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COMMENTARY

Some challenges and extensions to Ward's framework for future synaesthesia research

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In his position paper on the future of synaesthesia research, Ward's (2021) central argument is that the tendency to develop synaesthesia is just one consequence of a more general neurodevelopmental profile. He argues that the profile underlies many of the ways in which synaesthetes perform differently from controls in various mental tasks, even if there are still a few performance differences that are caused directly by synaesthesia. The profile impacts "lifestyle choices" such as careers. It is associated with an elevated tendency for autism and anxiety. Ward summarizes empirical evidence which suggests that this profile is shared by non-synaesthete near-relatives and appears strongest in those synaesthetes who experience many synaesthetic variants. These claims bring together much of the recent empirical work on synaesthesia and set out a useful scientific agenda.

Ward's introduction emphasizes three points: (1) Synaesthesia is *dichotomous* – i.e., the presence versus absence of synaesthesia in any individual is bimodally distributed. You have it or you don't, and there is no gradation. (2) Synaesthesia arises in a manner that is "*probabilistic rather than deterministic*". (3) Research should be less concerned with synaesthesia itself, and more focused on the underlying neurodevelopmental profile. Here I present some challenges or extensions to these points (Italicized text in quotes is verbatim text from Ward's paper.)

1. On dichotomy and definitions

Ward proposes that synaesthesia is dichotomous (you have it or you don't) even though (a) the neurocognitive profile underlying synaesthesia – or "synaesthetic disposition" – is itself continuous, and though (b) the total number of synaesthetic variants experienced by a synaesthete increase in a continuous manner with the strength of the underlying profile. However, no robust arguments are offered for *why* dichotomy arises from continuity, especially as the number of variants is postulated to be continuous. The only explanation offered by Ward is that "It is hard to imagine what an intermediate profile might be in terms of phenomenology (a hypothetical 'half-synaesthete')". Perhaps it is not as hard as he suggests?

For some prototypical synaesthesias it may *usually* be that people either have the experience strongly or have nothing, although this appearance could also be an artefact of a traditional focus on more extreme synaesthetes, or of self-selection by synaesthetes onto participant panels. However, for the two varieties of synaesthesia that I have worked with myself – namely sequence-space synaesthesia (where members of ordinal sequences such as calendar months are felt to be arranged in spatial patterns) and tickertape experience (where heard words are experienced visually as written subtitles) – intermediate profiles which converge with standard imagery are readily found (Holm et al., 2015; Price & Pearson, 2013). For example, a person might occasionally experience a weak and simple spatial layout of the calendar months, whose appearance they can to some extent control, and which might be plausibly derived from a wall calendar at school. Ward's denial of a continuity in synaesthetic experience also seems to clash with his own referral to "more extreme" synaesthetes, which is illustrated by his

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descriptions of two contrasting synaesthetes towards the end of his paper. It also clashes with Ward's own description of the differences in the experiences and test performance of associator-synaesthetes versus projector-synaesthetes. As a defining feature of synaesthesia, a dichotomy is therefore problematic.

Three other common defining features of synaesthesia that Ward endorses are also problematic – namely *automaticity*, *consistency* over time and *perceptual nature*. While he admits some controversy over the universality of these features, their limitations need stronger emphasis. For sequence-space synaesthesia and tickertape experience, degree of automaticity appears to vary from strong to weak feelings of involuntariness, and even to quite salient voluntary control (Holm et al., 2015; Price & Pearson, 2013). Consistency also fails as a universal criterion for sequence-space synaesthesia, because the spatial layout of calendar sequences can modify over years (Price & Pearson, 2013) and even change back and forth quite radically over a period of a few days (personal observation). The perceptual nature of synaesthesia is challenged by early work that refuted the equivalence of synaesthetic and real percepts (Mattingley, 2009), and by the fact that synaesthetic varieties such as ordinal linguistic personification (e.g., letters each having their own personality) are not primarily sensory.

Part of the problem is perhaps that the concept and definition of synaesthesia first evolved to deal with prototypical varieties such as coloured music. As the concept expands to embrace an increasing variety of psychological phenomena, some varieties start to sit uncomfortably far from the epicentre of a fuzzy set of core properties. This definitional diffuseness is acknowledged by Ward when he refers to "phenomena that fall under the synaesthetic umbrella". An alternative strategy could be to reject experiences such as sequence-space and tickertaping as true synaesthesias, but then the notion of a general synaesthetic trait is compromised. Here we cannot have our cake and eat it.

2. Is synaesthesia probabilistic?

The second point in Ward's list is that the tendency to develop synaesthesia is "probabilistic rather than deterministic". I suggest that this terminology is under-defined and potentially misleading, and that a contrast between probabilistic and deterministic causality is in any case not central to Ward's main thesis.

If the development of synaesthesia in a given individual were non-deterministic in the philosophical sense, it would not have causes that were potentially identifiable and predictable, but would instead be influenced by random events in the sense that radioactive decay is random. What Ward seems to be driving here is perhaps a variety of algorithmic non-determinism whereby an outcome is influenced by "outside" factors. Ward identifies two outside influences which he contrasts to hereditary pre-programming: (1) The likelihood of synaesthetic cross-connectivity between specialist processing areas is greater when they are located in brain areas that are close to each other and (2) the likelihood of developing synaesthesia is influenced by environment and learning. He labels these influences as "probabilistic" or "random". However, the spatial proximity of brain regions is genetically determined, at least in broad outline. Further, the influence of environment and learning really boils down to the old nature-nurture debate. Although the *relative* contributions of nature and nuture are debated within synaesthesia research, their dual involvement is uncontroversial and does not violate causal determinism. Even if only one of two identical twins develops synaesthesia after being raised together in the same environment, there is no need to invoke non-determinism. In the study of complex and chaotic systems, small deterministic influences can cause wide divergence in causal pathways from identical starting conditions.

3. What is the neurodevelopmental profile?

The third point listed by Ward is that synaesthesia research should be focused on the general neurodevelopmental profile – the synaesthetic disposition – of which synaesthesia is just one outcome. He further suggests that this neurodevelopmental profile is *unusual* and leads to a *distinctive* cognitive profile. These proposals raise the following inter-related questions, which expand on Ward's arguments.

3.1. What actually is this distinctive cognitive profile?

Ward provides no detail here, but his preliminary suggestion is that the "thinking style" of synaesthetes is

"based on inner scenery and associations between ideas" by contrast to "abstract thinking and logic". This seems to overlap the distinction between sensory-based and verbally based thinking modes that are partly captured by the so-called visualizer–verbalizer distinction. Could the latter be a productive and broader way to characterize differences in performance between synaesthestes and non-synaesthetes?

3.2 How much variance is directly carried by imagery skill?

As pointed out by Ward, there is considerable evidence that synaesthetes experience more salient mental imagery than average non-synaesthetes. Extending point #3.1 above, this begs the question of whether imagery skill directly accounts for some of synaesthetes' superior test performance (see Price & Mattingley, 2013). It also requires us to think carefully about which *types* of imagery are involved, because mental imagery manifests in many sensory modalities as well as in the multi- or supra-modal spatial modality, and these are associated with different skills and lifestyle choices (Blazhenkova & Kozhevnikov, 2010).

The importance of imagery as a mediating factor can be extended more radically to suggest that at least some synaesthetic experiences are best thought of *as varieties of imagery experiences* (see Price and Pearson (2013) for the case of sequence-space synaesthesia). Although this is a more extreme view of the "synaesthetic disposition" than Ward takes, he does speculate that imagery might mediate links between synaesthesia, improved memory and PTSD vulnerablity, and he goes as far as to ask whether "a heightened capacity for mental imagery is helpful for synaesthesia to develop in the first place" (see also Price, 2013).

On the other hand, some studies, which have tried to formally disentangle the contribution of imagery from other variables, find that differences in the salience or vividness of imagery cannot universally account for the elevated task performance of sequence space synaesthetes (e.g., Ward et al., 2018). Future studies should build on such examples and ensure that comparisons of synaesthetes and non-synaesthetes are able to measure how much variance in performance is carried by individual differences in the experience of various types of mental imagery.

3.3. Is the cognitive profile really so distinctive and unique?

Ward refers to the cognitive profile of synaesthetes as both "distinctive" and "unique". But do we really know this? Given that Ward himself suggests that the underlying neurodevelopmental disposition is a continuum, synaesthetes' performance on cognitive tests are best thought of as occupying part of this continuum rather than being *distinctive*. It could also be misleading to describe the synaesthetes as *unique* when we only know that they differ on average from randomly selected controls; we do not know how many non-synaesthetes in general, or especially how many non-synaesthetes with other phenotypic profiles also share these skills. We can also ask whether traits or conditions other than synaesthesia (e.g., strength of mental imagery) might be even more powerful at predicting that people lie at the extreme end of the proposed neurodevelopmental continuum.

3.4. What about the other end of the profile?

Ward omits the discussion of what happens at the other end of the neurodevelopmental disposition from where synaesthetes lie. If the continuous disposition approximates a normal distribution, and if we agree with Ward that the disposition rather than synaesthesia is the real target of our study, is it just as pressing and interesting to enquire about the skills and deficits that are associated with the verbal/logical/non-sensory end?

3.5. How important is the synaesthetic disposition?

Even if the proposed synaesthetic disposition is associated with measurable skills and deficits, it needs to be remembered that it may be a much less powerful predictor of mental skills and career choice than other traits such as spatial skill. In the clinical domain, many known predictors of anxiety are likely to be stronger than synaesthesia.

In summary, answers to the above questions could end up showing that synaesthesia research is even less of an end-in-itself than already suggested by

Ward, and even more a springboard to address general cognitive traits.

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