MAPPING THE MIND FOR THE

MODERN MARKET RESEARCHER

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ABSTRACT

Purpose: To describe the utility of three of the main cognitive neuroscientific techniques currently in use within the neuroscience community, and how they can be applied to the emerging field of neuromarket research.

Approach: A brief development of Functional Magnetic Resonance Imaging (fMRI), Magnetoencephalography (MEG) and Transcranial magnetic stimulation (TMS) are described, as are the core principles behind their respective use. Examples of actual data from each of the brain imaging techniques are provided to assist the neuromarketer with subsequent data for interpretation. Finally, to ensure the neuromarketer has an understanding of the experience of neuroimaging, qualitative data from a questionnaire exploring attitudes about neuroimaging techniques are included which summarize participants' experiences of having a brain scan.

Findings: Cognitive neuroscientific 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. These techniques come with complementary strengths which allow the market researcher to converge onto a specific research question. In general participants considered brain imaging techniques to be relatively safe. However care is urged to ensure that participants are positioned correctly in the scanner as incorrect positioning is a stressful factor during an imaging procedure that can impact data quality.

Value of paper: This paper is an important and comprehensive resource to the market researcher who wishes to use cognitive neuroscientific techniques.

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NEUROMARKET RESEARCH

On July 17th 1990 President George Bush issued 'Proclamation #6158' which boldly declared the following ten years would be called the 'Decade of the Brain' (Bush, 1990). Accordingly, the research mandates of all the US federal biomedical institutions worldwide were redirected towards the study of the brain in general and cognitive neuroscience specifically.

One of the greatest legacies of this ´decade of the brain´ is an impressive array of techniques that can be used to study cortical activity. We now stand at a junction where cognitive function can be mapped in time, space and frequency domains, as and when such activity occurs. These advanced techniques have led to discoveries in many fields of science including psychology and psychiatry. Unfortunately, neuroscientific techniques have yet to be enthusiastically adopted by the social sciences. Market researchers, as specialized social scientists, have an unparalleled opportunity to adopt cognitive neuroscientific techniques and completely redefine the field. The redefinition of market research to incorporate such techniques will see the further evolution of ´neuromarketing´ - the research of market behavior mediated by a specific cortical response. Bear in mind that, like cognitive neuroscience, market research is evolving. In light of this symbiotic development application of brain imaging to discover the 'buy button' in the brain cannot be the sole remit of neuromarketing (Lee et al, 2006). Cognitive neuroscience will help the neuromarketers to move away from traditional market research and towards research in marketing which has implications for understanding organizational behavior in a social context (see e.g. Lieberman, 2005)

The evolution of neuromarketing has already begun and, as is the case with any fledgling science, heated debate is regularly seen in the literature. One recent example, in the prestigious pages of the ultra high impact journal *Nature Neuroscience*, questions the ethics behind neuromarketing and as such is fundamental reading (Nature Neuroscience, 2004; see also Brammer, 2004). Putting ethics aside, this editorial highlights some of the key regions of the brain that would be implicated in consumer preferences. For example, one study cited revealed activity in the brain areas that mediate reward processing when the participants tasted their preferred cola (either Coca Cola or Pepsi Cola). Furthermore, when these respondents were told that the drink they had just imbibed was Coca Cola compared to their brand rival, Pepsi cola, a wider network of brain reward areas was activated, which was interpreted as indicating that Coca Cola had a more efficient advertising campaign (McClure *et al*, 2004). Another study examined the possible marketability of different types of cars and found that respondents who rated sports cars as being attractive engendered more activity in these brain reward areas when they were shown such cars compared to other vehicles (Erk *et al*, 2002). Attractive human faces also enjoy such privileged status and activate the brain reward areas more so than unattractive faces and, as our own experience tells us, are effective drivers of behaviour and thus ideal mechanisms to initiate consumer behavior (Senior, 2003). Given that emblems such

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as facial beauty or a particular brand of cola can activate these 'pleasure centers' and certainly drive social behavior, their study is thus one possible valid enterprise for neuromarket research.

These ´brain reward areas´ are parts of the same cortical network that people addicted to drugs stimulate with their drug of choice, and animal studies showed that female rats will ignore their pups to self administer electrical stimulation to these areas until they die of exhaustion (Valenstein and Beer, 1964; Routtenberg and Lindy, 1965). Knowing that such appetitive behavior is mediated by a specific network of brain areas that are also active for perception of a particular product brand, can provide insight into factors influencing consumer behavior. Moreover, knowledge of the areas in a consumer’s brain that are activated when they are shown a particular product can be a much more ´honest´ indicator of their cognition compared with other traditional measures such as focus groups where responses can be biased (see e.g, Wolpe et al, 2005).From a commercial standpoint the successful market researcher would need to employ as many different approaches as possible to ensure maximum market gain for a specific product. It's clear that an an integrative approach leading to 'methodological pluralism' should be adopted by neuromarket researchers.

The purpose of this paper is to introduce two main brain imaging techniques, these being functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) as well as a third technique called transcranial magnetic stimulation (TMS).

The provision of such a general introduction aims to encourage the use of these techniques by mainstream market researchers and scholars. To expedite this adoption the commentary provides a brief historical overview of the three techniques, a description of the core principles that mediate them, and outlines some of the possibilities and limitations of each technique. Examples of actual data from both brain imaging techniques (fMRI and MEG) are included to facilitate interpretation. Finally, to ensure that future neuromarketing protocols are carried out in an ethically sound manner, qualitative data taken from a broader study exploring participants' perspectives about neuroimaging techniques are provided from experimental participants who have undergone both fMRI and MEG scans (Cooke *et al.*, 2006). Taken together it is hoped that all aspects of this paper will allow market researchers to decide whether cognitive neuroscience can provide suitable tools to use, and if so, which tool is most appropriate. Bearing in mind that this commentary will only provide an introduction into these three techniques those readers who would like to gain a more in-depth understanding are directed to more comprehensive texts for detailed reading (e.g., Senior *et al*, 2006).

FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)

fMRI is just over a decade old and is undoubtedly the most prolific of all brain imaging techniques. Merely entering ´fMRI´ as a search term into the journal article search engine, WWW.PUBMED.COM, will return over 13 thousand items compared to a mere two thousand returned for ´MEG´. The utility of fMRI is mediated by one key factor - it is relatively easy to implement. It is a completely non-invasive procedure where the volunteer is simply moved into the centre of a high field circular magnet bore (See Fig. 1). Various experimental stimuli, such as advertisements for particular products, can then be projected into the centre of the bore, which the subject views via a small prism mirror placed just above the face.

A variety of neurophysiological information can be obtained using fMRI. For example, baseline cerebral blood volume measurements, changes in this blood volume, quantitative changes in the levels of blood oxygenation, as well as the rate of resting state oxygen extraction. More detailed descriptions of each of these measures are provided in Russell et al (2003). One measure that will have great utility for the neuromarket researcher is the ´BOLD´ contrast (See Fig. 1) and this is described further.

The ´BOLD´ in ´BOLD´ contrast stands for Blood Oxygenation Level Dependant (Tank *et al*. 1992). In brief, this signal is driven by a difference in the blood oxygenation levels in capillaries and veins compared to the arteries during a particular task. Deoxygenated blood is paramagnetic (attracted to a magnetic field) as opposed to when it is oxygenated (Pauling and Coryell, 1936). On presentation of a specific stimulus, oxygenated blood flow will increase locally within an ´active´ region of the brain. This will cause deoxygenated blood levels to decrease and subsequently decrease the magnitude of the magnetic field distortions between the two molecules which ultimately leads to a signal increase in the fMRI dataset (Ogawa *et al*, 1992).

The main limitation of this technique is that the signal begins to increase approximately two seconds after stimulus presentation, and reaches a plateau after about seven to 10 seconds (Logothetis *et al*, 2001). In specialist terminology, fMRI has excellent spatial resolution but relatively poor temporal resolution, *i.e.*, it can be used to detect activity in specific and, in some cases, quite small regions of the brain but it can tell you very little about the timing of that activity. Therefore, as a tool, fMRI should generally be used for the identification of certain brain areas only.

Please place Fig 1 about here

The functional activity revealed with the BOLD contrast then needs to be mapped on to a picture of the subject’s brain. To create a neuroanatomical picture, a rapid radiofrequency pulse is applied which forces the hydrogen protons in the various tissues of the brain to become aligned to it. When the radiofrequency pulse is switched off these protons relax and return to their original alignment with the magnetic field emitted by the MRI scanner. The different rates of proton relaxation across the various structures of the brain allow an image to be constructed (Russell *et al*, 2003).

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However, the rapid switching of the radiofrequency pulse required for the neuroanatomical MR image is loud and can cause permanent hearing loss in some cases, so most laboratories require subjects to wear ear protection during a scan. This, coupled with the fact that subjects are positioned inside the center of a very large superconducting magnet, the inner surface of which is sometimes inches away from the subject's face and body, would suggest that fMRI can be quite a stressful or traumatic procedure to undergo.

The obvious lack of ecological validity needs to borne in mind when carrying out neuromarket research. Obtaining responses from a subject in a potentially stressful environment may bias any results. However, our questionnaire data derived from experimental subjects suggest that, in general, they tend to consider fMRI to be a ‘surprisingly relaxing’ experience.

Participants’ perspectives about fMRI

As part of a broader study investigating participants’ perspectives about fMRI and MEG procedures 44 experiment participants were asked to complete an extensive questionnaire about their experiences, knowledge and attitudes to each of these brain imaging procedures. In addition to the quantitative questionnaire data which is reported elsewhere (Cooke *et al*, 2006) some participants provided qualitative comments regarding their neuroimaging experience(s) and these data are reported here. These subjects were undergraduate and postgraduate volunteers which are largely representative of a market research subject population. Questionnaire respondents were invited to: describe their previous experience of fMRI; and explain their response to questions including ‘do you think you could have refused to have fMRI if you had wanted?’; ‘did you feel you experienced any side effects during the fMRI procedure?’; and ‘did you feel that you could contact the researcher at any point during the procedure?’. Space was provided at the end of the questionnaire for respondents to add any additional comments about fMRI.

These data suggest that in general participants viewed the fMRI experience positively, reporting that they ‘*enjoyed taking part in the fMRI’*, found the procedure ‘*interesting’*, and the technology ‘*fascinating’*. Participants’ positive comments about fMRI appeared to be underpinned by three main areas. First, perceptions of the experimenter; second, awareness of informed consent procedures; and third, the contrast between negative expectations and the actual experience in the scanner. The nature of the experimenter’s/researcher’s interaction with participants was significant in terms of how participants experienced the scanning process. A number of participants reported that: *‘The researchers made me feel comfortable’* and that they *‘trust[ed] the researchers would not put me in any danger’*. The sense of trust and comfort conveyed by participants was underpinned by an awareness of the nature of informed consent procedures discussed with them. As one respondent reported ‘*everything was very clearly explained beforehand’.* Participants made numerous comments demonstrating their knowledge of informed consent procedures, especially the right to withdraw: *‘they told me at any point that if I didn’t want to continue or felt uncomfortable, there was no problem with me not doing it’.*

This thorough consenting process, which was communicated to participants in both written and spoken forms, encouraged a favourable perception of the experimenter, as one respondent wrote:

'I know about the 'right to withdraw' and researchers seemed friendly and understanding'. Thus feeling fully informed about the procedure coupled with a reassuring researcher (s/he '*frequently asked if I was ok with the situation'*) led participants to report that they were not '*pressured into it in any way'* and they did not *'ever feel pressured'* either to undergo the experiment or remain in the scanner if they became uncomfortable.

Clearly, given the technological intensiveness of the fMRI hardware, a thorough explanation of fMRI and a friendly approach adopted by the experimenter is essential for participants to view the experience favourably. However, some of the data did reveal that the fMRI procedure did have an ominous reputation. Such a reputation is probably due to negative preconceptions as the contrast between these preconceptions, and the actual experience were clearly embedded in participants' comments. For example: *'I was slightly apprehensive before the procedure as I had heard it could be very claustrophobic and noisy. However it was not unpleasant at all'* do show that the actual scan is a relatively acceptable experience. It seems that some participants reported feeling relieved that the actual procedure was relatively non-invasive. Comments such as *´It wasn't as scary as I thought from what friends/relatives described to me'* and '*it was much less* *claustrophobic than I had feared´* strengthened the notion that prior to the actual procedure participants considered fMRI to be daunting. Whilst *´I had been scanned before…it was still reassuring to have the various safety measures explained to me´* shows that the daunting reputation of the technique persists to some degree after experience with the scanner. This may adversely affect recruitment of subjects to participate in any neuromarket research program, and again underscores the importance of thorough and ongoing information provision and reassurance from the experimenter. However, participants also commented that they felt they would be happy to talk to other volunteers prior to participation because it would be *´reassuring for them´* thus suggesting a possible strategy to avoid future misconceptions about participation in fMRI experiments.

Evidence of potential side effects, both short- and long-term, of exposure to MRI is currently limited because fMRI is a relatively recent research technology. Respondents described their fMRI experience mostly in positive terms one participant reported that s/he *'became very sleepy towards the end'* of their time in the scanner. Nevertheless, participants were asked about any possible side effects. Only three of the 20 participants who provided qualitative questionnaire data described experiencing physical sensations following scanning. One participant reported that s/he felt *'a bit 'numb' in the head'*, another *'had a pins and needles sensation in my left hand'*. The third reflected that: *'It was in no way a frightening experience but an experience I am glad I have had. I would take part in more* *studies. The only trouble was the headache I experienced after but it wasn't or didn't affect any day to day procedures'*. Physical contraindications tend to be rare and these participants were more than likely reporting the effects of incorrect positioning rather than side effects of the scanning procedure *per se* e.g., the subject's head not resting comfortably etc. The fMRI technique is extremely sensitive to subject movement and the slightest shifting can result in motion artifacts that can seriously impact the quality of the data. For this reason, and also to maintain subject comfort, it is important to attain correct positioning from the start.

Taking in hand the fact that this is a cursory glance into participants' experiences during an fMRI scan it is worth noting the salient aspects that would affect the neuromarketer. First, even though the technique itself is non-invasive it does have a slightly negative reputation and this may impact on possible participation for market research studies. Secondly, to minimize perceived and actual side effects and to also ensure the integrity of the data, the subject must be correctly positioned in the scanner prior to beginning the procedure.

MAGNETOENCEPHALOGRAPHY (MEG)

Whilst fMRI is an ideal tool for locating cortical activity it may also be identified - this type of neurophysiological data is best collected with MEG. Obtaining MEG data is a very different process from fMRI as it involves the measurement of extremely weak magnetic fields generated by the electrical activity of neuronal populations

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(see Hämäläinen and Hari, 2002 for review). Compared with fMRI, MEG has excellent temporal resolution but relatively poor spatial resolution, i.e., it can detect cortical activity at the millisecond level but it is not very good at distinguishing the space where this activity originated. However, contemporary imaging techniques developed from radar technology do considerably improve on this poor spatial resolution (Hillebrand *et al*, 2005).

Measuring such minute neural activity is challenging due to the very weak nature of the neuronal clusters and interference with nearby electromagnetic noise. Noise sources arising from the subject's own body, such as coughing etc., can have serious implications for the integrity of the data. As is the case with fMRI scanning, contemporary image analysis software can ensure that most of these artifacts are controlled for at source. During a MEG scan the subject's head is raised into a ´dewar´ which houses an array of superconducting sensors called SQUIDS (Superconducting Quantum Interference Devices). To collect the optimal signal it is preferential to use dewars with as large a collection of SQUIDS as possible and the latest generation of MEG scanners can contain up to 300 separate SQUID detectors (Singh, 2006).

The temporal resolution of MEG is close to real time but its ability to detect the onset of cortical activity is not its only advantage. The use of MEG also allows study of changes in neuronal oscillatory rhythms, i.e., the specific frequency at which neurons in a particular cluster fire together (Hillebrand *et al*., 2005). A specific oscillatory frequency range, e.g., 28-40Hz, will either increase or decrease during an experimentally salient period of time, such as when participants view a visual stimulus (see e.g, Singh, 2006). Take for instance the modulation in activity between 28-40Hz that occurs when a subject recognizes a face (Rodriguez *et al*, 1999). This modulation in task related oscillatory behaviour is sometimes called Event Related Synchronization (ERS) or Event Related Desynchronization (ERD), depending on the direction of the change, i.e., either in the same frequency band or towards a different frequency band (Pfurtscheller, 2001; see Fig. 2). Whilst still preliminary there is emerging evidence that certain frequency bands can be identified as signatures for specific cognitive tasks e.g, 28-40Hz ERS for object recognition (see above) or 14-28 Hz ERS for verbal working memory (Hwang et al, 2005) or even 4-8Hz ERS for episodic recall (Klimesch et al, 2001). This may provide a further tool for neuromarketer in the understanding of market behavior.

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Due to the sensitive nature of the SQUIDS it is essential to implement a number of conditions prior to carrying out a MEG procedure. The dewar needs to be isolated in a double magnetically shielded room to ensure that data are not biased by transient electromagnetic fields in the local environment. Additionally, to ensure SQUID sensitivity it is imperative that the distance between the sensors and the subject's head is minimized as much as possible, thus many MEG laboratories use inflatable cuffs to ensure that the subject's head is tightly held in the dewar (Singh, 2006). The fact that the subject is held tightly in the MEG dewar may lead to the assumption that it is an uncomfortable procedure. However, examination of the subject responses in our qualitative questionnaire data show that whilst it is considered very different to fMRI it is not an uncomfortable procedure.

Participants' perspectives about MEG

Questionnaire respondents provided 31 written comments about their experience of MEG scanning. Again, comments such as *´would be happy to reassure anyone with concerns'* were observed throughout the questionnaires returned, suggesting that this procedure, like fMRI, does have an anxiety provoking reputation. Even though MEG procedures are silent and carried out in the dark, participants still found that *´it was an extremely uncomfortable procedure to undertake'*. The need to position the surface of the subject's head as close to the Dewar as possible may result in stressful head restriction. However, the neuromarketer can circumvent this problem by ensuring that the participant is lowered out of the Dewar at regular intervals during a specific procedure in order to alleviate any stress brought on by restricted movement. Participants described feeling fatigued and restricted: '*As the experiment progressed I became incredibly tired – it felt quite taxing, although it wasn't particularly mentally or physically demanding. I also found it difficult to stay very still for such a long time. I think this is why my muscles ached afterwards'*; *'Although I found the experiment interesting, while I was in the machine I found*

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myself becoming very drowsy'. This highlights the neuromarketer's need to be aware of participant fatigue and the measures used to combat it in order to prevent any possible corruption of data as well as discomfort to the volunteer.

As can be seen, MEG clearly has great utility for neuromarket research. Not only can it provide information about the onset of any cortical activity but can also provide information about the specific frequency by which clusters of neurons fire. However, it is surprising to note that any cortical activation revealed with a particular task cannot be used to infer that the cortical area implicated is actually necessary. Any engendered brain activation from MEG or fMRI may be epiphenomenal in nature - much like the heat given off by a light bulb (see Kosslyn, 1999).

Functional necessity can only be inferred if a decrement in a particular task is revealed when a specific area of the brain is removed. Obviously the neuromarketer cannot remove parts of potential consumers brains for the sake of science. However, Transcranial magnetic stimulation (TMS) is one way in which a safe and repeatable 'virtual lesion' can be created in healthy participants (Walsh and Cowey, 2000).

TRANSCRANIAL MAGNETIC STIMULATION (TMS) ?

TMS is not a brain imaging tool *per se* as one cannot apply it and 'see' activity in the brain. Rather TMS allows neuromarketers to 'switch off' part of the cortex for very brief periods of time and the index of functional necessity is revealed by differences in response times or other behavioral measures (Senior, 2001).

TMS operates by inducing a brief electrical current in areas of the cortex that cause the excitatory behavior of focused clusters of nerve cells. The effect is brought about by Michael Faradays principal of electromagnetic induction, which states that a single pulse of electric current flowing through a coil of wire will generate a magnetic field (see Mills, 1999, ch. 3). By alternating the magnitude of the magnetic field over a short period of time an electrical current will be induced in a nearby secondary conductor. In TMS investigations, a stimulating coil is placed over the subjects scalp and the magnetic field travels through the scalp and skull to induce the secondary electrical current in the cortex. The technique is ingenious insofar as the human scalp and skull have a relatively high resistance to electrical currents whilst no impedance to a magnetic field (Jahansahahi and Rothwell, 2000).

The early technique enjoyed a flourishing interest within the field of neuromuscular disorders (Mills, 1999) but it was Barker who produced muscular twitches with stimulation of the primary motor cortex and ensured that the application of TMS to cognitive studies was born (Barker et al, 1985). However, it was not until the discovery that a single magnetic pulse to the visual cortex, (approx 60-140 msecs after stimulus presentation) could render subjects incapable of detecting stimuli in a letter discrimination task that the use of this technology in cognitive neuroscience really began in earnest (Amassian *et al,* 1989). The same group further explored the finding that magnetic stimulation can be used to disrupt cortical function some years later where they found that a visual mask effect could be lost, and performance on a letter discrimination task improved with a single pulse of magnetic stimulation (Amassian *et al,* 1993). These two studies formed the bedrock of the contemporary development of TMS within the cognate sciences. The disruption of cognitive function that is caused with magnetic stimulation can be used to impair a behavioral task or improve performance on a particular task by disrupting cortical function that may be irrelevant or competitive in nature (Walsh and Cowey, 1998).

The application of a virtual lesion to induce disruption or improvement in a specific task is of particular interest to the neuromarketeter. Application of TMS resulting in an *improvement* in, for example memory recall, for a particular brand product can help to identify the competing cognitive factor that was impeding previous recall.

Whilst the application of a virtual lesion is the primary role of TMS the manipulation of the timing and foci of this disruption has allowed investigation of the timing of psychological function and the connectivity of the neural areas that mediate these functions (see Pascual-Leone et al, 2000 for a review). The ability to repeatedly disrupt cortical processing gives TMS a ‘functional resolution’ which is unique. Place this functional resolution alongside the superior temporal resolution of MEG and the spatial resolution of fMRI and one quickly becomes aware of the immense potential available to the neuromarketeter(see Pascual-Leone et al, 1999).

Participants' perspectives about TMS

To date there has been no examination of healthy subjects experiences during a TMS procedure. However, Walter et al. (2001) reported that psychiatric patients classified as depressed found transcranial magnetic stimulation (TMS) a positive procedure and would recommend it to friends and family. Clearly, further work is needed examining the perceptions of TMS by volunteers as this will help to facilitate best practice with the procedure.

DISCUSSION AND CONCLUSIONS

This paper aimed to introduce cognitive neuroscientific techniques that could be employed by the market researcher who wished to develop a specialized neuromarketing profile. Three ´mainstream´ techniques were discussed, these being fMRI, MEG and TMS. A brief overview of the central principles and procedures involved in each technique was provided as well as a discussion of their limitations. fMRI is an excellent tool for the localization of a specific area of the brain implicated in a particular task (See Fig. 1). However, fMRI is dependant on cortical hemodynamics and as such suffers from a lag of up to several seconds; it is thus a poor tool for study of the timing of cortical activity. On the other hand, as MEG detects the very small electromagnetic changes in neuronal clusters it is freed from the temporal constraints that the hemodynamic response imposes (See Fig. 2).

MEG also allows study of the oscillatory frequency of neuronal clusters that are linked to a specific event – be it a response to tasting a particular brand of cola, or perceiving a particular advertisement. Finally, TMS operates by inducing neuronal activity for very brief periods of time. This serves to interfere with any cortical processing that may be going on at that point, thereby creating a safe and repeatable 'virtual lesion'. The ability to create a neuropsychological ‘virtual patient’ gives TMS a functional resolution, which in turn can be used to explore the connectivity and the timing of cognitive events.

The experimental subjects positive experiential accounts of participating in experiments with these three techniques permit an optimistic endorsement for use in new fields such as neuromarket research. It is also clear that each technique allows the neuromarketer to study a unique perspective of the consumer's cognitions towards a specific product. However, it is the integration of each technique that could be extremely beneficial for the future of neuromarket research (Wasserman & Grafman, 1997).

An example of this novel approach would require a combination of fMRI, MEG and TMS. Take, for example, this thought experiment examining differences in memory for sexual vs non sexual imagery in perfume adverts. First you would show consumers one of two advertisements, one which contains sexual imagery and one which is non-sexual, whilst undergoing an fMRI procedure. The subjects will engender activity in a wide variety of cortical areas. Such an outcome is predictable and likely given that both types of advertisements are visually complex and have been designed to elicit appetitive behavior (i.e., purchasing a particular product). However, this outcome tells the neuromarketer nothing about whether advertisement one is a more effective visual cue than the second. To complete the neuromarket research process, the engendered activity from the fMRI procedure can then be used to guide analysis of subsequently collected MEG data. From this the neuromarketer can study differences in the onset of neuronal activity between the two advertisements and also identify differences in the neuronal frequency bands. Such an approach allows the both the localization of activity to be studied as well as the onset of that activity and its specific frequency signature. At this stage the neuromarketer would have a comprehensive data set converging on the neural activity engendered by two sets of advertisements. TMS could then be applied at the specific onset of activity for each of the two distinct advertisements in a memory task and subsequent recall could be tested. As the virtual lesion is applied at a point in time corresponding to brain activity revealed by MEG, which was in turn guided by fMRI, a subsequent memory decrement would allow you to infer that this activity is due to memory processes.

Bearing in mind the rapid evolution of other ´neuro´ techniques such as eye movement analysis (Henderson, 2006) and even neurogenetics (Mattey *et al*, 2006) the future possibilities for neuromarket research are promising. Embracing contemporary techniques such as those described here will enable neuromarketers to compete alongside other social scientists in a growing and exciting field.

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Fig. 1: Overview of an fMRI Experiment (Adapted from Aharon *et al*, 2001). (A) Subject is moved into the centre of the scanner where they can view material projected into the bore or listen to auditory material through MR compatible headphones. They can also make simple responses via an MR compatible response box. The system shown in the picture is the Siemens 3 Tesla scanner at Aston University. (B) Experimental response has to be subtracted from a baseline and in this example the hemodynamic response for attractive faces is subtracted from average faces. (c) Any activity that is over a certain threshold, the colour of the activity determines the p value which can be extracted from the colour bar by the side of the image, is then analysed further. In the example shown activity is highlighted in an area of the dorsal amygdala (D) In this example, differences in the hemodynamic response for attractive versus unattractive faces for both male and female faces were examined within the region of engendered activity.

Fig. 2: Overview of a MEG experiment (Adapted from Senior *et al*, 2005) (A). Subject is raised into the Dewar and visual material is presented to them on the screen in front of them. As is the case with fMRI the subjects can make simple responses via an response box. The system shown in the picture is taken from

www.ctf.com. (B) An event related increase in oscillatory power between 10 – 15 Hz is shown in the middle frontal gyrus (purple square) and decrease in the same frequency band in the superior frontal gyrus (black square). This activity is mapped onto a single subjects MR image.(C). A spectrogram showing the event related increase and decrease in oscillatory power only when the attractive faces are shown. Note also, that there is a general paucity of differences in the higher frequencies between the two epochs (frequency information is indicated on the Y axis of the spectrogram. Onset information for both experimental epochs is indicated on the X axis of the spectrogram. Finally, (D) examples of attractive and average faces used to generate the data which also indicate the different experimental epochs in the spectrogram.

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