

Acquired synaesthesia following 2C-B use

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Psychedelic drugs reliably trigger experiences that closely resemble *synaesthesia* (Luke and Terhune 2013), a condition in which inducer stimuli will reliably and automatically elicit atypical concurrent experiences (Ward 2013). These transient episodes are considered controversial because they do not meet behavioural diagnostic criteria for developmental synaesthesia (Terhune et al. 2016). However, if these behavioural markers are attributable to the consolidation of synaesthetic associations over time (Terhune et al. 2016), they should be observed in cases of acquired synaesthesia. Here we report a case of drug-induced acquired synaesthesia (LW) that meets standard diagnostic criteria for developmental synaesthesia.

LW is a 29-year-old male who reports continuously experiencing multiple forms of synaesthesia for over 7 years since ingesting approximately 70–150 mg of 2,5-dimethoxy-4-bromophenethylamine (2C-B) (Papaseit et al. 2018), which greatly exceeds the normal dosage (12–24 mg) (Shulgin and Shulgin 1990) (see [Supplementary Materials](#)). LW was contrasted against 10 non-synaesthete healthy controls, all of whom provided informed written consent. He reports that his synaesthetic associations became more stable over time and his response patterns met inducer-concurrent consistency thresholds for week-colour and instrument-colour, but not chord-colour, synaesthesia on a standardized battery (Eagleman et al. 2007). He experiences colours as visuospatially co-localized

with inducing faces (projector synaesthesia (Dixon et al. 2004; Terhune et al. 2015)), which was corroborated (Skelton et al. 2009). He reports that none of his immediate family members have developmental synaesthesia; two individuals who have known him since before the onset of his synaesthesia independently corroborated his reports. The transient induction of synaesthesia-like experiences through 2C-B use has been widely reported in online discussion forums of recreational drug users as well as in a previous survey of drug users (Luke et al. 2012), but we are unaware of any reports of acquired synaesthesia through the use of 2C-B or any other drugs.

To assess the automaticity of LW's face-colour synaesthesia, one of the hallmark behavioural features of developmental synaesthesia (Ward 2013), he was contrasted against controls on a priming task in which face primes were presented prior to judgments of colour patches that were either congruent or incongruent with the preceding prime according to LW's face-colour associations. LW displayed a larger congruency effect (incongruent–congruent) in error rates, 80% [95% CIs 71, 88], than controls, 2% [0.2, 2.6], $t(9) = 37.13$, $p < .001$ (Fig. 1), reflecting a difference of nearly 39 SDs, $z_{cc} = 38.95$ [38.40, 39.56], with a very low probability of occurrence in the general population, $p_{gp} = 1.8^{-9}\%$ [1.6^{-9} , 2.1^{-9}]. LW's congruency effect in response times for correct responses was also larger, 236 ms [24, 507], than that of controls, 20 ms [–1, 48], $t(9) = 5.07$, $p < .001$, corresponding to a difference of over 5 SDs, $z_{cc} = 5.32$ [4.63, 5.83], and a very low probability of occurrence, $p_{gp} = 3^{-2}\%$ [2^{-2} , 8^{-2}]. Bootstrap resampling revealed that LW's response distributions in congruent and incongruent conditions were completely independent for error rates and only minimally overlapping for response times whereas both sets of distributions overlapped considerably in controls.

LW's multiple forms of synesthesia exhibited inducer-concurrent consistency and his face-colour synesthesia exhibited automaticity, thereby meeting the two most widely used behavioural diagnostic criteria for synesthesia (Eagleman et al. 2007; Rothen et al. 2013; Ward 2013). Insofar as these criteria are not met by transient episodes of drug-induced synaesthesia, these results are consistent

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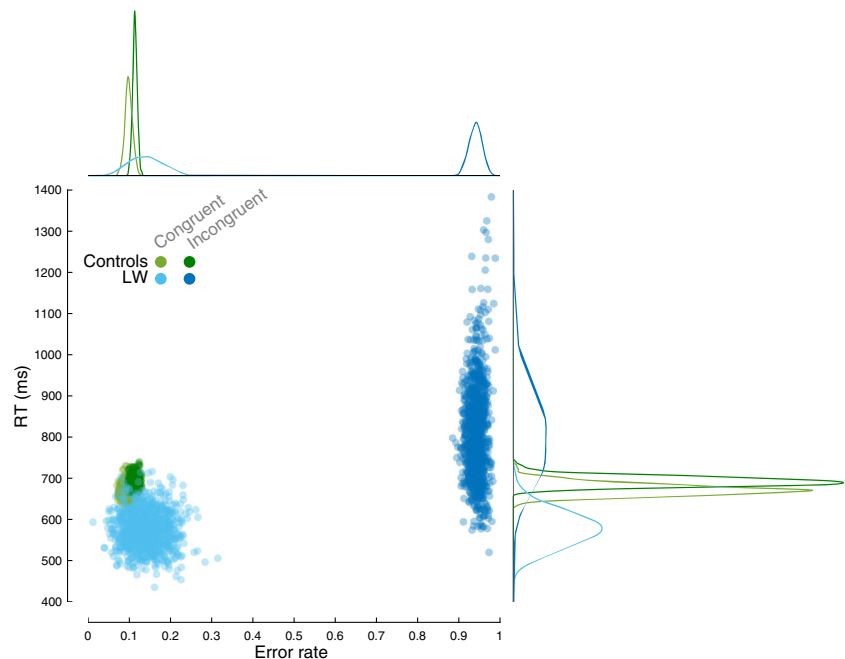
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Fig. 1 Face-colour automaticity in an acquired synaesthete (LW) and controls. Markers reflect 1000 bootstrap resamples for LW and control means in congruent and incongruent face-colour priming conditions. Marginal histograms reflect kernel density plots of the bootstrap distributions



with the proposal that automaticity and consistency are byproducts of the over-learning of associations rather than behavioural signatures of synaesthesia per se (Terhune et al. 2016).

Insofar as 2C-B is a partial serotonin agonist (Páleníček et al. 2013; Papaseit et al. 2018), these results add to a growing body of evidence implicating serotonin in the development of synaesthesia (Brogaard and Gatzia 2016; Luke and Terhune 2013). Although LW did not experience synaesthesia prior to consuming 2C-B, we cannot rule out the possibility that 2C-B use interacted with a latent predisposition for cortical disinhibition or hyperexcitability (Rothen and Meier 2014; Terhune et al. 2015). The factors that sustained his synaesthesia are unknown, but its continuity is plausibly attributable to the excessive dose of 2C-B (Shulgin and Shulgin 1990). Excessive serotonin from LW's 2C-B use (Papaseit et al. 2018) may have triggered elevated glutamate release, and concomitant hyperexcitability in visual cortex (Brogaard and Gatzia 2016), a neurophysiological characteristic of synaesthesia (Terhune et al. 2015; Terhune et al. 2011). Cortical hyperexcitability may have triggered sustained visual colour percepts that were perceived as visuospatially co-localized with environmental inducers similar to the induction of hallucinogen persisting perception disorder (HPPD), which may also have a serotonergic basis (Litjens et al. 2014; Martinotti et al. 2018).

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Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interests.

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