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Time–space synaesthesia – A cognitive advantage?

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ABSTRACT

Is synaesthesia cognitively useful? Individuals with *time–space synaesthesia* experience time units (such as months of the year) as idiosyncratic spatial forms, and report that these forms aid them in mentally organising their time. In the present study, we hypothesised that time–space synaesthesia would facilitate performance on a time-related cognitive task. Synaesthetes were not specifically recruited for participation; instead, likelihood of time–space synaesthesia was assessed on a continuous scale based on participants' responses during a semi-structured interview. Participants performed a month-manipulation task, which involved naming every second month or every third month in reverse-chronological order, beginning and ending with a target month. Using hierarchical multiple regression, we found that time–space synaesthesia corresponded with faster performance on both versions of the task. We propose that time–space synaesthesia may expedite the cognitive manipulation of time-based information. Our results also indicate that synaesthesia is far less unusual than widely believed.

1. Introduction

The past decade has seen a burgeoning of research interest in synaesthesia, the peculiar condition wherein one sensation (for instance, music) elicits another type of sensation (for instance, colours). Synaesthetic experiences are automatic, consistent over time, and idiosyncratic, in that they vary considerably from one individual to the next. Up to the present, much synaesthesia research has focused on verifying different varieties of synaesthesia through behavioural measures, as well as examining the conditions that enhance or subdue synaesthetic experiences. However, one key question remains, namely: what is synaesthesia good for? In other words, is the condition cognitively useful? This question has been one of much speculation, and yet few studies have empirically explored whether synaesthesia serves a useful function.

In seeking to address the question of function, we conjectured that one variety of synaesthesia had potential to offer informative clues. Individuals with *time–space synaesthesia* experience spatial imagery whenever they see, hear or think of time units, such as days of the week and months of the year (Price & Mentzoni, 2008; Smilek, Callejas, Dixon, & Merikle, 2007). For some, time units (such as months) are experienced as internal imagery, in their "mind's eye", while for others, this imagery occupies highly specific locations in external space (Smilek et al., 2007). As H reports, "When someone mentions a year, I see the oval with myself at the very bottom, Christmas day to be precise. As soon as a month is given, I see exactly where that month is on the oval. As I move through the year, I am very aware of my place on the oval at that current time, and the direction I am moving in. For example, now I am moving upwards, in a northwesterly direction. It is always anti-clockwise".

In spite of the resurgence of interest in synaesthesia over the past decade, relatively little research has targeted time–space synaesthesia. The dearth of publications on this particular type of synaesthesia is surprising given prevalence

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estimates of time–space mappings, which range from 1 in 30 (Galton, 1908/1973) to 1 in 5 (Sagiv, Simner, Collins, Butterworth, & Ward, 2006). These estimates are at least an order of magnitude higher than those for grapheme-colour synaesthesia, often cited as the most common form of synaesthesia (e.g. Blakemore, Bristow, Bird, Frith, & Ward, 2005; Rich & Mattingly, 2002).

Perhaps because of such high prevalence rates, there has been debate as to whether the propensity to map time units to space is truly a form of synaesthesia. After all, non-synaesthetes, if requested to assign spatial locations to hours of the day, might align the hours according to the traditional clock face. Unlike a clock face, however, the time–space mappings observed in this form of synaesthesia tend to be much more elaborate and idiosyncratic than those found in non-synaesthetes. For example, these individuals report a variety of month forms, including ovular, circular, horizontal, and vertical, with time units of varying sizes, and with January in different locations (Cytowic, 2002; Galton, 1908/1973; Smilek et al., 2007; see also Seymour, 1980).

Two notable hallmarks of synaesthesia are consistency and automaticity – that is, synaesthetic experiences are stable over time and are not under voluntary control. Smilek et al. (2007) have shown that for time–space synaesthetes, mappings of time units to space are both consistent and automatic. These researchers tested four time–space synaesthetes, two of whom experience months of the year as occupying spatial locations surrounding their bodies, and two of whom see a spatial arrangement of months in their "mind's eye". To assess consistency for the former two synaesthetes, Smilek et al. used a laser pointer mounted on a 360° compass. Synaesthetes were asked to point the laser so that it bisected the centre of each month, and the experimenters recorded the ensuing compass angles. Consistency for the "mind's eye" synaesthetes was assessed by having the synaesthetes indicate the relative locations of months on a computer monitor using a cursor. All four time–space synaesthetes were significantly more consistent at indicating their month locations across repeated testing sessions than control participants. To assess the involuntary nature of time–space synaesthesia, the authors used a spatial cueing task. Time–space synaesthetes were presented with months of the year (e.g., APRIL) in the centre of a computer screen, followed by a target square presented either to the left or the right of the month name. On half of trials, the target appeared on the side of space corresponding to the month's synaesthetic location (e.g., if April was perceived by the synaesthete as being on the left, then the word APRIL was followed by a target on the left); on the other half, the target appeared on the side opposite to the month's synaesthetic location (e.g., APRIL, followed by a target on the right). The authors found that three of the four synaesthetes showed significant synaesthetic cueing effects: they were faster to detect targets that fell in the location cued by the month name versus targets that fell in the opposite location. Because these cueing effects occurred even though the months were not actually "predictive" of the target location (i.e., on half the trials they cued the wrong location), and because the cueing effects occurred even when the target appeared very shortly (150 ms) after the onset of the month name (presumably before ny strategy could be adopted), Smilek et al. concluded that, at least for some synaesthetes, time units were capable of involuntarily directing synaesthetes' attention to locations in space.

A recent study by Price and Mentzoni (2008) examined whether month forms could induce a Spatial-Numerical Association of Response Codes effect (SNARC; Dehaene, Bossini, & Giraux, 1993) in synaesthetes. The SNARC effect refers to the finding that, in cultures that read from left to right, responses to early units in a sequence (e.g. low numbers, early months) are made faster with the left hand, while responses to late units in a sequence (e.g. high numbers, late months) are made faster with the right hand (Dehaene et al., 1993; Gevers, Reynvoet, & Fias, 2003). Four synaesthetes were tested: two who represented the early months of the year on the left (and later months on the right), and two whose spatial mappings were the opposite (early months on the right, later months on the left). Synaesthetes were presented with month names, and asked to indicate whether each month occurred in the first or second half of the year. On half of trials, participants responded to early months with their left hand and late months with their right hand; on the other half, the appropriate response hands were reversed. The two synaesthetes who synaesthetically located early months on the left were faster to make left-handed responses for these months and right-handed responses for later months. Consistent with their reverse time–space mappings, the other two synaesthetes showed the opposite pattern (Price & Mentzoni, 2008). These findings are seen as evidence for the involuntary and idiosyncratic nature of time–space mappings.

The findings reported by Smilek et al. (2007) and Price and Mentzoni (2008) provide converging evidence for the reality of time–space synaesthesia; taken together, they highlight its consistent, involuntary and idiosyncratic nature. Arguably, however, neither study captures what synaesthetes themselves often profess to be the most salient aspect of their condition – namely that it is cognitively useful. Time–space synaesthetes commonly report that they use their spatial forms when scheduling appointments, tracking important dates, and remembering the sequence of past events (Cytowic, 2002; Smilek et al., 2007; Ward, 2008). For example, Cytowic (2002) describes one synaesthete, MP, whose days progress in an upward spiral. When MP plans her day, she "blocks off" sections of the spiral, helping her to remember that those particular times are filled with activities (Cytowic, 2002).

Given such reports, we wondered whether time–space synaesthesia might facilitate people's ability to *manipulate* time-based information. Since looking back on the past and ahead toward the future are such common mental activities, a condition that facilitates such activities would clearly provide considerable benefit. If time–space synaesthetes are indeed capable of *looking* back (or ahead) on mental calendars, it is conceivable that their visuospatial mappings would enable them to mentally manipulate time units with greater ease than those individuals who do not experience time–space imagery.

To test this hypothesis, we designed a study with three parts: a semi-structured interview where our experimenter assessed the likelihood that a given participant had time–space synaesthesia; a behavioural month-manipulation task that required participants to list every second or every third month in reverse-chronological order, beginning with a target month; and finally a post-task questionnaire. The post-task questionnaire was designed to obtain quantifiable data regarding the