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THIS IS YOUR BRAIN ON NEUROMARKETING: REFLECTIONS ON A DECADE OF RESEARCH

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In 2007, two of this present author team published one of the first academic papers to mention the term 'neuromarketing' (Lee, Broderick, and Chamberlain, 2007). Whether that paper, or the one of Fugate (2007), was actually the first to use the term in a published scholarly article (although Smidts did use the term in his 2002 address to the Erasmus Institute of Management) is less important than the clear conclusion that we are now around a decade on from the earliest attempts to provide some kind of coalescing of the various diverse strands of then-existing work, into what could pass as an embryonic 'field of research'. Before then, marketing-relevant work had appeared across various different disciplinary boundaries, sometimes in marketing journals (e.g. Ambler et al., 2004), sometimes in economics or decision science (e.g. Camerer, Loewenstein, and Prelec, 2005), and sometimes in neuroscience itself (Braeutigam et al., 2001).

Since 2007 however, the last decade has seen, if not quite an explosion, then certainly a major upsurge in neuromarketing research in the marketing literature. From a point in 2007 where Lee, Broderick, and Chamberlain felt able to point out a "lack of take-up of brain imaging methodologies in marketing science" (p. 199), we are now in a situation where a special issue of one of our discipline's top research journals has been dedicated to neuromarketing (Camerer and Yoon, 2015), and it is no longer unusual to see individual studies appearing in the marketing literature that use neuroscientific methods. Conference sessions are regularly held to discuss neuromarketing issues (e.g. Reimann, Hedgcock, and Craig, 2016), and agendas for work in the area appear on a non-infrequent basis (e.g. Hubert and Kenning, 2008; Reimann et al., 2011; Smidts et al, 2014; Solnais et al., 2012). Indeed,

neuromarketing, and its associated term 'consumer neuroscience' (e.g. Javor et al., 2013; Kenning and Linzmajer, 2011; Plassmann, et al., 2015), have become increasingly popular topics of both empirical research, and conceptual theorizing. It seems opportune at this point then, to step back and take some stock of whether or not the promise identified in early neuromarketing papers has been fulfilled.

In this commentary, we reflect on the last decade of research in what we loosely define as the neuromarketing field. In particular, we present a basic schematic framework, that allows us to unpack a number of areas which we see as somewhat problematic. While they are not all unique to marketing, and for the most part have been covered in other fields of study (including neuroscience itself) it strikes us that the inherent subject matter of marketing research may make neuromarketing a field that is particularly susceptible to these problems. While we are unable to provide total solutions to these issues, we are able to point the reader towards potential directions in which such problems can be more coherently addressed, and advances in neuroscientific research that may help solve them.

Neuromarketing Research: An Illustrative Framework

Figure 1 presents what could be considered an illustration of the typical empirical neuromarketing study. At this point, it is important that we will use the term 'neuromarketing' to refer to research using methodologies drawn from cognitive neuroscience, that attempt in some way to measure brain activity. That is, techniques such as electroencephalography (EEG), magnetoencephalography (MEG), positron emission tomography (PET), and by far the most popular in this field, functional magnetic resonance imaging (fMRI). We also would consider techniques such genetic studies, skin conductance response, and the like to be within the field of neuromarketing. We recognize that this is a

reasonably informal definition, but it does tend to chime with similar work in management and organizational research (e.g. Senior, Lee, and Butler, 2011).

FIGURE 1 HERE

Figure 1 visualizes the basic process of a typical neuromarketing study, although of course we do recognize that there will be variance here, and also that some studies may operationalize a subset of these tasks and links. However, we feel this diagram presents a useful starting point from which to discuss the various key issues germane to neuromarketing research. Specifically, we consider that there are three critical points of interest here, which have not received enough discussion in neuromarketing-relevant literature. Taken together, they have substantive implications for the development of a more reflective neuromarketing, which in turn has greater potential to make a positive impact on marketing knowledge, marketing practice, and public perceptions of marketing activity in general. All three issues will be discussed in depth below, beginning with the dominant event-related reactive (i.e. stimulus-response) design of typical neuromarketing work. Following this, we will discuss the ability of the methods typically used in neuromarketing research to actually measure brain activity. Subsequently, we address important issues concerning inference. In other words, even if we measure brain activity in response to some stimulus, what does this actually tell us? This latter issue has received some attention in marketing-relevant studies, but we believe a significant proportion of neuromarketing work has fallen prey to some key errors of inference, which bears greater discussion. Following this, we will address why marketing research is in a particularly dangers position with regards to these issues, and present some recommendations for future neuromarketing work, to maximise its potential contribution.

On the Dominance of Event-Based Designs in Neuromarketing

The typical study design used in neuromarketing could be called event-based, or perhaps stimulus-based. Such a design is essentially what most researchers consider as the traditional controlled-experimental design. That is, subjects are exposed to some (hopefully) well-designed experimental stimulus, and their brain activity is measured, usually along with some behavioral response (e.g. a choice). Further, some other physiological and / or psychological variables may be measured (perhaps as controls), and the variables utilized in a regression-based analysis framework. Such approaches are dominant in cognitive neuroscience in general, and also in neuromarketing. Indeed, an informal review of neuromarketing research could find no empirical work that significantly differed from these fundamental principles.

This event-based design implies a view of the brain as a reactive system, where the brain receives sensory inputs, which cause some neural activity, which in turn cause some behavioral or cognitive / affective response of interest (Raichle and Snyder, 2007). While the approach has been the foundational workhorse of all cognitive neuroscience, it is also not without significant limitations. In particular, it has been observed that responses to the same stimulus are highly variable across multiple trials, even in so basic a setting as the measurement of response times (Braeutigam, Lee, and Senior, 2017). Such variations may be due to the endogenous activity that is present at all times within the human brain. Specifically, it is the case that the brain is never inactive, simply waiting for some stimulus to respond to. While most people readily understand that brain activity is necessary for basic homeostasis (i.e. the activity necessary for us to stay alive), fewer are aware that the brain's spontaneous activity is far more complex and significant. For example, in recent years, it has become well accepted that this intrinsic brain activity is not simply random noise, or due to mental tasks (like daydreaming for example). Rather, the resting activity of the brain also

occurs completely spontaneously, and can be described by specific patterns of coherence, observable across many different brain regions, beyond those necessary to maintain life (Braeutigam, Lee, and Senior, 2017). Importantly, it seems that the brain's resting activity actually requires almost the same amount of energy as even very demanding task-related activity (Raichle and Mintun, 2006), implying that task-focused activity is simply a temporary redistribution of energy. That resting activity consumes such a huge proportion of the body's metabolic rate (around 20%) implies that in and of itself, it plays some crucial role in human life.

In more recent years, various researchers have investigated intrinsic (also known as endogenous, or spontaneous) brain activity. For example, much attention has been focused on what is known as the default mode network, which has been suggested to be somehow implicated in self-awareness and social cognition (e.g. Schilbach et al., 2008). Further, an emerging consensus is that endogenous brain activity plays some role in the variability across identical trials within the same subject (Mennes et al, 2010). In other words, it seems likely that endogenous brain activity somehow interacts with stimulus-driven activity, in a complex non-linear way (Huang et al., 2015). In particular, Braeutigam, Lee, and Senior (2017) report the growing evidence that endogenous brain activity somehow influences perception, memory, motor control, and decision making. Perhaps most importantly for our purposes here, Braeutigam (2007) showed that endogenous brain activity differences were associated with differences in choice-making within a retail product choice context. In other words, the ongoing activity of the brain could be used to predict a subject's choice of product *before* the subject even saw the choice option stimuli.

If endogenous brain activity is somehow implicated in our responses to stimuli, it seems that existing neuromarketing research is only able to give us part of the explanation for how we make choices or respond to marketing stimuli. Importantly, it is impossible to capture such influences using the traditional event-based experimental designs. What is needed are *pre-stimulus* designs, where brain activity is measured prior to subject exposure to the experimental stimuli. Braeutigam, Lee, and Senior (2017) provide an introduction to this field of work, as well as the complex mathematics involved in capturing endogenous brain activity in a useful way. However, beyond this, it may be necessary to move beyond the dominance of fMRI methods if we wish to provide more insight into endogenous brain activity. Specifically, as will be seen below, fMRI has poor ability to resolve temporal information, which is crucial in such pre-stimulus designs. Indeed, most significant research in this area uses techniques such as EEG and MEG, which have much better temporal resolution.

Beyond fMRI: The Potential of Alternative Modalities in Neuromarketing

As already mentioned, functional Magnetic Resonance Imaging (fMRI) dominates neuromarketing research, although EEG is also a popular method. The picture is similar in cognitive neuroscience itself, where fMRI is by far the most dominant modality in empirical research. This dominance is such that it appears some critical observers of management and business research are under the impression that fMRI-based research *is* neuroscience (e.g. Lindebaum, 2016). Figure 2 however shows that there are a number of other techniques which could be employed to investigate neuromarketing questions. Figure 2 focuses on the variety of techniques which we argue below are most useful to neuromarketing research, and while we include a number of other techniques for reasons of exposition, it is important to recognise that the toolkit of neuroscience itself is broader than shown in Figure 2.

FIGURE 2 HERE

The first and possibly most important thing to note here is that fMRI does not in fact – contrary to popular believe – measure brain activity itself. Rather, fMRI (as employed in neuromarketing) measures what is known as the BOLD (blood oxygenation level dependent) response (although other contrasts are possible). In essence, this relies on the idea that increased brain activity in a given region results in increased blood flow to the active area. However, it should be noted that this response is not actually the brain activity itself, but in essence a proxy. It is important to understand that there are various limitations and caveats to the interpretation of the BOLD response as a proxy measure of brain activity. While most are beyond the scope of this commentary (we refer interested readers in particular to Logothetis, 2008 and Heeger and Ress, 2002), we focus here on issues concerning spatial and temporal resolution (as presented in Figure 2). Specifically, fMRI is generally considered to have a strength in terms of spatial resolution, in that it can accurately resolve location (dependent on the accuracy of the BOLD contrast as a proxy for actual neuronal activity). However, the BOLD response has comparatively poor temporal resolution, lagging actual activity in the order of seconds. This implies that fMRI is unsuitable to examine very quick or transient processes, and most useful to explore processes lasting a few seconds or more. In particular, research projects involving dynamic processes (e.g. watching TV advertisements) do require significant attention paid to their design, otherwise the results are broadly meaningless due to this issue. Another significant issue with fMRI is the growing concern regarding the statistical analysis of fMRI data, based both on the necessarily huge number of statistical comparisons involved (e.g. Vul et al., 2009), and potential issues with common software (Eklund et al., 2016). Concerns regarding sample size of fMRI studies are also of note (e.g.

Button et al., 2013), although Butler, Lee, and Senior (2017) show that the issues are more complex than are commonly understood.

Given the dominance of fMRI in mainstream cognitive neuroscience, it is understandable that it also assumes a dominant position in neuromarketing research. However, the issues pointed out above suggest that other modalities also have much to offer, particularly when cost-effectiveness is taken into account. Unfortunately, apart from EEG (e.g. Boksem and Smidts, 2015; Pozharliev et al., 2015), neuromarketing studies since 2007 appear to have largely ignored the potential for insight from alternative methods. However, the superior temporal resolution of techniques such as MEG (along with EEG) mean they have much to offer neuromarketing, particularly as the complexities of the decision process itself become more and more apparent. Prior to 2007, a few studies did employ MEG to investigate consumer choice contexts (e.g. Ambler et al., 2004; Braeutigam et al., 2001), but it appears these studies were the result of a serendipitous collaboration, and did not inspire the long-term take up of MEG in neuromarketing, That said, Braeutigam, Senior, and Lee's (2017) aforementioned introduction of endogenous brain activity into organizational research may have a galvanising effect on neuromarketing researchers regarding the use of MEG and EEG. Another method worth some attention is Steady State Topography (SST). This method was pioneered by Silberstein and colleagues (1990), and combines EEG with special goggles. A number of studies have employed SST in advertising research (Rossiter et al., 2001; Silberstein and Nield, 2008). One wonders however whether the fact that SST is a proprietary technology has led to its lack of take-up in academic research.

We certainly believe that greater attention to the use of MEG (and EEG) would provide a useful contribution to neuromarketing. However, again, it is important that researchers

understand that these techniques also have limitations, most obviously the difficulties in localizing the source of the electromagnetic signal within the brain. Furthermore, like fMRI, neither EEG nor MEG actually measures brain activity, but rather the secondary potentials arising from it (again making it a proxy), and also requires a reasonably large amount of synchronous neuronal activity to occur, in order to produce an electromagnetic signal large enough to be detected. Finally, while EEG is cost-effective and commonplace, MEG is more expensive and complex than fMRI.

Electrodermal Activity (EDA) has also seen some use in neuromarketing (e.g. Gakhal and Senior, 2008). While it is generally well understood that EDA is not a measure of brain activity, it is a well-validated measure of emotional arousal (Lee and Chamberlain, 2007). As such, it does allow an indirect implication of cortical activity at the overall system level (Senior, Lee, and Butler, 2011). It's particular benefit here is the accessibility in terms of cost, and ease of use, as well as the lack of invasiveness of the technique. Furthermore, EDA can be usefully combined with other neuroimaging methods, such as fMRI. Similarly, Transcranial Magnetic Stimulation (TMS) can also be usefully combined with other methods, to both counter some of their drawbacks, and enhance understanding. TMS allows researchers to safely occlude activity in cortical areas. In other words, it allows the researcher to stop particular areas of the brain working (Stewart and Walsh, 2006). Doing so can help provide positive evidence of the necessity of a given area for a given task. This allows one to go beyond the simple observation of brain activity in association with a given task as done with fMRI, MEG, and suchlike, towards inferring the causal necessity of a given area of brain activity for the completion of the task (i.e., the task cannot occur if that region of the brain is not active). The key drawback of TMS is that it can only be used on accessible areas of the cortex, rather than deep brain structures (many of which seem relevant to

neuromarketing explanations). However, one can possibly use neuropsychological participants with either natural or pathological brain lesions in deep areas to explore such questions (e.g. Koenigs and Tranel, 2008). That said, ethical questions regarding the use of neuropsychological patients for marketing research are of some importance here.

Finally, we will discuss the other techniques noted on Figure 2, which for better or worse have little to no application to neuromarketing. Positron Emission Tomography (PET) involves exposing the participant to a radioactive tracer (either by inhalation or injection), which can then be used to visualize blood flow to areas of the brain, similar to fMRI. Before the advent of fMRI, PET was a key method of functional neuroimaging. However, in recent years, its relative disadvantages (cost, lower spatial resolution, invasiveness) have meant that for cognitive neuroscience research at least (rather than medical purposes), PET has fallen from favour. Nevertheless it does have some advantages over fMRI, not least that it is far less sensitive to small movements. Single cell recordings are included not because they are a useful neuromarketing technique, but because the exemplify the difference between measuring *actual* brain activity and the various proxies discussed above. Single unit (or single cell) recording involves the use of micro-electrodes to directly measure brain activity at the level of a single neuron. However, this is exactly as invasive as it sounds. This renders its use virtually impossible for neuromarketing or other organizational research purposes (Butler, Lee, and Senior 2017). Indeed, it is only in clinical contexts that they can be used in humans (although they are commonly used in animals). That said, Cerf et al. (2015) demonstrate that neuromarketing-relevant concepts (along with others) can be studied while patients are receiving clinical treatment for epilepsy, making single-cell recording at least somewhat viable in the right circumstances.

Inference in Neuromarketing: What do Brain Scans Actually Tell Us?

Finally, we address questions regarding what inferences can be drawn from neuroscientific data, even if it does accurately reflect actual brain activity. In essence, the issues at hand concern a) whether or how we can actually usefully infer anything about psychological theories from neuroscientific data, and b) a more fundamental metaphysical concern regarding the reality of our subjective experiences of the world. Both issues are of course necessarily more philosophical than empirical in nature. While the former has received some attention in neuromarketing (e.g. Plassmann et al., 2015), the latter is yet to be examined at all, and has in fact rarely been touched on outside philosophy (Bagozzi and Lee, 2017).

Beginning with issues of inference, there are two basic ways that inferences can be drawn in neuromarketing-type studies. The first is termed *forward inference*, introduced by Henson (2006). In essence, a forward inference approach uses differential patterns of brain activity to distinguish between different psychological theories. For example, if there are two competing explanations of a given phenomenon, and if "theory 1 predicts that the same cognitive processes underlie two different experimental tasks, and theory 2 predicts that the tasks differ in terms of at least one cognitive process, then theory 2 will be supported when patterns of brain activity differ between the two tasks." (Heit, 2015, pp. 2). Such an approach depends on the assumption that there is at a minimum some kind of meaningful mapping from hypothesized psychological processes to actual brain activity, as well as that there is no unknown but correct third theory, nor any significant extraneous differences across experimental tasks. Such issues appear soluble (notwithstanding the metaphysical issues to be discussed later), but a more pressing problem is that not all psychological theories may make clear predictions of brain activity, rendering the forward inference concept moot. This may be why forward inference approaches appear to be very rare in neuromarketing research,

although the same could also be said for cognitive neuroscience in general (Lee, Senior, and Butler, 2012).

Poldrack (2006) explains the concept of *reverse inference* in depth, and a number of conceptual neuromarketing papers have drawn from this to present their own take on the topic (e.g. Breiter et al., 2015; Plassman et al., 2015). Poldrack (2006, pp. 2) characterises reverse inference as the "logical fallacy of affirming the consequent", and thus invalid for deductive inference. Poldrack (2006) shows how reverse inference is extremely prevalent in cognitive neuroscience using fMRI, and we see the same in neuromarketing. In simple terms, a reverse inference is made as follows (as described by Poldrack, 2006, pp. 1):

1. In the present study, when task comparison A was presented, brain area Z was active.
2. In other studies, when cognitive process X was putatively engaged, then brain area Z was active
3. Thus, the activity of area Z in the present study demonstrates engagement of cognitive process X by task comparison A.

The fallacy was most famously demonstrated by the 2011 *New York Times* op-ed by Martin Lindstrom entitled 'You Love Your Iphone, Literally', which claimed that activity in the insular cortex when subjects heard their phones indicated that they loved them. Of course, as pointed out by Poldrack (and 44 other neuroscientists) in their letter to the *NYT* on October 5 2011, this inference is nonsensical, being that the insular cortex is "active in as many as one third of all brain imaging studies…[and]…more often associated with negative than positive emotions". Similar problems can be detected very frequently in both popular and scholarly neuromarketing-relevant research. The key problem with reverse inference is that it is rare to see a consistent mapping between a given brain area, and a particular psychological process. That said, reverse inference is only a true fallacy if it is used in a deductive fashion, and can

indeed be useful to develop hypotheses for further study (Poldrack 2011, Hutzler, 2014), particularly when utilized in conjunction with large scale machine-learning or meta-analysis.

Even if one could justify strong inferences from brain scans to presumed mental processes though, the question would still remain, just what does this mean? In other words, is there anything more to mental experience than brain activity? What exactly *are* these psychological processes that our theories refer to? Do they have some independent reality over and above their physical manifestations (i.e. brain activity etc.), or are terms like 'emotion', 'attitude', 'thought', or any subjective experience at all, simply metaphors or folk-terms that have developed to describe what was heretofore mysterious? If so, should we now devote all our attention to further study of their physical manifestations, and phase out theories which refer to these metaphorical entities or properties, since we now have little justification to consider them real? Such questions are rarely explored by neuroscientists themselves, who appear to work under the assumption that indeed the mental experience is ultimately reducible to physical events (Bagozzi and Lee, 2017), and this view would appear to be shared by many in neuromarketing. This is especially evident in the common justifications of neuroscientific methods as being able to somehow uncover 'hidden' or 'more accurate' data (e.g. Couwenberg et al., 2016; Rampl et al., 2016). While such an approach has its attractions, it does little to provide a convincing explanation of how our subjective experiences (e.g. consciousness) are the *necessary* (as opposed to contingent) consequence of our physical brain activity (Nagel, 2012), and thus does not discount the possibility that brain states and subjective mental states are actually different things (Kripke, 1980). Such questions have significant bearing on how we should approach the future of neuromarketing, and indeed social sciences in general (Bagozzi and Lee, 2017), but they are yet to be addressed in any depth within the field.

Conclusions and Directions for the Coming Decade of Neuromarketing

10 years on from the publication of the first scholarly articles using the term 'neuromarketing' (at least that we can find), have we really come that far? There are at least two ways of answering that question. On the more negative side, it might be argued that for the most part, we remain in the same basic position as we did in 2007. That is, a reasonably fragmented set of research teams, individually pursuing what could be seen as quite piecemeal topics, spread across a wide variety of publication outlets, both within and outside marketing itself. Few articles appear to have addressed whether neuroscientific insights can help us build new and improved explanations of marketing phenomena, and the majority of published studies tend to use neuroscientific methods (most usually fMRI and sometimes EEG) to gain what are considered more accurate insights into existing marketing explanations. Rarely are competing theories tested (which would hopefully enable a forward inference approach), and often researchers fall into the tempting trap of reverse inference, assuming that complex psychological processes can be localized to individual brain areas, which are necessary and sufficient for their occurrence. Such temptations are most clearly seen in that work which receives significant public attention, and marketing is far from alone here. But in general, marketing and other social sciences are fertile ground for the growth of dangerous over-inferences from brain activity to psychological and social processes.

On a more positive note, it is undeniable that neuroscientific methodologies are now accepted as a viable tool to study marketing phenomena. This has to be seen as a positive, as it expands the set of tools available to scholars, and also provides reasonably strong evidence that neuroscientific methods can provide strong contributions to advancing knowledge. Further, the increasing attention given to neuromarketing in the top marketing journals should have the effect of inspiring more and more researchers to investigate the potential of

neuroscience for their own work. However, for these positive effects to become more dominant in future, a number of key issues are in need of greater attention.

The most important issues remain based around understanding, a) the capabilities and drawbacks of different neuroscientific methods, b) the benefits of studying biology and the brain for understanding marketing phenomena, and c) the conceptual problems which must be solved before drawing conclusions from neuroscientific data. Considerable work on various aspects of these issues has appeared in management and organizational research (e.g. Senior, Lee, and Butler, 2011; Lindebaum, 2016, Healey and Hodgkinson, 2014; Becker, Croponzano and Sanfey 2011; Waldman, Balthazard and Peterson, 2011; Butler, Lee, and Senior, 2017), but marketing has yet to have a robust discussion around many of these issues. Further, few marketing studies have engaged with the relevant management literature on these topics, nor the more foundational neuroscience work. Gaps in understanding such as this are dangerous, and may lead to poor research with meaningless results, such as how we love our IPhones. Work such as this (i.e. Lindstrom, 2011), while not published in scholarly journals, is often placed in the same general category as academic work by both the general public, and also those who may work in neuroscience itself. This leads to a generally negative perception of neuromarketing amongst just those people who we would wish more enthusiastic about working with marketing colleagues to investigate important problems. Indeed, fruitful collaboration between marketing and neuroscientific scholars is the most likely to lead to genuine contributions to our knowledge (e.g. Breiter et al., 2015).

So, in conclusion, our manifesto for a neuromarketing which can in the future make a greater contribution to knowledge would probably run along the following lines:

1. A robust debate amongst both supporters and detractors of the neuroscientific approach to marketing research, hosted by high-impact journals with wide readerships. This debate should take in how neuroscience can help understand marketing phenomena (or not), the ethics of employing such methods, what inferences can be drawn, and suchlike.
2. Greater attention to diverse modalities of neuroimaging, such as MEG, and TMS, as well as much greater attention given to the disadvantages associated with each method and the analysis of data.
3. More research that focuses explicitly on testing competing theories (forward inference), and on developing broad explanatory frameworks (e.g. Breiter et al., 2015).
4. Following the framework proposed in Bagozzi and Lee (2017), greater attention paid to linking various levels of explanation, from physical / objective, to mental / subjective. Or at least, further investigations and discussions on the relevance of both / either for our marketing (and social scientific) theories and explanations.
5. Perhaps most importantly, greater collaboration across marketing and neuroscientific researchers to create work with both stronger methodological foundations, and larger theoretical contributions. We would also add that collaborations with philosophers may be useful, to further develop ideas regarding objective / subjective experience, inferences, and suchlike.

While the above may seem a daunting list, it is not particularly far from how the fields of management and organizational research have addressed the very same issues. We have every confidence that marketing scholarship is willing to engage in a similar way, with the

same goal – that of increasing the value of what we do, and further advancing knowledge into important marketing phenomena.

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FIGURE 1: CONCEPTUAL SCHEMATIC OF NEUROMARKETING RESEARCH

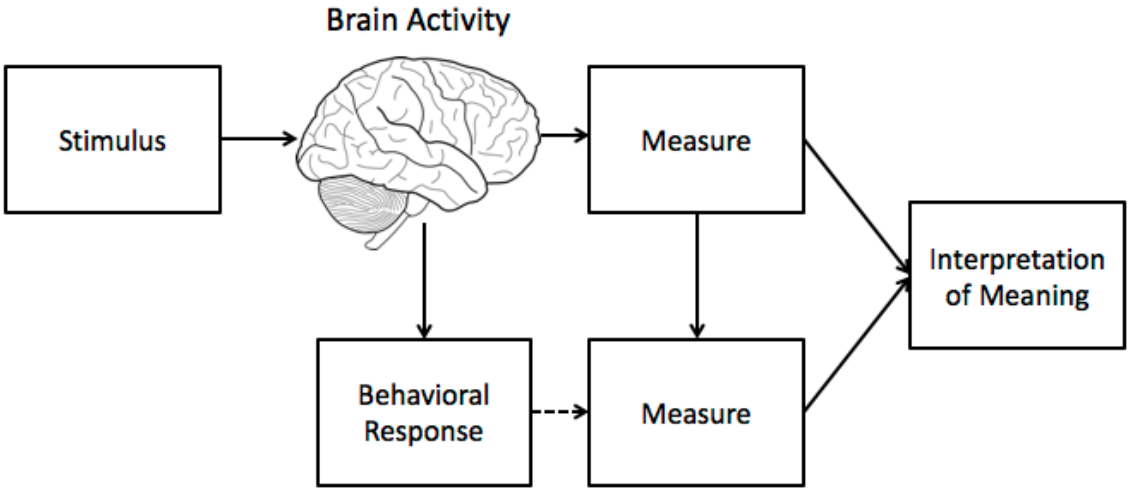
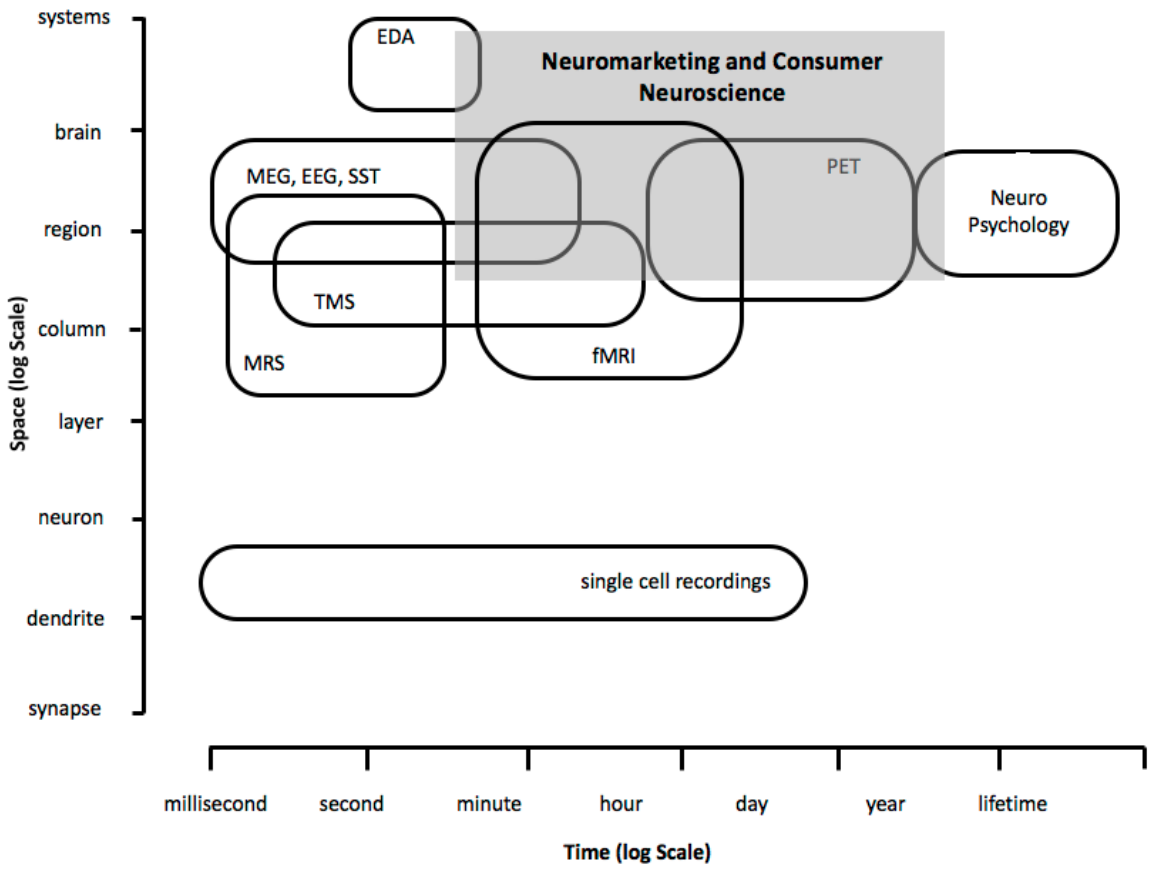


FIGURE 2: OVERVIEW OF VARIOUS NEUROSCIENTIFIC TECHNIQUES WITH THOSE RELEVANT TO NEUROMARKETING HIGHLIGHTED.



Modified from Senior, Lee, and Butler (2011).