	Yellow	Red	Red	Yellow	Yellow	Yellow
4	Red	Red	Red	Red	Red	Blue
5	Green	–	Green	Light green	Orange	Green
6	Pale blue	Dark blue	Dark blue	Dark blue	Dark blue	Blue
7	Light green	Light green	Nice green	Dark green	Green	Green
8	Orange	Orange	Orange	Light pink	Orange	Orange
9	Light blue	Royal blue	Dark blue	Orange	Light blue	Blue
0	Pink	Pink	Pink	Dirty pink	Pink	Pink
A	Red	Red	Red	Red	Red	Red
B	Brown	Brown	Brown	Orange	Orange	Brown
C	Yellow	Yellow	Yellow	Pink	Red	Yellow/red
D	Blue	Blue	Blue	Red	Red	Red
E	Orange	Yellow	Yellow	Brown	Brown	Brown
F	Purple	Brown	Brown	Orange	Orange	Orange
G	Green	Light blue	Orange	Green	Green	Green
H	Red	Red	Red	Red	Red	Red
I	Blue	Yellow	Yellow	Orange	Yellow	Yellow
J	Blue	Pink	Pink	Purple	Pink	–
K	Pink	Pink	Red	Pink	Pink	Red
L	Red	Red	Red	Red	Red	Red
M	Red	Red	Red	Red	Red	Red
N	Orange	Brown	Brown	Orange	Brown	Brown
O	Orange	Orange	Orange	Orange	Orange	Orange
P	Blue	Blue	Blue	Blue	Blue	Blue
Q	Grey	Yellow	Black	White	Pink	Pink
R	Red	Dark blue	Blue	Pink	Dark blue	Dark blue
S	Dark green	Dark green	Green	Red	Dark green	Green
T	Light green	Light green	Green	Green	Light green	Green
U	Red	–	White	Brown	Orange	–
V	Grey	–	Orange	Brown	Orange	–
W	Grey	Grey/blue	Brown	Yellow	Brown	–
X	Black	Red	Black	White	Red	–
Y	Red	Yellow	Black	Yellow	Yellow	–
Z	Black	–	Red	Brown	Brown	–

Procedure

The task was to name the colour of the displayed digit as rapidly as possible. Each trial began with a fixation cross, displayed for 1 sec, followed by a blank screen for 500 msec, followed by the digit, 6 cm high on screen, against a white background. Each digit was presented eight times in one run of the experiment, four times congruently coloured, four incongruently. There was an initial practice of four digits. Each of the boys ran the procedure six times over a period of a few days, making a total of 24 trials for each digit in each of the conditions.

RESULTS

Of the 480 trials, 49 (10.2%) were removed for R and 51 (11.25%) for T because the voice trigger either failed to detect the word, or was observed to be triggered by some extraneous noise such as a tongue click. A further 38 (R) and 19 (T) were removed because of being more than two standard deviations from the mean[1]. Mean reaction times for answers to congruent and incongruently coloured digits are shown in Figure 2. Both boys show an increased reaction time to incongruent colours, though the error bars suggest that only R might

Fig. 1 – *The congruent colours chosen by R (top) and T (middle), with a reproduction of the colours used in the jigsaw (bottom).*

[1]R = incongruent: 13 low and 8 high; congruent: 9 low and 8 high; T = incongruent: 3 low and 9 high; congruent: 2 low and 5 high.

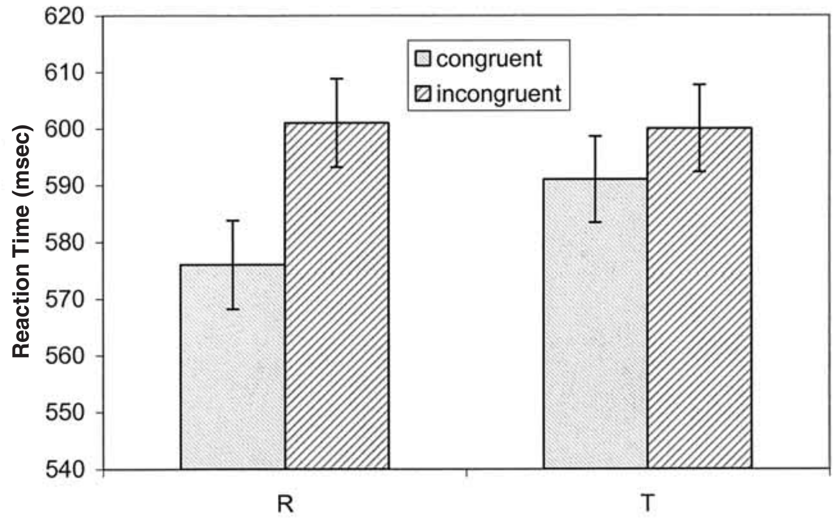

Fig. 2 – *Mean reaction times for correct responses for R and T. Error bars are standard errors.*

differ significantly. Anova shows that there is an effect of congruence [F (1, 794) = 4.5, $p < .05$] but no significant difference between the boys and no interaction. Therefore, although individual t-tests would confirm a difference for R but not T, it is not safe to conclude this, only that the effect of congruence appears to be driven by R. R also made more colour naming errors than T: a total of 11 (2.2%), where T made only one. It is possible that T was being somewhat more careful, which might account for his slightly slower overall reaction time.

Discussion

R and T show a small but detectable interference when the digit colours are "wrong". The difference shown by R, at 25 msec, is consistent with the 29 msec average reported by Merikle et al. (2002) for "associator" synaesthetes. This type of synaesthete sees colours "in the mind's eye", as opposed to "projector" synaesthetes who see the colour as an overlay on the digit. The boys reported experience is consistent with this: they do not report photisms or any sense of perceiving a colour, they simply know that zero is pink. Both these differences are a bit smaller than the 38 msec reported by Elias et al. (2003), for both a synaesthete and an individual who had learned a colour number association, in that case from associating cross stitch thread colours with numbers on a pattern. Elias et al. (2003) were able to distinguish their two participants by use of fMRI, where the synaesthete showed much stronger activation in visual areas on several tasks than the learned associator. It would clearly be of interest to test R and T with fMRI, to see in which group they fall. Their association is evidently learned, but unlike Elias et al.'s (2003) cross stitcher, it has not been overtly practised.

The general pattern of the results is similar to that of Smilek et al. (2002), who report monozygotic twins, only one of whom displays significant inhibition when the colours do not match. Smilek et al. (2002) report only the two individual t-test results, but it looks as though an interaction would be found for their data. The difference here is that both twins report the association and with a very similar set of colours.

Neither boy had seen the jigsaw for at least seven years at the time of testing. That the colours derive from it cannot be proven, but the accuracy of the match is striking, although each has clearly changed one colour. On seeing Figure 1 after the experiment, R claimed that he had made a mistake with 4, T did not know why he had chosen pink for 3. However, he had earlier reported that 13 is yellow, citing the reason that he doesn't like yellow and 13 is unlucky. Three is yellow on the jigsaw and reported colours for "teen" numbers generally match their single digit counterparts. R had also reported that 16 is deep blue, "because it is his favourite number and colour". Given that the jigsaw 6 is deep blue, it may also be questionable which direction that association runs, especially as blue was not his favourite colour at the time he played with the jigsaw. It seems more likely that either 16 became his favourite number sometime after blue became his favourite colour, or vice versa.

The frequency of synaesthesia is a matter of some debate, with early estimates of perhaps 1 in 25,000, but the first systematic study suggesting 1 in 2000 (Baron-Cohen et al., 1996). However, a recent study (Mulvenna et al., 2004) found four cases from 445 participants, which suggests an incidence as high as 1 in 110. The discrepancy may be because synaesthesia, like other syndromes with apparently increasing frequency such as autism, may not be an all or nothing effect, but more of a graded phenomenon, with enduring associations at one end of the scale, and full blown cross modal perception at the other. How many you find will depend on where you draw the line. Dixon et al. (2004) report that only 11% of their sample are "projectors", with the remainder classed as "associators". R and T appear to fit towards the mild end of the range: they have reliable, long lasting associations that cause a Stroop interference, but do not report consciously seeing anything.

What of the cause of their association, given that many children must play with such toys and few develop the enduring link? A genetic effect is possible, since their mother also displays a measurable colour number association (she was a participant in the studies of Gerstley, 1997). She reports having come across a set of toy bricks with numbers on, where the colours were "right" and suspects she may have played with a set in childhood. Another possible factor is that colours were particularly salient to T and R, since they often had items and clothes that were identical except for colour (e.g., T had a green bib and R a blue one). Finally, numbers were also salient, since they are both highly numerate, being some three years ahead of their peers in mathematics.

References

Baron-cohen S, Burt L, Smith-Laittan, F, Harrison J and Bolton P. Synaesthesia: Prevalence and familiality. *Perception, 25:* 1073-1079, 1996.

Dixon MJ, Smilek D and Merikle PM. Not all synaesthetes are created equal: Projector *versus* associator types. *Cognitive, Affective and Behavioral Neuroscience, 4:* 335-343, 2004

Elias LJ, Saucier DM, Hardie C and Sarty GE. Dissociating semantic and perceptual components of synaesthesia: behavioural and functional neuroanatomical investigations. *Cognitive Brain Research, 16:* 232-237, 2003.

Gerstley LD. *Cross-modal and Synaesthetic Perception in Music and Vision*. University of Stirling, UK: Unpublished Ph.D. thesis, 1997.

Merikle PM, Smilek D, Myles KM and Dixon MJ. *Individual Differences in Alphanumeric-Colour Synaesthesia*. Poster presentation: European Conference on Visual Perception, 2002.

Mills CB, Boteler EH and Oliver GK. Digit synaesthesia: A case study using a Stroop-type test. *Cognitive Neuropsychology, 16:* 181-191, 1999.

Mulvenna C, Hubbard EM, Ramachandran VS and Pollick F. *The Relationship between Synaesthesia and Creativity*. Eleventh Annual meeting of the Cognitive Neuroscience Society. San Francisco, USA, 2004

Odgaard EC, Flowers JH and Bradman HL. An investigation of the cognitive and perceptual dynamics of a colour-digit synaesthete. *Perception, 28:* 651-664, 1999.

Smilek D, Moffatt BB, Pasternak J, White BN, Dixon MJ and Merikle PM. Synaesthesia: A case study of discordant monozygotic twins. *Neurocase, 8:* 338-342, 2002.

Stroop JR. Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18:* 643-662, 1935.

Wollen KA and Ruggiero FT. Coloured-letter synesthesia. *Journal of Mental Imagery, 7:* 83-86, 1983.

Peter Hancock, Department of Psychology, University of Stirling, Stirling, FK9 4LA, UK. e-mail: pjbh1@stir.ac.uk