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Preference Inferences from Eye-Related Cues in Sales-Consumer Settings: ERP Timing and Localization in Relation to Inferring Performance and Oxytocin Receptor (*OXTR*) Gene Polymorphisms

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Abstract

Past physiological evidence, indicates that inferences on the mind of another person (i.e., goals, intentions, beliefs), is a well-defined brain process characterized by specific temporal and spatial properties. This study investigated brain responses during passive viewing (consumers' role) of branded products (i.e., chocolates, chips, non alcoholic beverages) and preference inferences (sales consultants' role) from eye-related information. Using EEG methods, event-related potentials (ERPs) were recorded while participants passively viewed pictures of branded products versus when they tried to infer others' product preferences from eye-related information. ERP amplitudes were examined in two time windows, corresponding to the P3 component and the late positive potential (LPP). Dissimilar brain responses were found for preference inferences compared to passive viewing for the P3 and LPP components. P3 and LPP amplitudes were greater for preference inferences compared to passive viewing. In addition, enhanced P3 and LPP amplitudes were found for preference inferences compared to passive viewing for the High Inferring Performance (HI) as opposed to the Low Inferring Performance (LI) group. Finally, enhanced posterior P3 and LPP amplitudes were found for preference inferences compared to passive viewing for the GG as opposed to the A-allele carrier individuals of oxytocin receptor (*OXTR*) gene. Taken together, the results suggest that posterior P3 and LPP amplitude during preference inferences from eye-related cues as opposed to passive viewing of branded products reflects increased socially motivated attention allocation required for the social inferring task, for the GG compared to A-allele carrier individuals.

Keywords: sales, social attention, *OXTR*, ERPs, social inference

1. Introduction

Social scientists acknowledge that the ability to identify the goals and internal states of other people is a key skill which facilitates our navigation into different social contexts. In this study we focus on specific sales-consumer settings where people taking the role of sales consultant infer other people's internal states and product preferences from external cues such as facial expressions and eye-related information in order to figure out what a consumer actually likes. This study investigated a number of questions related to the inferring process of others' product preferences by the salesperson. The first question addressed in the current study was related to the physiological processes associated with the inferring of others' product preferences from eye-related information. Specifically, the current study investigated whether these physiological processes are influenced by the salesperson's genetic makeup. To address these questions the current investigation explored the electro physiological differences between preference inferences from eye-related information versus passive viewing of branded products. Moreover, this study examined variation in a candidate gene, the oxytocin receptor (*OXTR*) gene, known to affect social cognition (Skuse et al., 2014: Smith et al., 2014) as one possible source of differences in cortical brain activity between preference inferences from eye-related cues compared to passive viewing of branded products. Finally, the inferring performance of each individual was used as behavioural validation of the EEG recordings.

2. Theory

2.1 Social Inference

Humans are social creatures. They have the natural crave to connect with other humans (Lieberman, 2007). In

order to establish social interaction in quick and efficient manner humans need to understand the thoughts, intentions, preference, goals and behaviours of other people around them (Lieberman, 2007). When we meet people for the first time, we normally make quick and unintentional impressions about them. In other occasions, we deliberately attempt to identify some specific traits and behaviours in others which might give us the opportunity to know something about their personality. For instance, in a sales-consumer interaction, a sales consultant will try to infer the preferences of a consumer regarding specific product characteristics (i.e., colour, brand, size). What are the possible sources of information he or she might look at?

According to the social neuroscience literature, social inferences can be performed in two specific manners. First, it can be achieved in automatic and spontaneous associative way, with very little mental effort, by using previously acquired knowledge and engaging basic cognitive operations such as similarity and associations (Adolphs, 2009; Ma et al., 2011). For instance, sales consultant viewing a consumers' face contracting in an expression of disgust when eating a dark chocolate might lead him to the intuitive and spontaneous conclusion that the consumer did not enjoy the taste of it. Similarly, sales consultant observing a consumer who persistently looks at a specific pair of shoes for prolonged time will make him automatically infer that the consumer is interested in it. Second, the symbolic system expresses more advanced and intentional approach that employs reasoning procedures and relies on logic standards (Adolphs, 2009; Keysers & Gazzola, 2007). Sales consultant viewing a consumer who does not display any overt behavioural information might need to use more deep and reflective reasoning about what this person would like to buy. For instance, the sales consultant might use other external cues such as clothing, gender, ethnical background, age, weight and integrate all this information in conscious manner using logical reasoning in order to infer the consumer preferences. However, making a clear distinction between the two processes, especially in sales-consumer interaction, is extremely difficult, because social inference is often neither strictly intuitive and spontaneous nor strictly reflective and conscious.

The main goal of the current study is not to solve the puzzle of the dual-processes approach (spontaneous versus intentional inferences) in relation to social cognition. No matter how one looks at this question, it appears that both sets of processes contribute to the social cognition and more specifically to the preference inferences of others.

The temporal and spatial brain activity differences between the two processes, especially in relation to trait and goal inferences have been a main focus in the social neuroscience research in the past decade (Ma et al., 2011; Van der Cruyssen et al., 2009; Van Duynslaeger et al., 2008; Van Overwalle et al., 2012). The current study speculates that in sales-consumer interaction the sales consultant make use of both spontaneous and intentional inferences even by integrating them in one common inference system, because he or she needs all the available information in order to infer as quickly and accurately as possible the consumer preferences (Keysers & Gazzola, 2007).

Large number of the previous neuroscience studies on social cognition and social inference were done with single person performing social inference task in relation to reading information (sentences) or viewing face images displayed on a computer screen. Following Schilbach et al., (2013) suggestion the current investigation makes an attempt to overcome the spectatorial gap in past social neuroscience research. By actually introducing a real social interaction between two people (second-person neuroscience) this study is trying to "go really social" (Hasson et al., 2012; Schilbach et al., 2013).

2.2 Eye-related Social Inference

Recent social science and neuroscience studies emphasised the important role of the eyes in social inference and social attention (Nummenmaa & Calder, 2009; Senju & Johnson, 2009). In general, if one needs to infer what another person is attending or thinking, he usually looks to their eyes (Stephen, 2010). In particular, the human gaze represent important and valuable social signal, which is interpret together with other face-related cues as well as the social context (George & Conty, 2008). For instance, others' gaze direction toward certain product generally reveals their direction of attention and focus of interest (George & Conty, 2008). But the human gaze contains much more information than just the direction of others' attention. For instance, Stephen, (2010) suggest that gaze following is an essential evolutionary developed ability, "which allows humans to understand what another individual is seeing by means of analysing their body, head and eye posture and then internally imagine or expressively mimic their perspective and thus associate their observable, physical point-of-view to their private, internal mental states". He also argues that this ability is part of our natural behaviour and it is expressed in sophisticated, effortless and automatic way. Previous studies suggest that as people naturally and in a reflex-like manner look at the object of the surrounding space which they prefer, their gaze direction can be undoubtedly regarded as a preference for the object of attention (George & Conty, 2008; Shimojo et al., 2003). In

sales-consumer interaction eye-related cues (i.e., eye movements, number of fixations, mean dwell times, pupil dilation) can be used to infer not only consumers' direction of attention toward certain product but also to infer current preferences and intentions (Nummenmaa & Calder, 2009; Venkatraman et al., 2014). For instance, several studies suggested that fewer fixations in combination with longer dwell times during ad viewing are likely to reflect more detailed cognitive processing (Horstmann et al., 2009).

Past studies on social inference from eye-related cues mainly focused on eye-related stimuli which were usually presented as a picture, animation, or short movie clip on a computer screen. On the contrary, as already mentioned in the previous section the current study measured physiological responses in relation to social inferences (product preferences) from eye-related information during a real social interaction occurring between two people (second-person neuroscience), instead of making use of static images or dynamic movie presentations. According to Pönkänen et al., (2010), despite the fact that a face image is capable of evoking physiological and psychological processes related to the mental state of a person, it cannot influence the perceiver physically. The results of their study clearly indicate that there is a difference on a physiological level, measured by electroencephalography (EEG), between processing gaze-related information from seeing a live face as opposed to pictorial stimuli. Following their suggestion, this study investigates social inference processes from live eye-related information rather than using images or movie clips.

To our knowledge, there is a limited amount of EEG research on brain responses in relation to gaze direction. Most importantly, there is no previous EEG research, in particular ERP research, on using eye-related information for social inference.

2.3 Event-related Potentials

Event-related potentials (ERPs) offer high temporal resolution of neural activity which makes them a valuable technique to explore the timing of the brain processing differences between intentional inferences of other person's preferences from eye-related information and passive observation of generic products.ERPs are electrophysiological brain responses to a specific cognitive, sensory or motor event. They reflect information-processing operations, where temporally distinct ERP waveform components represent different functions in this process. Some of these ERP components have been of particular interest to social cognition over the past 30 years. One of them is the P3, which is characterized by a positive-going waveform within the 250-450 ms latency range (Olofsson et al., 2008). The P3 is composed of two temporally distinct sub-components: P3a and P3b. P3a, which is evident in frontal scalp locations, has been frequently associated with novelty (unexpected event) and it is assumed to reflect involuntary attention (Polich, 2007). On the contrary, the P3b (the component that is the focus of the current study, and that will further be referred to as P3) appears at posterior-parietal scalp locations (Ibanez et al., 2012). Past electrophysiological studies suggested that posterior-parietal P3 amplitude reflects attention allocation, working memory and other higher level psychological processes required for social cognition tasks (Ibanez et al., 2012; Kok, 2001). Typically, the P3 amplitude is modulated by task-relevance and reaches the highest amplitudes at parietal scalp locations. P3 amplitude is extremely sensitive to the motivational significance of the visual stimulus, which in turn is highly influenced by the specific task context in which it occurs. For instance, stimuli requiring an overt response frequently elicit higher P3 amplitudes than stimuli which do not require response (e.g., Nieuwenhuis et al., 2005).

The LPP is a long-lasting, positive slow wave, and is maximal over centro-parietal sites and becoming evident between 500 and 700 ms after stimulus onset (Cuthbert et al., 2000; Olofsson et al., 2008). Past EEG studies suggest that LPP reflects sustained attention allocation and motivational significance to salient relevant stimuli (Hajcak, MacNamara, & Olvet, 2010; Pozharliev et al., 2015). Enhanced LPP amplitude was found in relation to visual stimuli that were perceived as silent due to specific task context, such as targets (Azizian, Freitas, Parvaz, & Squires, 2006). Most importantly, it has been frequently reported that LPP amplitude is larger for human faces compared scenes and objects images which implies that faces possess significance that is unique and unequalled by other categorise of visual stimuli such as generic products (Ferri, Weinberg, & Hajcak, 2012; Weinberg & Hajcak, 2010). Similar studies also conclude that images showing human faces appear to attract attention more easily than images that do not present faces (Ito & Cacioppo, 2000).

Previous ERP studies about social inferences have focused on variety of social targets such as goals, intentions, traits, situational circumstances and external causes of events. For instance, spontaneous and/or intentional trait inferences (actor's traits) studies have found enhanced P3 as well as LPP amplitude in relation to trait identification processes (Van Duynslaeger et al., 2008; Van Overwalle et al., 2012). Moreover, goal inference processes were also reflected by modulation of the P3 amplitude and were usually made prior the traits

inferences (Van der Cruyssen et al., 2009). None of these studies, however, investigates preference inferences from eye-related information.

2.4 OXTR Polymorphism

Oxytocin (OT) is a neuropeptide synthesized in the hypothalamus which is known to affects brain processes, especially those involved in social processing and social behaviour (Bartz & Hollander, 2006; Bos et al., 2012; Rodrigues et al., 2009). OT intranasal administration resulted in better performance of inferring mental states from eye region measure with the "Reading the Mind in the Eyes Test (RMET)" (Domes et al., 2007: Luminet et al., 2011), enhanced affective empathy and increased social learning (Hurlemann et al., 2010) and increased attention to the eye-region of faces, reflected by prolonged eye gaze (Guastella et al., 2008). A key factor of oxytocin functionality is the OT receptor, a proteinencoded by the *OXTR* gene that is located on chromosome 3p25 (Inoue et al., 1994). On specific SNP of *OXTR* (rs53576) has been frequently associated with social behaviour. In particular, individuals homozygous for the G allele (GG genotype) compared with the carriers of the non GG (AA, AG genotypes) alleles are known to have higher human social recognition skills (Skuse et al., 2011), enhanced sociality (Tost et al., 2010; Wu & Su, 2014), and to display higher behavioural and dispositional empathy (Rodrigues et al., 2009; Smith et al., 2014). In addition, individuals homozygous for the G allele were found to show higher nonverbal prosocial behaviour such as increased total gaze time toward the eye region than carriers of the A allele (Kogan et al., 2011).

2.5 OXTR Polymorphism and ERP

There is a limited amount of ERP research on brain responses in relation to oxytocin administration, especially on normal healthy individuals. For instance, enhanced late positive potential (LPP) amplitudes were found after oxytocin compared to placebo administration (Huffmeijer et al., 2012). The authors of the same study suggested that oxytocin administration increased attention to the feedback stimuli, reflected by late positive potentials (LPP) and enhanced the processing of emotional faces reflected by the vertex positive potential (VPP). However, to our knowledge, there is no previous ERP research, on social inference in relation to *OXTR* gene variation. The current study investigated the relations between oxytocin receptor gene variation and ERP responses during preferences inferences from eye-related information compared to passive viewing of branded products.

3. Objectives and Hypotheses

3.1 ERP

Previous ERP studies report enhanced P3 amplitude in relation to performing active task as opposed to passive stimulus processing (Polich, 2007). Moreover, higher posterior P3 and LPP amplitudeswere frequently reported to reflect attention allocation (Hajcak, MacNamara, & Olvet, 2010; Kok, 2001; Pozharliev et al., 2015). Preference inference from eye-related information requires active involvement and enhanced attention in order to be performed quickly and efficiently. On the other hand, passive viewing of products reflects passive stimulus processing which does not involve active task engagement, overt responses and thus requires less attention allocation with respect to preference inference. Most importantly, past neurophysiological studies suggest that P3 and LPP amplitudes are larger for human faces compared scenes and objects images, which implies that faces possess significance that is unique and unequalled by other categories of visual stimuli such as generic products (Allison et al., 1999; Ferri, Weinberg, & Hajcak, 2012; Weinberg & Hajcak, 2010). Similar studies also conclude that images showing human faces appear to attract attention more easily than images that do not present faces (Ito & Cacioppo, 2000). In the current experiment preference inference was actively done from eye-related cues which involved face processing. Thus, we hypothesize that higher ERP amplitudes will occur for P3 and LPP components during preference inference from eye-related cues as opposed to passive viewing of branded products.

3.2 OXTR Polymorphism

Individuals homozygous for the G allele (GG genotype) compared with the A-carriers (AA, AG genotypes) show higher levels of Theory of Mind (ToM) performance (Wu & Su, 2014), exhibit higher non-verbal intelligence (Lucht et al., 2009), and display higher behavioural and dispositional empathy (Rodrigues et al., 2009; Smith et al., 2014). Theory of Mind is defined as the ability to attribute mental states such as intentions, preferences, desires and beliefs to other people as a way to interpret and predict social behaviour (Premack & Woodruff, 1978). Thus, we hypothesize higher preference inference performance reflected by higher number of correctly inferred trials from eye-related cues for individuals with the *OXTR* GG genotype compared to A-carriers.

Previous studies suggest that gazing behaviour is associated with brain processes such as attention, and information processing (Georgescu et al., 2013; Haxby et al., 2000; Nummenmaa & Calder, 2009). According to

Kogan et al., (2011) individuals with *OXTR* GG genotype exhibit longer gaze duration toward the eye region than A-carriers. As already mentioned, past neurophysiological evidence suggest that ERP (P3 and LPP) amplitudes are enhanced during human faces processing (i.e., eye-region) as opposed to objects processing (Ferri, Weinberg, & Hajcak, 2012; Weinberg & Hajcak, 2010). Thus, we hypothesize that higher ERP amplitudes will occur for P3 and LPP components during preference inference from eye-related cues as opposed to passive viewing of products for individuals with the *OXTR* GG genotype compared to A-carriers.

4. Method

4.1 Participants

Fifty male and forty two female (Age M = 23.84, SD = 1.99) of mixed ethnicity (80.4% Caucasian, Asian 9.8%, and 9.8% other or multiple ethnicities) undergraduates from a Dutch University participated in this study. Initial analyses confirmed that *OXTR* variations did not significantly interact with gender. Participants enrolled in the experiment in exchange for course credit. All participants had normal or corrected-to-normal vision. Informed consent was obtained from each participant before the experiment and the study was authorized by the university's Ethics Commission.

4.2 Materials

Stimuli consisted of a pool of 64 pictures chosen from various product categories (chocolates, nonalcoholic beverages, chips and cakes). The pictures were selected by a group of four male and four female undergraduates (Age M = 23.50, SD = 1.85) from a Dutch University who received payment for this task. They were also asked to create 460 different couples of the previously selected 64 products.

4.3 Procedures

Before the start of the EEG sessions each couple of participants were invited in two separate rooms. Each of them was shown five couples of real products selected on a random base that they could touch and feel. They were asked the make a choice between each couple of products based on their personal preference. To assure that participants will make choice in accordance with their real preferences they were informed that as a part of the experiment they could win each of their choices. After participants made their choices they were invited to the EEG lab. The experiment was conducted in two sessions (Sales Consultant and Consumer condition). Participants were informed about the rules of the game. Each of the two participants played both roles. They were assigned to each role in random order. In both sessions, EEG recordings were collected from the two participants simultaneously. They were both accommodated in isolated, dimly lit, electrically shielded EEG laboratory. Participants sat beside each other in comfortable chairs approximately 100 cm away from, and at eye level with, a 40x30 cm IIyama PC computer screen. Participant who was performing the Sales Consultant role was facingthe other participant while the Consumer was facing only the computer screen. Participants interacted with each other during the installation of the EEG caps and in the period between the two sessions. In all sessions, the leader of the experiment left the room, ensuring that his presence did not affect the findings.

In both sessions, participants were shown a succession of 5 pictures representing two products each, which were randomly assigned among the 460 different variations created specifically for this experiment. Pictures was composed of two branded products each, one displayed in the left side and one displayed in the right side on the computer screen using E-prime presentation software (Psychology Software Tools, Inc). The pictures included branded products from different categories such as chocolates, nonalcoholic beverages, chips and cakes. The pictures shown on the computer screen were corresponding to the real choices that each participant, who was currently playing the Consumer role, made before the EEG registration sessions. The pictures were presented in random order, and each picture was viewed once only and in only one of the two conditions. Each picture was presented for 10000 ms followed by 6000 ms response time. The Sales Consultant was instructed to observe the face, in particular the eye region of the Consumer in order to infer his preferred product among the two options. He was specifically asked to look for some eye-related cues which might signal consumers' product choice. He was given some examples of eye-related cues to look at such as gaze behaviour, dwell times and eye movements. The Consumer was instructed to relax and watch the products on the computer screen without trying to reveal overtly his preference. The Consumer was specifically instructed to keep his eyes on one product at a time and occasionally shift his gaze a few times between each of the two products. He was not told how much time to spend looking at each product. During the response time the Sales Consultant was invited to select Left or Right for the product on the screen which he believed was the Consumers' choice. To insure that the Sales Consultant will make his best to infer the Consumer preferences he was informed that for each correctly inferred trial he will receive one euro. To insure that the Consumer will not facilitate the Sales Consultant by revealing intentionally his preferences he was informed that he will receive his preferred product from each couple when the Sales

Consultant was not able to infer the choice correctly. An interval of 10000 ms of fixation point (+) was presented in the center of the computer screen before the next picture. After the end of the first session participants switched their chairs and played to other role following the exact same procedure. Immediately after the two EEG sessions, participants were informed about their performance and receive the corresponding amount of money and products.

4.4 Electrophysiological Recordings and Analysis

The electroencephalogram (EEG) was recorded continuously from two identical 32 active Ag/AgCI electrode sites using a BioSemi 32-channel elastic head cap with standard international 10-20 system layout. Each cap signal was acquired from two separate, identical amplifiers (BioSemi Active-Two system AD-box) connected to each other and the same computer with optical cable. Flat-type active electrodes were attached to the right and left mastoids. Electrodes located on the outer canthi of each eye, as well as below and above the left eye measured bipolar horizontal and vertical EOG activity. In addition, an active pin-type electrode (CMS, common mode sense) and a passive pin-type electrode (DRL, driven right leg) were used to compose a feedback loop for amplifier reference. Online, EEG was digitized at a sampling rate of 512Hz, 24-bit A/D conversion.

Further off-line processing was performed with Brain Vision Analyzer (Brain Products GmbH, Germany; www.brainproducts.com). Off-line, the EGG signals were re-referenced to the average of the left and right mastoids. EEG data were band-pass filtered between 0.1Hz and 30Hz. Artifacts caused by ocular movements were removed by applying Independent Component Analysis (ICA) with Brain Vision Analyzer (for more details see Brain Products GmbH, Germany; www.brainproducts.com). Next, EEG signals for each picture were segmented with 200 ms pre-stimulus (baseline) to 2000 ms post-stimulus ERP epoch. The ERP signals were defined relative to the mean of the 200 ms pre-stimulus baseline period. Each segment was subjected to artifact-rejection processing. The artifact-rejection method excluded epochs with large amplitude (over ± 100 μV). EEG recordings were analyzed four times independently by two experienced EEG researchers (blind to the stimulation condition) with particular attention to residual contamination of the EEG epochs due to eye or muscle artifacts. As a result, only epochs completely free from artifacts were considered for the following statistical analyses. To ensure an adequate signal-to-noise ratio in the ERPs, subjects with fewer than 4 artifact-free epochs per condition (Sales Consultant, Consumer) were excluded from the analysis and were replaced (four subjects in total were replaced).

4.5 Genotyping

All genotyping was performed blind to demographic and clinical data. Buccal swabs were obtained from each subject. Genomic DNA was isolated from the samples using the Chemagic buccal swab kit on a Chemagen Module 1 workstation (Chemagen Biopolymer-Technologie AG, Baesweiler, Germany). DNA concentrations were measured using the Quant-iT DNA Assay kit (Invitrogen, Breda, The Netherlands). The average yield was 4 μg of genomic DNA per buccal swab sample.

The SNP markers rs53576 [Celera ID: C 3290335 10] is genotyped using TaqMan® SNP Genotyping Assays (Applied Biosystems, Foster City, CA, http://www.appliedbiosystems.com). TaqMan® PCR reactions were done with Universal Master Mix Amperase® UNG, 0.25L TaqMan probe mix and 2.25L of water for a 5L total volume. The PCR conditions for the TaqMan® SNP Genotype Assays were: one AmpErase® step at 50.0 ◦C for 2 min, one enzyme activation step at 95.0 ◦C for 10 min, and 40 alternating cycles of denaturation at 92.0 ◦C for 15 s and reannealing and extension at 58.0 ◦C for one minute. All PCR reactions were performed on a Perkin Elmer 9700 Thermocycler (Applied Biosystems, Foster City, CA). The fluorescence intensity of the final PCR product was measured using an LjL Analyst AD fluorescence microplate reader (LjL Biosystems, Sunnyvale, CA, http://www.moleculardevices.com) using LjL Criterion-Host Software.

Respondents were divided into two groups on the basis of their *OXTR* (rs53576) genotype: in the first group were individuals with two copies of the G allele (G homozygotes; n=39; 42.4%) and in the second group were individuals with both one copy of the A allele (A heterozygotes (A/G); n=37; 40.2%) and two copies of the A allele (A homozygotes (A/A); n=16; 17.4%). No sex differences could be detected. The genotype distribution does not deviate from the Hardy-Weinberg equilibrium: HWE: $\chi 2(1)= 1.855$, $p = .17$.

4.6 Statistical Analysis

Time-locked to the onset of each couple of branded product picture, ERPs were averaged per participant separately for each Role (Sales Consultant, Consumer). Participants viewed five pictures of two branded products in each of the two roles. As a result, Average ERP waveforms were computed of the five trials for each of the two Roles (Sales Consultant, Consumer), respectively.

To examine the topography effect, statistical analyses were performed using the 12 subsequent electrodes sites: left (F3, C3, P3, O1), midline (Fz, Cz, Pz, Oz), and right (F4, C4, P4, O2). These 12 electrodes allowed for Laterality (Left, Midline, Right) as well as Caudality (Frontal, Central, Parietal, Occipital) analyses.

In response tothe social task performed in this study, P3 and LPP were quantified at the posterior scalp locations, basing the chosen time windows on previous research (see for comparable time windowsFerri, et al., 2012; Olofsson et al., 2008; Polich, 2007; Weinberg & Hajcak, 2010) and visual inspection of grand-averages waveforms.

The P3 and LPP time windows area measures were evaluated with a repeated measures analysis of variance (ANOVA): within-subjects factors were Role (Sales Consultant, Consumer), Caudality (Frontal, Central, Parietal, Occipital), and Laterality (Left, Midline and Right) and between-subject factor were Genotype (AA/AG, GG) and Inference Performance (Low, High). We controlled for multivariate normal distribution with the Mauchly test of sphericity, and applied the Greenhouse-Geisser correction, when appropriate (Gardener et al., 2013). A p value of <.05 was considered significant. Significant interaction effects were followed by paired sample t-tests. Bonferroni correction was implemented to adjust for multiple comparisons. Statistics were analyzed with the IBM SPSS 13.0 software (Statistical Package for Social Sciences, SPSS Inc, Chicago).

5. Result

5.1 Behavioral Results

Based on the number of correctly inferred trials, derived from the game performance, the 92 participants were assigned to high (HI) or low (LI) inferring group. More precisely, based on median-split approach 51 participants were assigned to HI group (above versus below median scores = 3.00) and 41 to the LI group. The median split resulted in the following means for the HI group (M = 3.60 SD = 0.70) and LI group (M = 1.53 SD = 0.71).

In addition, pairwise comparison between the number of correctly inferred trials versus the number of not able to hide your preference trials (when the other participant was able to infer your preference) revealed significant difference between the earned amount of money in Euro (M = 2.68 SD = 1.24) compared to the earned number of products (M = 2.31 SD = 1.24), (t (91) = 2.030, p = 0.045). This indicates that participants were slightly better in inferring as opposed to not inferring other people preferences (M = 0.36 SD = 1.74).

5.2 Genetic Results

Based on the individual genetic profile the 92 participants were assigned to A/A (n = 16), G/G (n = 39), and A/G (n = 37) genotypes. Based on previous studies on *OXTR* variation in relation to social inference (Domes et al., 2007; Luminet et al., 2011; Rodrigues et al., 2009) we decided to aggregate the A/As and A/Gs in one group which we called AA/AG group (n = 53; 47.6%). Thus, the following statistical analysis was performed with the two genotype groups AA/AG and GG (n = 39; 42.4%).

Pairwise AA/AG versus GG contrasts for the HI group, indicated that there was no significant difference between the number of correctly inferred trials for AA/AG (M = 3.58 SD = 0.71) compared to GG group (M = 3.65 SD = 0.67), (t (49) = -0.345, p = 0.732). In addition, pairwise AA/AG versus GG contrasts for the LI group, indicated that there was no significant difference between the number of correctly inferred trials for AA/AG (M = 1.54 SD = 0.73) compared to GG group (M = 1.52 SD = 0.69), (t (39) = 0.085, p = 0.933).

5.3 ERPs

The overall shape of ERPs was similar across Roles (Sales Consultant, Consumer), and as expected it was characterized by P3 and LPP components. We identified a role effect: early posterior distributed ERPs in Sales Consultant condition were more positive-going than ERPs for Consumer condition. Importantly, however, and consistent with previous findings, we found a genotype effect who was shaped by the specific role: posterior distributed P3 and LPP, showed strong positivity, after inferring trial onset for individuals with *OXTR* GG genotype in the Sales Consultant relative to the Consumer role. There was no such enhanced positivity for AA/AG genotype across roles. To test these observations, ANOVAs were computed on ERPs from left (F3, C3, P3, O1), midline (Fz, Cz, Pz, Oz), and right (F4, C4, P4, O2) scalp areas, at the three time windows: P3 (270-420 ms), early LPP (500-700 ms), late LPP (1200-1800ms).

5.3.1 P3 (270-420 ms)

Repeated measures ANOVA on P3 mean amplitude in the 270-420 ms time window revealed significant main effects of Role [F (1, 88) = 4.67, p = .033], Caudality [F (3, 264) = 98.43, p < .001, $\hat{\varepsilon}$ = .631], and Laterality [F (2, 176) = 6.82, p = .001, $\hat{\varepsilon}$ = .930]. P3 mean amplitude was significantly higher in the Sales Consultant role (M = 2.33 $\pm$ 6.06μV) than in the Consumer role (M = 0.51 $\pm$ 5.07μV), (Figure 1). Pairwise Caudality contrasts

revealed that P3 mean amplitude was significantly different between Frontal (M = - 1.28 ± 4.10μV) and Central (M = - 0.44 ± 4.23μV), (t (91) = - 3.45, p = .001), between Frontal (M = - 1.28 ± 4.10μV) and Parietal (M = 3.26 ± 4.98μV), (t (91) = - 10.60, p<.001), between Frontal (M = - 1.20 ± 4.05μV) and Occipital (M = 4.19 ± 4.52μV), (t (90) = - 11.31, p < .001), between Central (M = - 0.44 ± 4.23μV) and Parietal (M = 3.26 ± 4.98μV), (t (91) = - 11.72, p < .001), between Central (M = - 0.42 ± 4.25μV) and Occipital (M = 4.19 ± 4.52μV), (t (90) = - 11.00, p < .001), and between Parietal (M = 3.33 ± 4.97μV) and Occipital (M = 4.19 ± 4.52μV), (t (90) = - 2.91, p = .004) scalp areas. Pairwise Laterality contrasts revealed that P3 mean amplitude was significantly different between Left (M = 1.64 ± 3.90μV) and Midline (M = 1.03 ± 4.33μV), (t (91) = 4.11, p < .001), and between Right (M = 1.58 ± 3.81μV) and Midline (M = 1.03 ± 4.33μV), (t (91) = 2.93, p = .004) scalp areas. There was no significant difference between Laterality Left and Right, p = .746. All pairwise comparisons are p < .05 (Bonferroni corrected).

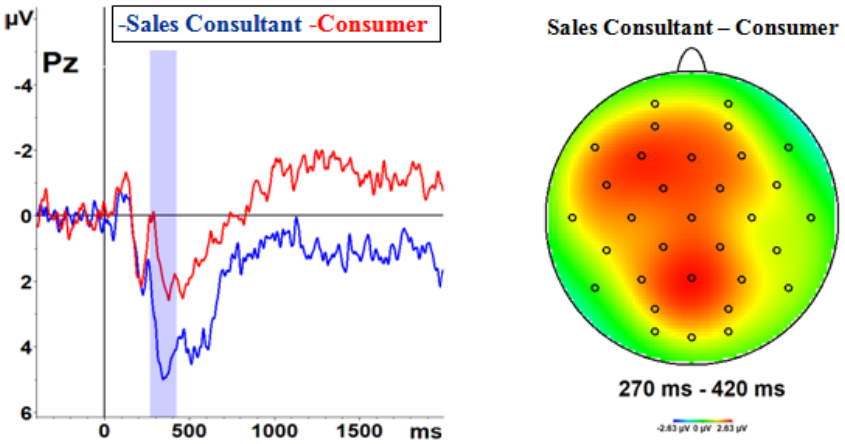

Figure 1. P3 role effect: The left panel depicts grand mean ERP waveforms from Pz electrode, elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer). The right side depicts scalp topographies for the difference between Roles (Sales Consultant minus Consumer) within the interval marked by the blue-shaded area (270-420 ms) in the ERP plot. Mean P3 amplitude was significantly higher in the Sales Consultant compared to the Consumer role (red).

These main effects were qualified by a second-order interaction Role x Inferring Performance [F (1, 88) = 8.61, p = .004]. Pairwise Sales Consultant versus Consumer contrast revealed that the P3 Role effect was significant in the High Inferring Performance group, with the P3 amplitude higher for Sales Consultant compared to Consumer role (Figure 2). Particularly, the P3 mean amplitude for Sales Consultant (M = 3.50 ± 6.13μV) was significantly higher than Consumer (M = - 0.33 ± 4.94μV), with (t (50) = 3.62, p = .001). However, the P3 Role effect was not significant in the Low Inferring Performance group, mean amplitude for Sales Consultant (M = 0.87 ± 5.71μV) and Consumer (M =1.55 ± 5.09μV), with (t (40) = - 0.55, p = .585), (Figure 2). This implies that respondents had greater activation for Sales Consultant compared to Consumer role when they were in the High Inferring Performance group as opposed to the Low Inferring Performance group.

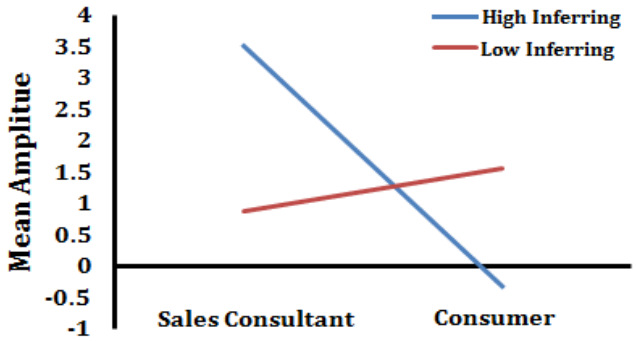

Figure 2. P3 inference effect: The plot depicts mean P3 amplitude for High Inferring group (blue) and Low Inferring group (red), elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer). Mean P3 amplitude was significantly higher in the Sales Consultant compared to the Consumer role in the High Inferring group as opposed to Low Inferring group.

Most importantly, the main affects were also qualified by a third-order interaction Role x Caudality x Genotype [F (3, 264) = 3.75, p = .030]. Pairwise Sales Consultant versus Consumer contrast at each Caudality position revealed that the P3 Role effect was significant for Parietal and Occipital scalp areas for Genotype "GG", with the P3 amplitude higher for Sales Consultant compared to Consumer role (see Figure 3, left panel). Particularly in Caudality "Parietal", the P3 mean amplitude for Sales Consultant (M = 5.24 $\pm$ 7.52μV) was significantly higher than Consumer (M = 1.51 $\pm$ 6.58μV), with (t (38) = 2.48, p = .017). In Caudality "Occipital", the P3 mean amplitude for Sales Consultant (M = 5.85 $\pm$ 7.32μV) was again significantly higher compared to Consumer (M = 2.41 $\pm$ 6.41μV), with (t (37) = 2.14, p = .038), (see Figure 3, left panel). However, the P3 Role effect was not significant in Caudality "Frontal" with p = .078 and "Central" with p = .199 for the Genotype "GG". Furthermore, the P3 Role effect was not significant in any caudality positions for the AA/AG genotype: Frontal, with p = .101, Central, with p = .177, Parietal, with p = .337, and Occipital, with p = .733 (see Figure 3, right panel). This implies that respondents had greater P3 activation for Sales Consultant compared to Consumer role when they were carrying the GG genotype as opposed to the AA/AG genotype only in the posterior (parieto-occipital) scalp areas.

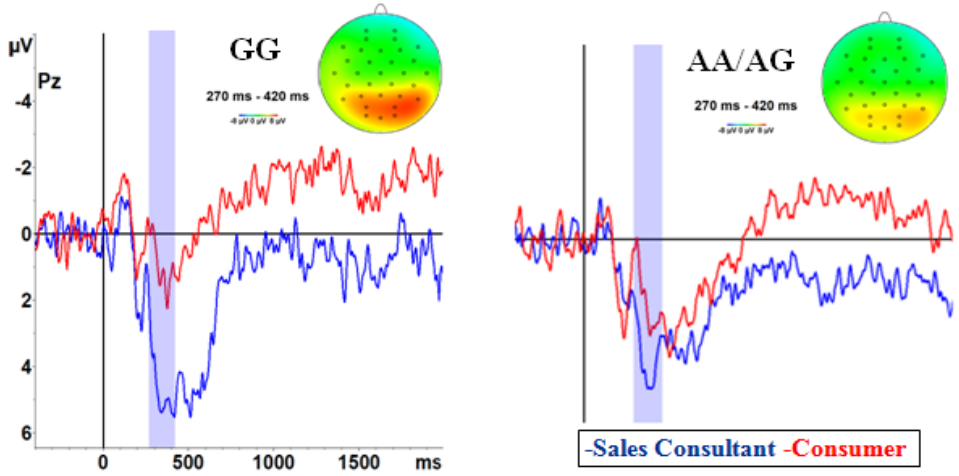

Figure 3. P3 genotype effect: The left panel depicts grand mean ERP waveforms from Pz electrode, elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer) for genotype GG. In the upper right corner, scalp topographies for the difference between Roles (Sales Consultant minus Consumer) within the interval marked by the blue-shaded area (270-420 ms) in the ERP plot. The right side depicts exactly the same for genotype AA/AG. Mean P3 amplitude was significantly higher in the Sales Consultant compared to the Consumer role in the posterior (parietal-occipital) scalp locations only for the genotype GG (left panel, in red on the scalp topographies).

5.3.2 LPP (early window: 500-700 ms)

Repeated measures ANOVA onearly LPP mean amplitude in the 500-700 ms time window revealed significant main effects of Role [F (1, 88) = 4.50, p = .037], Caudality [F (3, 264) = 99.03, p < .001, $\hat{\varepsilon}$ = .644], and Laterality [F (2, 176) = 6.69, p = .002, $\hat{\varepsilon}$ = .919]. Early LPP mean amplitude was significantly higher in the Sales Consultant role (M = 1.56 ± 6.38μV) than in the Consumer role (M = - 0.15 ± 5.09μV), (Figure 4, left panel). Pairwise Caudality contrasts revealed that early LPP mean amplitude was significantly different between Frontal (M = - 2.17 ± 4.62μV) and Central (M = - 0.49 ± 4.64μV), (t (91) = - 6.95, p< .001), between Frontal (M = - 2.17 ± 4.62μV) and Parietal (M = 2.64 ± 4.54μV), (t (91) = - 13.03, p < .001), between Frontal (M = - 2.17 ± 4.62μV) and Occipital (M = 2.85 ± 4.51μV), (t (91) = - 11.52, p < .001), between Central (M = - 0.49 ± 4.64μV) and Parietal (M = 2.64 ± 4.54μV), (t (91) = - 11.96, p < .001), and between Central (M = - 0.49 ± 4.64μV) and Occipital (M = 2.85 ± 4.51μV), (t (91) = - 8.48, p < .001) scalp areas. There was no significant difference between and between Parietal (M = 2.64 ± 4.54μV) and Occipital (M = 2.85 ± 4.51μV), (t (91) = - 0.74, p = .460) scalp areas. Pairwise Laterality contrasts revealed that early LPP mean amplitude was significantly different between Left (M = 0.91 ± 4.15μV) and Midline (M = 0.28 ± 4.57μV), (t (91) = 4.02, p < .001), and between Right (M = 0.91 ± 4.01μV) and Midline (M = 0.28 ± 4.57μV), (t (91) = 3.07, p = .003) scalp areas. There was no significant difference between Laterality Left and Right, p = .999. All pairwise comparisons are p < .05 (Bonferroni corrected).

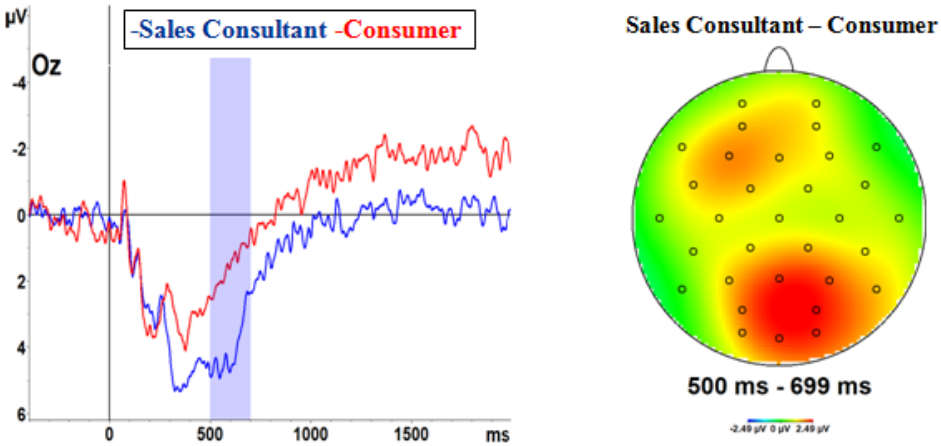

Figure 4. LPP (500-700 ms) role effect: The left panel depicts grand mean ERP waveforms from Oz electrode, elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer). The right side depicts scalp topographies for the difference between Roles (Sales Consultant minus Consumer) within the interval marked by the blue-shaded area (500-700 ms) in the ERP plot. Mean LPP amplitude was significantly higher in the Sales Consultant compared to the Consumer role in the posterior (parietal-occipital) scalp location (red).

These main effects were qualified by a second-order interaction Role x Inferring Performance [F (1, 88) = 7.90, p = .006] and Role x Caudality [F (3, 264) = 3.36, p = .044, $\hat{\varepsilon}$ = .578]. Pairwise Sales Consultant versus Consumer contrast revealed that the early LPP Role effect was significant in the High Inferring Performance group, with the early LPP amplitude higher for Sales Consultant compared to Consumer role (see Figure 5). Particularly, the early LPP mean amplitude for Sales Consultant (M = 2.63 ± 6.48μV) was significantly higher than Consumer (M = - 0.93 ± 4.72μV), with (t (50) = 3.01, p = .004). However, the early LPP Role effect was not significant in the Low Inferring Performance group, mean amplitude for Sales Consultant (M = 0.23 ± 6.07μV) and Consumer (M = 0.81 ± 5.42μV), with (t (40) = - 0.53, p = .597), (see Figure 5). This implies that respondents had greater activation for Sales Consultant compared to Consumer role when they were in the High Inferring Performance group as opposed to the Low Inferring Performance group. Pairwise Sales Consultant versus Consumer contrast at each Caudality position revealed that the early LPP Role effect was significant for Parietal and Occipital scalp areas, with the early LPP amplitude higher for Sales Consultant compared to Consumer role (see Figure 4, right panel). Particularly in Caudality "Parietal", the early LPP mean amplitude for Sales Consultant (M = 3.71 ± 6.95μV) was significantly higher than Consumer (M = 1.57 ± 5.87μV), with (t

(91) = 2.24, p = .027). In Caudality "Occipital", the early LPP mean amplitude for Sales Consultant (M = 3.95 ± 6.95μV) was again significantly higher compared to Consumer (M = 1.75 ± 5.78μV), with (t (91) = 2.32, p = .022), (see Figure 4, right panel). Furthermore, the early LPP Role effect was not significant in caudality positions: Frontal, with p = .090 and Central, with p = .272.

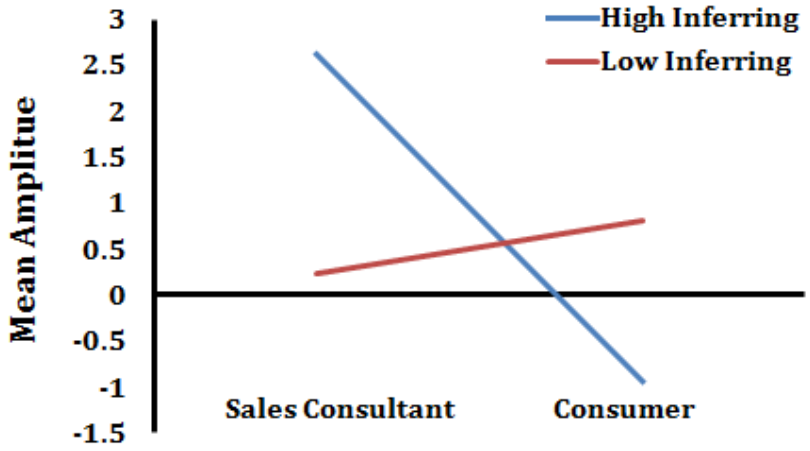

Figure 5. LLP (500-700 ms) inference effect: The plot depicts mean LLP amplitude for High Inferring group (blue) and Low Inferring group (red), elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer). Mean LPP amplitude within the interval (500-700 ms) was significantly higher in the Sales Consultant compared to the Consumer role in the High Inferring group as opposed to Low Inferring group.

Most importantly, the main affects were also qualified by a third-order interaction Role x Caudality x Genotype [F (3, 264) = 8.00, p = .001]. Pairwise Sales Consultant versus Consumer contrast at each Caudality position revealed that the early LPP Role effect was significant for Parietal and Occipital scalp areas for Genotype "GG", with the early LPP amplitude higher for Sales Consultant compared to Consumer role (see Figure 6, left panel). Particularly in Caudality "Parietal", the early LPP mean amplitude for Sales Consultant (M = 4.50 ± 7.63μV) was significantly higher than Consumer (M = 0.13 ± 6.58μV), with (t (38) = 2.68, p = .011). In Caudality "Occipital", the early LPP mean amplitude for Sales Consultant (M = 5.02 ± 7.93μV) was again significantly higher compared to Consumer (M = - 0.12 ± 6.48μV), with (t (38) = 3.11, p = .004), (see Figure 6, left panel). However, the early LPP Role effect was not significant in Caudality "Frontal" with p = .354 and "Central" with p = .365 for the Genotype "GG". Furthermore, the early LPP Role effect was not significant in any caudality positions for the AA/AG genotype: Frontal, with p = .146, Central, with p = .528, Parietal, with p = .658, and Occipital, with p = .979, (see Figure 6, right panel). This implies that respondents had greater early LPP activation for Sales Consultant compared to Consumer role when they were carrying the GG genotype as opposed to the AA/AG genotype only in the posterior (parieto-occipital) scalp areas.

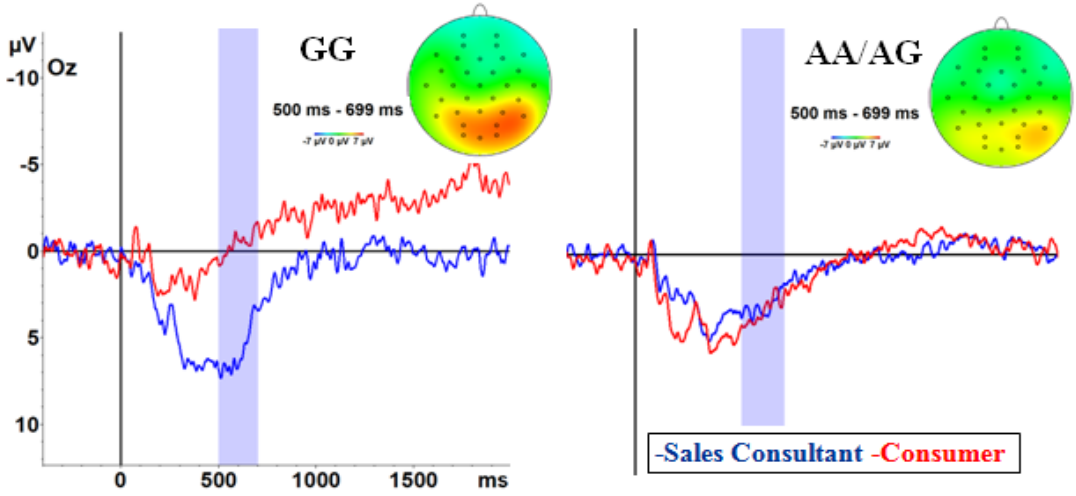

Figure 6. LPP (500-700 ms) genotype effect: The left panel depicts grand mean ERP waveforms from Oz electrode, elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer) for genotype GG. In the upper right corner, scalp topographies for the difference between Roles (Sales Consultant minus Consumer) within the interval marked by the blue-shaded area (500-700 ms) in the ERP plot. The right side depicts exactly the same for genotype AA/AG. Mean LPP amplitude was significantly higher in the Sales Consultant compared to the Consumer role in the posterior (parietal-occipital) scalp locations only for the genotype GG (left panel, in red on the scalp topographies).

5.3.3 LPP (late window: 1200-1800 ms)

Repeated measures ANOVA on late LPP mean amplitude in the 1200-1800 ms time window revealed significant main effects of Caudality [F (3, 264) = 4.13, p =.013, $\hat{\varepsilon}$ = .771]. Pairwise Caudality contrasts revealed that late LPP mean amplitude was significantly different between Frontal (M = - 0.41 ± 4.00μV) and Parietal (M = 0.35 ± 4.07μV), (t (91) = - 2.63, p = .010), between Central (M = - 0.35 ± 4.03μV) and Parietal (M = 0.35 ± 4.07μV), (t (91) = - 3.07, p =.003), and between Parietal (M = 0.35 ± 4.07μV) and Occipital (M = - 0.61 ± 4.31μV), (t (91) = 3.66, p < .001) scalp areas. There was no significant difference between Frontal and Central, with p = .807, between Frontal and Occipital, with p = .552, and between Central and Occipital, with p = .450 scalp areas.

The main affect was qualified only by a third-order interaction Role x Caudality x Genotype [F (3, 264) = 3.87, p = .042]. Pairwise Sales Consultant versus Consumer contrast at each Caudality position revealed that the late LPP Role effect was significant for Occipital scalp areas for Genotype "GG", with the LPP amplitude higher for Sales Consultant compared to Consumer role (see Figure 7, left panel). Particularly in Caudality "Occipital", the LPP mean amplitude for Sales Consultant (M = 0.27 ± 6.48μV) was significantly higher compared to Consumer (M = - 2.40 ± 5.91μV), with (t (38) = 2.41, p = .021), (see Figure 7, left panel). However, the late LPP Role effect was not significant in Caudality "Frontal" with p = .981, "Central" with p = .835, and "Parietal" with p = .100 for the Genotype "GG". Furthermore, the LPP Role effect was not significant in any caudality positions for the AA/AG genotype: Frontal, with p = .071, Central, with p = .260, Parietal, with p = .126, and Occipital, with p = .472, (see Figure 7, right panel). This implies that respondents had greater late LPP activation for Sales Consultant compared to Consumer role when they were carrying the GG genotype as opposed to the AA/AG genotype only in the occipital scalp areas.

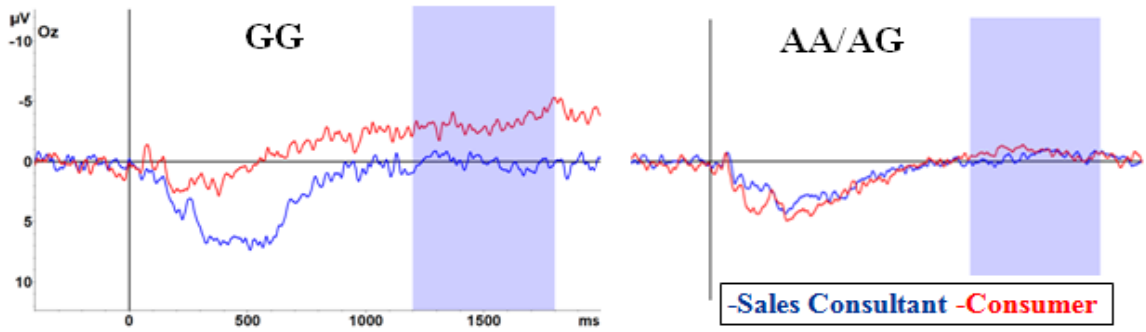

Figure 7. LPP (1200-1800 ms) genotype effect: The left panel depicts grand mean ERP waveforms from Oz electrode within the interval marked by the blue-shaded area (1200-1800 ms), elicited by preference inferring from eye-related cues (Sales Consultant) and passive viewing of branded products (Consumer) for genotype GG. The right side depicts exactly the same for genotype AA/AG. Mean LPP amplitude was significantly higher in the Sales Consultant compared to the Consumer role in the occipital scalp locations only for the genotype GG.

6. Discussion

This study investigated the relationship between a well-known SNP in the oxytocin receptor (*OXTR*) gene and individual behavioural differences, measured by inferring performance, as well as physiological differences, measured by ERPs, in preference inferences from eye-related cues as opposed to passive viewing of branded products.The results revealed higher P3 and early LPP amplitudes for preference inferences from eye-related cues as opposed to passive viewing of branded products. Although, we did not find individual differences in preference inferences performance, in relation to the rs53576 variant of the *OXTR* gene, we found enhanced P3 and early LPP amplitudes during preference inferences from eye-related cues compared to passive viewing of branded products for the High inferring group as opposed to the Low inferring group. Finally, in line with our last hypothesis results revealed higher posterior distributed P3 and LPP amplitudes for preference inferences from eye-related cues as opposed to passive viewing of branded products for individuals homozygous for the G allele, as opposed to those carrying an A allele for the rs53576 variant of the *OXTR* gene.

6.1 Theoretical Implications

Previous ERP research discusses multiple determinants of the P3 amplitude in relation to the experimental task and stimuli used in each specific study. For instance, early studies hypothesized that P3 reflects allocation of perceptual/central resources as opposed to response-related processing (see Kok, 2001). However, this suggestion is mainly based on dual-task studies. Another important factor influencing the P3 is the task relevance which can be defined as amount of attention allocation and processing capacity toward the specific task or stimulus (Kok, 2001). A number of ERP studies have found enhanced P3 amplitude in relation to performing active task as opposed to passive stimulus processing (Polich, 2007). In a recent study Pitts et al., (2014) have studied P3 in relation to task relevance and visual awareness. The authors suggest that P3 reflects specific post-perceptual processes required for the execution of certain active task but not uniquely for consciously perceiving the visual stimuli. More precisely, when subjects were not specifically asked to report about certain visual stimuli, P3 was not enhanced even for trials with conscious perception. On the contrary, when subjects were asked to provide specific information about task-relevant stimuli, enhanced P3 amplitude was observed. When performing the preference inference as opposed to the passive viewing of products subjects were instructed to focus their attention on specific stimulus feature (eye-region) and asked to provide information about the stimuli after each trial. Thus, it can be assumed that the lower P3 amplitude in the passive viewing of branded products is reflecting a task-irrelevant condition in which subject did not have to report about the visual stimuli and thus those stimuli could have been completely ignored or could have attracted less attention resources.

In relation to the later ERP component, higher posterior LPP amplitudes were frequently reported to reflect allocation of capacity-limited resources such as sustained attention allocation toward motivationally salient environmental visual stimuli (Hajcak, MacNamara, & Olvet, 2010; Kok, 2001). For instance, newborn infants prefer to direct their attention to faces or face-like objects compared to other objects which suggest that this preference for faces is a natural ability of evolutionary importance (Valenza et al., 1996). In early life, already by the age of 2 months infants display preference for looking at the eye region over other regions of the human face

(Maurer, 1985). Recent neurophysiological studies found enhanced posterior distributed LPP for human faces compared to objects images indicating that faces carry motivationally silent significance that is unparalleled by other categorise of visual stimuli (Weinberg & Hajcak, 2010). Similarly, recent study found that images showing people attract more sustained attention, reflected by larger posterior LPPs, than images that do not show people (Ito & Cacioppo, 2000). In particular, enhanced parietal LPP amplitude was found only for neutral images containing faces with neutral expressions and neutral background as opposed to neutral images without faces (Ferri, Weinberg, & Hajcak, 2012). This LPP effect was less prominent or inexistent when the visual stimuli possessed strong emotional content (i.e., threatening images with faces in an attack scene versus images without faces showing hands holding weapons). In the current experiment preference inference was actively done from eye-related cues which also involved face processing. Moreover, when playing the consumer role the participant was specifically instructed to keep his facial expression neutral and to not reveal his preference in any explicit way. Based on this evidence we suggest that the enhanced LPP in the preference inference role compared to the passive viewing role reflects sustained attention allocation to the facial processing, i.e., eye-related regions as opposed to passive viewing of branded products. Several studies suggest that the eyes are the primary source used by others who want to extract some social information, especially in real scenes (Birmingham et al., 2008). The attention to the eyes in a social context where social information needs to be derived is defined as social attention (Birmingham et al., 2008; Langton et al., 2000). Thus, the sustained attention, reflected by the enhanced ERPs, observed during preference inferences from eye-related cues trials as opposed to passive viewing of branded products in real social context can be interpret as socially motivated attention.

Differentiating task-related effects on the P3 versus the LPP is posing some difficulties, especially in the 300 to 1000 ms time range following stimulus onset. Past ERP studies quantify P3 and LPP components in relation to various experimental paradigms in different time windows (see Olofsson et al., 2008). Importantly, both peak and area measures of P3 and LPP components can be indifferent to component overlap and thus complicate further the specific distinction of components that share spatial and temporal features (Hajcak, MacNamara, & Olvet, 2010). However, the longer duration, which has been also observed in the current results, of the LPP suggests at least some temporal distinction from the P3. In relation to both ERP components, it can be argued that the dynamic social settings and complex structure of the experimental task that was used in the current study require for more cautions interpretation of the P3 and LPP results in terms of underlying physiological processes and related resources.

The interpretation of the P3 and LPP role effect in terms of processing capacity and attention allocation could partially explain the enhanced mean amplitudes for these two components during preference inference compared to passive viewing for the high inferring performance group as opposed to the low inferring performance group. Based on the results we assume that higher level of attention and/or higher processing resources are required for increased inferring performance. However, this suggestion is somehow speculative because of the limited number of trials used in the current experiment which is inevitably involving the risk that the inferring performance of each participant is a result of chance.

On the other hand, the results did not show individual differences in preference inferences performance, measured by the number of correctly inferred trials, in relation to the rs53576 variant of the *OXTR* gene. Although there is no previous research on social preference inferences in relation to the rs53576 variant of the *OXTR* gene some past studies suggests that individuals homozygous for the G allele (GG genotype) compared with the A-carriers (AA, AG genotypes) display better Theory of Mind performance (Wu & Su, 2014). Individuals homozygous for the G allele of rs53576 compared to A-allele carriers were also found to be more adept at inferring mental states of others displayed by higher performance on the "Reading the Mind in the Eyes (RMET)" Test (Rodrigues et al., 2009). One possible explanation for not finding modulation of the preference inference performance by *OXTR* gene is the limited number of trials implemented in the study. As already discussed, performing only five inferring trials is significantly reducing the possibility to have enough variation within our behavioural data and increasing the risk to have them by chance. Creating real social situation, such as live sales-consumer context, which includes real social outcomes, such as winning real money and preferred products is involving some trade-off. Designing an experiment with thirty or more trials and using ninety or more participants would be extremely difficult to manage because of the enormous amount of financial resources needed for the real social outcomes, such as money and products. From logistic point of view, having on stock so many real branded products that participants can see, touch and take at the end of each session requires to perform the experiment in a supermarket which could be a nice idea for a future research. Recently developed wireless EEG equipment, such as Emotiv EPOC EEG, might be a useful tool to investigate sales-consumer interaction in a supermarket or a shop context. Another possible explanation for not findings influence of *OXTR*

variation on the behavioural measures of preference inferences performance are the divergent findings reported by previous studies. As already discussed individuals with one or two copies of the A allele (AG/AA) display lower levels of inferring others' mental states, as measured by the RMET test (Rodrigues et al., 2009). On the contrary, in recent study A-allele carriers gave fewer incorrect answers when evaluating face images as measured by the same RMET test (Lucht et al., 2013). Both studies used the same test, but the reported results were in disagreement regarding the risk allele.

However, the results of the current study indicate higher posterior distributed P3 and LPP amplitudes for preference inferences from eye-related information as opposed to passive viewing of branded products for individuals homozygous for the G allele, as opposed to those carrying an A allele of the *OXTR* gene. Already from early age humans preferentially look at the face and eye-region compared to objects (Valenza et al., 1996). It has been suggested that viewing faces is rewarding (Hayden et al., 2007). Individuals homozygous for the G allele compared with the A-carriers show enhanced pro-social behaviours and higher levels of empathy (Rodrigues et al., 2009; Smith et al., 2014; Tost et al., 2010). In particular, recent study report that individuals homozygous for the G allele display increased total gaze time toward the eye region than carriers of the A allele (Kogan et al., 2011) which might suggest that they experience face processing and in particular looking at others' eyes as more rewarding.

Furthermore, previous EEG studies report higher P3 and LPP amplitudes for human faces (i.e., eye-region) as opposed to objects processing (Ferri et al., 2012; Weinberg & Hajcak, 2010). In line with past evidence, in the current study these enhanced ERP amplitudes for the GG participants in relation to preference inference from eye-related cues as opposed to passive viewing of branded products are interpret as enhanced responsiveness toward the socially relevant stimuli. Previous P3 and LPP studies suggest that this enhanced responsiveness toward the face and eye-region is reflecting physiological processes such as attention allocation and information processing which in the context of the current study might be interpret as socially motivated attention (Hajcak, et al., 2010; Haxby et al., 2000; Kok, 2001; Nummenmaa & Calder, 2009). GG individuals display higher levels of pro-social behaviours and empathy, which is expressed in increased attention allocation toward people's eye-region from which they try to infer information about their preferences, emotional behaviour and mental states (Langton et al., 2000). This increased socially motivated attention effect was also observed for the later LPP time window (up to 2 sec.), suggesting that this social attention effect was sustained as opposed to being just early automatic response. However, in the later LPP time window the difference between preference inferences and passive viewing was only present when the effect of the *OXTR* gene variants were taken into account, suggesting that the social attention allocation was strongly modulated by the participants' genetic profile, especially in relation to the later more sustained and conscious aspect of it. For the A allele participants there were no ERP difference between viewing human face during the preference inference task and passively viewing branded products. The A allele of the rs53576 has been associated with reduced physiological responsiveness to social support (Chen et al., 2011). In agreement with past research, the ERP results of the current study indicate the A allele compared to GG individuals pay less attention or alternatively socially motivated attention to the others' face and eyes which might reflect their lower level behavioural manifestation of prosociality (Kogan et al., 2011; Rodrigues et al., 2009; Smith et al., 2014). The results also suggest that A carriers might be less sensitive toward the reward-relevant features of the human face or to just find the face and eyes processing less rewarding compared to GG individuals (Marsh et al., 2012). The difference between GG and A individuals in relation to attention allocation during social inference as opposed to passive viewing of objects might be explained by the influence of the *OXTR* gene variations on the function and structure of specific brain regions, such as the hypothalamus and the amygdala, which have been frequently associated with sensitivity to social reward (Tost et al., 2010). For instance, the A allele carriers show reduced amygdala activation during face processing (Tost et al., 2010). Finally, several studies have reported about association between attention deficits and failure to look at the other's eye region (e.g., Adolphs et al., 2005; Dalton et al., 2005). Failure to look at the eye-region lack the brain of important visuosocial information, and may suggest a general insensitivity to (or avoidance of) social stimuli (Shepherd, 2010).

6.2 Limitations

There are number of limitations which will be addressed in the conclusive part of this study. First, in this study physiological responses in relation to social inferences from eye-related cues were measured during a real social interaction occurring between two people (second-person neuroscience) seating next to each other. By showing live real face instead of image or movie clip this study attempted to replicate in more natural way an actually occurring sales-consumer interaction. Moreover, the current experimental setting is giving more freedom to participants (sales consultant) to use and interpret the eye-related and/or face-related information in order to

make adequate social inference. The main limitation of this approach is the restricted control over the experimental condition and in particular over the participants' behaviour and performance during the experimental task. Using static images or dynamic movie presentations definitely allows for more control over participants' actions and behaviour, leading to more straight forward interpretation of the current findings, but is inevitably incorporating more unnatural way of doing social inference. In addition, previous EEG research frequently reported about ERP differences between processing gaze-related information from seeing a live face as opposed to pictorial stimuli (Pönkänen et al., 2010). However, a trade-off always needs to made, because the advantages of one approach are limitations of the other and vice versa.

Second, both male and female participants took part in the current investigation. Previous findings suggest that on average females respond more strongly than males to social information (Geary, 1998). For instance, women follow gaze more than males (Bayliss et al., 2005). Other biological factors, especially does associated with sex differences (i.e., hormones), which were not currently examined might have influenced the physiological findings of this study.

Finally, the ERP results in the current study were based on averages of five trials. Using thirty or more preference inferring trials would have definitely improved the signal-to-noise ratio (SNR) and thus the reliability of our results. However, as already mentioned with the current experimental task which attempted to replicate real social interaction with real social outcomes (i.e., winning money or products at the expenses of others) using thirty or more trials was challenging to attain due to financial and more importantly due to logistic reasons. Despite the abovementioned limitations, which definitely call for more cautious interpretation of the current results, we believe that the current findings are in close agreement with previously reported physiological evidence and contribute to the research on *OXTR* gene variations in relation to social attention in dynamic social context.

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