

Neuromarketing

- Theoretical foundations and practical implications -

If meaning to establish neuromarketing in marketing research, at least four things are necessary: First, a neurophysiological signal has to be identified that reliably and univocally indexes a specific psychological process to avoid the reverse inference fallacy. Second, this process has to be understood in terms of a functional theory. Third, the process has to be relevant for purchase decisions. Fourth, it has to predict purchase decisions in the real world in ways that are somehow advantageous compared to the current standard.

This paper will summarize recent developments concerning all of these four points.

Avoiding the Reverse Inference Fallacy: Approach Motivation and the Frontal Alpha Asymmetry

Most basic research manipulates *psychological processes* to investigate their impact on *neurophysiological signals*. This is called a forward inference and implies a strict causal direction: from process to signal. For marketing research, it is necessary to reliably infer a psychological process from a given signal, however, which is problematic because the probability of a process given a signal (i.e. a reverse inference) is often unknown.

One solution to this reverse inference fallacy is the use of Bayes statistics. Ariely & Berns (2010), for example, showed that activity within the nucleus accumbens (NAcc) is reliably associated with reward expectancy, with a probability of 0.90 for a reward task, given activity in the NAcc. Following their example, we recently analyzed almost 200 experimental manipulations to quantify the relationship between an EEG measure called frontal alpha asymmetry (FAA) and motivational approach and withdrawal tendencies (Briesemeister, Tamm, Heine & Jacobs, 2013). Bayes statistics revealed that the probability of approach/withdrawal motivation given an FAA effect is 0.79, which is moderate but reliable evidence when using the FAA as a diagnostic tool. This suggests that the FAA paradigm sufficiently avoids the reverse inference fallacy.

Approach Motivation, Familiarity and Relevance: The Zurich Model of Social Interactions

Knowing that the FAA reliably indexes approach motivation, the next step is to explore the *functional processes* underlying approach motivation. Early research documents the importance of emotions, showing that e.g. anger modulates approach motivation as measured by FAA (Harmon-Jones & Allen, 1998). More recent work suggests that personal relevance and familiarity might affect the FAA (Ravanja, Somervuori & Salminen, 2013), showing that left-frontal (i.e. approach-related) activity increases when subjects are presented with needed (relevance) or well known national label products (familiarity).

A theory that incorporates all of these factors (i.e. emotions, familiarity, relevance and approach/withdrawal motivation) is the Zurich model of social interactions (ZMSI, Bischof, 1989; Schönbrodt, Unkelbach & Spinath, 2009), which suggests that approach motivation in social interactions is modulated by three factors: distance to the social object (SO), familiarity with the SO and relevance. Moreover, if some factor hinders the execution of approach or withdrawal, this elicits specific emotional responses like fear, curiosity, submissiveness or anger. Finally, the ZMSI assumes that humans differ in their responsiveness to these factors in the sense of a personality trait.

To test whether the ZMSI can be used as a theoretical framework for FAA effects, we asked 15 subjects (8 males, mean age 25, SD 6, range 18-34) to play a computer game of cards while recording a 32 channel EEG. In each round, they received two random cards with specific values that added up to a total of anything between four and 22 points. Then they were asked whether they wanted to keep their set of cards, or whether they wanted to switch cards with their opponent. After their decision, the player with the more valuable card set received 5 cent from the player with the lesser value and the next round began. The idea behind this was as follows: Of course, playing a computer game of cards has not much to do with social approach motivation. But as Anderson (2010) suggested, evolutionary young processes (e.g. playing a game of cards) often reuse evolutionary old brain structures (e.g. social approach networks) and thus follow comparable mechanisms. It seems plausible that subjects seeking for security in social interactions also prefer the safe bet in a card game, and that socially curious subjects are more risk taking in general. We thus predicted that the FAA would predict our subjects decisions (see Ravanja et al., 2013) and that the ZMSI personality structure as measured with a standardized questionnaire (Schönbrodt et al., 2009) would explain some variance in this effect.

Surprisingly, the FAA (electrodes F3/F4, 8-12Hz, 1000ms before the decision) showed no statistically significant difference for keep vs. switch cards decisions. Adding the three ZMSI scales security, enterprise and power as covariates changed that, however. Both, the keep vs. switch cards FAA effect and its interaction with enterprise reached significance. Moreover, there was a tendency for an interaction with security. This demonstrates the importance of an underlying theory and the explanatory power of the ZMSI for FAA effects.

The Frontal Alpha Asymmetry: Modulated by Purchase Intentions

The aforementioned study by Ravanja et al. (2013) not only discovered that relevance and familiarity seem to modulate the FAA, but also showed that FAA signals can predict purchase decisions in the lab. In a simple

experiment where subjects were asked whether or not they would buy different products at varying prices, the FAA reliably predicted the subjects' decisions. Low prices, high product need, brand familiarity, and high product quality were all associated with increased left FAA. Moreover, the greater the FAA was in the predecision period, the more likely was the participant to purchase the presented product. Ravanja et al. (2013) thus clearly demonstrate that the FAA can predict purchase decisions. It is therefore not only reliable and theoretically grounded, but also relevant for marketing research.

From the Lab to the World: Predicting Real Sales with the Frontal Alpha Asymmetry

The remaining but very crucial question is whether lab recordings of the FAA signal are predictive for real purchase decisions made by the whole population in actual shopping situations. First experiments have shown that neuroimaging studies can indeed predict population behavior, based on different fMRI signals (Berns & Moore, 2012; Falk, Berkman, & Lieberman, 2012). Dmochowski et al. (2014) additionally showed that the temporal reliability of small sample EEG data can predict different behavior on the population level. Together, these studies show the predictive potential of neurophysiological data, albeit none of them uses the FAA.

To test the predictive power of FAA for population level effects, we partnered with the German internet platform ebay Kleinanzeigen and created three want ads for a second hand bicycle ergometer. The ads were identical in wording and price, but differed with respect to the attached picture: PicA showed the dirty ergometer in a cluttered garage, PicB showed the still dirty ergometer in front of a house, and PicC showed the clean ergometer in front of a white background to present an ordinary persons imitation of a professional product presentation.

First, a focus group of five experts in psychology of decision making (two of them with a business background), were asked to judge which of the three want ads would actually sale the ergometer. Second, the three want ads, together with 19 distractors constructed from real want ads for ergometers, were presented to 18 right-handed subjects¹ (2 male, mean age 25, SD 4, range 18-32) while we recorded their 32-channel EEG to later calculate the FAA (electrodes F3/F4, 8-12Hz, 300-1500ms after onset). The experimental setup was designed to imitate the real ebay Kleinanzeigen website. Participants were asked to name one of the ergometers that they would recommend to an interested older relative, which was done to limit the influence of the participants financial backgrounds. Since all participants chose one of the distractors for recommendation, we later on emailed them again, asking which of the three want ads of interest they would buy.

Finally, parallel to the in-lab data collection, the three want ads were published on ebay Kleinanzeigen Germany to collect click-rates and to determinate which ad would lead to an actual sale.

The focus group articulated a clear preference with PicC > PicB > PicA. This pattern was replicated in the email questionnaire, where PicC was chosen twice as often as PicB, which was chosen twice as often as PicA. The averaged FAA showed no significant differences between the conditions. An inspection of the signal change over time revealed that the relative left FAA signals for PicA and PicC were constantly decreasing over time, however, while it was increasing for PicB. Taking the order of maximum and minimum FAA peak into account (decreasing: min-max, increasing: max-min), PicB showed a statistically significant stronger signal than both other pictures.

Empirically, the PicC want ad was clicked 44% more than the two alternatives, which did not differ. This is in line with the focus group and questionnaire predictions, but not with the FAA analyses. Interestingly, the ergometer was sold via PicB, however, as predicted by the FAA.

Awaiting replication, this single case data indicates that the FAA recorded on a small sample in the lab can predict real world purchase decisions. In that, it outperformed standard questionnaires and expert focus groups.

Implications for Practice: FAA predicts real world purchases, but time matters

Since most neuromarketing vendors have to be very secretive concerning their algorithms, reliable evidence that neuromarketing methods actually deliver what is claimed is still sparse. Despite early efforts (Ohme, Matukin & Szczurko, 2010; Ohme, Reykowska, Wiener & Choromanska, 2010), this is also true for the FAA.

The research presented here means to overcome this lack of information, showing that:

- a) the FAA is reliably related to approach motivation, thus avoiding the reverse inference fallacy. Neuromarketing vendors using the FAA thus can be assured that they really measure approach motivation.
- b) personality traits as defined by the ZMSI modulate FAA effects. This provides a functional framework for the interpretation of FAA effects in marketing research and thus allows for a new perspective and new hypotheses concerning how humans make purchase decisions and the way they are affected by marketing.
- c) the FAA, even when recorded on single trials, can actually predict real world shopping behavior. It also highlights the importance of temporal variances, as already suggested by Dmochowski et al. (2014).

In sum, this paper provides a scientific basis for the use of FAA signals in neuromarketing.

All of these data are currently prepared for publication (Briesemeister, Tamm, Heine & Jacobs, in prep.).

¹ The actual sample size was 20, but two subjects were excluded due to noisy data

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