Neural Prediction of Market-Level Crowdfunding Outcomes

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In this paper, we present a real-world scenario in which neural data predicts market-level behavior significantly better than traditional behavioral methods. This is the first work to assess the neuropsychological processes implicated in the crowdfunding marketplace. These findings highlight the ability of neuropsychological inferences to scale to the aggregate level.

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Reinvestigating Fundamental Concepts of Marketing and Consumer Research—How Consumer Neuroscience Adds Additional Value to Our Discipline

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Paper #2: Neural Prediction of Market-level Crowdfunding Outcomes

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Paper #3: We Are What We Know: Using Consumer Neuroscience to Build a Better Understanding of Price Knowledge

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Paper #4: Effectiveness of Print and Digital Media: Insights from Neuroscience

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SESSION OVERVIEW

Since the early days of marketing, next to product- and distribution-related decision, marketing communications and pricing have always been of utmost importance. From a consumer research point of view, it is vital to understand the effects of any such marketing activity on the cognitive and affective information processing as well as on the decision-making of the consumer. Traditional methods of marketing and consumer research can capture those effects only to a certain extent. Consumer neuroscience, as a joint discipline between neuroscience and consumer research, provides an additional approach to add to our current understanding of why and how marketing actually works. Studies within the area of consumer neuroscience may support, help refine or reject established theories. Consumer neuroscience aims at extending our knowledge by adding biological data to complement our understanding of human consumption behavior. Currently, this understanding is predominantly based on behavioral and psychological data. While having started as a niche-phenomenon about two decades ago, today, consumer neuroscience has its fixed place in the consumer researcher’s toolbox. In our special session, we want to provide examples of how consumer neuroscience can advance knowledge in regards to selected fundamental concepts of our discipline. In particular, we provide examples on how consumer attitudes and preferences as well as consumer decision-making can be explained within a consumer neuroscience context. We discuss neural findings on consumer behavior-related phenomena as a result of cognitive (impact of pricing) and affective (effect of communications) information processing. The main objective of this special session is to broaden our horizon and way of thinking about fundamental concepts which have been relevant to marketing ever since (e.g., price knowledge and effectiveness of advertising). Our four papers presented in the special session will showcase empirical examples which provide a solid basis for a joint discussion on the added value of neural data to better understand fundamental phenomena in marketing and consumer research. We also want to discuss the potential difficulties and challenges that might come with applying neuroscientific methods to resolving questions relevant to consumer behavior. Hence, our four papers raise the following two joint questions for a comprehensive discussion:

What in particular can we learn about selected fundamental concepts of marketing and consumer research by using neuroscientific methods?

How does consumer neuroscience provide added value to our discipline and what can it not provide?

This special session was organized by Monika Koller, WU Vienna. In the following, we present the extended abstracts of the four papers included in our special session.

Emotional Responses to Movie-Trailers Predict Individual Preferences for Movies and Their Population-wide Commercial Success

EXTENDED ABSTRACT

Consumer neuroscience, applying neuroscience methods to marketing, has gained considerable popularity in recent years amongst scholars and practitioners alike (Smidts et al., 2014). As noted by Ariely & Berns (2010), there appear to be good reasons for this enthusiasm. First, because brain data are considered to be less noisy than data obtained through conventional marketing methods, it is thought that data from smaller samples can generate more accurate predictions, making neuroscience methods cheaper and faster than traditional methods. Second, it is believed that neuroimaging methods could provide marketers with information that is not obtainable through conventional marketing methods. This idea is based on the assumption that people cannot fully articulate their preferences when asked to express them explicitly, and that consumers’ brains contain hidden information about their true preferences.

Indeed, several decades of research in psychology have shown that many important mental processes occur below the surface of consciousness (Dijksterhuis, 2004), leaving people very limited in their ability to predict their own future behaviour and to accurately identify their internal mental states through verbal or written self-reports (Nisbett and Camp Wilson 1977). These issues with self-report data are particularly problematic in the measurement of emotional responses. This is a particularly salient problem because marketing researchers have observed that the emotions evoked by marketing stimuli are important determinants of commercial success and sales. That is, advertisements that manage to evoke the strongest (usually positive) emotions are considered to be the most effective
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(Batra & Ray, 1986). However, accurately measuring these emotions is not straightforward due to the limited capacity for introspecting on sub-conscious processes. Moreover, reporting on these processes with a high temporal resolution (for example every second for a video stimulus), might actually alter the ongoing emotional process (Wilson and Schooler 1991).

For the present paper, we set two goals: (1) decode the emotional experience from our participants’ brains while they were exposed to marketing stimuli, without relying on self-report, and (2) use this decoded emotional experience to predict individual preferences and choices as well as sales in the population at large.

We had participants perform two tasks, while undergoing fMRI scanning. In the first task, participants passively viewed photographs selected from the IAPS database to represent the four quadrants of affective space (positive and negative valence, and high and low arousal). In the second task, participants viewed cinematic trailers of 18 movies that they had not previously seen. Movie trailers can be seen as advertisements for movies and play a crucial role in the marketing efforts by the movie industry (Gazley, Clark, and Sinha 2011). In addition, we collected both individual stated (willingness to pay) and revealed (choose three DVDs to take home) preference measures, as well as self-reported valence and arousal experienced during trailer-watching. Finally, we obtained US Box Office results of the viewed movies as a measure of population choice/real-world preference.

Our analyses of the data proceeded in several steps. First, we localized the brain areas most strongly associated with processing the emotional content of the IAPS pictures with a support vector machine (SVM) searchlight algorithm. Neural activations from these areas were subsequently used to train two emotion (i.e., valence and arousal) SVM classifiers to predict the emotional content of the IAPS pictures. Then, the trained classifiers were applied to the neural responses during movie-trailer watching to decode the pattern of neural activity at each brain volume into two emotion attributes (i.e., valence and arousal). That is, we classified every brain volume acquired during the viewing of the trailers as either positive or negative in valence, and high or low in arousal. Finally, we took the time course of decoded emotional brain states from every trailer, and tried to predict from this data (1) participants’ self-reported emotional state, (2) their preferences and choices with regards to the movies they watched, and (3) the population response to the movies (US Box Office).

The results first showed that the trained SVM classifiers performed well in decoding the emotional content from the brain: using leave-one-out cross-validation, it could predict emotional valence with 57% accuracy (chance = 33%), and arousal with 65% accuracy (chance = 50%). Applying the trained classifiers to the neural data obtained during movie-trailer watching results in two time series (one for valence and one for arousal) of decoded emotional content per trailer and per subject. To test whether these time series actually represent valence and arousal, we tested whether the emotional response decoded from the brain was associated with the self-reported emotional experience. To do this, we aggregated each time series into a single measure of valence and arousal respectively. The results showed that indeed, self-reported experienced arousal could be predicted from our decoded neural arousal measure, while self-reported valence could be predicted from our neural valence measure.

Finally, we tested whether the decoded emotional response was predictive of preference and choice. We found that the neural valence measure was predictive of both stated preference (WTP), as well as revealed preference (the three DVDs they chose to take home). In addition, we found that both the decoded emotional valence, as well as arousal significantly predicted choice in the population at large (US Box Office). Importantly, while self-reported arousal was also significantly associated with Box Office, self-reported valence was not and the variance in Box Office explained by self-report measures was relatively low ($R^2=15\%$). Adding our neural decoded response measures to this model showed that both decoded valence as well as arousal significantly added to the model and resulted in a significant increase in explained variance ($R^2=41\%$).

Our findings show that, using neuroscience methods, we are able to obtain an implicit measure of the emotional experience evoked by marketing stimuli, and that these measures can be used as a neural marker for commercial success. As such, we provide evidence that neural activations reflecting the emotional experience in response to marketing stimuli are related to real-world outcomes, and that such neural measures significantly add to prediction models of choice behaviour in the population at large.

Neural Prediction of Market-level Crowdfunding Outcomes

EXTENDED ABSTRACT

Although established economic and psychological theories (such as revealed preferences and behaviorism) imply that past choice is the best predictor of future choice (Bernheim, 2008), there may be some fundamental elements of the decision making process that scale more effectively to predict behavior at the market level (Ariely & Berns, 2010). Recent neuroimaging research has demonstrated that neural activity measured in a small laboratory sample can augment behavioral predictors of aggregate behavior (Genevsky & Knutson, 2015). In this work we demonstrate that neural data can predict market-level outcomes in a large consumer marketplace significantly better than traditional behavioral methods.

Crowdfunding refers to the practice of using small financial contributions from a large group of investors to fund new projects or ventures. The popularity of crowdfunding on the internet has grown exponentially in recent years, and in 2015 raised over $34.4 billion (Massolution, 2015). Crowdfunding websites offer a unique opportunity for individuals to engage with products as both financial supporters and consumers. However, despite its growing popularity and economic significance, the neural and psychological mechanisms responsible for individual decisions to fund projects have not been explored.

Neural activity has been effectively used to predict individual choices in contexts of consumer purchasing (Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007). We investigated how people weigh these factors to make purchasing decisions. Consistent with neuroimaging evidence suggesting that distinct circuits anticipate gain and loss, product preference activated the nucleus accumbens (NAcc and financial risk preferences (Kuhnen & Knutson, 2005). Fewer studies, however, have used neural data to predict market-level behavior. For instance, researchers have found neural correlates of aggregate responses to popular music sales (Berns & Moore, 2012), public health message (Falk et al., 2011), and movie box office returns (Boksem & Smidts, 2015). In the present paper, we seek to identify which neural precursors to individual choice best generalize to forecast aggregate behavior. We investigate this question by using neural activity to predict individual and aggregate choices within a crowdfunding context.

To assess the ability of neural activity to predict funding success, thirty subjects (14 female, mean age=23.32) were recruited for a functional magnetic resonance imaging (fMRI) study and asked to make incentive-compatible decisions regarding 36 actual document-
tary film projects which had been posted online on a crowdfunding website (www.kickstarter.com). We used neural data collected during the task to predict both individual decisions to fund and the real-world funding outcomes of these projects on the internet.

On each trial, participants were first presented with the image from each project page (2 secs), followed by a screen depicting the remainder of the project’s brief text description (6 secs). Subjects then indicated whether or not they would like to fund the project using spatially counterbalanced (i.e., left or right) ‘Yes’ or ‘No’ prompts by pressing one of two corresponding buttons (4 secs). Finally, subjects fixated on a cross (variable 2-6 secs) until the next trial began. After scanning, subjects rated their liking of each project as well as their predicted likelihood of each project reaching its funding threshold (i.e., perceived project success). Subjects also rated their own affective responses to each of the projects using two scales: one indexing valence (positive–negative) and the other indexing arousal (highly arousing–not arousing).

Neural analysis contrasting whole-brain activity in trials in which subjects decided to fund versus trials in which they did not, indicated significant differences in a defined subset of regions associated with positive affect (i.e., nucleus accumbens or NAcc) and value integration (i.e., medial prefrontal cortex or MPFC). Greater activation in these areas while viewing the projects was associated with eventual decision to fund. This activity occurred before the choice phase of the trial, and thus preceded activity associated with the act of indicating a choice. We next investigated how well laboratory sample behavioral measures and neural activity could forecast market-level outcomes on the internet. A logistic regression model was used to forecast market-level funding outcomes for each of the projects, and included subject’s self-report ratings of affect, project liking, and perceived project success, as well as actual funding choices, and neural activity. Of these predictors, only NAcc activity was significantly associated with internet funding outcomes. All other self-report variables and activity in other neural regions of interest were not associated with funding outcomes.

We examined whether affective neural mechanisms could forecast crowdfunding outcomes — both in individuals, and at the aggregate level of an internet market. While activity in both NAcc and MPFC brain regions predicted individuals’ choices to fund in a laboratory sample, only NAcc activity generalized to forecast aggregate funding success. Further, neural forecasts of market-level outcomes outperformed models incorporating self-reported preferences, affect, and even behavior. These results demonstrate in the context of crowdfunding that a subset of the neural mechanisms that predict individual choice can scale to forecast market-level outcomes. The findings also carry the applied implication not only that neural activity might add value to behavioral measures, but may also reveal otherwise hidden information relevant to forecasting aggregate outcomes (Ariely & Berns, 2010). These results highlight a need for marketers and neuroscientists to better understand when, where, and how neural activity can be leveraged to more accurately forecast aggregate choice.

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We Are What We Know: Using Consumer Neuroscience to Build a Better Understanding of Price Knowledge

EXTENDED ABSTRACT

Price knowledge (PK) is an important behavioral pricing theme in consumer research (e.g., Kukar-Kinney et al., 2012). However, research neglects that PK should not depend solely on product-related or psychological factors, but should also consider neurobiological factors. This neglect is astonishing, given the understanding that PK is stored in consumers’ brain memory system (e.g., Monroe and Lee 1999). In addition, there is evidence that PK depends on consumers’ individual abilities to remember prices and consists of affective (implicit PK) as well as cognitive (explicit PK) capacities (Kennedy & Plassmann 2005). Recent studies in consumer neuroscience show, that the interplay of these processes is at least partially determined by neurobiological processes (e.g., Plassmann & Weber, 2015). As there is at best inconsistent evidence on individual consumer characteristics that determine PK (e.g., Gaston-Breton & Raghubir, 2013), this research tries to answer the following question: Can the integration of neuroscientific methods (i.e., fMRI) lead to a better understanding of PK? The fMRI study was designed to justify the assumptions behind PK and its neural correlates. We propose to find neural activity changes in regions associated with cognitive and affective information processing due the fact that PK has an implicit as well as an explicit component.

In our study, subjects (N=20; 11 female, 9 male healthy, right-handed subjects; Mage=41.85 years, SD=3.88) participated in a product-price-decision task (modified task by Knutson et al., 2007) where they had to decide whether or not to buy a certain product for a given price. In order to focus on the processing effect of PK our study has two key aspects: First, we used a fixed product category and only varied decisions with respect to prices. Second, our user sample was pre-screened for consistently using and buying the products. The first parameter used in our study—“price differential”—refers to an explicit and direct integration of the price the consumer saw in the trial before and is defined as the difference of the seen price in t and the price they judged in t-1. The second parameter—“price average”—takes into account that participants develop a more implicit task-dependent PK in the course of the task. This parameter is defined as the average of all prices the participants judged until the current trial. Data analysis was conducted with the SPM8-freeware (Friston et al., 1994) using MatLab as a working base. A General Linear Model (GLM) models events of interest with a parametric modulator for the price phase and decision phase and the two task-dependent PK parameters “price differential” (Dprice_diff) and “price average” of prices shown before (Pprice_avg). The parametric modulators were defined as follows: (1) $P_{price\_avg} = \text{mean}(\text{price}(1:t-1))$. The parametric modulators were defined as follows: (1) $P_{price\_avg} = \text{mean}(\text{price}(1:t-1))$. We calculated the following first-level single-subject contrasts of interest: 1) decision modulated by Dprice_avg, 2) decision modulated by Dprice_diff, and 3) decision modulated by Dprice_avg. Third, on second-level, for extracting differences of single-subject contrasts between subjects we computed a one sample t-test. Post hoc tests of neural activity changes in regions of interest (ROIs) identified by the second-level group analysis by contrasts of Dprice_avg and Dprice_diff were computed by running three additional GLMs that separated regressors following the procedure in Litt et al. (2011).

To check for behavioral differences in positive judgments between the selected prices, we entered the shares of positive buying intention ($pS_{price}$) and gender as between subject factor into one-way ANOVA (with price: [66:1.24]) corrected for repeated measures using the Greenhouse-Geisser (GG) correction criterion, and found a significant main effect for price; F(3,011, 54.189) = 26.150, p < .001, but no main effect for gender; F(1, 18) = 0.243, p = .628, as well as no interaction effect of price*gender; F(3,011, 54.189) = 0.074, p = .425. For observing a possible integration of task-dependent PK for the given parametric modulators, we checked for inconsistent judgments for a given price level for each participant, which could be confirmed. Additionally, to control for behavioral differ-
ences in inconsistent judgments with regard to the different flavors we entered an interaction term of price shown and ps\textsubscript{product} to model this possible acceptance bias into an one-way ANOVA (with flavor: [A, J]) and found no significant main effect for flavor; F (9, 80) = 0.126, p = .999.

Next, we generated statistical parametric maps for the given contrasts of interest (D\textsubscript{price}\textsubscript{avg}, D\textsubscript{price}\textsubscript{diff}, D\textsubscript{price}\textsubscript{avg}) that displayed the t-value of each peak voxel meeting a p < .001 (uncorrected) significance level with an extent threshold voxel of k = 5. We found neural differences in brain structures associated with integrating background (price) knowledge, decision making and information processing in dependency of the seen product-price combination. In detail, we found that activation in the left medial prefrontal cortex (BA 10), the right and left anterior cingulate cortex (BA 24) and the right parahippocampal gyrus (BA 36) was negatively correlated with the price parameter within the decision phase. Furthermore, we found neural activity changes in brain structures associated with information and knowledge processing according to our task-dependent PK parameters (D\textsubscript{price}\textsubscript{diff}, D\textsubscript{price}\textsubscript{avg}) that differed from the results with regard to the absolute price-level parameter. In detail we found that activation in the insula was positively correlated with increasing price differentials within the decision phase and the parahippocampal gyrus and the caudate were negatively correlated with increasing price averages within the decision phase.

This research helps to provide further understanding of the different aspects of price-dependent decision making in consumers. We demonstrated the complexity of antecedents of price-dependent decision making. The results provide evidence that especially unconscious processes associated with the integration of background (price) knowledge, decision making and information processing influence the brain activation and behavior. First, the integration of explicit and implicit task-dependent PK leads to activity changes in brain regions associated with information processing and decision making and these activity changes differ from the findings with regard to absolute prices. This leads to the conclusion that the integration of PK is a rather complex and dynamic process, depending on various situational factors.

**Effectiveness of Print and Digital Media: Insights from Neuroscience**

**EXTENDED ABSTRACT**

Does it matter whether you are reading your favorite novel as a physical book or on a kindle? What are the implications for long-term memory? Given major advances in digital media over the past decade, there has been an emerging interest in comparing print (or physical) versus digital (or electronic) media across various contexts (e.g., Verdi et al., 2002; Terrenghi et al., 2007; Steinme et al., 2010; Kim and Anderson 2008; Millward Brown, 2009; Eden and Eshet-Alkalai 2012). This is a particularly important question in marketing where despite the growing popularity and complexity of managing marketing communications across physical and online media channels (often referred to as cross-media marketing), little is known about the effectiveness of each of these channels and their impact on the consumer buying process.

In this study, we used a novel experimental design involving multiple neurophysiological methodologies (traditional self reports, eye tracking, heart rate, skin conductance and functional neuroimaging, fMRI) to better understand how consumers process print versus digital advertisements. We focused specifically on the differences in cognitive processing across the two formats, both during exposure and retrieval. To overcome the practical difficulties involved with experimental control when participants are interacting with physical stimuli, we conducted the study over two separate experimental sessions with the same set of participants. Both experimental sessions occurred approximately one week apart. A total of 56 participants completed both sessions of the study.

In the first session involving eye-tracking and biometric measures, participants were exposed to a mix of physical and digital ads. A total of 40 ads ranging across CPG products, services and restaurants were used in the study. They were split into two groups of 20 ads each, and randomly assigned to physical or digital condition across participants. Therefore, each participant viewed each ad only once during exposure, in physical or digital format. The digital ads were presented on a Tobii T60XL eye-tracker in the form of emails pre-loaded into offline gmail app. Participants could open the emails in any order and spend as much time as they desired viewing the ads. For the physical ads, they physically placed the ads onto a small platform where the processing could be captured using a combination of camera and eye-tracking system. Processing was measured after they positioned the ads into the platform. The size of the ads was controlled across both formats. At the end of the session, participants were re-exposed to the ads a second time in the same format, while seated in front of a computer. During re-exposure, traditional self-report measures were collected after each ad to measure preferences and attitudes about the ads and their contents. The order was counterbalanced across participants.

We found no significant differences in self-reported preferences and attitudes for the ads between the two formats. Participants spent more time when interacting with physical advertisements (t = 5.807, p < 0.001). Yet, their eye gazes tended to be more mobile (e.g., greater proportion of time spent on saccades) compared to digital ads (t = 3.253, p = 0.002). They also had a greater proportion of long fixations (>150ms) when looking at digital ads and spent more time per fixation when processing the ad (t = -1.834, p = 0.072). Finally, using frequency domain analysis of heart rate variability, we found that digital ads were also associated with greater parasympathetic tone (HF) (t = -2.552, p = 0.015). Together, these results suggest that digital ads were associated with greater attention and more systematic processing than physical ads (Venkatraman et al., 2014). However, the level of engagement to key components of the ads, such as the products and/or brands featured, showed no differences between the formats. It is possible that the extended exposure time in physical format compensated for lesser attention. We also found converging evidence for greater levels of arousal during exposure to physical ads. The average pupil size was significantly larger when participants viewed ads in the physical format (t = 9.754, p < 0.001). Similarly, the tonic and phasic skin conductivity were higher at the anticipation of looking at physical ads relative to digital ads (t = 4.764, p < 0.001).

In order to understand whether the differences in levels of attention and arousal between the two formats were associated with greater depth in processing and improved memory during subsequent purchase decisions, we used functional magnetic resonance imaging (fMRI) in Phase 2 to study memory (item and source) for each of the 40 ads, and purchase intentions (willingness to pay, WTP) for the products and services featured in the ads. We found that participants were more likely to remember an ad and its context if they were previously exposed to it in the physical format. This behavioral difference was corroborated by increased activation in the hippocampus and parahippocampal regions during memory retrieval for physical relative to digital ads. The parahippocampal region has been consistently associated with processing of scenes and places in previous studies (Epstein et al., 1998; Epstein and Ward, 2010).
Therefore, these differences could reflect superior recollection of the context surrounding the ad, when it had been exposed in physical format previously.

Using a BDM auction procedure, participants were asked to provide their WTP for the products and services featured in the ad. There were no differences in the self-reported purchase intentions or willingness to pay for the items featured in the ads based on prior exposure. However, we found increased activation in the ventral striatum when participants were estimating their WTP for items previously exposed in the physical relative to digital format. Based on prior results and the role of this region in reward processing and desirability (Venkatraman et al., 2015), we argue that exposure in physical format could lead to increased desirability for the products and services featured in the ad.

In summary, our findings have tremendous practical implications for marketers and marketing theory. By demonstrating the complementary nature of the two formats using a carefully controlled experimental design, we provide valuable insights for marketers to optimize their media mix.

REFERENCES


