MEASURING AFFECTIVE INFORMATION PROCESSING IN INFORMATION SYSTEMS AND CONSUMER RESEARCH – INTRODUCING STARTLE REFLEX MODULATION

Completed Research Paper

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Abstract

Over the last two decades, scholars in information systems and consumer research have started to successfully apply methods from neuroscience to research questions on emotional aspects related to IS or consumption behavior. However, there is still a lack of understanding regarding which particular facets of emotion can actually be measured by the various neuroscientific techniques. Especially when it comes to their ability to measure underlying affective information processing, some neuroscientific methods are more suitable than others. We discuss startle reflex modulation as one possibility for validly measuring the valence of affective information processing. The biologically deep-rooted startle reflex (eye-blink as a response to, e.g., an acoustic startle probe) is a valid measure of affective information processing, which is the basis of all emotions. We review three examples of startle reflex modulation having been successfully applied in the context of IS and consumer neuroscience and propose directions for further research.

Keywords: Startle reflex modulation, neuroscience, neuroIS, emotion

Introduction

Many of us might have already experienced situations in which new technologies have elicited an emotional response. For instance, imagine a new self-service check-in facility at the airport. When you use it for the first time, it may elicit excitement and joy because it is new and fun to use. In the worst case, it might elicit anger, if you are in a hurry and it is not performing properly or you do not know how to use it. Especially in conjunction with the use of new technologies, a lot of affective information processing occurs.

Traditional behavioral methods, such as self-reports in the form of questionnaires, or experimental or interview-based approaches, can contribute to a better understanding of affects relevant to human behavior only to a certain extent. For instance, in information systems (IS) research, if we are interested in human interaction with information technology (IT) solutions, we could ask participants about the perceived usefulness or perceived ease-of-use of a certain IS application. This has been done extensively - a multitude of studies have applied the TAM (technology acceptance model) to behavioral data (Davis et al. 1989). However, measuring technology acceptance based on self-reports can still only serve as a proxy for what human brains really process, especially regarding affective aspects. Why is that? The main reason lies in the very nature of self-reports: explicitly-given responses are a reflection of the cognitive processing of information. If one is interested in those cognitive reflections, then a survey-based investigation is the way to go. However, if one is interested in the affective elements underlying and/or accompanying those cognitions, then behavioral measures such as self-reports cannot capture the entire picture. For example, verbal statements measuring aspects of joy or excitement related to the use of a new technology will always be a cognitive reflection of what the respondent is able to tell us about his or her consciously experienced affective states. Such consciously perceived affective states are called feelings. However, they are no longer equal to the core affective states; they are already the outcome of a cognitive evaluation of the raw, underlying affective information (Walla and Panksepp 2012). In the case of an interaction with self-service technologies, this could be the consciously perceived feeling of anger if the technology does not work as expected or, in a more positive setting, joy and fun if it is easy to use and works correctly or is even fun to play with. However, the true underlying primary affective processing may be different from these feelings. In short, when investigating emotional aspects in conjunction with self-service technologies via self-reports, the answers given will be biased due to cognitive influence (Geiser and Walla 2011). This is partly due to the fact that some of the underlying affective processes that guide human behavior are not accessible to language and consciousness (Camerer et al. 2005), making it impossible for respondents to correctly reflect on those affects. This model underlines the predominant role of affective information processing in decision making but what is actually meant by the term affective information processing? If not self-reports, which methods from neuroscience and psychophysiology are suitable for measuring those affective processes in the applied settings of business and IS research? The present manuscript aims to provide answers to these questions.

On the one hand, a multitude of studies from various disciplines revolve around discussing the major advantages and disadvantages of various brain-imaging and physiological methods, focusing on their strengths and weaknesses in terms of, for example, better spatial versus temporal resolution or the costs involved (Kenning et al. 2007). However, there is a lack of understanding regarding the particular facets of emotion that can actually be measured by the various neuroscientific techniques. Especially when it comes to their ability to measure raw affective information processing, some neuroscientific methods are more suitable than others. To the best of our knowledge, previous research has neglected to combine neuroscience and psychophysiology and discuss the suitability of different methods from the two disciplines for measuring affective information processing and emotions. The major aim of the present paper is to cover the following three issues:

First, a comprehensive discussion of potential neuroscientific methods available for measuring the valence of affective information processing and associated levels of arousal is provided. Valence is usually understood as a graded value, reflecting attractiveness or aversiveness with respect to a specific stimulus or a set of stimuli. Pleasant stimuli are associated with positive valence, whereas unpleasant stimuli are associated with negative valence. On the other hand, arousal is a specific grade of readiness for action, independent from valence. Pleasant and unpleasant stimuli can both elicit the same levels of arousal.

Second, two methods, one of which selectively measures the valence aspect of affective information processing while the other is only sensitive to the arousal aspect, are introduced. The valence-sensitive method is called startle reflex modulation. It is a valid approach for selectively measuring the valence of affective information processing. The biologically deep-rooted startle reflex (eye-blink as a response to a short but loud acoustic stimulus, e.g., a gunshot) is a valid indicator of affective information processing. The crucial aspect is that eye-blink responses to startle stimuli vary as a function of affective valence (Mallan and Lipp 2007; Vrana et al. 1988). Because it is a nonverbal reflex, it can be used in a wide number of situations (e.g. Grahl et al. 2012) where other tools such as self-reports or reaction time tasks are inappropriate (Dawson et al. 1999). Skin conductance on the other hand is an appropriate method for selectively measuring the arousal aspect of affective information processing. Three selected empirical examples of how startle reflex modulation can be applied to investigate topics in IS and consumer neuroscience are discussed.

Third and finally, five avenues for future research in the field of IS and consumer neuroscience are suggested.

Short Review on the Status quo of NeuroIS

In the search for a biological model of human (consumption) behavior, various streams of new joint disciplines between neuroscience and social sciences research have emerged over the past 15 years (Lee et al. 2007; Schilke and Reimann 2007). The ultimate goal of these joint disciplines is to gain a more comprehensive understanding of the underlying biological forces of human behavior. Moreover, the investigation of non-conscious information processing and emotions has become particularly popular within these joint disciplines.

When it comes to measuring affective information processing alone and/or in conjunction with cognitive processing, combining neuroscientific methods with traditional behavioral methods has proven to be a successful pathway. This alternative stream of research may support, or help refine or reject established theories about human (consumption) behavior. In any case, it complements traditional methods of research based on the survey or interview approach or classical experimental methods. The beauty of this joint discipline is that neuroscientific methods can be used as a diagnostic tool to provide a better understanding of human behavior. Since the potential has been recognized of integrating methods from neuroscience so as to better understand the human behavior related to economic decision making and consumption, various subfields, all termed with the prefix 'neuro', have emerged. Starting with applications in psychology and economics, the term 'neuroeconomics' was established first, followed by various other applications in marketing, management, organizational behavior, and IS, given terms such as 'neuromarketing', 'neurofinance' and 'neuroIS'. What all these terms have in common is the application of methods taken from neuroscience to resolve research questions related to the respective subfields of business and IS research. Dimoka et al. (2011) provide a nice overview of the current field of 'neuroIS'.

'Technostress' has recently been shown (Riedl et al. 2012) to be predominantly non-consciously perceived and best measured through physiological methods. Physiological methods are, in contrast to self-reports and other subjective measures, objective. In the aforementioned authors' study, participants had to perform a human-computer interaction task, which resulted in a system breakdown for the experimental group, while for a control group everything worked perfectly. The dependent measure was saliva samples, used to measure perceived stress via cortisol levels. The results indicated that the computer crash did cause a non-conscious stressful condition: the saliva samples showed a significantly enhanced level of stress among the system-breakdown group (Riedl et al. 2012).

This example nicely underlines the major strength of using methods from neuroscience: it provides new insights into the very nature of affective information processing. Increasing empirical evidence suggests that the idea of the pure homo economicus might be outdated. Experimental evidence from neuroeconomics has already underlined the dominant role of affective processes in forming humans' attitudinal perceptions (e.g., Phelps 2009). Camerer et al. (2005) provide a summary of what is currently understood by the terms of cognitions and affects, and how they interplay with one another. According to their summary, all affects have a valence and many of them carry motivational (action) components. They cite Zajonc (1998), who defines affective processes as those that address 'go/no-go' questions that motivate approach or avoidance behavior (Zajonc 1998, cited by Camerer et al. 2005). In contrast, cognitive processes are those that merely answer true/false questions. They conclude that cognition can only produce action (behavior) if the affective system is involved.

Another important issue in IS research is the study of the acceptance of new technologies. As mentioned above, the TAM has been used to explain attitudes and behavioral intentions related to various technology-enabled innovations. For instance, the acceptance of online settings among older consumers (McCloskey 2006), the acceptance of t-commerce (Yu et al. 2005), and the acceptance of biometrics (James et al. 2006) have all been tested based on the TAM. Dimoka and Davis (2008) investigated the neural activities of participants as they responded to the items of scales measuring the core TAM constructs, such as perceived usefulness, ease-of-use and behavioral intention to use new technologies. The authors concluded that using brain-imaging techniques such as functional magnetic resonance imaging (fMRI) can help to uncover hidden components of IS constructs that cannot easily be inferred from self-reported measurement scales. It is beyond doubt that adding neural data as another piece of information can help to refine the conceptualization of latent constructs. Hence, pre-testing the validity of scales by recording participants' neural activity as they respond to the scale items is a valuable approach that should become a standard procedure in scale development.

As a final piece of support for the use of objective neuroscience methods, we want to mention that the traditional self-report involves two major issues when one is aiming to measure true underlying affective processing. The first is a 'cannot' and the second a 'do not want to' issue during the answering process. The first issue ('cannot give an answer') is the consequence of the fact that affective aspects that remain at a non-conscious level can never be reliably verbalized by the participant, as this kind of information is not accessible to language by nature (see next section). These affective processes can guide behavior at an automatic, non-conscious level though. The second ('do not want to give the right answer') issue is that the participant is of course able to intentionally misreport his own emotion-related experience. This cognitive awareness can give the participant the opportunity to answer in a, for example, socially desirable way (cognitive bias). It is to help the social sciences tackle these two major issues regarding self-reports when it comes to measuring the affective processing underlying emotions that methods from neuroscience have been introduced. To provide a clearer understanding of affective versus cognitive information processing, we next dive into evolutionary neurobiology.

Affective and Cognitive Information Processing

In this section, we want to provide a more comprehensive biological explanation of how cognitive and affective information processing work in our brains. When we talk about information processing, especially from a layman's perspective, we automatically think of cognitions and not necessarily emotions, or affective processing, which are another type of information. Emotions have always had a slightly different connotation, being related to something more superficial and complex. Thinking of emotions as the consequence of processing affective signals might seem counterintuitive at first. However, given that all information in the brain is processed through neural activity, emotions must also originate from the processing of (affective) information. Neuroimaging techniques have made it possible to actually investigate the neuroanatomy of the areas of the brain underlying affective information processing. Before we further elaborate on that, it seems worthwhile putting the entire concept of affective information processing in an evolutionary context. Let us go back in time to when the human species had not yet evolved and only primitive creatures explored the world. If you were such a creature, you would be exposed to new and unknown environments with every single step you took. What would have been more important to you, to have known what you were seeing or to have had an idea about whether you could approach it or should avoid it? It is obvious, for pure survival, that it is more important to have a danger detection system than the ability to know what all the objects in your environment are actually there for.

At an early stage, you would not even have had the cognitive ability to name anything, but evolution provided you even then with the capacity to evaluate your environment – you were capable of affective information processing. It evolved to allow you to detect potential harm and to find appetitive sources in an ever-changing environment. This was the very beginning of the decision making that guided and adapted behavior (see Walla and Panksepp 2012).

Only later did evolution equip organisms with a cognitive system that allowed language to come into existence. Since affective processing evolved earlier than any cognitive development, it obviously did not depend on language. Thus, affective information was never meant to be verbalized. Only semantic information, the very basis of cognition, is designed to be put in to words. As human beings we all have the cognitive ability to use words to verbalize not only what we see and our thoughts but even affective information. However, due to its non-cognitive nature, words may fail decidedly to describe the latter, and even worse, words can easily be used to intentionally misinform others about our affective inner worlds (the 'cannot' and the 'do not want to' problem mentioned above).

Unfortunately, for modern marketing research this means that using a questionnaire to acquire information about the likes or dislikes related to services and actual goods may result in biased responses. Again, this bias can be the result of incorrect introspection or intentional misinformation. The only solution to the problem is to utilize objective measures of affective information processing that do not rely on self-reports.

Going back to basic neuroanatomy, the core location of affective information processing, according to multiple studies, is the amygdala (there is one in each hemisphere of the brain, the size of a hazelnut) (see, e.g., LeDoux 1995). This brain structure serves as a detector of negative affective incidents, which may result in a particular affect such as fear. This core function of checking whether a stimulus from the external environment is potentially dangerous is rooted in evolution and makes the amygdala a kind of 'negativity detector'. Importantly, subjective feeling is neither critical nor necessary for the brain to determine whether affective information processing has occurred. The experienced fear might be accompanied by certain, observable behavioral reactions. Such bodily reactions are the behavioral aspects or consequences of affective information processing. Some of them may have evolved to communicate affective states to the social environment, such as sweating, shivering or facial expressions (Ekman et al. 1980; Phelps 2009). These bodily reactions are then recognized as emotions that may be the embodied consequences of affective processes (Walla and Panksepp 2012).

Following this reasoning, affective information processing does not necessarily equal a feeling or an emotion. Anyway, in IS and consumer neuroscience, it is usually not the observable physiological parameter that is of interest. Instead, we are interested in what sort of affective processing is elicited by a product or a service and, thus, it is not so much the level of arousal but the valence of the affective processes that is of predominant interest. As these processes can only be measured via certain neuroscientific methods, and certainly not through self-reports or qualitative or projective techniques, it is time to give a structured and comprehensive overview of those methods that are actually able to measure affective information processing, which is the basis of all emotions.

Taking a Deeper Look into the Toolbox of the 'Consumer and IS Neuroscientist' – Which Method Should we Choose to Measure Emotions (Affective Processing)?

Brain-imaging Techniques

In both IS neuroscience and consumer neuroscience, the methods used to study affective processing and emotions are mainly based on brain-imaging technologies such as fMRI and electroencephalography (EEG), or traditional psychophysiological methods such as skin conductance and eye tracking. fMRI is currently the most frequently used brain-imaging technique as it has a very good spatial resolution (see, e.g., Kenning et al. 2007; Phelps 2009; Schilke and Reimann 2007) and therefore serves best for mapping anatomical brain structures, the origins of neural activity. fMRI provides data that allow us to define the neural correlates of, for example, decision making, brand perception and, most importantly, the (non)-conscious affective processes accompanying and/or influencing conscious decision processes (Kenning et al. 2007). Explaining individual purchase decisions has always been of great interest in consumer behavior research (Hubert and Kenning 2008). Over the past 50 years, various models have been established that also incorporate underlying cognitive and emotional phenomena (for an overview, see e.g. Hansen 1972; Hansen 2005). With the technological innovation of fMRI in the early 1990s, there began a new era in explaining human behavior (Bandettini 2007; Senior et al. 2007). Neuroscience got the opportunity to look inside the 'black box' (the human brain) and monitor its activities in a more comprehensive manner.

However, along with this groundbreaking opportunity, fMRI comes with significant shortcomings. First, the participant must lie in a narrow tube, which is a very unrealistic setting, significantly limiting the external validity of the experimental results gained. To measure brain activity, the head must be enclosed within an even narrower head-coil. Second, fMRI does not directly measure neural activity. It measures blood supply as a consequence of neural activity, which is why it has a poor temporal resolution (a delay of a few seconds). The advantages of fMRI are that it also measures activities in subcortical areas and does not face the so-called inverse problem as the spatial information is inherent in the fMRI signal. This is not the case for the EEG signal however. The signal detected by the individual electrodes is blurred and algorithms are needed to calculate where it came from (the inverse problem). Thus EEG is not as good as fMRI in terms of localizing brain activity, but EEG does directly measure neural activity (not the blood supply associated with it). Hence, it has a much better temporal resolution; EEG is perfectly suited to defining the timing of neural events. For example, is affective information really processed before cognitive information in the brain? EEG provides us with a better answer to that question than fMRI.

Electromyography (EMG) is another physiological method that has been used, but hardly ever to describe affective information processing. EMG is sensitive to potential changes that are associated with muscle contraction. It has been used to investigate facial expressions since these are the consequences of muscle contractions in the face, but facial expressions are caused by affective information processing, which cannot be detected directly through EMG. However, in the frame of this review paper, we want to propose another, more innovative, use of EMG. It is possible to indirectly measure affective information processing via EMG with perfect accuracy and with a much better price-performance ratio than can be achieved using fMRI or EEG. This alternative method is even more attractive if one is interested in the differences in affective valence on a finely graded scale. Moreover, it is portable, and thus provides better external validity and is more suited to applied studies. The method is named startle reflex modulation. We will talk about this method in the next section. We also discuss skin conductance, which can easily be combined with startle reflex modulation and is sensitive to arousal, the other aspect of affective processing.

Startle Reflex Modulation and Skin Conductance

Until recently, startle reflex modulation had been applied only rarely in IS and consumer neuroscience. This is astonishing as the startle reflex (or eye-blink) is a valid indicator of affective information processing. Because it is a nonverbal reflex, startle can be used in a wide number of situations where other tools such as self-reports or reaction time tasks would be inappropriate (Dawson et al. 1999). In addition, it is inexpensive and non-invasive. All one needs is a physiological recording device (e.g., the portable Nexus 10 device from Mindmedia) that is capable of EMG (recording muscle potential changes). The device can be as small as two cigarette boxes. It can even be wireless, which allows field experiments to be conducted. Only three electrodes have to be attached to a participant's face (see Figure 1b); together with headphones through which the startle stimuli are presented, the setup is ready to go. For a more detailed description, please see Walla et al. (2011).

Following pioneering investigations using rodents, it was found that humans too demonstrate a modulated startle reflex as a function of their emotional state (Mallan and Lipp 2007; Vrana et al. 1988). The startle reflex is hard-wired at a basic level, representing an automatic response but, crucially, eye-blink amplitude is reduced in cases of positive emotion and increased in cases of negative emotion in relation to a so-called lead stimulus (foreground emotional stimuli to which a participant is exposed, Lang et al. 1998). Therefore, startle reflex modulation is seen as an accurate and objective measure of deep neurological processes that are related to affective information processing. It has even been shown that rapid changes in emotion valence related to lead stimuli are reflected in eye-blink amplitudes as startle responses (Bradley et al. 1993). For example, random presentations of different facial expressions have been found to lead to corresponding modulations of eye-blink amplitudes (Anokhin and Golosheykin 2010; Dunning et al. 2010).

Besides the objective nature of this method, its crucial advantage is its independence from cognitive information processing. The fact that startle responses adapt quickly to changing emotional contexts, together with their independence from cognitive influence, makes this an ideal tool with which to quantify pure affective processing on a finely graded scale. Affects comprise two dimensions: valence and arousal (Russell 1980; Lang et al. 1993). While startle reflex modulation is well known for its sensitivity to valence, the measure of skin conductance is known for its sensitivity to arousal. Fortunately, the two methods can easily be combined and used simultaneously to register the valence and arousal aspects of emotional stimuli at the same time. Combining these methods makes perfect sense, as arousal alone is not a valid measure of emotional valence. An enhanced arousal level may look the same in cases of negative and positive affective processing. Following this reasoning, skin conductance may be applied to capture the arousal aspect of emotion, while startle reflex modulation measures its valence aspect.

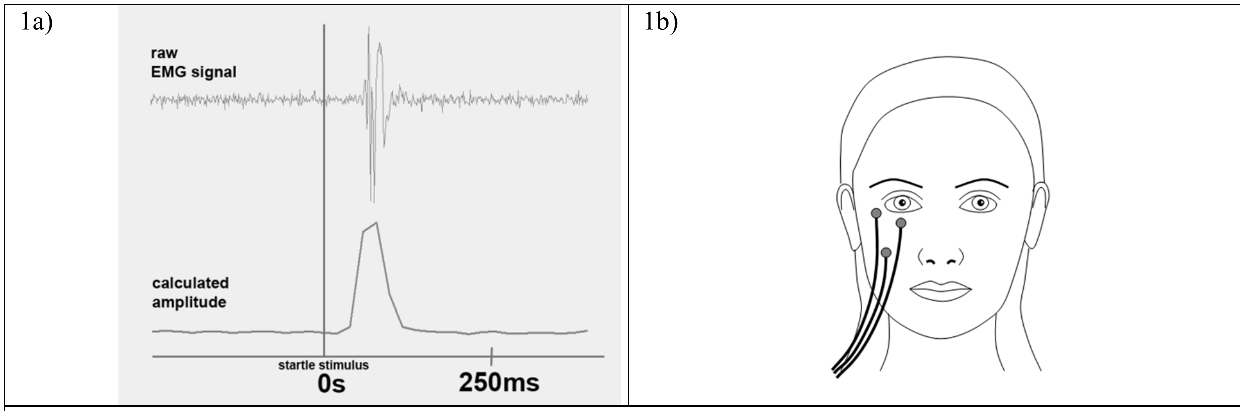

Figure 1. Startle Reflex Modulation

Figure 1a provides an example of the output of a recorded EMG signal. The upper line depicts the raw EMG signal, as recorded via so-called bipolar recording, using three electrodes as illustrated in 1b. The lower line in figure 1a shows the calculated amplitude signal used to run the statistical analysis (Figure 1a is adapted from Walla et al. 2011). Figure 1b shows an example of where the electrodes are usually attached to the face. One electrode is attached directly below an eye, another one is placed at the outer side of the same eye. A third electrode, which serves as the ground electrode, is attached to the cheek.

Skin conductance measures can easily be taken by using two special sensors that are attached to two different fingers of one hand (see Figure 2). The sensors are connected to the recording device and the data are stored on a computer. Ideally, the same device that records EMG data will also be capable of measuring skin conductance changes (e.g., the Nexus 10 from Mindmedia). Please see Walla et al. (2011) for a more detailed description of this measure.

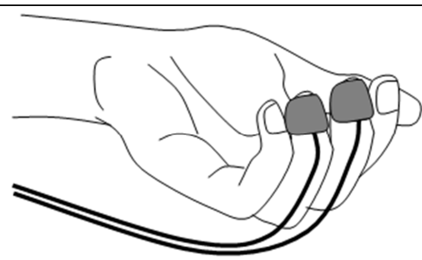

Figure 2. Skin Conductance

However, neither method is a brain-imaging technique. Hence, they cannot depict anatomic brain structures that underlie valence- and arousal-related brain activity. This might look like a shortcoming at first sight. Further consideration, though, shows that it is usually not important for IS and consumer neuroscience research to detect, for instance, the activity of the amygdala, as it is already common knowledge that the amygdala will be activated when negative affective information is processed. Startle reflex modulation is, on the other hand, able to map valence on an impressively fine-graded scale, which makes it preferable to fMRI. Similarly, skin conductance is highly sensitive to even subtle changes in the level of arousal. In the end, it is usually more useful to know to what degree neural structures are activated than to accurately locate them.

Over several years, the affective modulation of the human startle reflex has proven to be highly replicable, which is rare in psychological science (Bradley et al. 1999). There has been a continuous increase in the number of studies using startle reflex modulation to investigate emotional and attentional processes in psychophysiology and clinical research (Grillon and Baas 2003). Given the successful examples of the application of startle reflex modulation to measure emotions in various scientific disciplines, it is quite surprising that it has hardly ever been used in IS and consumer neuroscience. In the following, we review three examples of it having been successfully applied in this context. Moreover, we propose directions for further research on the topical and methodological issues involved in applying startle reflex modulation in IS and consumer neuroscience.

In Table 1, the core methods that have been applied in IS neuroscience and consumer neuroscience studies are described in terms of the facets of emotion and physiological parameters they are able to measure.

Table 1. Methods in IS and Consumer Neuroscience – Facets of Emotion Measured

Method	Facet of emotion	What is measured, in terms of anatomy and physiology
fMRI (functional magnetic resonance imaging)	Affective information processing, valence	Cortical and subcortical activity
EEG (electroencephalography)	Cognitive information processing or affective information processing reflected in cortex	Cortical activity or cortical reflections of subcortical activity
Startle reflex modulation	Affective information processing, valence	Bodily response; muscle potential changes related to eye-blinks (modulated by stimulus valence)
Facial EMG (facial electromyography)	Emotion (valence), embodied affective information processing	Bodily response; potential changes in facial muscles
Skin conductance	Arousal, not valence of emotion	Bodily response (electrodermal activity); sweat glands controlled by sympathetic nervous system
Self-report	Cognitive reflections of perceived affects (feelings)	No physiological measure

Applications of Startle Reflex Modulation in IS and Consumer Neuroscience

Having underlined in the theoretical framework section above the relevance of being able to validly measure affective information processing, we will now present the outcome of a literature review we carried out on the topic. Our main goal was to find examples of the use of startle reflex modulation to address topical issues tangential to both subfields, namely IS neuroscience and consumer neuroscience. We have selected three such examples. We will discuss the studies based on the following two criteria: First, we will describe how the method of startle reflex modulation was used in the respective experimental settings. Second, we will evaluate the relevance of the studies in terms of enhancing knowledge in the fields of IS neuroscience and consumer neuroscience.

The Emotional Part of Brand Attitudes – Measured by Startle Reflex Modulation

The first example uses startle reflex modulation to measure attitudes towards brands. Research on branding from a consumer research perspective has always been a hot topic. For instance, the Journal of Consumer Psychology devoted a special issue to advancements in brand insights, comprising new findings gained from the integration of neurophysiological and psychological approaches, at the beginning of this year (Shiv and Yoon 2012). Startle reflex modulation was not mentioned, but could be an ideal method of studying the emotional side of brand attitude. To the best of our knowledge, there is no other method, either behavioral or neuroscientific, that can explicitly measure the valence of the underlying affective information processing of the emotional side of brand attitude at a reasonable price-performance ratio. fMRI would be the only alternative way of measuring the valence of these affective processes. However, fMRI only maps neuroanatomy in terms of the brain structures that are activated. In the case of negative brand attitude, this would probably be the amygdala but this is already common knowledge in neuroscience. Another applied experiment showing amygdala activation in terms of disliked brand names (negatively evaluated brands) would be very costly. In contrast, experiments applying startle reflex modulation are much cheaper and less resource-intensive. Hence, testing whether it would be possible to use startle reflex modulation to measure attitudes towards brands seems a worthwhile endeavor.

Walla et al. (2011) used startle reflex modulation to assess the emotional side of brand attitudes without any of the cognitive blurring that is usually seen with traditional behavioral measures. 21 subjects participated in their study. Prior to the startle experiment, the participants had provided the researchers with a list of brand names that they liked and a list that they disliked via an online questionnaire that presented them with 300 common international brands. Hence, the stimulus material for the actual startle experiment was created specifically for each individual participant. This approach significantly enhances both the internal and external validity of experiments within IS and consumer neuroscience and could help to overcome one of the major criticisms of these joint disciplines, namely their lack of validity. In the startle experiment, the lists of individually-ranked brand names, together with some filler brands, were presented in turn to each participant. Figure 3 depicts an example of the startle reflex modulation data (adapted from Walla et al. 2011). The left bar represents the mean eye-blink amplitude (measured as startle response) related to liked brands. The right bar represents the mean eye-blink amplitude related to disliked brands. Significantly reduced eye-blink amplitudes were found for the liked brand names compared to the disliked brand names. The resulting conclusion was based on the well-known phenomenon that reduced eye-blink responses reflect positive affective processing, whereas enhanced eye-blink responses reflect negative affective processing. Thus, reading disliked brand names evoked a significantly stronger startle reflex (as they elicited a negative emotional state) than reading liked brand names (which elicited positive emotions) (see Figure 3). It was concluded by the authors that their results highlighted emotion-related differences depending on liking or disliking individual brands, objectively measured via startle reflex modulation.

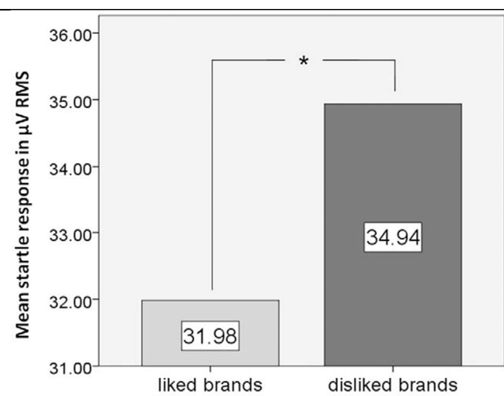

Figure 3. Startle reflex modulation data (adapted from Walla et al. 2011)

Startle Reflex Modulation as an Objective Measure of Affective Information Processing in Virtual Reality

The second example applies startle reflex modulation as an objective measure of affective processing in the human brain. It also shows how applying startle reflex modulation could enrich knowledge in both IS and consumer research. Virtual realities have received considerable research interest in contemporary IS and consumer research (see, e.g., Spiers et al. 2008). In this second example (Geiser and Walla 2011), Google StreetView was used as a virtual setting in which to objectively assess the affective processing associated with urban environments with different, controlled, median real estate prices. For this purpose, six different districts in Paris were chosen on the basis of the median real estate price. Study participants had to virtually walk through these districts while being startled (five times in five minutes) and their eye-blink magnitudes were recorded via EMG. After the recording session, the participants were asked to rate the subjective pleasantness of each of the six districts. The real estate price turned out to be highly correlated with the verbal ratings of pleasantness (see Figure 4a). These behavioral results were backed up by the biological data. Startle amplitudes from 16 participants suggested that the real estate prices were a valid, objective indicator of the perceived affective quality of these urban environments (see Figure 4b). However, this was only true for the two extreme conditions, the most expensive and the cheapest districts. This highlights a possible discrepancy between subjective and objective measures of affective processing, which could become a critical field of application in IS and consumer neuroscience. The startle reflex, as a basic biological and phylogenetically old mechanism, was thus concluded to be able to validly detect the affective evaluation of urban environments (without using a questionnaire).

Generally speaking, the possibility of combining verbally-given responses to a stimulus with recorded physiological data is a major advantage in IS and consumer neuroscience. As mentioned above, it may even turn out that objective measures capture what the subjective measures miss. Figure 4a shows the subjective ratings of pleasantness related to the six districts in Paris. Note the correlation between the average real estate price (x-axis) and the subjective pleasantness rating (y-axis) (adapted from Geiser and Walla 2011). Figure 4b shows the startle reflex modulation data. Note that virtually walking through the cheapest district elicited the most enhanced eye-blink response, reflecting the most negative affective processing. On the other hand, virtually walking through the most expensive district elicited the most reduced eye-blink response, which in turn reflects the most positive affective processing. However, note also that the second most expensive district elicited a relatively high eye-blink response, which could indicate that walking through this district elicits quite negative affective processing that is not reflected in the subjective rating performance. Discrepancies such as this may turn out to be the most critical findings in future applications of this technique (adapted from Geiser and Walla 2011).

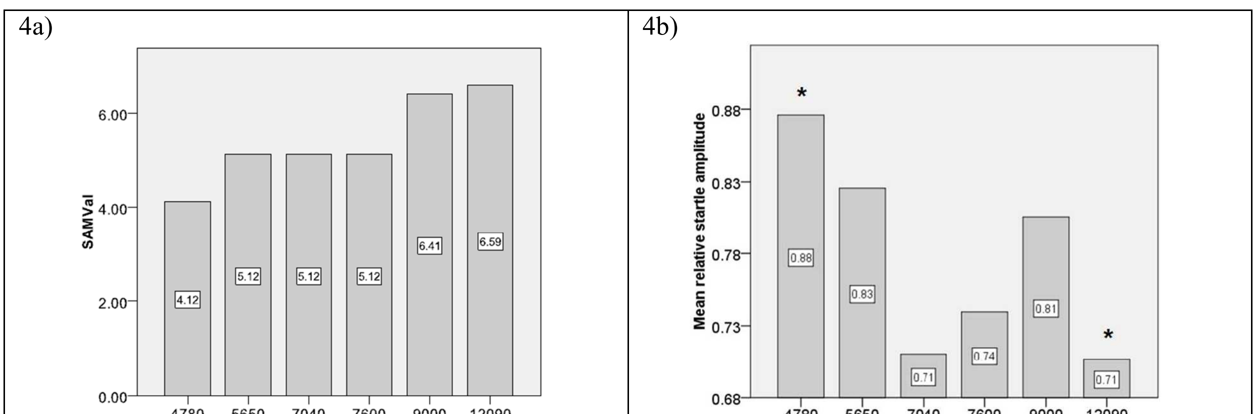

Figure 4. Subjective ratings and startle reflex modulation data (adapted from Geiser and Walla 2011)

Startle Reflex Modulation and the Quantification of Motivational States in Food Consumption

The third example introduces the use of startle reflex modulation as a valid method of measuring valence aspects related to food intake. Consumer research on food consumption has grown into a major stream, driven by health care and societal initiatives aimed at preventing childhood obesity and other negative consequences (e.g., Dhar and Baylis 2011). Previous studies had predominantly relied on behavioral data but, in a study by Walla et al. (2010), startle reflex modulation turned out to be a reliable approach for objectively measuring how intakes of different foods evoke different emotional states in humans. Specifically, participants ate ice cream, yoghurt and chocolate while their startle responses were recorded. As shown in Figure 5a, eating ice cream resulted in the most reduced eye-blink responses, reflecting the most positive affective processing. This was found to be true across both genders (see Figure 5a, showing mean response amplitudes across all 20 study participants related to the test startle stimulus and related to all food conditions of interest). However, a separate analysis of females and males indicated that females demonstrated the most strongly reduced eye-blink response when eating chocolate and yoghurt, whereas among the males these two food categories provoked the most strongly increased responses (see Figure 5b, showing mean response amplitudes separated for females and males related to the test startle stimulus and related to all food conditions of interest). Startle reflex modulation might thus be an excellent means by which to quantify emotional and motivational aspects related to the evaluation of consumer products (Walla et al. 2010). As EEG data were also recorded, another important potential area of research is pointed out in the study, namely combining startle reflex modulation with other neuroscientific methods. Triangulation, in terms of combining various methods from neuroscience to resolve a single research question, may help to enhance the results gained, in terms of validity and reliability.

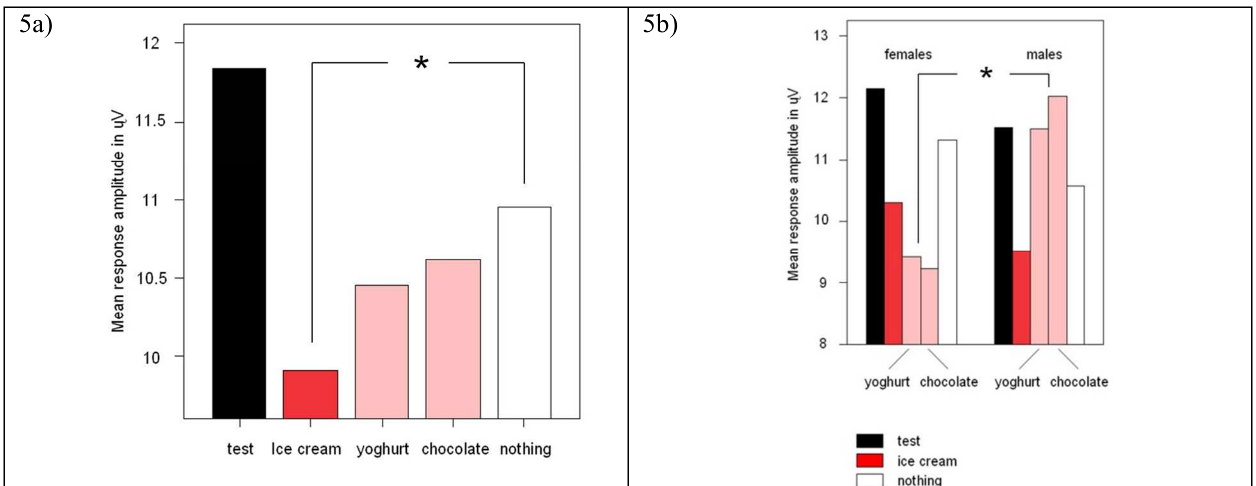

Figure 5. Startle reflex modulation data (adapted from Walla et al. 2010)

Selected Suggestions for Future Applications of Startle Reflex Modulation in IS and Consumer Neuroscience

The investigation of non-conscious information processing and emotions has become particularly popular within the joint disciplines of IS and consumer neuroscience. Scholars have started to re-investigate already well-established theories and models from a biological and neuroscience perspective. For instance, Dimoka et al. (2011) discuss neural correlates of the constructs incorporated in the extensively researched TAM, measured in a fMRI study. They conclude that neural correlates of cognitive constructs such as perceived usefulness are not only found in areas of the brain associated with cognitive information processing but also in those associated with emotions. This is a nice example of how neuroscientific methods can add new insights into well-established models in traditional survey-based IS research such as the TAM. However, given the strengths and weaknesses of certain neuroscientific methods in terms of capturing the valence and arousal aspects of affective information processing, as outlined earlier in this manuscript, we would suggest applying startle reflex modulation in future technology acceptance studies. In particular, the affectively-toned facets of, for instance, perceived value in terms of emotional and social value perceptions related to a new technology could be more objectively assessed by applying startle reflex modulation. The corresponding arousal could be captured validly via skin conductance. As the equipment for measuring both of these is portable, it can easily be applied in a field setting, increasing the external validity of the studies. For instance, individuals can comfortably be seated in front of a computer screen while startle reflex modulation and skin conductance are used to measure affective information processing, in usability research or other research foci within the field of HCI. More specifically, given the continued importance of mobile technologies and social media over the past decade, startle reflex modulation lends itself to a more detailed study of the affective information processing related to their use. Table 2 summarizes our suggestions for how startle reflex modulation and skin conductance can contribute to some of the key foci in traditional IS and consumer research.

Table 2. Startle Reflex Modulation and Key Research Areas in IS and Consumer Research

Area of research	Particular foci	Method
Technology Acceptance (TAM)	Perceived usefulness and perceived relative advantage - multidimensional value perceptions associated with the use of a new technology or mobile device	Startle reflex modulation (affectively toned facets) Self-report (cognitively toned facets)
Human Computer Interaction (HCI) and Usability	Affective information processing related to content and design elements of, e.g., websites, online surveys, mobile interfaces or social media applications	Startle reflex modulation (affective information processing - valence) Skin conductance (affective information processing - arousal)

Conclusion and Research Agenda

The main focus of this paper has been to discuss the current state of research on the methods in IS and consumer neuroscience that best measure affective information processing. The short review presented in this paper discusses the ability of the current neuroscientific methods to capture different facets of affective information processing and bodily reactions related to emotions. Moreover, this paper introduces the method of startle reflex modulation, which has to date been relatively neglected in IS and consumer neuroscience. Based on three selected examples of empirical IS and consumer neuroscience studies, this paper highlights the potential of startle reflex modulation to assess affective processing in consumption and IS-related contexts. To conclude, we propose a research agenda for IS and consumer neuroscience. We present five avenues for further research in this area, predominantly discussing how startle reflex modulation could successfully broaden the scientific knowledge.

First, although the state-of-the art equipment for recording the startle reflex is portable, cost-efficient and very convenient in terms of usability, the sample sizes in such experiments are usually smaller than in traditional survey studies. This could be an issue for IS and marketing practice, in which large sample sizes are often preferred. Should an actual startle reflex experiment not be possible for some reason in industry, we would suggest that, at the least, the survey measurement instruments should be pre-tested using physiological methods. For instance, as a first step, we would suggest applying startle reflex modulation to establish valid and reliable scales for measuring different types of emotions. The emotional facet captured by each item in these scales should be pre-analyzed in a startle reflex experiment. Then, the scales that have been developed in this way could be applied in traditional behavioral field research. Moreover, startle reflex modulation could be used to pre-test the affective components of questionnaires in general. Survey studies usually suffer from low response or high drop out rates. This could be due in part to a negative affective state elicited by the perception that answering a questionnaire is boring. Hence, diagnosing the affective potential of a survey via startle reflex modulation might help researchers to create better and more user-friendly questionnaires.

Second, startle reflex modulation was initially investigated in rodents before being extended to wide use in human research (Grillon and Baas 2003). Therefore, it is an excellent example of how knowledge from animal studies can help to build the biological model of (consumption) behavior. With the emergence of new, non-invasive technologies and methods, consumer neuroscientists are able to dig deeper into the human (consumption) behavior driven by deep-rooted biological processes.

Third, startle reflex modulation could be used to assess the acceptance of new technologies. It might serve particularly well for testing pilots of innovations during the new product development process. A major obstacle for traditional new product development studies based on self-reports is that participants tend to overstate the importance of functionality and downplay the role of affective components. This is underlined in a study on perceived value facets related to wireless telecommunication and smartphone usage (Koller et al. 2011). Smartphone users tend to stress cognitive facets such as the functional and economical value associated with their phones but downplay emotional and social value facets. Moreover, in some cases, consumers cannot even explain why they like a certain product or brand, saying 'I just have a feeling that I might like it, but I cannot tell you exactly why'. This phenomenon might also be called 'intuition', which could be seen as a consequence of non-conscious affective information processing. Startle reflex modulation could thus help us to measure intuition and the affective components of perceived value.

Fourth, the joint discipline of neuroscience and the social sciences is still in its infancy. Although it has been around for almost two decades, progress is being made rather slowly. This is basically due to the fact that experimental studies within this new field are usually very complex and resource intensive. Today, the state of the field can best be described as 'IS and consumer neuroscience 1.0'. We hope that future research in this area will lead us to an advanced field of research, namely 'IS and consumer neuroscience 2.0'. We have provided only a selection out of a multitude of areas in which startle reflex modulation could potentially be a useful methodological approach. Moreover, the theoretical discussion on the interplay between cognitive and affective information processing, as well as on feelings and bodily emotional reactions, should continue. The question of what really drives human (consumption) behavior remains partially open. Is it cognitive or affective information processing or a mixture of both? If purchasing behavior is triggered by both cognitive and affective information processing, might this mixture vary across situations or individuals? Might cultural differences be involved? We hope that our short review of startle reflex modulation and the examples given will provide guidance for the development of other innovative ways of applying the method, so as to advance research in IS and consumer neuroscience.

Fifth and finally, the labels used to name this new joint field of research between neuroscience and business disciplines is an important issue that needs to be discussed in further detail. Until now, 'neuroIS' has been defined as a subfield of IS research (Dimoka et al. 2012). However, given the following reasoning, the field would be better termed 'IS neuroscience', as we are talking about applying neuroscientific methods to resolve questions related to the IS discipline. The idea behind the suggestion of renaming the field is based on the following. The discussion started with the renaming of the term 'neuromarketing', which in particular has become a well-known synonym for this recent marriage between brain and social sciences. Scholars have recently changed the label 'neuromarketing' to 'consumer neuroscience' as the meaning of the term 'neuromarketing' has been altered by commercial use to comprise slightly different elements than the scientific field of 'consumer neuroscience' (Hubert 2010; Plassmann et al. 2012). In the special case of integrating neuroscience with the social sciences, choosing 'neuroscience' and adding prefixes such as 'consumer' seems a wise decision. The term 'neuroscience' is appropriate as that field in general tries to explain human behavior by describing neural processes, regardless of whether that behavior is consumption behavior, choosing a life partner or making a career decision. Neuroscience is thus a proper term to include all the various possible facets of behavior in our every day lives. However, 'consumer neuroscience' seems to be a better label for the marriage of neuroscience and marketing research, since it captures the various traditions that have emerged within each discipline. The term 'consumer' specifies the type of behavior that we are aiming to understand. In short, we propose a move away from the prefix 'neuro' to the term 'neuroscience' plus a label indicating the questions that are to be resolved. It makes sense to refer to 'consumer neuroscience' when we are talking about applying neuroscientific methods to resolve questions related to marketing or consumer behavior research. One might say that how we name the marriage between neuroscience and different disciplines of the social sciences is just a question of terminology. However, it is important that scholars should find appropriate labels as quickly as possible, in order to develop a joint understanding of the terminology and avoid an inflationary usage of terms or the invention of different terms for the same phenomenon. For instance, scholars made even more detailed distinctions regarding biological methods used to resolve questions related to IS research. 'Physioeconomics' was introduced as a new field of joint research comprising the application of psychophysiological methods such as skin conductance or heart rate to resolve questions in economics, explicitly distinguished from the traditional 'neuroIS' field (Adam et al. 2011). In the end, the core of these fields of research stays the same, no matter how they are named: methods from neuroscience are used to provide biological (neural) information to help resolve questions in the respective social science domains. From a biological point of view, the brain's core function is to adapt its behavior to an ever-changing environment (Walla 2011). There is no doubt that the term used for the discipline related to the functioning of our brain, namely 'neuroscience', is the most adequate label to use to bring all these areas under one roof. On the one hand, it covers various topical areas of behavior that we are aiming to understand better and, on the other hand, it covers the psychophysiological and brain-imaging methods that are used to investigate these behavioral facets. As all behavior has its origin in neural activity, psychophysiological reactions such as skin conductance can also be categorized within the field of 'neuroscience'. To conclude, we hope that our reasoning presented here also contributes towards moving forward and resolving the scientific debate centered around the labeling of this fascinating field of joint research between neuroscience and the business disciplines.

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