RUNNING HEAD: THE NEUROSCIENCE BEHIND BEHAVIOUR

Comments & Reflections

Neuroscience-inspired design: From academic neuromarketing to commercially-relevant research

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ABSTRACT

Companies and organizations the world over wish to understand, predict, and ultimately to change, the behaviour of those whom they interact with, advise, or else provide services for: Be it the accident-prone driver out on the roads, the shopper bombarded by a myriad of alternative products on the supermarket shelf, or the growing proportion of the population who are clinically obese. The hope is that by understanding more about the mind, using recent advances in neuroscience, more effective interventions will be designed. But just what insights can a neuroscience-inspired approach offer over-and-above more traditional, not to mention contemporary, behavioural methods? This article focuses on three key areas: neuroergonomics, neuromarketing, and neurogastronomy. The utility of the neuroscience-inspired approach is illustrated with a number of concrete real-world examples. Practical challenges with commercial neuromarketing research, including the cost, timing, legality and access to scanners (in certain countries), and the limited ecological validity of the situations in which people are typically tested are also discussed. This commentary highlights a number of the key challenges associated with translating academic neuroscience research into commercial neuromarketing applications.

KEYWORDS: NEUROIMAGING; NEUROERGONOMICS; NEUROMARKETING; NEUROGASTRONOMY; NEUROSCIENCE-INSPIRED DESIGN

1. Introduction

Researchers have been using neuroscience techniques to facilitate their product development and marketing/advertising endeavours for decades (e.g., Krugman, 1971; Weinstein, 1981; Weinstein et al., 1984, for early examples). What is different, at the present time, is simply the sheer number of academic researchers, not to mention commercial neuromarketing companies, engaged in, or offering, neuroscience solutions to business. In fact, over the last decade or so, it has been estimated that more than 100 companies have sprung up around the globe offering some form of commercial neuromarketing service (Wall, 2013; Plassman et al., 2012, put the figure even higher at c. 150).

While there are currently a range of different brain-imaging techniques available for research in this area (including positron emission tomography - PET, electroencephalography - EEG, magnetoencephalography - MEG, etc; see Senior et al., 2007), in the majority of real-world cases, it is functional magnetic resonance imaging (fMRI), and to a lesser extent EEG, that has captured the interest of the business and marketing world (see Ariely & Berns, 2010, for a review). In fact, according to Kable (2011), 60-70% of all empirical studies that have applied neuroscience to the study of decision-making have used just one technique, fMRI. In part, this is presumably because of the colourful and intuitively appealing results that this technique can deliver (see also Beck, 2010; Keehner et al., 2011). No surprise, then, that as the popularity of neuroimaging has grown over the last decade or two, *'neuromania'*, to borrow Legrenzi and Umiltà's (2011) pejorative term, has swept through many areas of research and popular discourse.

1.1. On the power of persuasive brain images and neuroscience explanations

While it is often suggested that neuroimaging techniques such as fMRI help provide answers to specific business questions, colourful and scientific-looking brain images also serve a purpose in their own right within organizations as a powerful tool of persuasion. This is true regardless of the scientific value, or meaning, that such images may have. In fact, one often sees competing factions within an organization battling it out in terms of the most appropriate direction to take (for a new product launch, say). Those wielding the brain scans are often at something of an advantage relative to other groups brandishing more traditional forms of research data (think questionnaire, or focus group research; Catterall & Maclaran, 2006; Lunt, 1981; cf. O'Connor et al., 2012).

An oft-cited study by McCabe and Castel (2008) hints at just how persuasive brain images can be. These researchers demonstrated that even scientifically literate audiences (who should, presumably, know better) are more likely to believe an argument presented in a news story if it happens to be accompanied by a colourful brain-scan. Worryingly, this was true even if the brain image had nothing to do with the argument that was being made! That said, more recent research shows that claims regarding the seductive appeal of the colourful brain-scan may not be quite as strong as McCabe and Castel's early findings led many to believe (see Farah & Hook, 2013; Michael et al., 2013).

Elsewhere though, Weisberg et al. (2008) have demonstrated that arguments that have been given a neuroscience explanation (or spin) are judged more plausible than those that are not by novices and students alike. As O'Connor et al. (2012, p. 220) note: *"logically irrelevant neuroscience information imbues an argument with authoritative, scientific credibility"*. No wonder, then, the growing presence of neuroscience in the public domain. Worryingly, according to an analysis of almost 3,000 neuroscience articles that appeared in the British press in the opening decade of the 21st Century, media reports often distort and embellish the findings described in the underlying scientific research (O'Connor et al., 2012).

Given such findings, it should come as little surprise to find that critical appraisals of what neuroscience really tells us have also become more frequent. Some of the overstated claims of those who use neuroscience, and neuroscience-based explanations in the public domain, to theorize well beyond their own areas of expertise has recently come in for some vigorous, and well-deserved, scrutiny/attack (e.g., see Editorial, 2004a; Marcus, 2012; Quart, 2012; though see also Brammer, 2004). This backlash against *'brain porn'*, defined by Alissa Quart (2012) as the *"willingness to accept seemingly neuroscientific explanations for, well, nearly everything"* has taken place across a range of disciplines from politics to economics, and from literary theory through to neuroaesthetics. One particularly bruising public spat occurred when a group of neuroscientists and neuromarketers published the results of an fMRI study of a small number of 'swing voters' in the 2008 US elections as they responded to the leading presidential candidates (see Iacoboni et al., 2007). Scathing critiques of this research, which appeared in an op-ed (invited opinion) piece in *The New York Times*, were not long in coming. Some went so far as to compare it to modern-day phrenology (see Aron et al., 2007; Editorial, 2007).

1.2. On the problems of commercial neuromarketing

It is important to note that the new techniques of analysing the mind of the customer, consumer, or whoever else the target audience of a company or organization might happen to be, have their own constraints and limitations (e.g., see Javor et al., 2013; Senior & Lee, 2008, 2013; Lee, Senior, & Butler, 2011, 2012; Senior, Lee, & Butler, 2011, for detailed discussion of a number of these points). Some of the most salient of which include the not-inconsiderable cost (Ariely & Berns, 2010), the limited availability of scanners in many parts of the world (especially in the developing world), and the banning of commercial neuromarketing in certain countries (see Oullier, 2012; see also Eaton & Illes, 2007; Editorial, 2004b; Murphy, Illes, & Reiner, 2008). There is also a question-mark when it comes to the ecological validity of the isolated participant lying flat on their back, often with their head restrained, while subjected to loud background noise, inserted half-way down a narrow tube (e.g., Spence & Piqueras-Fiszman, 2014; Wall, 2013).

Another potential concern with many of the commercial neuromarketing studies that have been conducted to date concerns just how representative of society at large the small number of participants who typically take part in neuroscience research really are (though, of course,

a similar criticism can be levelled at much focus group research too). A few years ago, for instance, Henrich et al. (2010) highlighted how the majority of participants in psychological research are from societies that are WEIRD – that is, Western, Educated, Industrialized, Rich, and Democratic. Worse still, it has been estimated that somewhere in the region of 95% of all psychology research is conducted on North American psychology undergraduates (see Jones, 2010) – hardly the most representative sample, when it comes to marketing research (or any other kind of research for that matter). There would seem to be little reason to believe that the make-up of those taking part in neuroimaging experiments should necessarily be any different. Finally, there is also the potential public/media backlash to consider. Scare stories concerning big corporations prying into the minds of their consumers are never too far from the media's gaze. While such a putatively negative response is by no means restricted to the field of commercial neuromarketing (e.g., see Packard, 1957, for an early scare along these lines), the headlines suggesting that companies are peering inside their consumers' brain to try and find the 'buy button' typically don't go down all that well in the boardrooms of the companies that have been fingered. That said, corporate concerns regarding the reputational risk associated with this kind of criticism would seem to have declined somewhat in recent years.

More problematic than any of the above concerns, though, when it comes to commercial neuromarketing is the fact that, practically-speaking, the time-frame for conducting neuroimaging research often falls well outside of the tight deadlines that those working in the fields of marketing and product development typically have to operate within. Furthermore, while neuroimaging can provide a relatively clear answer to black-&-white questions, it is rather less well-suited to discriminating between shades of grey questions. And, very often, it is just those shades of grey questions that the marketing manager or product developer desperately wants an answer to. Given such problems, business leaders might well be forgiven for wondering whether the neuroimaging approach is really worth the effort (not to mention time and cost). One other worry here is the exceedingly small sample sizes that are sometimes used in published neuromarketing research (e.g., 3 participants in Ambler et al., 2000; 11 in Stoll et al., 2008; and 14 in Basso et al., 2014). This problem obviously being exacerbated by the fact that those participants were, anyway, most likely WEIRDo's (Henrich et al., 2010; Jones, 2010).

Over the years, one of the problems with many neuromarketing companies is that they have tended to make claims that are hard to evaluate independently. Too often, they offer their clients 'black box' solutions. "Go with solution B, not A or C," they say. When the client asks why, they will often be told that that is confidential information and hence that the methods used cannot be divulged. As Wall (2013) notes: *"the tendency of these companies to keep their methods secret also hampers serious evaluation"*. This would not necessarily be such a problem if it weren't for the fact that so many spurious claims are made on the basis of commercial neuromarketing techniques/approaches that could not give a reliable answer to the question posed (see Wall, 2013). As Oullier (2012) notes: *"That a technique is still in its infancy doesn't stop people from trying to sell it or from buying it. And damage can be done*

even if the victims of neuromarketing hype are not the general public but the gullible heads of companies who are being overcharged."

There have also been a number of well-documented cases where the commercial neuromarketers have gone beyond the conclusions that can legitimately be drawn from the data. As Eric du Plesssis (2011, p. 151) said of the sensationalist tone used to describe the findings of a $7 million study reported by Martin Lindstrom in his 2008 book *Buy-ology: How everything we believe about why we buy is wrong* in which more than 2000 people had their brains scanned: *"I have my doubts when any study concludes that neuroscience has now proved that everything we knew about behaviour is wrong."* (Lindstrom has also come in for some robust criticism from other quarters too; e.g., see http://www.russpoldrack.org/2011/10/nyt-editorial-fmri-complete-crap.html) Sometimes there is also a question-mark as to just how similar the situations and decisions that are modelled in the scanner environment are to those of real-life (Anonymous, 2005). For instance, having the participants in one's neuroimaging experiment make a judgment about which of a range of cars they see in pictures on a computer screen 'that they would buy' (Tusche et al., 2010) is obviously very far removed from someone actually going out to spend their hard-earned cash on a new vehicle (cf. Ariely & Berns, 2010).

1.3. On the need for new solutions

Given these problems with commercial neuromarketing, one might well start to wonder why the neuroscience approach to the study of consumer behaviour has become so popular in recent years. There are several answers here. On the one hand, across a range of sectors, the majority of the estimated 30,000 new consumer product launches each year fail. The actual figure is variously estimated to be around 70-80% (from market research performed in 1997 by Linton, Matysiak, & Wilkes Inc.; Crawford, 1977; Nielsen Monitor, 2011; Underhill, 1999, p. 163) all the way up to 95% (e.g., see Nobel 2011; Schneider & Hall, 2011; see also Robinson, 1998, p. 134; Zaltman, 2003, p. 3). As such, current/traditional methods clearly are not working. This is all the more worrying given the amount of money that is being spent: As Mast and Zaltmann (2005, p. 423) note: *"…in 2002, an estimated US$ 6.8 billion was spent on conventional marketing research tools in the United States alone. This is an enormous amount of money considering that there is little scientific evidence to support the widespread use of focus groups and growing concerns about the accuracy of other verbal report techniques."*

Various explanations for this exceedingly costly rate of attrition have been put forward over the years (Crawford, 1977), including the suggestion of inappropriate market segmentation (Nobel, 2011). However, especially relevant to the commercial neuromarketing theme discussed here is the suggestion that people may simply not want to say what they really believe, or more commonly, that they may not have particularly clear access to the drivers of their own behaviour (Blakeslee, 2004; Spence, 2009). Ogilvy pithily captured this sentiment in his oft-cited quote on advertising: *"The trouble with market research is that consumers*

don't think how they feel, they don't say what they think, and they don't do what they say." The hope, then, from the contemporary neuroscientists is that: *"Cognitive neuroscience techniques have great utility in market research and can provide more "honest" indicators of consumer preference where traditional methods such as focus groups can be unreliable."* (Senior et al., 2007, p. 153).

Of course, every new marketing technique comes with the promise that it will help bring down the number of new product failures. However, while it is possible to find in the literature post-hoc accounts of how commercial neuromarketing can help explain what has already happened, it is much harder to find examples of future successes being predicted *in advance* using such techniques (though see Jarrett, 2015). One explanation for this might be because such examples are kept under lock-and-key by the companies who funded the research in the first place. Alternatively, the scientific research journals simply might not find there to be enough 'theoretical meat' on those papers describing research that is too close to the real concerns of the marketplace. Despite all of the hype, there really haven't been all that many examples where the commercial neuromarketing (or consumer neuroscience) approach has led to long-term market success – success that could not have been predicted by behavioural techniques. One of the few examples that gets closest to what we are after here, by Gregory Berns and his colleagues will be described later (Berns et al., 2010; Berns & Moore, 2012).

Please do not get me wrong here. I am not an evangelistic neuroskeptic (e.g., see Power, 2008; Tallis, 2008a,b), although I am admittedly sometimes wheeled out to play that role (Spence, 2015). Rather, I am a strong proponent of the 'neuroscience-inspired approach to multisensory design' (Spence, 2012c; Wethey, 2013). It is clear to most people, I think, that neuroscience has made phenomenal progress in furthering our understanding the fundamental workings of the human mind in recent decades. What is more, neuroscience (here I am thinking specifically of academic neuromarketing research)[1] has delivered, and continues to deliver, worthwhile understanding of the basic mechanisms underlying many of our real-world behaviours (see Ariely & Berns, 2010; Yoon et al., 2012, for reviews). However, from a practical point-of-view, one should always ask whether neuroimaging solutions *per se* are strictly necessary, appropriate, or even practical. In the majority of commercial settings, the answer may well be no (see also Page & Raymond, 2007). Some combination of the various limitations highlighted above often mean that neuroimaging is not the key technique in problem solving or new product development, at least not in the commercial setting.

1.4. Neuroscience-inspired design

At one level, neuroscience research (what I will call academic neuromarketing) undoubtedly plays an important role in theory development in the area of consumer decision making (e.g.,

[1] Javor et al. (2013) argue for a somewhat different terminology: *"We argue for a differentiated terminology, naming commercial applications of neuroscientific methods 'neuromarketing' and scientific ones 'consumer neuroscience'."*

Ariely & Berns, 2010; Yoon et al., 2012). Ultimately, though, every company or organization is really interested in monitoring, predicting, and/or changing the behaviour of their target audience, be they customers, consumers, the general public or even other companies when it comes to business-to-business (B2B) interactions. Therefore the question that anyone who is toying with the idea of using neuroscience to try and understand the behaviour of their target audience should ask themselves is whether that behaviour change can't simply be measured more effectively, and possibly more cheaply, by actually observing some aspect of people's behaviour or assessing their opinions. Sure, people have problems verbalizing what they think, but a range of implicit behavioural tests are now available (Mast & Zaltman, 2005; Parise & Spence, 2012). More often than many companies realize, the most efficient solution may result from neuroscience-inspired behavioural testing rather than commercial neuromarketing *per se*. If what you are really interested in is people's behaviour, and how to navigate behaviour change more effectively, then surely you ought to be able to achieve that by studying behaviour in the first place (cf. Page & Raymond, 2007)? What relevant additional information exactly could knowing what is going on in the brain provide? Where neuroscience has provided useful insights it has normally come from relying on the research findings that are already out there in the public domain (in some cases, from published academic neuromarketing research), rather than on a particular company commissioning their own research from scratch. Note that the distinction (and gap) between academic and applied practice in the neurosciences has also been highlighted by Senior and Lee (2013).

Mast and Zaltman (2005, p. 426) are worth quoting at length here: *"The use of neuroimaging techniques in marketing contexts is very much in its infancy. Although very promising, a great deal of experimental work is required to determine what set of problems are best addressed using this approach and how neuroimaging techniques might best supplement existing methods. Neuroimaging does not generate hypotheses and to formulate interesting hypotheses, it is necessary to have a deep understanding of the issues involved in the research context. For this reason, it is likely that neuroimaging methods might best be used in areas where there is substantial knowledge already."*[2] Mast and Zaltman go on to cite McClure et al.'s (2004) famous study involving the blind versus sighted tasting of big name cola brands. They point out how this neuroimaging study built on an extensive pre-existing literature on branding and studies of blind and sighted taste tests (e.g., see Davis, 1987; Martin, 1990; Spence, 2010). That said, in recent years, researchers working in the field of neuromarketing have started to try and give the subject a firmer theoretical basis/framework to counter such criticisms (see Breiter et al., 2015; Plassmann et al., 2012; see also McGlone et al., 2013).

Ultimately, for anyone interested in understanding, predicting, and changing behaviour, what is of interest must ultimately be observable in terms of people's behaviour (Breiter et al., 2015; Falk et al., 2015). The majority of our work is inspired by the latest findings from cognitive neuroscience, although the research that we do is mostly behavioural in nature, often utilizing some form of implicit behavioural testing. The approach is perhaps best

[2] Though many would wish to dispute the claim that: "Neuroimaging does not generate hypotheses"

characterized as neuroscience-inspired design. In other words, the research from the cognitive neurosciences, broadly-defined, undoubtedly provides a host of useful ideas, insights, suggestions, theories, and methods that can often be fruitfully incorporated into the design of the study when one is trying to address a variety of real-world problems. What the cognitive neurosciences offer is really a range of cutting-edge techniques that have been finely honed to detect often-small behavioural effects (or differences) as robustly and efficiently as possible. As such, these techniques can play an important role in claims support. (Though note that such research rarely makes it into the journals.) The neuroscience not only provides techniques but can also provide relevant fundamental insights too (particularly in the area of academic neuromarketing).

1.5. Interim summary

To summarize, the solution to business problems very often involves seeking inspiration and insight from neuroscience research that has typically been conducted by others (often, but not always, this may be best characterized as academic neuromarketing). The findings of such research is then used to feed into the design of (neuroscience-inspired) behavioural tests that can be conducted within the relevant timeframe and budgetary constraints. This kind of solution would appear more valuable than that offered by the majority of commercial neuromarketing practitioners.

In the remainder of this article, we take a critical look at the growing interest in, and usefulness of, research on the neuroscience of behaviour (i.e., understanding how the brain does it) from a practical commercial point of view. Three real-world areas from the neuroscience of behaviour/perception are highlighted: neuroergonomics (Fafrowicz & Marek, 2007; Parasuraman, 2003; Spence, 2012a), neuromarketing (see Breiter et al., 2015; Legrenzi & Umiltà, 2011; Spence & Gallace, 2011; Spence et al., 2014), and neurogastronomy (Shepherd, 2006, 2012; Spence, 2012b, 2015). By the end, the benefits of the neuroscience-inspired approach to design, and by extension, to the modification of people's behaviour should hopefully be clear. Ultimately, knowing about the mind of one's customer or client has got to provide a competitive advantage in the marketplace. While the nature of that advantage is currently easier to see in certain sectors than in others, eventually, it will be true across the board.[3]

2. Neuroergonomics: On the neuroscience-inspired approach to interface design

The term neuroergonomics refers to the study of the neural circuits involved in people's interactions with interfaces (Fafrowicz & Marek, 2007; Parasuraman, 2003). The majority of the research in this area has been in the domain of driving (see Spence, 2012, for a review).

[3] Here, though, it is important to stress, once again, that while knowing about the mind of one's customers is undoubtedly potentially helpful, that does not necessarily mean that it is worth a company investing heavily in commercial neuromarketing research.

Indeed, in recent decades, researchers have started to investigate the network of brain areas that 'light-up' while people are driving or, more usually, while they are engaged in some form of simulated driving task (i.e., when driving in a video game/simulation; see Calhoun et al., 2002; Spiers & Maguire, 2007). One of the hopes of those working in this area has been that by gaining a better understanding of the mental state of the driver, it might be possible to modulate the delivery of warning signals, and other in-car alerts/information. So, for example, a drowsy older driver may well need a greater lead time than an attentive younger driver when responding to a warning signal. One of the key challenges here, at least while people are still driving cars (Markoff, 2011), is to make sure that any warning signals are presented with enough of a lead in order to allow the driver to update their behaviour, but not so far ahead of a potential danger that the warning signals give rise to 'cry wolf' phenomenon (see Ho & Spence, 2008). There is a constant arms race between the delivery of ever more technology that may potentially distract the driver, and the growing use of new technologies to warn of the danger of impending danger on the road ahead (e.g., Ashley, 2001; Hudson, 2013; Vlasic, 2008).

Many of the car companies have been interested in analysing the neural signatures associated with specific driving behaviours. Some, for instance, have investigated how much useful information can be derived from drivers wearing a cap to measure their electrophysiologcal responses while on the road (e.g., Anon., 2005; Harlow, 2011). Meanwhile, a helmet developed by Honda a few years ago allowed drivers to execute one of four commands using direct neural control (Harlow, 2011). The difference here from commercial neuromarketing, say, is that the large sums of money involved, and the relatively slow rate of progress, are not necessarily such limiting factors when it comes to research in the field of neuroergonomics. That is, the car companies are used to spending huge sums on research and the timelines tend not to be as punishing as in the world of marketing.

A few years ago, Toyota wanted to know whether it was possible to: *"Demonstrate that cognitive neuroscience can help to design multisensory warning signals for drivers that are significantly better than a smart (i.e., intuitive) engineer can come up with."* The inspiration for the research addressing this question came from neurophysiological findings reported at the single-cell level (Stein & Meredith, 1993). In particular, key neuroscience rules underpinning multisensory integration that have been incorporated into recommendations for the design of more effective warning signals include everything from the beneficial effects of spatial co-location (e.g., Ho & Spence, 2008; Spence & Driver, 2004; see also Liu & Jhuang, 2012), temporal synchrony, or perhaps slight asynchrony (e.g., Spence & Driver, 1999; Chan & Chan, 2006). There has also been interest in the breakthrough of multisensory (as compared to unisensory) warning signals, at least when the component unisensory signals happen to be presented from the same spatial location, or direction, at more or less the same time (see Spence, 2010b, for a review). Importantly, none of these principles/solutions would appear to have been picked-up intuitively by the engineers working on the design of warning signals (Spence & Ho, 2008; Spence & Read, 2003).

Another relevant insight emerging from the basic neuroscience research conducted over the last decade or so relates to the discovery of specialized brain circuits that monitor the space

just behind the head (see Occelli et al., 2011, for a review): This is the space that we do not see, at least not directly (and that we rarely think about). Interestingly, researchers have demonstrated that placing an auditory warning signal in this region of near-rear peripersonal space results in faster head-turning responses by drivers in the laboratory and also, more importantly, in the driving simulator than when the same or other modality warning signal is presented in frontal space (Ho & Spence, 2009; Spence, 2012). Note that this counts as an example of neuroscience-inspired design: That is, the discovery by neuroscientists of these specialized brain circuits preceded, and subsequently prompted, the applied behavioural research. It would not have been practical, or, for that matter, financially viable, for the car company concerned to pay for the underlying brain research in the search for such neural circuits that could one day feed into the design of enhanced warning signals for car drivers.[4] However, it was eminently sensible for the applied researchers to piggyback on the emerging neuroscience insights that were appearing in the scientific journals. The practical challenge (this time for the engineer) was to try and figure out how those findings could be used to aid in the development of more efficient warning signals. In this case, Toyota were unable to capitalize on the insights by developing a new piece of headrest-mounted technology that they could protect, and by so doing, protect the bit of space behind the driver's head that our research had highlighted to be so interesting. Nevertheless, other vehicle manufacturers (e.g., Volvo) have now started to present auditory information via the headrest (see http://apps.volvotrucks.com/launch/fhfm/en-gb/downloads/FH_image.pdf, p. 27).

Over the last decade or so, the neuroscience-inspired approach has also been applied to the design of a variety of other user interfaces (Baldwin et al., 2012), including those used by pilots (Previc, 2000) and those used in air-traffic control (Ngo et al., 2012). One day the same neuroscience-inspired insights might well be applied to enable traders to respond more rapidly on the trading floor too. What all of these various situations have in common is that every millisecond counts: Just take the following quote from an article that appeared in the magazine Information Week: *"A 1-millisecond advantage in trading applications can be worth $100 million a year to a major brokerage firm."* (Martin, 2007). Hence, in conclusion, it can be argued that knowing about the mind of the interface operator, no matter whether they be on the road, in the air, or on the trading floor, can potentially lead to enhanced neuroscience-inspired design solutions (see Spence, 2012).[5]

3. Neuromarketing: Sensory marketing & multisensory product design

[4] Furthermore, given that the underpinning research was conducted at the single-cell level in monkeys, there would potentially have been an extra level of negative fall-out from the animal rights lobby had too much information leaked out into the public domain.

[5] One other example of the neuroscience-inspired approach that falls broadly within this area concerns the recent development of a novel range of bike lights designed to promote safer behaviour from drivers (see Ho et al., submitted). In the underpinning research, a series of laboratory-based experiments was conducted to demonstrate how bike lights in the image of a cyclist, seen side on, effectively primed the appropriate notions in the mind of drivers; A much needed solution for those drivers who have yet to purchase one of those cars that automatically hits the brakes when it detects a cyclist veering into the car's path (see Massey, 2013).

The number of commercial neuromarketing volumes out there on the marketing shelves has grown rapidly in recent years (e.g., see Lindstrom, 2008; Pradeep, 2010; Renvoisé & Morin, 2007). A quick look at the back cover of these books reveals that the authors promise revolutionary new techniques that 'speak to the old brain' (Renvoisé & Morin, 2007), show the reader how to press the 'buy button' in their customer's brain (Lindstrom, 2008; Renvoisé & Morin, 2007; though see also Blakeslee, 2004; Hubert & Kenning, 2008; Lee et al., 2007), or else reveal the secrets for selling to the subconscious mind (Pradeep, 2010). Or take the following from a Millward Brown study conducted on behalf of the Royal Mail which apparently showed that physical media (i.e., as opposed to digital) generated 'deeper' brain activity (if only one knew what that means, or whether or not it is a good thing! Millward Brown, 2009). There can be no doubt though that consumer neuroscience is big business (Hubert & Kenning, 2008). Nowadays, the term 'neuromarketing' itself covers a number of distinct areas of research, including the study of advertising effectiveness, product design (what some call *neurodesign*; Legrenzi & Umiltà, 2011), neuromerchandizing (Roper, 2014), etc. (see Breiter et al., 2015). In the following sections, we will briefly take a look at a few of these areas.

3.1. Neurodesign

Over the last three or four decades, there has been a steady trickle of interest in the use of neuroimaging in the field of packaging design (e.g., Basso et al., 2014; Stoll et al. 2008; Weinstein 1981). However, given what is in the public domain, there is not really much in the way of actionable insights here. That is, the neural insights rarely seem to go much beyond what has already been provided by the behavioural data (cf. Page & Raymond, 2007). What is more, and as already noted, the sample sizes used in many of the studies in this area are often very small. Furthermore, additional challenges arise as soon as the participant is required to open/interact physically with the packaging, say. Note that neuroimaging techniques typically require the researcher to average over many repetitions of the same stimulus in order to eliminate some of the noise that is inherent in the neural signal (Wall, 2013). Forcing the participant lying passively in the brain scanner to repeatedly try and make the same stereotypical gesture will obviously result in any surprise associated with a novel packaging format soon wearing off.

Much more promising when it comes to neurodesign is the use of the various cognitive-neuroscience inspired approaches (what Senior et al., 2007, call "neuro" techniques). These include everything from the growing use of eye-tracking (e.g., Blazquez et al., 2015; Clement, 2007; Gofman et al., 2009; Juravle et al., 2015; Piqueras-Fiszman et al., 2013; Wedel & Pieters, 2007) through to the latest in behavioural tasks such as modified versions of the Implicit Association Test (e.g., Maison et al., 2004; Parise & Spence, 2012). The suggestion from those working in the field is that such neuroscience-inspired implicit behavioural testing approaches effectively overcome many of the limitations associated with subjective report (Mast & Zaltman, 2005).

Oftentimes, the converging methodologies approach represents the most desirable solution (Anonymous, 2015; Kenning & Plassmann, 2008; Mast & Zaltman, 2005; Salgado-Montejo et al., 2013; Schaefer & Rotte, 2010), assuming, that is, that the various different approaches end-up converging on a common solution/conclusion. After all, it can sometimes be difficult to know quite how to interpret eye-fixation data when this response measure is presented in isolation – i.e., is a shorter or longer fixation duration desirable? However, when eye-tracking data is combined with the results of other measures, such as grasping data (see Juravle et al., 2015), or top-of-mind techniques, such as Word Analysis (Piqueras-Fiszman et al., 2013), then it can help packaging and graphic designers to think differently about what they are trying to achieve and which of a range of different design alternatives best meets those objectives (or a given design brief).

3.2. Neuroscience-inspired design

Over the years, designers, or marketers, have sometimes intuitively picked-up on an effective means of modifying people's product perception, preference, or choice (e.g., Cheskin, 1957). However, without the neuroscience underpinning, they have not known why, nor how their specific finding could potentially be extended to deliver more general suggestions that work across a range of product categories (see Batra et al., 2015; Spence, 2012d). Researchers have, for example, been working on generalizing neuroscience explanations for observations such as that people do not like products as much when they point toward them or else point downward (Shen et al., 2015; Velasco et al., 2015b), or that people seem to engage more with those packages or products that appear to be smiling at them (Salgado-Montejo et al., 2015). The neuroscience-inspired approach is also increasingly being used in the design of logos and labels (see Batra et al., 2015; Salgado-Montejo et al., 2014; Spence, 2012d). Such neuroscience-based insights are now starting to deliver actionable guidelines for business. Furthermore, in some cases, these insights are already impacting the design of products that one finds on the supermarket shelves (Spence & Zampini, 2007). Before too long, they will likely be impacting the field of typeface design as well (Velasco et al., 2015a).

There is growing interest in the area of embodied mental simulation (Elder & Krishna, 2012), and the ways in which food products can be presented on product packaging in order to appear more appealing to the consumer. In these cases, 'knowing how the brain does it' or establishing the backstory underlying people's preferences allows the researcher to extend their insights regarding how to enhance the consumer proposition from one product category to another (e.g., Spence, 2012d; Velasco et al., 2015b). There is also scope to use the growing neuroscience understanding of sound symbolism and naming in order to enhance one's product offering (e.g., Abel & Glinert, 2008; Alter & Oppenheiner, 2008).

3.3. Internet-based testing

While much of the development in consumer neuroscience, and neuroscience-inspired design has taken place in the laboratory, the emergence of online testing platforms such as Mechanical Turk and Prolific Academic offer a great resource for large-scale consumer testing (see Woods et al., 2015, for a review). At a stroke, the behavioural researcher can drastically increase their sample size simply by moving their research online. What is more, solutions can be delivered in a relatively short time-frame and potentially at a fraction of the cost of laboratory-based or neuroimaging research. Another aspect of the internet-based testing approach that can be seen either as a benefit, or as a limitation, is that very often the participants in such studies perform the allocated task in the comfort of their own homes. What such testing scenarios obviously lose in terms of highly-controlled stimulus presentation (as captured by laboratory research), they make up for this in terms of enhanced ecological validity (see Woods et al., 2015; though see also Harford, 2015). Some of the possibilities associated with crowd-sourced research that are especially exciting include everything from the large-scale analysis of visual saliency by tracking the eye position of those sitting in front of a camera-enabled computer (Xu, et al., 2015) through to the remote monitoring and assessment of people's emotional responses (e.g., to assess advertising effectiveness; see http://www.nviso.ch/).

3.4. From academic to commercial neuromarketing

Over the last decade or so, a number of neuroimaging studies have highlighted key structures underlying the various stages of neural processing associated with product evaluation and purchase decisions, for everything from cars (Erk et al., 2002) through to expensive boxes of chocolates (Knutson et al., 2007; see also Plassman et al., 2007). So, for instance, in one oft-cited study, Knutson et al. demonstrated that excessive prices activate the insula while at the same time leading to a deactivation of the medial prefrontal cortex (mPFC) prior to a purchasing decision being made (see also Dagher, 2007). There has also been a great deal of interest in how branding and pricing information affects the neural response (e.g., Plassman et al., 2008, 2012; Plassmann & Weber, 2015; Schaefer, & Rotte, 2007; Venkatraman et al., 2012). Meanwhile, in another intriguing study, Yoon et al. (2006) used fMRI to assess whether similar neural substrates underlie person and brand judgments. Their results suggested that in contrast to the common view held in the marketing literature at the time, different neural correlates are associated with judgments of people vs. brands/products. Specifically, greater activation was seen in mPFC when participants were making semantic judgments concerning people, whereas greater activation was documented in left inferior PFC when participants made semantic judgments concerning products instead. It can be argued that such results provide useful 'neuro' evidence against the 'brand as personality' metaphor.

When it comes to changing people's behaviour, perhaps the best solution is to be able to predict it. As Ariely and Berns (2010, p. 287) note *"for real-world marketing applications, it may be more important to predict future behaviour than to understand the 'why' of behaviour."* In one nice example, Berns et al. (2010) demonstrated that the neural responses of a small number of adolescents (N=32) at one point in time to songs from largely unknown

artists predicted population purchase behaviour several years later. In particular, these researchers collected behavioural measures of the preferences and neural responses of a group of adolescents while listening to 15-s clips of songs downloaded from the site http://MySpace.com (a repository of unbranded and unadvertised music). The adolescents' 'liking' ratings for the songs correlated highly with activity in the caudate nucleus (a part of the brain that has been implicated in reward and valuation). Berns et al. also reported that the tendency amongst those they studied to change their evaluations of a song in line with its popularity (i.e., as a function of the ratings of the peer group) was positively correlated with activation in the anterior insula and anterior cingulate cortex (ACC).

Subsequently, Berns and Moore (2012) went on to show that the individual neural responses (in the orbitofrontal cortex - OFC and nucleus accumbens - NAcc) to the songs in their initial study could be used to predict purchase decisions by the general population assessed via the total number of units sold several years later. Importantly, in this case, subjective reports made in the earlier study did not predict sales success in the later epoch. While not a practical commercial example, these studies (Berns et al., 2010; Berns & Moore, 2012) nevertheless do hint at the potential use of extracting neural predictors from a small number of scanned individuals to infer the consumer response. In particular, while subjective ratings of liking of the songs did not predict future sales, activity in the ventral striatum/NAcc did.

That said, it would have been a brave investor who placed their bets on future sales based on the neuroscience data (weighing it more highly than the subjective report data collected at the time). Indeed, no matter the success of the neuromarketing approach, a more fundamental problem limiting the uptake and growing influence of any of these new approaches/technologies is that, as of last year, when questioned, half of marketers still admitted that they went with their gut feel when deciding where to spend their marketing budget (Anonymous, 2014). And, of course, even if neuroimaging data should prove to be a better predictor than actual behaviour, that doesn't mean that some other behavioural indicator, such as, for example, people's Web search behaviour might not turn out to be better still (Goel et al., 2010). One could also argue that perhaps the liking question asked of participants in Berns and colleagues' (2010) study was simply not precise enough to predict future sales success. Thus, while definitely moving things in the right direction, this research still falls some way short of practical predictive, or prospective, neuroscience. Wall (2013) makes a very similar point when he states that: *"There is currently very little data about whether EEG-derived measures actually have any effect in the real world (e.g., predict anything at all about buying decisions)".*[6]

In another intriguing study, Tusche et al. (2010) presented a group of participants (N=32) with a series of pictures of different cars while lying in the fMRI brain-scanner. The participants either had to perform a visual fixation task (this was the low-attention group) or else they had to rate their liking for each of the cars (the high-attention group). Subsequently, and unexpectedly, all of the participants were asked to rate their willingness to purchase the cars. Multivariate analysis of the data highlighted those brain regions whose activity

[6] Here, though it is perhaps worth taking a look at Haynes and Rees (2006).

predicted subsequent purchase intent in the two groups. The results revealed that distributed activation patterns in the insula and medial prefrontal cortex (mPFC) reliably encoded (i.e., could be used to predict) subsequent choices in both the low- and high-attention groups. That such results should have been obtained when the participants were not really attending to the car pictures, and under conditions where they were not aware that they would be subsequently asked to make a willingness-to-purchase decision, is certainly interesting. That said, no cars were actually purchased in this study, and so all we can say with any degree of certainty is that self-reported willingness-to-purchase judgments were correlated with activity in certain brain areas (cf. Tusche et al., 2010, p. 8030, on this point).[7] Nevertheless, there are those (e.g., Ariely & Berns, 2010; Plassmann et al., 2012) who believe that the increasing use of such neural pattern classification techniques and multivariate decoding analysis (of e.g., fMRI data) will revolutionize consumer neuroscience research. Let's wait and see.

Much of the work that has been published in the area of neuromarketing (e.g., Ambler et al., 2000; McClure et al., 2004) has more of a theoretical feel than actually having been commissioned to answer a pressing business need (that is, it is more academic than commercial neuromarketing). Furthermore, as Plassman et al. (2012) note, the problem of reverse inference is widespread in much of the consumer neuroscience literature. That is, researchers and neuromarketing companies alike have all-too-often ended-up inferring that a particular neural process, like, attention or memory, is involved in a given situation because a particular part of the brain, lights-up. Or, as Wall (2013) puts it: *"An experimenter might observe a change in the EEG signal and infer that this means the participant is paying more attention. Unfortunately, logically this doesn't work."* Ultimately, my feeling is that neuroimaging is likely to be more useful for something like advertising than for the field of multisensory packaging design. The passive viewing of adverts would certainly seem much more similar to the environment of the participants lying prone in the brain scanner or even sitting upright in a MEG scanner (e.g., Ambler et al., 2000; Astolfi et al., 2008; du Plessis, 2007, 2011; Kato et al., 2009; Rossiter et al., 2001).

3.5. Interim summary

In conclusion, given the evidence reviewed in this section, it can be argued that while a great deal of money has been spent by companies on commercial neuromarketing, the benefits do not always justify the cost. Page and Raymond (2007, p. 132) noted that: *"…brain scanning technologies such as fMRI and EEG are fantastic at illustrating how the brain works, but the leap from that to creating better marketing is a big one. It is not a given that these techniques will be better than 'conventional' market research."* And ultimately, if you want to change people's behaviour, behavioural assessment techniques ought to be capable of providing solutions. Such behavioural solutions will increasingly come to be inspired by, and based on, the known neuroscience, but they will likely remain behavioural. Indeed, a growing number

[7] Though, that said, the key brain areas highlighted in Tusche et al.'s study are pretty similar to those identified by Knutson et al. (2007).

of neuromarketing companies who entice their clients with the promise of unpicking the mind of their consumers, only for them to end up offering a neuroscience-inspired behavioural solution. That being said, some of the latest findings to have emerged in the literature have certainly got some of the commentators suggesting that the era of genuinely useful neuromarketing research might finally be upon us (see Jarrett, 2015).

4. The era of predictive neuromarketing

A couple of recent studies have demonstrated that brain scans can be used to help predict future consumer behaviour. In one, Salk et al. (2015) demonstrated that neuroimaging data could be used to help predict whether those reading an anti-smoking email would end-up clicking on a link that took them to a website offering advice on quitting or not. That is, neural evidence obtained in a small group of participants (N = 50), specifically activation in a 'self-localizer' defined region within mPFC was capable of predicting the population response (N = 400,000 individuals who received an email). In the other study, neuroimaging helped predict the box-office success of movies (Boksem & Smidts, 2015). Although both studies were published retrospectively (i.e., once the outcome was already known), taken together they do start to hint at how neuroimaging evidence might, one day be used in a genuinely predictive manner when trying to assess the likely success or failure of a planned intervention in the marketplace.

Crucially, Salk et al. (2015) demonstrated that by adding in the neuroimaging data they were able to explain 65% of the variability in the results as compared to just 38% of variability in terms of people's (N=63) click-through rates on the emails being explained by the results of an MTurk online survey. Assuming that the right questions were asked in the MTurk survey then such neuroimaging results are potentially exciting. Note, though, how it is the converging methodologies approach that proved most useful here. That is, no one is suggesting, at least not yet, that neuroimaging will completely replace other behavioural techniques. Rather the suggestion is that under the appropriate conditions it can provide a useful source of additional data.

Meanwhile, in the other study, Boksem and Smidts (2015) had 29 participants view a number of movie trailers for films that they hadn't yet seen. They rated how much they thought that they would like the films and how much they would have been willing-to-pay (WTP) for the DVD. EEG was also recorded. Analysis of the WTP data only helped to explain 1% of difference between actual box office receipts of the best- and worse-performing films. However, adding data from the modulation of gamma brain waves (that seem to correlate with enjoyment) tripled how much of the real-world data could be predicted. Now, of course, here one can always wonder as to whether WTP is really the most appropriate behavioural measure, given that good/successful movies don't cost any more at box office. The authors argued that while predicting only 3% of the variance might not sound like a lot, given the vast sums involved, every little helps. One final point to note about both of these studies is the

modest sample sizes used (N = 50 in Falk et al., 2015; and N = 29 in Boksem and Smidts) as compared to what one normally sees in audience/consumer research.

5. Neurogastronomy

Neurogastronomy is the term used to refer to the brain on food (e.g., Shepherd, 2006, 2012; Spence, 2012b; Toepel et al., 2015). As yet, the majority of the published research in this area has tended to be at the more academic rather than commercial end of the neuromarketing spectrum – what Javor et al (2013) call consumer neuroscience rather than neuromarketing. There are undoubtedly a number of important questions in this field: Everything from assessing the impact of branding, pricing, organic labels, and descriptive labels on people's response to foods and beverages through to a consideration of what, if anything is different about the brains of obese individuals (or others suffering from some form of eating disorder)? It is certainly clear that we need new ideas when it comes to trying to understand why society is currently having so little success in fighting the global obesity crisis. Indeed, as Shepherd (2012, p. 233) puts it: *"A possible advantage of a new term like neurogastronomy is that it can help focus public policy more effectively in applying advances in brain science to issues related to food and flavour."*

It has been known for years that branding, pricing, and other forms of product-extrinsic information changes what people say about what they taste (see Davis, 1987; Martin, 1990; Spence, 2010a). What has never been clear, though, at least not until recently, is whether such information really changed the taste of the food, or merely what people chose to say about the taste? The classic experiment on the neural substrates of branding was conducted by McClure et al. (2004). The participants in this oft-cited academic neuromarketing study had their brains scanned while a cola drink (either Coke or Pepsi) was periodically squirted in their mouth while different visual information concerning the brand of cola that they were apparently tasting was projected onto a screen. Under blind tasting conditions, ventromedial prefrontal cortex activity was found to correlate with the participants' behavioural preference. Qualitatively different patterns of brain activation were, however, observed depending on which brand of cola the participants thought that they were tasting. On being led to believe that they were tasting Coke, increased activation was observed in the hippocampus, dorsolateral prefrontal cortex, and midbrain.

In a more recent follow-up, Kühn and Gallinat (2013) observed greater activation in the left ventral striatum when their participants believed that the cola that they were tasting was a strong rather than a weak brand (e.g., Coke or Pepsi versus a national or fictitious brand). Intriguingly, this effect was stronger in those participants who drank cola infrequently, possibly pointing to a greater reliance on brand cues in less experienced consumers (see Plassmann, et al., 2012, for a review of the consumer neuroscience literature on branding). Meanwhile, Linder et al. (2010) have demonstrated that labelling a food as organic led to increased activity in the ventral striatum, a part of the brain that is involved in controlling the motivation to acquire and eat food.

Neuroscientists working over in California investigated what would happen in the brain of social wine drinkers (students) when they were given different, and sometimes misleading, information about the price of red wine (Plassmann et al., 2008). A $5 bottle of wine was either correctly described in terms of its price, or else was mislabelled as costing $45 a bottle. Another bottle of wine actually cost $90 and was either described as a $10 wine or as a $90 wine. The third wine was correctly referred to as a $35 wine. The price was displayed on a computer monitor whenever a small amount of wine was squirted into the participant's mouth. On some trials, the participants had to rate the intensity of the wine's taste on a 6-point scale, whilst on other trials they rated its pleasantness instead. Sometimes, no behavioural response was required. While flavour intensity was not influenced by the price information, participants reported liking the wine more when labelled as expensive than when labelled as a cheaper wine (see also Plassmann & Weber, 2015).

Crucially, analysis of participants' brain scans revealed increased blood flow in the mOFC in those trials in which a higher wine price was shown. While such results are clearly of theoretical import when it comes to understanding how product-extrinsic cues change the consumer's response to food and beverages, it is perhaps less clear as to whether any company would really be willing to pay for the results of a study such as that conducted by McClure et al. (2004). What these and many other neuroimaging studies clearly do show, though, is that branding, labelling, and pricing information can give rise to changes in neural activation in some of the earliest brain areas coding the sensory-discriminative and hedonic aspects of gustatory, olfactory, and flavour information (see Spence, 2015, for a review). Undoubtedly, such results are of interest to the research scientist; what is less clear, is whether such results would satisfy (i.e., count as value for money) the food and beverage companies concerned. (Once again, we are back to the distinction between academic and commercial neuromarketing.)

I would like to end this section by looking at the results of a few of the studies that have addressed the question of how the brain of those with some form of eating disorder (such as, for example obesity) may differ when presented with (normally visual food cues) as compared to the brain of a normal weight individual (see Petit et al., 2011; Spence et al., 2015). For example, those individuals who suffer from binge-eating disorder and bulimia exhibit greater reward sensitivity, brain activation, and arousal, in response to viewing images of pleasant foods (Schienle et al., 2009). By contrast, obese individuals exhibit significantly less activation of the reward-related brain areas in response to food consumption than do normal weight individuals. Such a pattern of results suggests that those who are obese may anticipate more reward from food intake while, at the same time, experiencing less sensory pleasure from eating (Stice et al., 2008). In other research, obese individuals exhibited increased visual attention to food images as compared to normal weight individuals (e.g., Castellanos et al., 2009; see also Spence et al., 2015, for a review; see also Petit et al., submitted). Obese individuals also appear to be more sensitive to the expected pleasure of consumption than are non-obese individuals (Berridge et al., 2010; Petit et al., 2011; Pursey

et al., 2014).[8] In conclusion, academic neurogastronomy research has already provided a number of intriguing insights that will, no doubt, soon bepicked up by commercial neuromarketing, if they haven't done so already!

6. Conclusions

In conclusion, it is time to return to the question of whether the neuroscience approach to understanding the mind and behaviour of the consumer really lives up to the hype (see Legrenzi & Umiltà, 2011). Under a small subset of conditions, it does. That said, it is fair to say that the excitement over the neuroimaging approach (specifically commercial neuromarketing) seen a decade ago has waned somewhat in recent years. There are clearly certain questions that behavioural techniques, even neuro-inspired behavioural techniques, simply cannot answer. The fundamental problems limiting the more widespread uptake of neuroimaging techniques by business (what has been labelled here as commercial neuromarketing) includes the time required to reach an answer, the expense involved, and the sheer number of participants that may be required to answer the shades of grey questions. There are also more mundane, but no less limiting day-to-day issues concerning the legality and ethics of commercial neuromarketing (see Oullier, 2012; Stanton, Sinnott-Armstrong, & Huettel, 2016). Furthermore, the lack of widespread access to the latest neuroimaging techniques in many emerging economies is also currently a major constraint for companies around the world. Finally, there is also very real potential for consumer/press backlash (e.g., see http://www.dailymotion.com/video/xr6cos_neuromarketing-votre-cerveau-les-interesse-1-2_news for one media sting that caught up a number of those working in the field a few years ago). Given the potential negative press coverage, it should not come as any surprise that many of the companies who utilize commercial neuromarketing have been understandably reticent to have that information out there in the public domain.

Looking forward, excitement surrounds the possible use of neuroimaging to segment groups of consumers based on their differing patterns of brain activation (see Plassmann & Weber, 2015; Yoon et al., 2012). The hope is that one day, neuroimaging techniques could be used to account for some of the heterogeneity of consumer behaviour that is so often seen in the marketplace. In terms of the implications for marketing practice, it is worth noting that commercial neuroimaging is getting cheaper, neuroimaging facilities are slowly becoming more widely available, statistical analysis techniques are continually improving, and the body of background knowledge (largely from published academic neuromarketing, or consumer neuroscience research) ever larger and more sophisticated. All of which ought to suggest a growing utility of commercial neuromarketing in the future (e.g., Smidts et al., 2014).

[8] One ethical concern in this area is that companies might use neuroimaging in order to develop what Ariely and Berns (2010, p. 289) describe as *"a 'super-heroin of food' – a product so delicious that all but the most ascetic individuals would find it irresistible."* However, we are still quite some way from such a point. And again, it is unclear whether neuroimaging would necessarily deliver such a solution, if it even exists, any faster than other neuroscience-inspired techniques.

While neuroscience has undoubtedly made great steps forward in recent years (Ariely & Berns, 2010), the interface with business, and the concerns of big business continues to be challenging. The neuroscience-inspired (multisensory design) approach constitutes one of the more fruitful approaches in this area. By adapting the tools, techniques, methods, and understandings that have emerged, and continue to emerge, from the field of academic cognitive neuroscience research, broadly defined, it is possible to help address real-world business problems concerning people's behaviour, in a realistic timeframe, at an affordable cost, and ideally in a manner that is scalable. As Ariely and Berns (2010, p. 287) note: *"If neuromarketing is to compete with conventional marketing approaches on the basis of efficiency,"* in the years ahead *"then the costs of labour and overheads will have to be reduced."* Elsewhere, they state that: *"It is not yet clear whether neuroimaging provides better data [than] other marketing methods."* The same basic approach can be used no matter whether we are dealing with the neuroscience-inspired design of multisensory warning signals for car drivers (Ho & Spence, 2009; Spence, 2012), trying to advise companies on the future design of their product packaging (Juravle et al., 2015; Parise & Spence, 2012; Spence & Zampini, 2007), or considering the design of more effective/healthy foods (Spence et al., 2015).

Ultimately, perhaps the most parsimonious line here is not to frame consumer neuroscience as a fundamental challenge to more traditional behavioural research methods, but rather as a complementary approach (Hubert & Kenning, 2008). Navigating the converging methodologies approach to applied research (be it in the area of organizational research, or elsewhere; see Becker & Cropanzano, 2010; Halvorson & Rock, 2015; Lee & Chamberlain, 2007; Powell & Puccinelli, 2012; Rock & Schwartz, 2007), and bringing traditional approaches to analysing consumer behaviour into the 21st century is a challenge that will likely keep many of those working in the field busy in the years to come. The argument put forward here is that we will likely make most robust progress if we keep the distinction between academic and commercial neuromarketing clear.

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