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Niklas Ravaja, Outi Somervuori, and Mikko Salminen

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Predicting Purchase Decision: The Role of Hemispheric Asymmetry Over the Frontal Cortex

Niklas Ravaja
Aalto University, Helsinki Institute for Information Technology (HIIT), and University of Helsinki

Outi Somervuori and Mikko Salminen
Aalto University

This article examines how approach motivation as indexed by electroencephalographic (EEG) asymmetry over the prefrontal cortex predicts purchase decision when brand and price are varied. In a within-subjects design, the participants were presented purchase decision trials with 14 different grocery products (seven private label and seven national brand products) whose prices were increased and decreased while their EEG activity was recorded. The results showed that relatively greater left frontal activation (i.e., higher approach motivation) during the predecision period predicted an affirmative purchase decision. The relationship of frontal EEG asymmetry with purchase decision was stronger for national brand products compared with private label products and when the price of a product was below a normal price (i.e., implicit reference price) compared with when it was above a normal price. Higher perceived need for a product and higher perceived product quality were associated with greater relative left frontal activation.

Keywords: purchase decision, price, brand, electroencephalography, neurophysiology

According to the neoclassical view of a rational Homo Economicus, humans make choices based on rational Bayesian maximization of expected utility, as if they were equipped with unlimited knowledge, time, and information-processing power (Naqvi, Shiv, & Bechara, 2006; Oullier, Kirman, & Kelso, 2008). This view has been challenged, for example, by the Prospect Theory stating that subjective utility is dependent on a reference point and that people tend to strongly prefer avoiding losses over acquiring gains (Kahneman & Tversky, 1979). A mounting body of evidence shows that emotional processes play a crucial role in economic decision making (e.g., Bernheim & Rangel, 2004; Kahneman, Ritov, & Schkade, 1999; Loewenstein & Lerner, 2003; Shiv & Fedorikhin, 1999; Slovic, Finucane, Peters, & MacGregor, 2004), and deficits in emotional processing can impair the quality of decision making (e.g., Bechara & Damasio, 2005). The present study was designed to examine how emotional-motivational factors as indexed by electroencephalographic (EEG) asymmetry over the prefrontal cortex (relative activity of the left and right hemispheres) predict purchase decision for national brand and private-label (grocery) products when their price levels were varied. We also examined the factors influencing frontal EEG asymmetry. We think that frontal EEG asymmetry can potentially broaden our view on emotional-motivational processes affecting purchase decision.

Frontal EEG Asymmetry and Approach/Withdrawal Motivation

According to Davidson's influential approach-withdrawal motivational model of emotion, the left- and right-anterior brain regions are part of two separate neural systems underlying approach and withdrawal motivation, respectively (e.g., Davidson, 1995, 2004). Relatively greater left frontal activity, either as a

Niklas Ravaja, School of Business, Aalto University, Helsinki, Finland, Helsinki Institute for Information Technology (HITT), Department of Social Research, University of Helsinki, Finland; Outi Somervuori and Mikko Salminen, School of Business, Aalto University.

Correspondence concerning this article should be addressed to Outi Somervuori, Runeberginkatu 22-24, 00100 Helsinki, Finland. E-mail: outi.somervuori@aalto.fi

trait or a state, indicates a propensity to approach or engage a stimulus, while relatively greater right frontal activity indicates a propensity to withdraw or disengage from a stimulus (for reviews, see Coan & Allen, 2004; Davidson, 2003; Demaree, Everhart, Youngstrom, & Harrison, 2005). Source localization of frontal asymmetry in the alpha frequency band (i.e., the index of frontal asymmetry in EEG studies) has indicated that it reflects activity in the dorsal prefrontal cortex (PFC; Pizzagalli, Sherwood, Henriques, & Davidson, 2005). Trait (resting) prefrontal EEG asymmetry (asymmetrical activation of left-frontal vs. right-frontal brain regions) has been shown to predict state-related emotional changes and responses (e.g., affective responses to emotional film clips; Wheeler, Davidson, & Tomarken, 1993) and to be associated with psychopathology or risk for psychopathology (especially depression and anxiety; e.g., Gotlib, Ranganath, & Rosenfeld, 1998; Wiedemann et al., 1999). Increased resting left-lateralized activity has also been associated with a stronger bias to respond to (monetary) reward-related cues (Pizzagalli et al., 2005). Likewise, resting-state hypoactivity in the right lateral PFC has been found to predict higher monetary risk taking (Gianotti et al., 2009) and a lower willingness to punish in the ultimatum game (Knoch, Gianotti, Baumgartner, & Fehr, 2010).

A relationship between emotional states and concomitant changes in frontal EEG asymmetry has also been established; that is, approach-related emotions (e.g., joy and anger) are associated with relatively greater left frontal activation, whereas withdrawal-related emotions (e.g., disgust and fear) are associated with relatively greater right frontal activation (e.g., Coan & Allen, 2003; Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Ekman & Davidson, 1993; Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). Davidson, Marshall, Tomarken, and Henriques (2000) have also argued that anterior asymmetry is associated with pregoal attainment emotion elicited while attempting to achieve a goal (e.g., enthusiasm), but not with postgoal attainment emotion (e.g., contentment; cf. the distinction between wanting and liking; see also Tomarken & Zald, 2009). The state engagement in approach-related responses and perceived high as compared with low choice to engage in action (commitment to counterattitudinal or proattitudinal action) has been shown to increase left-sided frontal activity (Amodio, Devine, & Harmon-Jones, 2007; Harmon-Jones, Harmon-Jones, Serra, & Gable, 2011; see also Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006).

Frontal EEG Asymmetry and Purchase Decision

According to Prelec and Loewenstein (1998), a consumer's purchase decision involves a tradeoff between the pleasure derived from consumption and the pain of paying. That is, paying money triggers a perception of loss (i.e., prices are considered as a potential loss), even though it has also been suggested that money spent in buying goods is not "coded" as a loss (no loss in buying hypothesis; Bateman, Kahneman, Munro, Starmer, & Sugden, 2005). In regard to motivational tendencies, anticipatory pleasure of acquisition should be associated with approach motivation, whereas anticipatory pain of paying should be associated with withdrawal motivation. A situation where approach motivation elicited by a preferred product exceeds withdrawal motivation should be associated with an affirmative purchase decision. This (and the aforementioned suggestion that anterior asymmetry is associated with pregoal attainment emotion, but not with postgoal attainment emotion) leads to our first hypothesis:

> *Hypothesis 1:* Relatively greater left frontal activation during the predecision period (i.e., higher alpha asymmetry scores and approach motivation when seeing an image of a product) will predict an affirmative purchase decision, but the decision to purchase the product will not be associated with postdecision alpha asymmetry.

Reference Price and Approach/Withdrawal Motivation

Whereas a price increase from a reference point represents a loss, a price decrease from a reference point represents a gain (e.g., Hardie, Johnson, & Fader, 1993; Putler, 1992). It is also well established that consumers weigh losses from a reference point more heavily than equivalent sized gains, a phenomenon known as loss aversion (Tversky & Kahneman, 1991). Recently, using functional MRI (fMRI), Knutson, Rick, Wimmer, Prelec, and Loewenstein (2007) found that product preference activated the nucleus accumbens (i.e., a brain region associated with anticipating gain and one of the anatomical structures comprising the approach system; Davidson, 1998), excessive prices activated the right insula (i.e., a region associated with anticipating loss and that is part of a circuit governing positive and negative affect; Davidson, 2004), and reduced prices activated the mesial prefrontal cortex (i.e., a region implicated in integrating gains and losses) prior to the purchase decision. Importantly, activity from each of these regions independently predicted subsequent purchasing decisions. Thus, neural processes underlying purchase decisions may be different depending on whether the price of a product is below or above a reference price. It is also well known that perceptions of quality are positively correlated with price (Rao & Monroe, 1989). Recently, Plassmann, O'Doherty, Shiv, and Rangel (2008) showed that increasing the price of a wine increased subjective reports of flavor pleasantness and activity in medial orbitofrontal cortex (mOFC; i.e., a region thought to encode for experienced pleasantness during experiential tasks; there was also inconclusive evidence that the increase in activation might be more pronounced in the left compared with the right mOFC). This suggests that a high price may elicit conflicting motivational tendencies (i.e., both withdrawal and approach motivation), which may mask the association of asymmetrical frontal cortical activity with a purchase decision. That being so, this association may be more evident when the price of a product is below a reference price. In the present study, we used the normal selling price of a product as a proxy for a reference price (i.e., implicit reference price). Thus, our next hypothesis is:

> *Hypothesis 2:* Relatively greater left frontal activation will be more strongly associated with an affirmative purchase decision when the price of a product is below a normal price (i.e., implicit reference price) compared with when it is above a normal price.

Brand and Approach/Withdrawal Motivation

Evaluative judgments of brands can be based on two distinct types of information or inputs: (a) declarative information (i.e., brand attributes and brand knowledge) and (b) experiential information (i.e., emotions and experiences evoked by the brand; Brakus, Schmitt, & Zarantonello, 2009; Pham, Cohen, Pracejus, & Hughes, 2001; Schwarz, 2004). Declarative information may be used in a systematic, step-by-step fashion (e.g., expectancy-value model, Fishbein & Ajzen, 1975) or heuristically (e.g., elimination-by-aspects, relational heuristics; for a review, see Bettman & Luce, 1998; see also Maheswaran, Mackie, & Chaiken, 1992). The process where judgments and decisions are based on subjective affective responses to the target, which appear to be seen as indicative of the target's value, has been referred to as the "How-do-I-feel about-it?" heuristic (involving conscious inspection of feelings toward the target; Pham, 1998; Pham et al., 2001) and the "affect heuristic" (encompassing conscious and nonconscious affective influences; Slovic, Finucane, Peters, & MacGregor, 2007). Likewise, the "somatic marker hypothesis," proposed by Damasio and colleagues, suggests that decision process is consciously or nonconsciously influenced by marker signals that arise in bioregulatory processes expressing themselves in emotions and feelings (e.g., Bechara & Damasio, 2005). Through learning and experience, images of options become "marked" by positive and negative feelings linked directly or indirectly to somatic or bodily states.

Brand associations are formed when interacting with the brand (e.g., store visits and actual consumption) and during prior indirect brand exposures (e.g., via brand communications; Esch et al., 2012). Strong (familiar) brands have been suggested to have stronger and more positive brand associations compared with weak (familiar) brands and unfamiliar brands (e.g., Hoeffler & Keller, 2003). Recently, a brain-imaging study by Esch et al. showed that, when evaluating brands, strong brands elicited activations of the pallidum associated with positive emotions, whereas weak and unfamiliar brands elicited activations of the insula associated with negative emotions. In the present study, we focus on national brand and private-label products. Previous research suggests that the influence of deviations from the reference price on purchase behavior may be different for national brand products and private-label products (for the moderating role of quality-tiers in loss aversion, see Hankuk & Aggarwal, 2003). Consumers tend to perceive brands in the high-quality tier (e.g., national brands) as offering "comfort, security, and value," whereas brands in the low-quality tier (e.g., private-label brands), offer lower prices but lower quality too (Hankuk & Aggarwal, 2003). It is also possible that images of private-label products are not marked by strong positive and negative affective feelings; rather, the associations may be neutral. Thus, purchase objectives and psychological processes underlying purchase decision may be different for national brand products and private-label products. Given the discussion above, it would be expected that emotional-motivational factors play a greater role in determining purchase decision for national brand products compared with private-label products. This leads to the following hypothesis:

> *Hypothesis 3:* Relatively greater predecision left frontal activation will be more strongly associated with an affirmative purchase decision for national brand products compared with private label products.

Perceived Need, Product Quality, and Frontal EEG Asymmetry

We also examined the predictors of frontal EEG asymmetry. Hunger and thirst—signals of biological needs—lead to the motivation to get food and water (i.e., appetitive/approach motivation). Likewise, a consumer's motivation to purchase a product or service is triggered by an expectation that the object of purchase will satisfy his or her perceived biological or other needs. Recently, Gable and Harmon-Jones (2008) showed that self-reported liking for dessert and time since eaten were associated with greater relative left frontal EEG activation during viewing dessert pictures, but not during viewing neutral pictures. Thus, cues signaling potential satisfaction of perceived needs would be expected to elicit approach motivation and relatively greater left frontal activation.

Product attributes, such as perceived quality (i.e., a consumer's judgment about the overall superiority or excellence of a product; Zeithaml, 1998), may also exert an influence on approach motivation. As noted above, consumers tend to anticipate that high-quality products will offer "comfort, security, and value" (Hankuk & Aggarwal, 2003). Thus, images of high-quality products are expected to be marked by positive feelings, thereby eliciting approach motivation. This leads to the following hypothesis:

> *Hypothesis 4:* Higher perceived need for a product and higher perceived product quality will be associated with greater relative left frontal activation during the predecision period (when seeing an image of a product).

Method

Participants

The participants were 33 right-handed healthy business students (14 males and 19 females), who ranged from 20 to 44 years of age ($M = 27.0$). All participants were students who were responsible for their own household's grocery purchases.

Design

A 7 (Product Category) × 2 (Brand) × 15 (Price) within-subjects design was employed.

Seven product categories were selected for the research: detergent, chocolate, coffee, chips, orange juice, chocolate cookies, and toothpaste. For each product category, two products were selected: one national brand product and one store-labeled product (altogether 14 different products). We selected product categories from which two products could be found that are nearly equal in other components except the product wrapping and brand. The selected national brand products were the market leaders of that product category. A corresponding product was selected from the private label category.

The third factor, the price, included 15 different price levels plus one duplicate for the normal price level to control the participant consistency. Altogether, each product was presented 16 times (16 trials). Each product's normal selling price at a local supermarket was selected as a reference price. The price decrease and corresponding increase levels were 3%, 6%, 10%, 25%, 40%, 60%, and 75%. The behavioral data (the influence of a price decrease and increase on buying behavior) have been reported in Somervuori and Ravaja (2011).

Product Ratings

After the experiment, the participants filled in a questionnaire on the Internet where they rated each of the products on several dimensions. Perceived product quality was rated on a 5-point scale, ranging from 1 (*poor quality*) to 5 (*high quality*). Perceived need for the product was also rated on a 5-point scale, ranging from 1 (*not at all*) to 5 (*very much*).

Procedure

In the laboratory, the participant was first given instructions on the task (i.e., a modified version of the Savings Hold or Purchase [SHOP] task; Knutson et al., 2007) and tested for task comprehension. After the briefing, the participant filled out an informed consent form. Electrodes were then attached, and the participant was seated on a chair. The participant was left alone in the laboratory for a 7-min rest period, followed by the experiment that took, on the average, 52 minutes. The participants received 40 € in cash to spend on products during the experiment. They were asked to imagine them grocery shopping in a local supermarket and having 40 € (their endowment) to spend. All participants were presented with 224 trials in a random order. Each of the 224 trials consisted of the following phases: (a) a fixation cross on a screen presented for 1 s to focus the attention of the participant to the middle of the screen (fixation period), (b) an image of a product with a price shown for 6 s (predecision period), (c) a prompt on the screen to choose either to purchase the product or not by selecting either Y for yes or N for no, and (d) an interstimulus interval varying randomly from 7 to 9 s while the screen was black. The trials were presented using Presentation 10.4 software.

To ensure the participant's engagement in the purchasing task, one trial for each product was randomly selected to count for real (participants were informed about this in the beginning of the experiment). If the participant had chosen to purchase the product in the randomly selected trial, they paid the price shown in the trial from their endowment. In return for their participation, the participants could keep the purchased products and that part of the endowment they had not spent when leaving the experiment. In addition, the participants were introduced a bonus schema where they were able to gain additional 5 € bonus if they answered "yes" for more than 30% of the trials.

After finishing with all trials, the electrodes were removed, and the participant was debriefed and thanked for participation.

Assessment of EEG

Electrodes mounted in a stretch-Lycra cap (Electrocap; Electro-Cap International, Eaton, OH) were used to record EEG activity from left and right frontal (F3, F4), central (C3, C4), temporal (T7, T8), parietal (P3, P4), and occipital (O1, O2) scalp sites (10–20 International System; Jasper, 1958). The electrodes were referred to linked ears, and the ground lead was located at the left collarbone (e.g., Harmon-Jones & Allen, 1998). Electrode impedances were reduced to less than 5 kΩ. All signals were amplified by a factor of 50,000 with the Psylab EEG8 amplifiers (Contact Precision Instruments, London, United Kingdom). During the data collection, 1-Hz high-pass and 200-Hz low-pass filters were used; a 50-Hz notch filter was also employed. To facilitate artifact detection, ocular movements were recorded with two electrooculogram (EOG) channels. For vertical eye-movements, the electrodes were placed below and above the right eye; for horizontal eye-movements, the electrodes were placed at the outer canthi of the left and right eye. The data collection was controlled by Psylab SAM2 software, and all signals were sampled at a rate of 1,000 Hz.

Data Reduction and Analysis

After the recordings, the EEG data were filtered with 0.5-Hz high-pass and 70-Hz low-pass filters. For each trial, the EEG data were segmented into three 1-s epochs before stimulus (image of a product) onset (seconds 1 to 3) and eight 1-s epochs after stimulus onset (seconds 4 to 11). For artifact removal, all 1-s epochs containing activity outside the range of -85 μV to $+85$ μV, on any of the EEG or EOG channels, were detected and removed from further analyses. For all the remaining 1-s epochs, the power spectra were derived by the fast Fourier transform (FFT) method with a Hanning window (applied to the distal 10% at each end of the epoch). Power values (in μV^2) within the alpha

(8–12 Hz; Buzsáki, 2006) frequency range were extracted for each 1-s epoch (in alpha asymmetry research, the 8–13 Hz frequency band has also been used; Allen, Coan, & Nazarian, 2004). Mean power density values were derived for the following periods: (a) baseline (seconds 1 and 2; i.e., two seconds preceding the fixation period), (b) predecision period (seconds 4 to 9), and (c) postdecision period (seconds 10 and 11; for another example of short stimulus periods, i.e., 3-s affective picture viewing, in alpha asymmetry research, see Harmon-Jones et al., 2006). As in previous research (Allen et al., 2004), a frontal asymmetry index (natural log of alpha power on the right minus natural log of alpha power on the left) was computed for each period, using midfrontal sites (F3, F4). For comparison purposes, asymmetry indexes for the other sites (C3/4, T7/8, P3/4, O1/2) were also computed. Because cortical alpha power is inversely related to cortical activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Laufs, Kleinschmidt, et al., 2003; Laufs, Krakow, et al., 2003; for a review, see Allen et al., 2004), higher scores on the index indicate greater relative left hemisphere activity. Change scores for alpha asymmetry (Δ alpha asymmetry) were computed by subtracting baseline alpha asymmetry from predecision alpha asymmetry and postdecision alpha asymmetry (cf. Allen, Harmon-Jones, & Cavender, 2001; Papousek & Schulter, 2002); these change scores reflected changes in asymmetry from the (local) baseline of each trial.

All data were analyzed using the Generalized Estimating Equations (GEE) procedure in SPSS. In the GEE procedure, the dependent variable is linearly related to the factors and covariates via a specified link function. The model allows for the dependent variable to have a non-normal distribution and covers widely used statistical models (e.g., logistic models for binary data). The GEE procedure extends the generalized linear model to allow for analysis of repeated measurements or other correlated observations. The GEE approach requires the specification of the correlation structure of the repeated observations of the dependent variable, distribution of the dependent variable, and link function. The GEE models were introduced by Liang and Zeger (1986), and the method has received wide use in medical and life science research (Ballinger, 2008).

We specified Participant ID as the subject variable and trial number as the within-subject variable. On the basis of the Quasi-likelihood under Independence Model Criterion (QIC), we specified unstructured as the structure of the working correlation matrix. When predicting purchase decisions, we specified a binomial distribution with logistic link. When predicting EEG alpha asymmetry, we specified a normal distribution with identity as the link function. The terms included in different models are described under the Results section.

Results

Table 1 shows the results of the GEE analyses for purchase decision. The purchase decision was affirmative in 38% of the trials (n = 224).

Hypothesis 1

Hypothesis 1 predicted that relatively greater left frontal activation during the predecision period (i.e., higher alpha asymmetry scores and approach motivation when seeing an image of a product) will predict an affirmative purchase decision, but the decision to purchase the product will not be associated with postdecision alpha asymmetry. When testing Hypothesis 1 and Hypothesis 2, product category, normal price, price multiplier, Δ alpha asymmetry, and the Dichotomized Price Multiplier × Δ Alpha Asymmetry interaction were included in the GEE model. As predicted, the results revealed a significant main effect for predecision Δ alpha asymmetry in predicting purchase decision, $p <$ .001. That is, the relatively greater left frontal activation was (i.e., higher approach motivation), the more likely the participant was to purchase a product.

To examine whether the effect was specific to the frontal regions as predicted, we also performed the analysis using the other asymmetry indexes as predictors. Predecision Δ alpha asymmetry in the central and temporal regions was not significantly associated with purchase decision, ps > .10. However, the parietal alpha asymmetry index was positively associated, B = .141, SE = .033, Wald's chi-square (df = 1) = 17.85, $p <$ .001, and occipital asymmetry index was negatively associated, B = −.072, SE = .030, Wald's chi-square (df = 1) = 5.92, p =

Table 1
Results of Generalized Estimating Equations (GEE) Analysis of Purchase Decision Data

Variable	*B*	*SE*	Wald χ^2	*df*	*p*
Hypothesis 1 (Predecision asymmetry)					
(Intercept)	4.740	.224	449.24	1	<.001
Product category					
Detergent	0.913	.130	49.30	1	<.001
Chocolate	0.065	.107	0.37	1	.546
Chips	0.378	.100	14.14	1	<.001
Coffee	0.459	.112	16.75	1	<.001
Chocolate cookies	0.402	.114	12.45	1	<.001
Orange juice	0.075	.101	0.56	1	.455
Toothpaste	0[a]				
Normal price	−0.996	.067	219.68	1	<.001
Price multiplier	−3.117	.166	351.10	1	<.001
Δ Alpha asymmetry[b]	0.199	.034	33.62	1	<.001
Dichotomized Price Multiplier × Δ Alpha Asymmetry[b]	−0.247	.045	30.04	1	<.001
Hypothesis 1 (Postdecision asymmetry)					
(Intercept)	3.790	.162	550.90	1	<.001
Product category					
Detergent	0.761	.086	78.53	1	<.001
Chocolate	0.102	.095	1.16	1	.282
Chips	0.467	.081	32.87	1	<.001
Coffee	0.167	.074	5.13	1	.024
Chocolate cookies	0.675	.091	54.84	1	<.001
Orange juice	−0.035	.086	0.16	1	.687
Toothpaste	0[a]				
Normal price	−0.963	.036	719.21	1	<.001
Price multiplier	−3.073	.100	949.09	1	<.001
Δ Alpha asymmetry[b]	0.210	.028	56.88	1	<.001
Dichotomized Price Multiplier × Δ Alpha Asymmetry[b]	−0.322	.035	86.72	1	<.001
Hypothesis 2 (Predecision asymmetry)					
(Intercept)	4.272	.168	649.89	1	<.001
Normal price	−0.701	.038	340.54	1	<.001
Price multiplier	−3.292	.148	498.22	1	<.001
Brand	−0.513	.079	42.04	1	<.001
Δ Alpha asymmetry[b]	0.059	.013	20.52	1	<.001
Brand × Δ Alpha Asymmetry[b]	0.074	.035	4.50	1	.034
Hypothesis 2 (Postdecision asymmetry)					
(Intercept)	3.167	.133	570.78	1	<.001
Normal price	−0.567	.046	151.10	1	<.001
Price multiplier	−2.947	.084	1231.33	1	<.001
Brand	−0.330	.061	29.39	1	<.001
Δ Alpha asymmetry[b]	0.026	.020	1.73	1	.189
Brand × Δ Alpha Asymmetry[b]	0.269	.025	113.80	1	<.001

Note. For purchase decision, 0 = not buying (reference category), 1 = buying.
[a] Set to zero because this parameter is redundant. [b] Predecision alpha asymmetry (ln[F4/F3]) minus baseline alpha asymmetry.

.015, with an affirmative purchase decision (these associations were weaker compared with that found for frontal asymmetry).

In disagreement with Hypothesis 1, also high postdecision Δ alpha asymmetry scores were significantly related to an affirmative purchase decision, $p < .001$. In addition to the computation of postdecision Δ alpha asymmetry described above (i.e., postdecision alpha asymmetry minus baseline alpha asymmetry), we computed postdecision Δ alpha asymmetry also by subtracting predecision alpha asymmetry from postdecision alpha asymmetry (this change score reflected additional changes in asymmetry not accounted for by the predecision period). Also this alternative postdecision Δ alpha asymmetry score was positively related to an affirmative purchase decision, $B = .133$, $SE = .025$, Wald's chi-square ($df = 1$) = 27.67, $p < .001$.

Hypothesis 2

Hypothesis 2 suggested that relatively greater left frontal activation will be more strongly associated with an affirmative purchase decision when the price of a product is below the normal price (i.e., implicit reference price) compared with when it is above the normal price. The results showed that, in addition to the significant main effect for Δ alpha asymmetry, there was a significant Dichotomized Price Multiplier × (Pre-Decision) Δ Alpha Asymmetry interaction in predicting purchase decision, $p < .001$. That is, as predicted, predecision Δ alpha asymmetry was positively related to an affirmative purchase decision when the price of a product was below the normal price, but not when it was above the normal price (see the top panel of Figure 1). The results revealed also a significant Dichotomized Price Multiplier × (Post-Decision) Δ Alpha Asymmetry interaction for purchase decision, $p < .001$. As was the case for predecision Δ alpha asymmetry, postdecision Δ alpha asymmetry was associated with an affirmative purchase decision only when the price of a product was below the normal price.

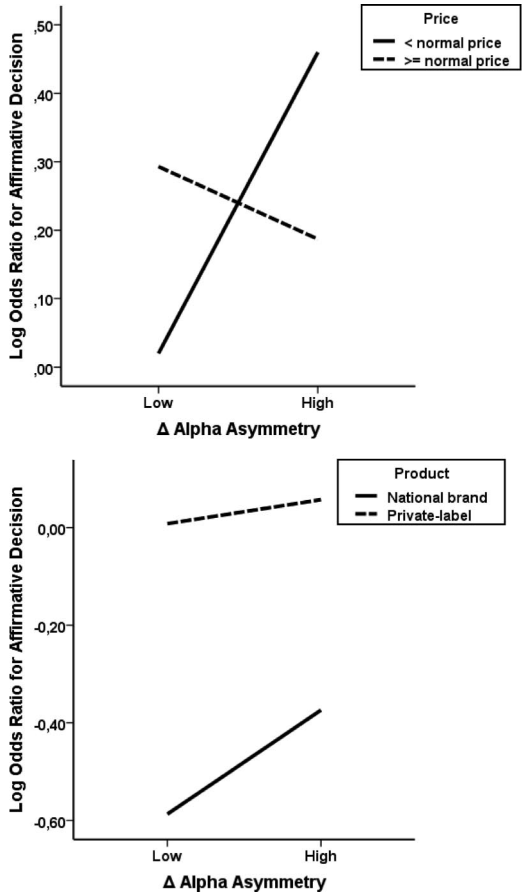

Figure 1. The relationship of predecision Δ alpha asymmetry with purchase decision as a function of dichotomized price multiplier (top panel) and product (national brand or private label; bottom panel; low Δ alpha asymmetry = M −1.5 SD; high Δ alpha asymmetry = M + 1.5 SD).

Hypothesis 3

Hypothesis 3 suggested that relatively greater left frontal activation would be more strongly associated with an affirmative purchase decision for national brand products compared with private label products. When testing Hypothesis 3, normal price, price multiplier, brand, Δ alpha asymmetry, and the Brand × Δ Alpha Asymmetry interaction were included in the GEE model. The results showed that both the Brand × (Pre-Decision) Δ Alpha Asymmetry interaction and Brand × (Post-Decision) Δ Alpha Asymmetry interaction were significant in predicting purchase decision, $p = .034$ and $< .001$, respectively. In agreement with Hypothesis 3, predecision and postdecision Δ alpha asymmetry scores were more strongly positively associated with an affirmative purchase decision for national brand products compared with private label products (see the bottom panel of Figure 1).

Hypothesis 4

Hypothesis 4 predicted that higher perceived product quality and need would be associated with relatively greater left frontal activation during the predecision period (i.e., higher approach motivation when seeing an image of a product). When testing Hypothesis 4, perceived product quality and need for the product were included in the GEE model. As predicted, the results revealed significant main effects for both perceived product quality, $B = .009$, $SE = .003$, Wald's chi-square ($df = 1$) = 8.80, $p = .003$, and perceived need, $B = .016$, $SE = .002$, Wald $\chi^2(df = 1) = 45.32$, $p < .001$, in predicting predecision Δ alpha asymmetry. That is, both perceived product quality and perceived need were positively associated with relatively greater left frontal activation.

Discussion

In the present investigation, the authors examined (a) how approach motivation as indexed by EEG asymmetry over the prefrontal cortex predicts purchase decision for national brand and private-label (grocery) products when their prices were varied and (b) the factors influencing frontal EEG asymmetry.

Frontal EEG Asymmetry and Purchase Decision

As hypothesized, we found that relatively greater left frontal activation during the predecision period (i.e., higher approach motivation when seeing an image of a product) predicted an affirmative purchase decision. This is the first study to show that frontal EEG asymmetry predicts purchase decision. The present finding supports the view that a situation where approach motivation evoked by anticipatory pleasure of acquisition exceeds withdrawal motivation evoked by anticipatory pain of paying is associated with an affirmative purchase decision (see Prelec & Loewenstein, 1998). As expected, central and temporal asymmetry indices were not related to purchase decision. However, the parietal asymmetry index was positively associated with an affirmative purchase decision, although most previous studies have found no association of parietal asymmetry with emotional-motivational processes (e.g., Amodio, Shah, Sigelman, Brazy, & Harmon-Jones, 2004; Davidson et al., 1990; but for an exception, see Heller, 1993). Also unexpectedly, relatively greater right occipital activation was related to an affirmative purchase decision. What may account for this association is unknown at the present time (the association was weaker compared with that found for frontal asymmetry and the possibility of Type I error cannot be ruled out).

As opposed to our expectation, we found that also relatively greater postdecision left frontal activation was related to an affirmative purchase decision (this was the case also for an increase in relative left frontal activation from the predecision to postdecision period). This finding appears to be in disagreement with the suggestion that anterior asymmetry is associated with pregoal attainment emotion, but not with postgoal attainment emotion (Davidson et al., 2000). However, the present study design was not optimal for testing the latter part of our hypothesis, given the procedure that, after completing all trials, only one trial/decision for each product was randomly selected to count for real. That is, at the time of the decision, the participant didn't know whether he or she had really achieved his or her goal (whether an affirmative purchase decision resulted in acquisition of a preferred product). In effect, the fact that both relatively greater predecision and postdecision left frontal activation was related to an affirmative purchase decision increases our confidence in the present findings (Type I error is less likely).

The Moderating Influence of Reference Price and Brand

As also expected, the results showed that greater relative left frontal activation was more strongly related to an affirmative purchase decision when the price of a product was below the normal price (i.e., implicit reference price) compared with when it was above the normal price. This was the case for both predecision and postdecision alpha asymmetry, again increasing our confidence in the finding. Our finding may suggest that there are conflicting motivational tendencies (i.e., both withdrawal and approach motivation) when the price of a product is above the reference price, which may mask the association of frontal EEG asymmetry with a purchase decision. That is, a price increase from a reference point represents a loss (e.g., Hardie et al., 1993; Putler, 1992), which would be expected to elicit withdrawal motivation. However, a high price may also elicit a perception of higher quality, thereby potentially eliciting also approach motivation (cf. Plassmann et al., 2008). The present finding is also in line with the suggestion that neural processes underlying purchase decisions are different depending on whether the price of a product is below or above a reference price (Knutson et al., 2007).

We also found that greater relative left frontal activation was more strongly associated with an affirmative purchase decision for national brand products compared with private-label products. Again, this was the case for both predecision and postdecision alpha asymmetry. This finding suggests that emotional-motivational factors play a greater role in determining purchase decision for national brand products compared with private-label products. Brand associations have previously been suggested as being stronger and more positive for strong (familiar) brands compared with weak (familiar) brands and unfamiliar brands (e.g., Hoeffler & Keller, 2003). The present results suggest that images of private-label products may not be marked by strong positive or negative affective feelings (see, e.g., Bechara & Damasio, 2005); the brand associations for private-label products may rather be neutral. Apparently, not only purchase objectives but also psychological processes underlying purchase decision are different for national brand products and private-label products.

Predictors of Frontal EEG Asymmetry

In agreement with our hypothesis, the results showed that higher perceived need for the product was associated with greater relative left frontal EEG activation during the predecision period (when seeing an image of a product). Given that a need elicits appetitive/approach motivation, this finding supports the validity of frontal EEG asymmetry as a measure of approach motivation. The present finding is in line with the view that a consumer's motivation to purchase a product or service is triggered by an expectation that the object of purchase will satisfy his or her perceived needs. It is also in line with prior research showing that time since eaten (indexing a biological need) was associated with greater relative left frontal EEG activation during viewing dessert pictures, but not during viewing neutral pictures (Gable & Harmon-Jones, 2008). We also found that higher perceived product quality was related to greater relative left frontal activation during the predecision period. Given that high-quality products are anticipated as offering "comfort, security, and value" (Hankuk & Aggarwal, 2003), their images are expected to be marked by positive feelings, thereby eliciting approach motivation.

Limitations

Although the modified version of the SHOP task used in the present study entails the advantage that the decisions made by the participants have real monetary consequences for them, an apparent limitation was that the decision making situation, nevertheless, differs from that typical for purchasing grocery products (the present situation resembles, to some extent, a Web auction). It is unclear, however, whether this difference should have any influence on the results obtained. It should also be noted that the present results apply to grocery products of relatively low price. One may expect, however, that the results would have been even stronger for more expensive products.

An additional limitation relates a procedural issue that produces interpretational difficulties. As has been customary in most of the previous research, we quantified asymmetry as the difference between right frontal activation and left frontal activation. This computation of asymmetry implies that there is a single bipolar (reciprocal) continuum of cortical activation, thereby being in contrast with the view that approach and withdrawal motivation are largely independent (Ito & Cacioppo, 1999). It is also of note that several different patterns of activation may be represented by the same asymmetry score (e.g., a moderate asymmetry score can indicate either high left and high right frontal activation or low left and low right frontal activation). Also, the limited spatial resolution provided by EEG is an issue that arises in regional EEG research (and we used only a few electrodes).

Finally, it might have been advantageous to have a separate product period (image of a product without a price) and a price period (image of a product with a price) in the trials of the experiment (see Knutson et al., 2007). This would have been optimal for studying separately the approach/withdrawal motivation elicited by preferred products and prices, although the present factorial design varying the product and price is basically also able to tease out this information.

Conclusions

The present study showed that greater relative left frontal EEG activation during the predecision period predicted an affirmative purchase decision for grocery products. This relationship was stronger when the price of a product was below a normal price (implicit reference price) compared with when it was above a normal price, suggesting that there may be conflicting motivational tendencies (i.e., both withdrawal and approach motivation) when the price of a product is above the reference price. The results also suggested that emotional-motivational factors play a greater role in determining purchase decision for national brand products (the images of which are marked by strong affective feelings) compared with private-label products. In general, the results provide further evidence for the importance of emotional-motivational factors in purchase decision. This study also supports the usefulness of frontal EEG asymmetry as a measure of approach/withdrawal motivation when studying purchase decision. Frontal EEG asymmetry adds a new dimension to our understanding of emotional-motivational processes affecting purchase decision—a dimension that we cannot necessarily tap, if we only record behavioral responses.

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