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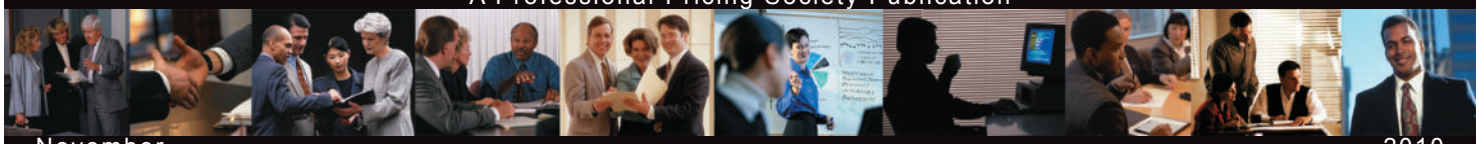

November 2010

Product Pricing Using Novel Tools From Neuroscience

Neuromarketing, the application of advanced brain research techniques to marketing, has enjoyed widespread media coverage in recent years. Three of the dominating technical approaches, functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG) and electroencephalography (EEG), are presented here. The author identifies how these techniques may be used for optimizing prices. He speculates that EEG recordings may become a mainstream approach and that neuromarketing may develop into an additional tool for market researchers. Kai-Markus Mueller, PhD, is a consultant with Simon-Kucher & Partners. For his PhD in neuroscience he investigated the visual system of humans and monkeys using invasive and non-invasive brain research techniques. He can be reached at kai-markus.mueller@simon-kucher.com.

Selling and buying products is reminiscent of a bluffing game. **Manufacturers know all the costs associated with their products, but they will not let potential buyers know these costs. Instead, a manufacturer will try to maximize its profits by estimating the buyers' maximum willingness to pay and setting the price close to that limit.**

The buyers, on the other hand, are unwilling to reveal their true willingness to pay and try to buy products as cheaply as possible. Therefore, the better manufacturers or salespeople understand the minds of their customers, the better they are positioned in this wager. Brain research technology has advanced at breathtaking speed in recent decades, opening up new avenues for better understanding the mental processes that are relevant for pricing.

There are two fundamentally different reasons for conducting neuroscientific marketing and pricing research: (1) basic research of academic interest and (2) applied research yielding intuitive and actionable information with an adequate cost-benefit ratio.

From an academic perspective, it is highly interesting to know which brain areas respond to certain relevant features of a product, such as its price. However, only knowing that activity in a certain area correlates with a specific product characteristic is insufficient for applied market research. Practitioners need imple-

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mentable results based on robust and to some degree standardized measures.

Understanding the minds of others

Humans are one of only a few – if not the only – species which are fully aware that other individuals of that same species have a mind of their own. Philosophers and neuroscientists call this phenomenon having a "theory of mind". Having a theory of mind about others allows us to exhibit characteristic human behaviors such as feeling empathy, playing jokes, and deceiving others. It is at the heart of neuromarketing to not only know that other individuals have a mind of their own, but also how that mind works and what happens in it. Fortunately, all our thoughts and emotions are located within one organ, the brain. The main challenge is therefore to pick up signals from the brain and make sense of them – in other words, trying to read someone's mind.

Such "mind reading" has become increasingly successful as computation and technology have advanced. In neuromarketing this academic exercise is put into practice. The central theme of the neuromarketing methods is similar irrespective of the specific technical apparatus used: A study participant is presented with a series of varying stimuli, such as a sequence on a screen of the same product at different prices. At the same time, his or her brain activity is measured non-invasively. The data are interpreted with the help of established neuroscientific knowledge about how far the acquired signals indicate different states of emotion, attention, or other psychological constructs. For instance, it is well-known that blood flow activity in the medial orbitofrontal cortex – a small part of the brain not far from the eyeballs – correlates with positive feelings. A measurement combined with a statistical algorithm identifying such blood flow activity in the medial orbitofrontal cortex consequently seems invaluable to marketing professionals. In addition to the technical improvement of biomedical devices, the quality of the algorithms processing the recorded signals has significantly improved in recent years with advances in machine learning, multivariate statistics and computational power. In fact, for companies offering neuromarketing services, the algorithm used for deciphering the brain process of interest is their key asset and sometimes even patent-protected. Technical aspects are less relevant since the recording devices are standardized and can be bought or hired at local research facilities.

Functional magnetic resonance imaging (fMRI)

One drawback of fMRI is that it takes about 4 to 5 seconds until the local blood overshoot peaks. That means immediate reactions of the brain cannot yet be identified reliably using this method.

Functional MRI has arguably become the most popular branch of cognitive neuroscience, and it is a driving force in the public media coverage of neuromarketing. Magnetic resonance imaging is a non-invasive technique that enables nearly any anatomical structure in the body to be reproduced in three dimensions. In simplified terms, subjects are exposed to a magnetic field and radio frequency pulses. An MRI scanner picks up a resonance signal measuring the amount of hydrogen at different points in space. Given that different anatomical structures contain different concentrations of hydrogen, it is possible to reconstruct 3D images of organs such as the brain.

Functional MRI (fMRI) scans take advantage of a particular physiological phenomenon: When the nerve cells (neurons) of a specific brain region are particularly active, the blood supply for that region is enhanced, presumably because the neural activity requires additional energy. Due to the magnetic properties of hemoglobin in the blood it is possible to measure blood flow with the MRI technique. By subtracting different stimulation conditions (such as different prices of a product) a statistical algorithm can identify the location of these changes in the blood flow. For instance, it has been found that activity in the medial orbitofrontal cortex, the area presumably involved in encoding pleasure, was higher in connection with consuming a wine labeled as expensive than with a wine labeled as cheap. In fact, it was irrelevant that subjects drank the same wine in both cases.

One drawback of fMRI is that it takes about 4 to 5 seconds until the local blood overshoot peaks. That means immediate reactions of the brain cannot yet be identified reliably using this method. Nevertheless, given enough subjects and sufficient runs per subject to achieve statistical reliability, fMRI is feasible for pricing research. As a downside, MRI scanners with a strong enough magnetic field to conduct high-resolution functional scans are mainly located in well-funded research hospitals or academic institutions with appropriately trained medical personnel. The hospital expenses for the equipment are typically apportioned to hourly fees charged to the user.

Magnetoencephalography (MEG)MEG measures brain activity using a superconducting quantum interference device (SQUID). A subject is placed inside an electrically and magnetically shielded environment containing several of these SQUIDs. The SQUIDs pick up magnetic field changes that arise directly from the electrical activity in the brain, usually a population of neurons located close to the brain surface, i.e. close to the skull. The MEG signal has an excellent temporal resolution; brain activity is virtually picked up in real time.

In order to determine where in the brain something took place, however, MEG is

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far inferior to fMRI. The source of the magnetic changes can be guessed using appropriate mathematical tools, but on a much coarser scale than fMRI and with a greater margin of error. Just like MRI scanners, MEG devices are not portable and therefore behavioral and perceptual tests are limited to the laboratory setting. In fact, the subject must not move at all during the recordings. Similarly to MRI scanners, MEG devices are very expensive to buy or to hire.

So how could a pricing or marketing question be answered with the help of an MEG device? Due to their high temporal resolution, both MEG and EEG, which will be discussed in the next section, particularly lend themselves to studying processes which happen very quickly. One example of a fast process is the mental engagement at any point in time during an advertisement clip. The amount of engagement evoked by displayed price information during such a clip is valuable for improving the ad and potentially even for optimizing the price of the product that is being promoted.

Electroencephalography (EEG)

To measure EEG signals, external electrodes are attached to the head, often using a characteristic cap that holds the electrodes in place. These electrodes measure minimal electric variations across the skull. The signals measured during EEG recordings are closely related to those measured during an MEG session; EEG measures changes in the electric field while MEG measures changes in the magnetic field. EEG also measures brain activity virtually in real time. Like with the MEG, the origin of the signal can only be vaguely localized. The signals of MEG and EEG correspond to distinct neural events and minimally different locations in the foldings of the brain, but for applied market research these differences are purely of an academic nature.

Another difference between MEG and EEG is the number of recording positions or channels. Some modern MEG systems have more than 300 channels, whereas most EEG cap systems are usually limited to around 100 channels or even far fewer for technical and practical reasons (for example, good signal acquisition requires a series of time-consuming work steps for each electrode individually). Although the number of channels in MEG vs. EEG seems to speak in favor of MEG, this difference is only relevant for basic academic research.

Signals from very few electrodes can yield noteworthy insights into what happens in the mind of a consumer or customer. For instance, when a sequence of pictures is shown to a subject, signals from a single electrode (positioned on top, slightly towards the back of the head) can reliably indicate which of the pictures has evoked attention in the observer's brain. Equipment and software for measuring the EEG are available at acceptable costs. Furthermore, the EEG is more robust than fMRI and MEG with respect to the subject's mobility.

EEG has been applied not only in the laboratory setting but also in field studies, such as while subjects were walking through aisles of a store or driving a car.

The basic principle of a pricing investigation also holds for the EEG: Those signals which distinguish attention from no attention or positive vs. negative psychological states can be recorded and interpreted in the context of different prices, price displays, price bundles and the like.

An extra tool in the market research toolbox

The marketing community has picked up on technological progress in the cognitive neurosciences in recent years. Businesses have recognized how novel tools can shed light on implicit processes and thereby pave the way for a better understanding of the customer's mind. Of the three research methods presented here, MEG and EEG yield good insights into when something happens in the

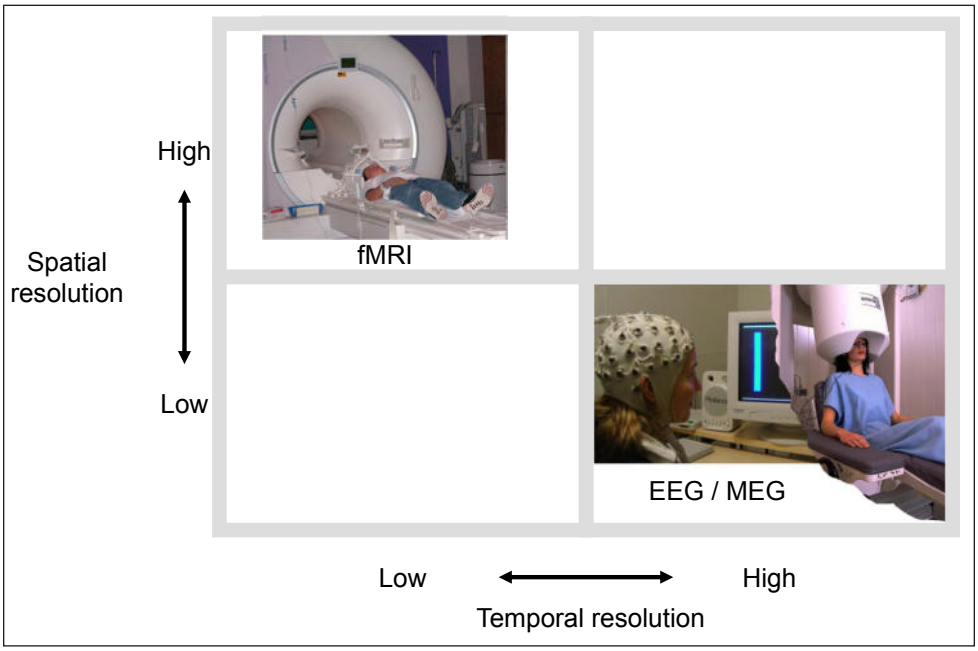

Figure 1: The three advanced brain research techniques discussed in the context of neuromarketing. EEG and MEG (southeast quadrant) measure brain activity in real time, since the signal they acquire is based on electromagnetic variations arising directly from activity of the neurons in the brain. However, these techniques have limited capacity to pinpoint the exact brain area of activity. With fMRI (northwest quadrant), on the other hand, neuroscientists can localize activity with high accuracy. On the downside, fMRI has an inferior temporal resolution since the signal is associated with rather slow changes in the blood flow following neural activity.

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brain, while fMRI tells us where it happened.

Figure 1 (on previous page) summarizes these differences of the acquired signals. None of the techniques discussed has really become a mainstream approach yet. Some research agencies, however, have started to focus on EEG recordings as a market research tool because it has two core advantages:

- The opportunity to conduct field tests outside the laboratory
- Relatively low cost

We initially identified the two branches of neuromarketing, basic and applied research. The outstanding spatial resolution of fMRI has contributed to our understanding of the neural responses, which can be evoked by different prices. Similarly, the MEG represents an advanced tool that will help to improve our understanding of the brain.

Unfortunately fMRI and MEG pay a high price for their slightly superior signal quality: They are highly sensitive to the subject's head movements and the huge devices cannot be moved, so experiments are limited to the laboratory. Costs for devices necessary to record MEG and fMRI run to millions and exceed the cost of EEG equipment by a factor of about 1,000. This is one reason why MEG and MRI devices are generally hired, while EEG equipment can easily be bought.

It is well possible that neuromarketing will become a standard tool in market and product research. A neuromarketing company recently announced its first neuromarketing omnibus study. Using neuromarketing as an additional research tool will therefore probably become cheaper, more efficient and more standardized in the future. It is advisable for companies to prepare for this advanced level of market research.

Finally, is directly measuring brain activity really better than simply asking the customer which price he or she prefers?

Finally, is directly measuring brain activity really better than simply asking the customer which price he or she prefers? This question brings us back to the analogy of selling and buying as a bluffing game and the importance of knowing what happens in the mind of the customer.

Questionnaires and behavioral experiments suffer from heavy cognitive filtering. In particular, when asked about prices, a significant proportion of subjects may think that their answers will directly influence the final price of the product, so they may indicate a price below their true willingness to pay.

Alternatively, subjects may feel that a certain answer is desired and they fall for the perceived social pressure. It is conceivable that future recordings of brain activity will counteract such biases stemming from questionnaires or other behavioral research. This will give buyers fewer chances to bluff successfully, irrespective of whether their bluffing was intentional or unconscious. Neuroscientific techniques may therefore lead to a better understanding of customers' mental processes, enable more accurate predictions of buyers' behavior, and ultimately generate higher profits.