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How Neuroscience-Based Research Methodologies Can Deliver New Insights to Marketers

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ABSTRACT: While traditional market research methods are focused on surveys and group discussions, consumers' attitudes, the choices they make, and the behaviour they display are all driven by a complex set of factors, and much of what is happening takes place in the subconscious mind. Learning that a stimulus engages in a positive way and that memory formation is taking place does not tell the marketer anything about the quality and impact of these memories or the engagement. With the technological advances, the emergence of neuroscience-based methodologies offers a higher degree of reliability. In the recent years, a noticeable increase in the use of eye-tracking and EEG frontal asymmetry technique was observed to measure cognitive processes of consumers among which are attention and perception to gain insights into their decision-making processes, consumer preferences and/or motivations. Using a real-world use case, this study highlights the importance of using neuroscience-based methodologies to evaluate packaging design to identify how well the brand is positioning itself on the subconscious level. While results from our study suggest that subjects displayed avoidance behaviour according to the lower frontal alpha asymmetry score, the statistical analysis failed to show significant difference between left and right hemisphere. Regardless of the statistically insignificant EEG findings, relatively longer times to first fixation among the areas on the visual suggest that the visual is not optimally designed and that for obtaining insightful data in product packaging field, relying on eye-tracking techniques is sufficient for reliable insights.

KEYWORDS-Neuromarketing, Neuroscience-Based Market Research, Eye-Tracking, Neuroimaging, Concept Testing, Neuropackaging

I. INTRODUCTION

Traditional market research methods such as surveys and group discussions rely on the consumer's ability to tell us what exactly is going on in their mind. However, consumers' attitudes, the choices they make, and the behavior they display are all driven by a complex set of factors, and much of what is happening takes place in the subconscious mind [1, 2, 3]. A consumer may want to be helpful and tell us what is driving a purchase decision or how they feel about a package design or product, but they are not able to delve into their subconscious [3, 4, 5].

Professional marketers have been aware of these limitations, but until recently there was no viable alternative for exploring the consumer's mind due to a lack of equipment that could tell us what is going on the consumer's mind and a lack of software that could translate physiological measures such as eye movements, brain waves and response times into meaningful marketing metrics. In recent years, a noticeable increase was observed in the popularity of using eye-tracking technique to measure cognitive processes of consumers among which are attention and perception to gain insights into their decision-making processes, consumer preferences and/or motivations [6]. Eye-tracking systems (i.e., systems that constantly detect the place of a person's gaze while seeing or interacting with a visual picture) have recently been common in research. Researchers can not only calculate which parts of the visual picture were focused (viewed) but also for how long, and how many times based on a sample of the person's eye orientation [7] Eye tracking is particularly useful when marketers need to understand which elements of an exposure (e.g. an advertisement, social media post, in-store product display, website, etc.) attract the consumer's attention and engage the consumer [8, 9, 10, 11, 12]. Finding out which elements of an exposure the consumer does not see is, of course, often equally important [13] This technique grants a possibility to evaluate the gaze or fixation point, the gazing time, the movement of the eye including the sequence of eyes shifting from one spot to another, pupil dilation and the number of blinks in order to extract meaningful results [14, 15] Measurements can be obtained while subjects are viewing either static or dynamic stimuli. A qualitative analysis of measurements, such as heat/fog maps and gaze plots, can provide a solid foundation for the interpretation of results. The heat map reveals the focal

points that attract the participants' attention, while an analysis of the fixation points allows us to identify which parts of a focal point attracts the most attention [16,17].

At the end of the 20th century, the variet y of brands and products in the market skyrocketed, as did the amount spent on marketing. Marketers use advertising ads as a primary communication tool, yet traditional media (printing) has become crowded with brand promotions. As a result, attracting and maintaining the attention of customers has become increasingly challenging [18]. Advertisements that failed to capture and hold customers' focus are ineffective, yet attention alone isn't enough: Advertising must leave long-lasting effects of brands in people's minds. Eye-tracking seems to have become a significant research instrument that is progressively being employed by advertisers and their firms. Eye movements are one of the most obvious signs of visual attention or gaze. What is currently lacking in eye movement research is a thorough examination of the processing that occurs when information is stored in long-term memory [19]. Wedel and Pieters took attempt to explain the process like the hierarchical Bayesian model by which eye fixations on print advertising lead to memory for the advertised brands; however, data derived from substantial attention and memory theory. The model is calibrated using eyemovement data gathered during individuals' responses to magazine advertising and subsequent brand awareness in a visual memory challenge. During ad exposure, the frequency of fixations is tracked on advertising components: brand logo, visual, and text, as well as the accuracy and latency of recall during the memory test. The frequency of fixations on the advertising components, as well as the accuracy and latency of recall, is thus the only accessible data [20].

As ads are usually made to get people's attention. Two factors can assist a marketer in improving an ad throughout its creation phase in order to increase the return on advertising investment: To begin, determine which aspects of the advertisement customers pay attention to and which aspects they disregard. Secondly, how they emotionally react to the stimuli they are exposed to. The fixation data inform us if we've succeeded and, more crucially, if the ad is drawing attention to the most vital element of our message. Fixation data is especially actionable or predictive. If a crucial piece of information about a brand fails to attract attention i.e., there is no fixation point, our ad has failed, and we must make most likely significant modifications.

Even though visual attention, cognitive processes underlying choice, and implicit preference can be measured with eye-tracking metrics, this method cannot give insights on whether fixation is a function of interest or confusion, nor what impact an exposure has had on the consumer's subsequent choices. For this reason, it is important to use a multidimensional approach and explore if additional insights on different aspects of brand attitude could be gained by combining eye tracking with EEG [21] since brands themselves are not unidimensional but rather multidimensional concepts [22].

According to Morin [23] measurement of alpha brain waves (8-13 Hz) in the left frontal lobe indicates the existence of positive emotions, which may be used as a good indicator of how a buyer, for instance, is motivated by packaging, price, a brand, or a marketing campaign. Two frequency bands, theta and alpha, are closely related to frontal asymmetry. Theta band (48 Hz) waves can be observed during sleep while theta waves are generated when engaging in tasks that require increased mental effort and sustained concentration [24]. In his study, Adhami [25] used both eye-tracking and EEG to gain insights on the emotional response of the brain and concentration of attention of users while they are browsing, selecting and purchasing items on a mobile phone, while Khushaba et al. [26] examined the importance of the design and presentation of products during decision making. Additionally, fixation data tells us if we've piqued the consumer's curiosity by making this section of the exposure intriguing, emotionally engaging, or perplexing. However, the results of the EEG during the fixation phase should offer some insight into this. Dimigen et al [27] demonstrated word-by-word presentation to study brain-electric connections of reading, which removes essential components of the typical text comprehension and prevents comparative analysis between neural activity and oculomotor action. The impact of term dependability on eye movements (EM) and fixation-related brain potentials (FRPs) during spontaneous sentence reading were examined in this study. EEG and EM (through video-based eyetracking) were recorded simultaneously during the reading and movement of the eyes. Co-registration of EM and EEG might open up new insights into the relationship involving fixation duration and single-trial EEG magnitude, as well as the total duration of forecasting effects in both [27]. Comeoretinal artefacts, uneven overlapping, and visual- and motor-related brain capacities, all of which change with sensorimotor activity, impact fixation-related potentials. These indirect effects of EM attitude on the EEG might easily be misinterpreted as actual changes in the brain's system of the focused item [28].

When an investigator looks at a fixed visual stimulus, such as a photograph or any advertisement, his or her visual searching is a distinct process that is broken down into intervals of around 300 milliseconds whereby the eye is generally immovable (fixations), interspersed by rapid leaps of the eye from one location to the next (saccades). Fixations are thought to be when visual information is processed, whereas saccades are when vision is effectively repressed. Fixations, which tell us how long the customer retains their visual attention on a single spot with their eyes largely stationary, are arguably the most significant data which can be obtained. During fixation, almost all visual information is received. This is the point at which the eyes stop scanning the advertisement and lock on the center foveal vision, allowing the consumer to take in more comprehensive information about it [29]. Gaze points, or the instantaneous spatial positions of the visual axis landing on the stimuli, are determined via eye-tracking equipment. The measurement is accompanied by a coordinate and a timestamp. The time intervals during which measurements are obtained by the

equipment impact the number of glance points. Fixations are made up of several gaze locations and last for a certain amount of time.

The notion that eye fixation and concurrent cognitive functions are linked is known as the "eye-mind" connection. The cognitive approach has not digested any knowledge, as evidenced by the fragmented, fast movement. The amount of fixations is likely to reflect how effective the customer is in finding crucial data. The period of fixation may suggest perplexity, but the frequency with which you return to a certain fixation may represent the priority you have on that aspect of the experience. Eye movement measurements which may be obtained with little invasiveness, give away to collect real-time data regarding a learner's cognitive activity and psychological condition. The user's efficacy in looking for significant data can be linked to the number of fixations. The user's quest for information on the computer monitor becomes less effective as the number of fixations increases. The eye-tracking technique might be useful for gathering additional validated standards of users' cognitive activity and allowing trainers and programmers to create appropriately incorporated kinds of multimodal educational materials. The most effective usage of multimedia presentations may be domain-specific [30]. The connection between pictures and words is frequently a topic of discussion. Multimodal shift or the length of time focus switches from words to pictures or vice versa, is one of three metrics developed to provide insight on this relation. The multitude of days the test subject's fixation moves from text to image, suggesting that the consumer is utilizing text to assist their perception of related pictures, is measured using the text-to-diagram transition. And transitional, i.e. the number of fixation changes from content to a region of the picture that correlates to the content [31].

The purpose of this article is to demonstrate how a combination of neuroscience-based methodology can deliver insights well beyond what traditional market research techniques are able to offer with deployed group discussions and surveys to assess the likely effectiveness of alternative design concepts. The fact that some 80 percent of newly launched fast-moving consumer goods fail within a year suggests that these traditional methodologies have been less than helpful [32]. In the current study a real-world use case is used to evaluate product packaging at the subliminal level of consumers with the combination of eye-tracking and EEG. Orange & Green, a pharmaceutical company specializing in innovative primary preventive health solutions, developed a new product, Imunoalfa, a dietary supplement to boost immunity. The research objective is threefold: first, to assess the impact of the design concept to identify shortcomings that needed correction in order to optimize it and better position brand “Imunoalfa” in minds of their consumers; second, to demonstrate how neuroscience-based methodology can provide valuable insights within the field of product design; third, to show that reliable and insightful results can be achieved with eye-tracking alone.

II. MATERIALS AND METHODS

A. Participants

A total of 55 subjects, 41 males and 14 females (age range 25-50, all right handed or ambidextrous) from Zagreb, Croatia were recruited to participate in the study. All had normal vision, active interest in health and health diet. None of the subjects suffered from any neurological and psychiatric illnesses nor used medication that affects the central nervous system. They were also asked not to consume any drinks containing caffeine three hours, and alcohol for six hours before testing. The research was performed according to the ethical code of the Institute for Neuromarketing, ICC/Esomar, Neuromaketing Science and Business Association (NMSBA) and complied with all General Data Protection Regulation requirements. All participants were informed in detail of the purpose and aims of the research and gave their written consent.

B. Materials

The eye tracking and EEG assessments were carried out at the premises of the Institute for Neuromarketing. Subjects were asked to sit in front of a monitor 24" in size, resolution 1920x1080, at a prescribed distance of about 60 cm, with eye tracking equipment (Gazepoint, GP3, HD, 60Hz) installed on top of the monitor. Neopren EEG headbands were placed on the participants’ heads (Enobio8, USB 2.0., with sample rate 500 Hz, 0.1-Hz high pass filter frequency and 50 Hz notch filter was employed, artifact threshold 400 [in μV). During the testing participants had 2 electrodes attached to record EEG activity in the left and right frontal sites (F7, F8) to obtain frontal asymmetry index. The data was analysed using iMotions (version 8.1.) and NIC2 (version 2.0.11.4.) on an Intel core i7 processor, Windows 10.

C. Experimental Procedure

After a ten-minute rest, which served as an EEG baseline, subjects were asked to look at the advertising visual post of the “Imunoalfa” on Facebook (Figure 1) to assess product packaging, as well as to investigate the subliminal effect of the brand name on customers and what further modifications in product design are needed. Participants were directly presented with the Imunoalfa image. The html Facebook link for accessing the company’s Facebook page in this instance was not used in order to avoid optical distortion with other images presented on the page. The total exposure time to the image for each participant was 10 seconds. During the exposure, both the eye-tracking system and EEG were capturing the behaviour. Throughout the experiment, participants were also able to use a mouse for clicking to move forward with the experiment or to stop it. Such behaviour was characterized as the lack of interest in the image presented. Afterwards, both quantitative and qualitative analyses were done. First, the image was divided into three main areas of interest within the product package in order to extract the eyetracking metrics and compare them

with each other. In this way it was possible to understand which parts of image had greater visual attention and with the one-way repeated measure ANOVA statistically verify if there is a significant difference within them. A heat map and static gaze visualizations were also obtained to get the graphical representation of where the highest number of fixations on the image was. The activity in EEG electrodes F7 and F8 was used to calculate frontal alpha asymmetry index, while statistical analysis was performed to assess the difference between these electrodes.

Figure 1. Experimental setup of Imunoalfa on Facebook page.

III.RESULTS

The following measurements were taken to assess packaging design to identify how well the brand is positioning itself on the subconscious level: heat map, static gaze visualization, time to first fixation (TTFF) (average amount of time needed for subjects to notice specific AOI from the stimulus onset), percentage of participants who fixated on the target (AOI) (percentage of how many of the subjects that saw the stimulus actually saw the AOI) , duration of the first fixation on the target (AOI) (how long first fixation lasted for), time spent fixating on the target (AOI) (average amount of time subjects spent looking at a specific AOI) and frontal asymmetry (a marker of approach and avoidance). Three target areas (AOIs) are depicted on the Figure 2.

Figure 2. Areas of Interest (AOIs) used in evaluating product packaging design for Imunoalfa.

To inspect which elements of the image attract more attention, a heat map was used. Heat map is a color gradient overlay visualizations showing general distribution of gaze points. Red color depicts higher number of gaze points, while green color represents lower number directed towards specific parts of the image. According to the Figure 3, subjects spent most of the time looking at the upper part of the image in the area of brand logo.

Although the heat map shows the focal areas, a more detailed examination of the gaze plots was used to establish precisely all the other areas which registered attention, and which were not identified as focal areas on the heat map (see Figure 4).

Figure 3. Attention results based on the heat map.

Figure 4. Gaze patterns.

Regarding the eye tracking measurements, a one-way repeated measures ANOVA was performed. Results from Table 1 suggest no significant differences in the time spent fixating on the AOI(F (2,107) = 1.99, p = 0.14), duration of the first fixation in the AOI (F (2,107) = 1.23, p = 0.30), nor percentage of the participants fixating on the AOI (F (2,6) = 1.21, p = 0.36). However, a significant difference was observed for the time to first fixation (F (2,107) = 4.13, p = 0.02), where a post hoc Tukey Test using the Bonferroni correction revealed that the AOI depicting the name of the product (AOI A)had a significantly shorter time to first fixation (M = 1.25, SD= 1.09), then the area containing additional information (AOI C) (M= 2.15, SD= 1.30) (Figure 5). No significant difference in the time to first fixation between AOI A (M = 1.25, SD = 1.09), and AOI B (M = 1.62, SD = 2.88.), nor between AOI B (M = 1.62, SD =) and AOI C (M = 2.15, SD = 1.30) was found (Table 2).

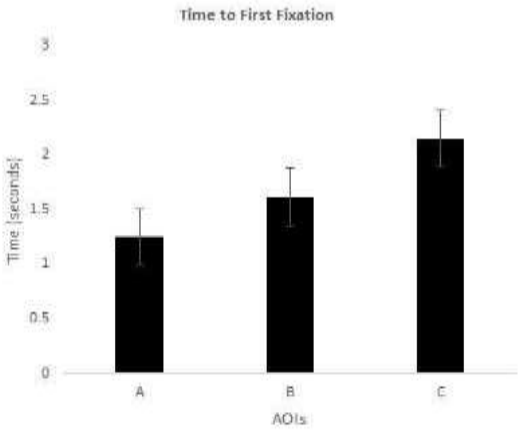

Figure 5. Average amount of time needed for subjects to notice specific AOI from the stimulus onset.

The EEG index of Frontal alpha asymmetry was used to assess "approach-avoidance effect" in motivation. It was calculated using the frontal asymmetry index formula (ln (alpha power right F8 / alpha power left F7). Scores were then normalized to fit 0-1 range where scores higher than 0.5 denote "approach motivation" while scores lower than 0.5 indicate "avoidance motivation" [33, 34]. While observed frontal asymmetry of 0.09 suggests that the visual elicited rather negative emotional responses, no significant difference in the left (F7) and right (F8) electrode was observed (t (9) = 0.42, p = 0.69) (Table 3).

Table I. Obtained Neurometrics Using Eye-Tracking Device.

AOI	*TTFF sequence*	*TTFF (s)*	*Dwell Fixation Time (s)*	*First Fixation duration (s)*	*Respondent Ratio (%)*
A	1	1.25	0.50	0.03	89.1
B	2	1.62	0.42	0.04	63.6
C	3	2.15	0.29	0.03	47.3
		F (2,107)= 4.13, p = 0.02	F (2,107) = 1.99, p = 0.14	F (2,107) = 1.23, p = 0.30	F = (2,6) 1.21, p = 0.36

Table II. Descriptive Statistics for Ttff Differences.

					95% Confidence Interval	
(I) AOI	*(J) AOI*	*Mean Difference (I-J)*	*Std. Error*	*Sig.*	*Lower Bound*	*Upper Bound*
A	B	-0.37	2.88	0.41	-1.05	0.31
	C	-0.90	3.15	0.01	-1.65	-0.15
B	A	0.37	2.88	0.41	-0.31	1.05
	C	-0.53	3.36	0.25	-1.33	0.26
C	A	0.90	3.15	0.01	0.15	1.65
	B	0.53	3.36	0.25	-0.26	1.33

Table III. Descriptive Statistics for Eeg.

				95% Confidence Interval of the Difference				
	Mean	*Std. Deviation*	*Std. Error Mean*	*Lower*	*Upper*	*t*	*df*	*Sig.*
Alpha F7 – Alpha F8	0.09	0.10	0.04	-0.08	0.11	0.42	9	0.69

IV. DISCUSSION

The average consumer is exposed to 11 million bits of information a second (which consumers perceive with all their senses) but the cognitive mind is only able to process 50 bits of information per second. Therefore 10,999,950 bits of information remain unnoticed [35].

Precisely for this reason, the way consumers absorb the information they are exposed to has via facti become the foundation stone of scientific neuromarketing research.

Our choice of using eye tracking to demonstrate how neuroscience-based research can deliver deep insights was not accidental. Eye tracking is not only a useful methodology in its own right, but is often combined with other research techniques (26,

36). For example, a virtual store environment allows us to gain insights into shoppers' choice behavior [37]. However, not knowing where shoppers looked before they picked a particular product off the shelves tells us only half the story. Which alternatives did shoppers look at before making their decision? And when it came to the winning package, which elements attracted the shopper's attention? Similarly, the use of EEG can tell us about the response to a packaging or advertising concept. But knowing what exactly consumers were looking at when their emotions peaked or memory formation took place provides us with actionable information.

With respect to the visual tested, heat map suggests that participants noticed the area around Imunoalfa most often in that visual. However, the results also suggest to change the position of the text marked AOI B from the position AOI C (See Figure 2), so that consumers would notice first the purpose of the product and thus be able to categorize it effortlessly and quickly. In fact, within 6.0 seconds, 34/55 participants read "dietary supplement for immunity, for children and adults" (fixation number 16), while 47/55 participants read the name of the company (fixation number 27). The research showed that participants did not notice the composition of the product emphasized on the packaging at all, and it was recommended that it would be better to stress the lower part of the product packaging, i.e., "Tablets made from goat's and mare's milk with added herbs", and that the ingredients of the product be removed from the packaging.

Although heat maps and gaze plots are simple to use, their presentation (without quantitative data processing) relies largely on intuitive conclusions, which may result in mistaken interpretations of the results. Such qualitative measurements do however provide valuable input into quantitative analyses, allowing us to draw important conclusions. When looking at the eye-tracking metrics, a significant difference in the time to first fixation between AOI A and AOI C, suggest that results are congruent with the obtained heat map visualization, as well as that AOI A with the Imunoalfa sign is the area that is highly visually prioritized and it is eye-catchiest when compared with others.

Because interaction of the various processes in the human brain (cognitive, linguistic, emotional and perceptive) is extremely rapid, measuring the impact of exposure on the consumer's brain using EEG sometimes can be of an added value in neuromarketing research. Out of all brain imaging techniques available, EEG is favorable imaging method in advertising research within neuromarketing context because it is relatively easy to use (it is non-invasive), its price is acceptable in comparison with fMRI, and it is thought to deliver reliable data [38]. By measuring electrical activity in the brain it is possible to identify the interactions between different areas of the brain that can affect consumer behavior [39]. EEG has very high temporal resolution, which enables us to record cognitive functions in real time [40]. In fact, the impact of cognitive functions can be recorded by EEG more accurately than with magnetic resonance imaging (MRI) or positron emission tomography (PET).

Dr Stephen J. Genco notes that "EEG is most effective for measuring nonconscious approach-avoidance motivational reactions to stimuli, using a characteristic of brain processing called hemispheric asymmetry. This is a property of motivational processing in which the power of particular brain wave frequencies differs in the left and right frontal lobes when we are experiencing an approach or avoidance response to a stimulus [41]. Such special effect of the asymmetry in frontal power was first observed in biomarkers of personality research [42], where subjects with increased left-frontal alpha processed information in positive way, whereas right-lateralization showed a more negative processing mode. Similar results were also observed in Coan et al. [43] where higher engagement on the left, relative to the right frontal brain, is related to positive feelings and higher engagement. Recent evidence also suggests that this 'emotional' effect reflects someone's motivation in whether or not someone is drawn towards or away from something [44]. On the other hand, it is suggested that sophisticated and expensive imaging techniques such as EEG should be chosen carefully as they are not always indispensable for addressing marketing questions due to their scarce predictive value [45], limits in the interpretation and in the universal applicability of the results [46]. While results from our study suggest that subjects displayed avoidance behavior according to the lower frontal alpha asymmetry score, the statistical analysis failed to show significant difference between left and right hemisphere. Regardless of the statistically insignificant EEG findings, relatively longer times to first fixation among the areas on the visual suggest that the visual is not optimally designed and that for obtaining insightful data in product packaging field, relying on eye-tracking techniques on this occasion was sufficient.

While we can get insights on the subconscious level of the potential customers it is certainly important to mention potential pitfalls and shortcomings of the neuroscience based-research methodologies. First one is the cost of the investigation and, on occasion, the time required to conduct the research, has led to the use of small samples. Moreover, the sample used is often not representative of the target population because it favors respondents who value the monetary incentive offered for spending time in a laboratory.

The second issue that applies to most of the methodologies is the lack of a widely shared standard for the analysis of physiological measures. While it makes sense for research agencies to develop their own proprietary, confidential software, this makes it impossible for a client to judge the effectiveness of that software in translating physiological measures into reliable, meaningful metrics. Here eye tracking and the Response Time Test are exceptions as the resulting measures are, in themselves, meaningful. But EEG, fMRI, GSR and other neuroscience-based methodologies require a degree of 'translation' into meaningful measures, and these translations themselves are not always straight-forward [38]. For the marketer, the key issue is typically to

identify to what degree an exposure to a stimulus has changed the brand memory pattern in the consumer's mind, as this brand memory pattern – typically including a multitude of associations with other memory patterns – is a key driving force when it comes to purchase decisions [47, 48, 49, 50]. Learning that a stimulus engages in a positive way and that memory formation is taking place does not tell the marketer anything about the quality and impact of these memories or the engagement.

Finally, the research setting can be an issue. Do consumers process exposures while inserted into an fMRI machine in the same way as when sitting on their living room couch? In some instances, there are also social effects. For example, being exposed to a company, brand or product on social media and commenting or sharing related information or experiences can dramatically alter the impact of the exposure [51, 52]. A test that ignores this social element is likely to miss much of the impact the exposure has on the brand memory pattern.

Of course, research is never perfect. It delivers an indication of what will happen when consumers are exposed to a stimulus, or insights into what most likely happened when consumers were exposed in the past. It sheds light on important purchase drivers, but it cannot fully explain – and thus predict with certainty – which stimuli a marketer should use to guarantee the desired impact. However, we can be sure that neuroscience-based market research methodologies offer more reliable and deeper insights than traditional surveys or group discussions [53, 38]. As these methodologies are developed further, we anticipate their reliability and relevance being enhanced. However, market research will never deliver absolute clarity and certainty, and this may be a good thing if we do not want to rely on algorithms that leave little room for creatively-driven marketing decisions.

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APPENDIX

Figure 6. G*Power output.

Based on the G*Power output [54] to detect the effect with 90% power, a two-sided significance level of 5% and a sample size of n=35 is required.