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Neural signals of selective attention are modulated by subjective preferences and buying decisions in a virtual shopping task

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ABSTRACT

We investigated whether well-known neural markers of selective attention to motivationally-relevant stimuli were modulated by variations in subjective preference towards consumer goods in a virtual shopping task. Specifically, participants viewed and rated pictures of various goods on the extent to which they wanted each item, which they could potentially purchase afterwards. Using the event-related potentials (ERP) method, we found that variations in subjective preferences for consumer goods strongly modulated positive slow waves (PSW) from 800 to 3000 milliseconds after stimulus onset. We also found that subjective preferences modulated the N200 and the late positive potential (LPP). In addition, we found that both PSW and LPP were modulated by subsequent buying decisions. Overall, these findings show that well-known brain event-related potentials reflecting selective attention processes can reliably index preferences to consumer goods in a shopping environment. Based on a large body of previous research, we suggest that early ERPs (e.g. the N200) to consumer goods could be indicative of preferences driven by unconditional and automatic processes, whereas later ERPs such as the LPP and the PSW could reflect preferences built upon more elaborative and conscious cognitive processes.

Recent evidence has shown that brain activity measured with the event-related potentials (ERP) method co-varies with preferences for consumer goods (Junghöfer et al., 2010; Pozharliev, Verbeke, Van Strien, & Bagozzi, 2015; Schaefer, Buratto, Goto, & Brotherhood, 2016; Telpaz, Webb, & Levy, 2015). This is an important development in an emerging field – consumer neuroscience – that aims to investigate consumer behaviour (CB) with neuroscience methods. The results from two of these studies (Telpaz et al., 2015; Junghofer et al., 2010) suggest that early brain potentials (neural signals occurring less than 300 ms after participants first see the image of a consumer good) can index consumer preferences.

These results can be interpreted from the perspective of the "motivated attention" theoretical framework (Lang, Bradley, & Cuthbert, 1997; Schupp, Flaisch et al., 2006), which contends that similar early ERPs reflect automatic attentional processes towards motivationally relevant stimuli (Olofsson, Nordin, Sequeira, & Polich, 2008; Schupp, Flaisch et al., 2006; Walker et al., 2011). However, a striking aspect of ERP studies of CB is that they do not report consistent links between consumer preferences and late ERP positivities, which are often modulated by motivationally relevant stimuli (Olofsson et al., 2008), and are thought to reflect post-perceptive and controlled selective attention processes (Schupp, Stockburger et al., 2006). In order to investigate this issue, the primary goal of this study was to examine the ERP correlates of consumer preferences with a particular focus on late ERP positivities. In the remainder of this section we briefly review past work on motivated attention processes and their electrophysiological correlates. We then review existing ERP studies of consumer behaviour and provide an overview of the present study.

1. Electrophysiological correlates of motivated attention

Motivated attention is classically separated in two subprocesses: A quick, "preattentive" mechanism of attentional orientation; and a more overt and controlled form of attention (LeDoux, 1996; Vuilleumier & Huang, 2009). This theoretical approach is based on the notion that, from a neurobiological perspective, attention is seen as the enhancement of neural activity in sensory cortices (Vuilleumier & Huang, 2009), and that the modulation of these

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processes by affective-motivational factors can occur through two different routes. First a “quick” route would involve subcortical structures predominantly involved in the evaluation of motivational relevance (e.g. the amygdala; Pessoa & Adolphs, 2010; Schaefer et al., 2006). These structures would detect the presence of motivationally relevant information in the environment through sensory inputs and would subsequently modulate activity in sensory cortices through relatively direct pathways (Vuilleumier & Huang, 2009). This route is classically thought to be automatic (Vuilleumier, Armony, Driver, & Dolan, 2001), although evidence suggests that it can be modulated by top-down controlled processes (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002; Pessoa, Padmala, & Morland, 2005).

The second pathway of motivated attention is one in which neocortical networks (mainly frontal and parietal areas) receive inputs conveying emotional information, and subsequently modulate sensory cortices. This mechanism is thought to be linked to overt and controlled attentional processes (LeDoux, 1996; Vuilleumier & Huang, 2009). Beyond the main theoretical distinction between a quick “preattentive” and a slower overt attentional response, a third process is often proposed in which attentional resources would be allocated to motivationally-relevant stimuli in a temporally sustained manner. This third subtype of motivated attention would most likely involve working memory (WM) processes and facilitate a more elaborative processing of motivationally-relevant information (Schupp, Flaisch et al., 2006; Watts, Buratto, Brotherhood, Barnacle, & Schaefer, 2014).

ERP researchers have identified three types of brain potentials to emotional pictures that map onto the three attentional subprocesses described above. As some of us explained in previous articles (Walker et al., 2011; Watts et al., 2014), ERPs to stimuli of higher motivational relevance (e.g. emotional stimuli, faces, affective stimuli) can be divided into three subtypes. First, pre–400 ms ERPs to motivationally relevant stimuli are thought to reflect a rapid and automatic orientation of attention triggered by evolutionary and/or motivationally relevant properties of external stimuli (Mavratzakis, Herbert, & Walla, 2016; Olofsson et al., 2008; Schupp, Flaisch et al., 2006). Second, an ERP called “Late positive potential” has often been observed after 400 ms following the onset of a motivationally relevant stimulus. This ERP is characterised by a strong positivity that can be observed across the entire scalp with maxima in posterior scalp sites (Codispoti, Ferrari, & Bradley, 2007; Schupp et al., 2000). The latencies of this effect vary across studies but they tend to be predominant between 400 and 800 ms (Codispoti, De Cesarei, & Ferrari, 2012). The LPP is thought to reflect overt, post-perceptive attentional responses to motivationally-relevant stimuli that are more sustained in time and for which the involvement of controlled processes would be more important than the pre–400 ms effects (Codispoti et al., 2007; Schupp, Flaisch et al., 2006; Walker et al., 2011). Third, a more sustained ERP positivity for motivationally relevant pictures has been observed after 800 ms post-stimulus onset. This effect consists of a sustained waveform that can last a few seconds after stimulus onset (Diedrich, Naumann, Maier, & Becker, 1997; Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006; Hajcak & Olvet, 2008). The topography of this effect is often widely distributed across the scalp over both fronto-central and centro-parietal sites (Foti & Hajcak, 2008; Hajcak & Olvet, 2008). These ERP effects are commonly labeled as positive slow waves (PSW) (Schupp, Flaisch et al., 2006) or as “late LPP” (Leutgeb, Schäfer, & Schienle, 2009; Schienle, K & chel, & Leutgeb, 2011), and they are thought to reflect sustained attentional processes related to the maintenance and potential manipulation of information in working memory (Schupp, Flaisch et al., 2006).

2. Event-related brain potential studies of consumer behaviour

The vast majority of studies investigating the ERP correlates of motivational relevance have used stimuli conveying an intrinsic emotional and evolutionary meaning, such as pictures of faces displaying emotional expressions or pictures of emotional scenes (e.g. dead bodies, scenes of violence and threat, etc.). It is not yet well established if these results can be generalized to objects that have acquired their motivational relevance because of their economic value. We define the economic value of an object as the computation of subjective benefits and costs that determines if an object will be preferred (see Levy & Glimcher, 2012; Montague & Berns, 2002). The choice of acquiring an object is thought to be strongly determined by its economic value (Padoa-Schioppa & Assad, 2006). The evaluation of the economic value of an object is thought to involve the assessment of the value of several of its attributes, and this process can vary across different types of objects. However, it is believed that the human brain can represent this information into a “common scale” of value that allows comparing between different potential choices (Levy & Glimcher, 2012). Importantly, it has been suggested that the economic value of objects and actions can be determined by a previous history of gains and losses that can be understood from the perspective of reinforcement learning models (Montague & Berns, 2002; Schaefer et al., 2016), although it is often suggested that a number of contextual effects can also modulate these valuation processes (Kalwani, Yim, Rinne, & Sugita, 1990).

Consumer goods are typical examples of objects that have acquired motivational relevance through their economic value, as the “desire to own” (Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007) a consumer good is largely determined by an evaluation of its subjective benefits and costs (Kalwani et al., 1990; Knutson et al., 2007; Winer, 1986). However, despite a recent surge of studies using neuroimaging (Karmarkar, Shiv, & Knutson, 2014; Knutson et al., 2007; Plassmann, O’Doherty, & Rangel, 2007; Smidts et al., 2014; Tusche, Bode, & Haynes, 2010) and psychophysiological methods (e.g. Rasch, Louviere, & Teichert, 2015; Walla, Brenner, & Koller, 2011) to investigate consumer behaviour, only a very limited number of studies have approached this question using the ERP method. Previous studies that have examined ERPs related to preferences for consumer goods have focused mainly on early (pre-400) ERPs. For instance, Telpaz et al. (2015) found a relationship between the N200 component and product preferences measured by a behavioural choice procedure in which participants needed to choose between pairs of products. Telpaz et al. (2015) suggested that this N200 effect could reflect an effect of the Feedback-Related Negativity (FRN), an ERP component that overlaps with the N200, and which has been linked to the evaluation of prediction errors in decision-making tasks (Mushtaq, Wilkie, Mon-Williams, & Schaefer, 2016), and more recently, to positive surprise and buying preferences in a virtual shopping task (Schaefer et al., 2016). Furthermore, a study using magnetoencephalography (MEG) found that early brain potentials (between 110 and 230 ms post-stimulus onset) reflecting motivated attention were related to gender-specific preferences for consumer goods (Junghöfer et al., 2010).

Although these studies provide evidence in favour of the notion of the involvement of early attentional responses in consumer preferences, evidence regarding later effects is scant and contradictory. Pozharliev et al.’s (2015) study reported a relationship between the LPP and preferences for luxury goods only when participants were in a social context, and Bosshard et al. (2016), although not using pictures of consumer goods, found a relationship between the LPP and the extent to which brand names were liked. In contrast to these studies, the work by Telpaz et al. (2015) described above did not find effects in the LPP or in any later time window. In addition, to our knowledge no study has reported testing the relationship between the PSW and preferences for consumer goods in a shopping context. Furthermore, the apparent contradiction between Telpaz et al. (2015) and Pozharliev et al. (2015) regarding late positivities is difficult to resolve as they used markedly different methods: First, Telpaz et al. (2015) repeated the presentation of every individual stimulus 50 times whereas Pozharliev et al. (2015) used single presentations for each item, which may have caused differences between these studies regarding potential habituation effects of late positivities (Ravden & Polich, 1998); Second, Telpaz et al. (2015)