Book Review

Soto-Faraco, S., Kvasova, D., Biau, E., Ikumi, N., Ruzzoli, M., Morís-Fernández, L. and Torralba, M. (2019). *Multisensory Interactions in the Real World* (Elements in Perception). Cambridge University Press, Cambridge, ISBN: 9781108468220 (paperback) / ISBN: 9781108578738 (online)

Charles Spence *

Department of Experimental Psychology, Anna Watts Building, University of Oxford, Oxford, OX2 6GG, UK

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* E-mail: charles.spence@psy.ox.ac.uk

1. Introduction

Multisensory Interactions in the Real World, a topic close to my own heart, is the title of the extended chapter, released as a book as part of the Cambridge Elements Series in 2019. The *Elements in Perception* series, of which this volume forms the third instalment, is edited by Distinguished Professor, James T. Enns from the University of British Columbia, in Canada. The latter, one of the few cognitive psychologists out there who, on his webpage, from memory at least, lists 'extreme skate-boarding' as one of his favourite hobbies! Who says that all cognitive psychologists are hirsute and boring? Talking of which, hirsute I mean, the lead author of this work, my long-time collaborator, Prof. Salvador Soto-Faraco, who is also on the Editorial Board for the Series, has written this piece together with a host of former and current students, most of whom are still based at Universitat Pompeu Fabra, in Barcelona.

This youthful group of cognitive neuroscience researchers, well, all apart from the senior author that is, have brought together a broad range of empirical data from both the lab and the real world, with a focus on the cognitive neuroscience mechanisms that underpin our multisensory perception, or at least that is the stated aim in the work's Abstract. Though, as the authors themselves readily admit, oftentimes the limited research that has so far been conducted on more real-world stimuli/situations is perhaps best described as nothing more than 'naturalistic laboratory research'. Furthermore, the authors also rightly stress the challenge that nearly always exists between obtaining the appropriate level of experimental control, easier to obtain in the setting of the laboratory, and acquiring ecological validity, easier to obtain by doing one's research out there in the real world.

It is safe to say that Prof. Soto-Faraco, together with his many collaborators, have been at the forefront of much of the most interesting research of audiovisual integration and attention for a number of years now. Indeed, the text itself certainly reveals an easy familiarity with all the latest cognitive neuroscience techniques, and the list of acronyms included at the end of this work relates solely to neuroimaging terminology. There are also a number of helpful figures capturing many of the key phenomena discussed in the text. The focus of this selective review of the literature, as might be expected, is skewed somewhat toward the lead author's own interests/research output. And yet, overall, I think it is fair to say that a balanced assessment of the available, and sometimes conflicting, data that is discussed is maintained throughout.

At the same time, however, one might question what exactly the benefits of knowing about the neural underpinnings of multisensory integration actually are when it comes to many real-world interventions. For while, in principle, this undoubtedly sounds like a good idea, in practice it can perhaps be argued that there are not too many examples where a neuroscience-based understanding has really facilitated our understanding of attention and perception in a real-world setting. Sometimes, perhaps, if one wants to change or modify a person's behaviour, the easiest way to do that is by means of studying the factors that affect that behaviour, rather than by trying to predict what will happen based on current neuroscience understanding of the connections between the senses in the human, or animal, brain.

The focus of *Multisensory Interactions in the Real World*, it should be pointed out, is squarely on audiovisual interactions in near-frontal space in neurologically-normal adults. In this sense, the focus is similar to that of Störmer's (2019) recent cognitive neuroscience review of audiovisual crossmodal links in exogenous attention. While touch, the third of the so-called 'higher' spatial senses, makes a brief appearance in the text, it is only ever a bit-part player in the discussion/theorizing running through this work. Of course, given the limited word count, it would most likely have been overly ambitious to try to tackle the chemical senses as well. That said, one does find a couple of references to the topic of food and flavour in both its applied and basic context (see Dalton *et al.*, 2000; Puigcerver *et al.*, 2018). These senses, in other words, would still not quite seem to be integrated into the mainstream of multisensory research (see Spence, 2015, for a review). At the same time, however, the Front Matter to this work reveals that the distinguished professor Paul Breslin (2019), has already published a volume in the *Elements in Perception* series devoted to this very topic, perhaps explaining this topic's absence from Soto-Faraco and colleagues' work.

It can be argued that the failure to extend from those learnings established in the most oft-studied case of audiovisual integration to the case of crossmodal spatial, or temporal, interactions involving the tactile modality, or the chemical senses, represents something of a lost opportunity. I, for one, would certainly have been interested to know the authors' take on whether they believe that the same attentional mechanisms and principles, identified here for the audiovisual case as, for example, when watching someone else's lip movements as they speak to you, could also be applied to what is going on in the mouth when experiencing flavours. See, for instance, Spence (2019a), and Spence *et al.* (2017), for some preliminary discussion of attention, segregation, and integration in the experience of flavour in food and drink.

While there is, of course, certainly no necessity to tackle flavour perception, especially if one's focus is squarely on audiovisual interactions, the authors themselves appear to have somewhat broader ambitions, ending their work by concluding that: *"Ultimately, we (researchers) should help other communities use cross-modal interactions to, for example, come up with better designs, improve road safety, foster cross-modal plasticity to overcome sensory loss, or, referring to one of the opening examples, simply to make meals more enjoyable"* (p. 47). Now, while I certainly agree that there are lots of things that we, as researchers, <u>should</u> be doing to make our research more impactful out there in the real world, my sense is that there was not much here that is directly applicable to improving the crossmodal perception of food!

What is more, there is little attempt by the authors to consider whether the mechanisms and principles of audiovisual crossmodal interaction that they summarize would necessarily extend to those interactions involving the tactile modality. And anyone out there with a penchant for the vestibular, kinaesthetic, and/or proprioceptive senses will find little to get their teeth into here. It should be said that this piece ('article'? 'book'? — I am not quite sure what to call it given its intermediate length), comes with a reference list after my own heart. In fact, fully a third of the volume is taken up with citations, primarily to the cognitive neuroscience of attention and perception involving specifically audiovisual crossmodal interactions.

2. Real-World Cognitive Neuroscience

I am all for taking the latest cognitive neuroscience findings out from the constrained setting of the science/psychophysics laboratory in order to see how well the principles and rules documented there provide insights that are relevant to a variety of real-world settings in which we might find ourselves (see Maguire, 2012; Spence and Ho, 2015a, b). Indeed, as the Abstract to this work suggests, real-world multisensory phenomena may be expressed differently from what is seen in the laboratory: sometimes, they may be larger, sometimes smaller, and sometimes they may disappear altogether. I certainly know all too well about the unpredictable outcome when the lab is taken to the real world, after having spent the last quarter of a century trying to apply laboratory research on crossmodal links in attention to the design of warning signals for drivers (e.g., see Ho and Spence, 2008; Spence, 2012).

At the same time, however, one might also want to question whether anyone wanting to gain a specifically cognitive neuroscience understanding of multisensory perception would really be best advised to study the phenomena of interest in the real world. My sense, I must admit, is that real-world research may be best suited to a behavioural approach. Indeed, the question posed by the title of one of the papers cited in this volume by Matusz *et al.* (2019) captures the uncertainty here when the authors ask: *"Are we ready for real-world neuroscience?"*

My suspicion is that the majority of cognitive neuroscience techniques may still be best suited to laboratory-type investigations, whereas real-world research may better suit behavioural and/or psychophysiological measures, such as heart rate and skin conductance monitoring. It is not that companies do not try to apply neuroscience methods in real-world settings. But, as the debate between 'neuromarketing' and 'consumer neuroscience' has made all too clear, the aims and possibilities associated with research in these two environments can sometimes be worlds apart (see Spence, 2019b, 2020, for reviews).

In terms of the coverage of interactions between the higher senses, the role played by attention is key. As such, one can consider just how much development in terms of our understanding of spatial attention in a multisensory context, even just an audiovisual context, has taken place in the years since the appearance of Spence and Driver's (2004) edited volume, *Crossmodal Space and Crossmodal Attention,* sixteen years ago (see also Calvert *et al.*, 2004). It is undoubtedly the case that the focus in *Multisensory Interactions in the Real World* is much more on the temporal side than on summarizing the finer points of spatial interactions. There is certainly lots of discussion on the theme of neural oscillations, and their role in temporal organization. There is also extensive discussion of the link between attention and integration in the context of multisensory perception, a debate that runs and runs.

Again, though, even within this narrow range of senses studied, the coverage of the developmental angle, e.g., the emergence and decline of multisensory perception, is given little to no attention (see Bremner *et al.*, 2012; Lewkowicz and Lickliter, 1994, for reviews of multisensory interactions in the context of human development). The focus, then, in Soto-Faraco *et al.*'s volume is squarely on the behavioural/neuronal processes underpinning multisensory integration in the normally-developed adult brain. Deficits in multisensory integration, and what some consider abnormal cases of integration, such as perhaps represented by the condition of synaesthesia, are not covered at all (see Cytowic and Eagleman, 2009; Simner and Hubbard, 2013, for cognitive neuroscience approaches to the latter condition). Similarly, there is virtually no discussion of the similarities and differences seen in those who have lost a sense, say those who are blind (see Bach-y-Rita, 1972). Issues of cortical plasticity do not really get a look in.

Comparing this volume with what might be considered the benchmark review of all things multisensory published a third of a century ago now by Welch and Warren (1986) is potentially instructive here. Certainly, given my own current interests in the crossmodal correspondences (see Spence, 2011, for a review), I am acutely aware of the absence of this topic in Welch and Warren's early work. Indeed, neither synaesthesia nor the correspondences are mentioned, at least not by name in Welch and Warren's authoritative early chapter. In Soto-Faraco *et al.*'s volume, by contrast, the crossmodal correspondences at least get a name-check. However, I would question whether the single brief paragraph devoted to the topic really captures the explosion of research on this topic over the last decade, even within the limited case of audiovisual attention research (e.g., Chiou and Rich, 2012, 2015; Klapetek *et al.*, 2012; Orchard-Mills *et al.*, 2013a, b, for a few empirical examples; and see Marks. 2004, for a review).

3. Just How Important is Space to Multisensory Interactions?

At around the time that Welch and Warren (1986) were writing, one can see the initial optimism about the single-cell neurophysiological level of analysis from early work on audiovisual interactions being reported in the superior colliculus (e.g., see Wickelgren, 1971). Shortly thereafter, however, there was also a sense that the 'rules' discovered at the level of the single cell in the anaesthetized animal might not make such clear predictions about what was happening at the level of the hopefully conscious subject, or as we nowadays like to call them, participant in a laboratory psychophysical, or cognitive neuroscience, study (see Regan and Spekreijse, 1977).

Related to this debate, one claim that is often found at the start of multisensory research papers, inspired by the research on the superior colliculus (SC) popularized by the work, and the many associated publications, of Barry Stein, Alex Meredith, and their colleagues at Wake Forest University over the last three decades or so (see Stein and Meredith, 1993, for a review), is that spatial coincidence is a crucial precondition for multisensory integration. As Soto-Faraco *et al.* (2003, p. 1849) once wrote: *"An extensive body of behavioral and neuroscience research has demonstrated that the most powerful multisensory integration effects occur when stimuli from different sensory modalities are presented from the same position at approximately the same time, and fall off as the spatial and/or temporal separation between the stimuli increases"*. In fact, as it turns out, the evidence mostly shows that this is not the case (see Spence, 2013, for a review). Or rather, spatial coincidence only seems to matter when space is somehow relevant to the participant's task. One might therefore have expected to find some mention of the conditions under which space is relevant to multisensory integration in this volume.

4. Is Audiovisual Speech Special?

This volume exhibits a strong focus on audiovisual integration in the case of speech perception. This makes sense, both in the sense of the lead author's prior career, where he has published extensively on the role of attention, and the temporal binding window, on multisensory integration in speech perception, and because both the ventriloquism illusion and the McGurk effect can be considered paradigm cases of multisensory integration (e.g., Alais and Burr, 2004; Jackson, 1953; McGurk and MacDonald, 1976; though see also Meijer, Veselič, Calafiore, and Noppeney, 2019). It also, I think, represents a change from the early days of multisensory research, at least in the context of the International Multisensory Research Forum (IMRF) where the speech researchers appeared to exist in a world apart from the multisensory research community (e.g., Massaro, 1987, 1998). At the same time, however, it should never be forgotten that some researchers have wanted to question whether speech may, in some way be special (e.g., Vatakis *et al.*, 2008). Soto-Faraco *et al.*'s volume would appear to place speech perception firmly within the remit, perhaps even at the centre, of contemporary multisensory research.

5. Comparing the Real World to the Laboratory

One of the most striking differences between the laboratory and the real world is that the body is very often in motion in the real world, whereas the majority of laboratory research, especially in the field of multisensory perception, tends to involve participants who are firmly instructed to remain static, not even moving their eyes during the course of a block of experimental trials. I did not see many examples of multisensory integration of information in those participants who were themselves either planning, or executing, a movement, despite this being stressed as an important topic in the introduction to this work. Importantly, our perception of space, or at least the neutrally represented boundaries between different regions of space, may be modified as a function of our movement, or ability to move (see Previc, 1998, 2000; Spence *et al.*, 2017).

One of the other salient differences between the laboratory and the real world is that the latter tends to present a much more complex array of inputs — just think of the proverbial cocktail party situation (e.g., Cherry, 1953). Here, though, the evidence reviewed in this volume shows that the cognitive neuroscience researchers have started to get a handle on the complexity of this situation in naturalistic lab conditions (e.g., Zion Golumbic *et al.*, 2013).

One of the classic applied situations in which information from different senses must be attended to, and where every millisecond really does matter, is driving (see Spence and Ho, 2015a, b, for reviews). A number of applied driving research papers, though mostly of the 'naturalistic laboratory research' variety, are discussed. However, other real-world situations where insights regarding multisensory warning signals might also be useful are not really discussed (see Baldwin *et al.*, 2012).

In my own research, for example, I have found that when taking the crossmodal exogenous spatial cuing paradigm (e.g., Lee and Spence, 2017; Spence *et al.*, 2017), frequently studied, and frequently replicated in frontal space in the lab, somewhat different rules appear to hold in rear space. In particular, sounds presented from the rear, just like those from the front, appear to direct people's visual attention to the front, this despite our participants having no difficulty localizing the rear sounds to the rear. This surprising result was certainly not predicted on the basis of any of the previous laboratory research. Note that the motivation for placing sounds behind our participants in this case came from a consideration of how to alert a driver crossmodally to what might be going on in their blind spot (see also Ho and Spence, 2009).

6. Similar Interactions across Different Modality Pairings?

One question of great interest to many researchers is the extent to which principles derived from one pair of modalities, such as audiovisual interactions, can be extended to the case of visuotactile or audiotactile interactions. That is, are the rules of integration amongst the spatial senses common, or are there some fundamental differences between the way in which the senses interact that may be based on physiology and/or use/practice that mean that what is found for one pair of senses, audition and vision, say, cannot necessarily be extended to another pair of senses, such as, for example, audition and touch? We learn little about such questions from this review of the literature, though the laboratory research clearly highlights a number of important differences between those parts of space that are visible and those that are not (Occelli *et al.*, 2011; Spence *et al.*, 2017).

7. Conclusions

Given the explosion of interest in multisensory interactions in recent years, it would be impossible for a slim volume such as this to cover the topic extensively. However, accepting the relatively narrow focus on audiovisual interactions in near-frontal space in neurologically healthy adults, what this volume undoubtedly achieves is a balanced and up-to-date review of the latest cognitive neuroscience research findings on the border between basic and applied research relating to issues of perception and attention.

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