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A Neuropsychological Study on How Consumers Process Risky and Secure E-payments

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Abstract

Dependable online payment systems (e-payments) are fundamental in promoting future online purchases. Yet little research has focused on either the differences between secure and risky e-payments or consumer reactions to the different systems. This study reverts to neuroscience (fMRI) to 1) identify the neural effects pertaining to risky and secure e-payments and 2) reveal the underlying brain mechanisms when confronted with two widespread systems: debit cards and Paypal. Thirty subjects participated in an experiment simulating a low-involvement online purchase. The analysis reveals that perceived risky e-payments activate brain areas linked to negative emotional processing, while areas involved with reward prediction are strongly triggered by secure e-payments. Furthermore, the study not only reveals a greater intention of use toward Paypal, but sees it as more secure, rewarding and affective. Debit card e-payments, by contrast, elicit brain activations associated with negative and risky events. Interestingly, the right cerebellum response (responsible for value encoding) covaried with more positive use intention toward Paypal. These results offer invaluable insight into the unconscious origin of the choice of payment systems among consumers.
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Keywords: E-payment; Risk; Security; fMRI; Paypal; Debit card

Introduction

The current commercial market organization and offer have progressively changed due to the technological revolution of the last years of the 20th century. The last two decades have seen the creation of new options for consumers to save time and money, and benefit from a variety of improved services linked to the introduction of the new tools of information and communication (Vroman, Arthanat, and Lysack 2015). Information and Communication Technologies (ICTs) and the adoption of the Internet by business have facilitated both the use of institutional networks (such as Facebook or Twitter) as well as the emergence of the electronic commerce (e-commerce).

The American Marketing Association (2016) defines e-commerce as the wide variety of Internet-based business models which incorporate elements of the marketing mix to guide users to a website with the purpose of purchasing a product or service. Online shopping today provides consumers with the tremendous advantages of accessibility on an ongoing basis, a wide variety of high-quality information, a face-to-face relationship with producers, effortless price comparison, as well as great ease in establishing an immediate communication with the firms (Chiou and Ting 2011). Furthermore, a growing number of consumers are currently reverting to online systems to seek pre-purchase information and purchase products (Oliveira et al. 2017).

With the rapid growth of shopping through the Internet, online consumer behavior has emerged as a major area of research in various scientific disciplines such as psychology, marketing, and Information Systems (IS). While many of the early studies in these disciplines focus on how consumers adopt and apply online shopping (e.g. Hansen 2005; Moon 2004), more recent research has focused on purchase and online repurchase behavior (e.g. Chen et al. 2016; Hsu et al. 2014). In this framework, a fundamental process necessary to complete economic transactions on the Internet is online payment, defined as the transfer of an electronic value of payment from a payer to a payee through an e-payment mechanism (Lim 2008). However, the scientific community has paid little attention to its effects on consumer's attitudes and behavior.

Abbreviations: fMRI, functional Magnetic Resonance Imaging

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With the development of e-commerce, there is an ongoing transformation of payments from brick-and-mortar retailers to online systems. As a result, a large number of online payment systems (e-payments) have been developed using debit/credit cards and virtual payment systems or e-wallets (e.g. Paypal). Perceived risk has been proposed as the main determinant of consumer payment system choice. Yet only a few papers have focused on the effects on consumers of risky and secure e-payments, neither on the perceived risk associated with different online payment systems such as debit card systems vs. Paypal (Yang, Qing et al. 2015; Yang, Yongqing et al. 2015; Yu, Hsi, and Kuo 2002). Furthermore, no research in this field to date has resorted to neuropsychological tools that are more appropriate for investigation as risk perception is associated with unconscious and automatic information processing mechanisms that cannot be addressed easily through self-reports (Dimoka 2010). The present study thus constitutes a first step in this direction as it investigates neural responses to risky and secure online payment systems, as well as the underlying neural and self-reported mechanisms linked to two e-payment methods: debit cards and Paypal.

Literature Review

Online Payment Systems

Numerous classifications are currently being put to use in the analysis of e-payments (Liébana-Cabanillas, Herrera and Guillén 2016). The main classification criteria are 1) the moment the payment is submitted (Business Model: Ramezani 2008), 2) the type of payment validation (Wang and Yuan 2010), 3) the nature and medium of the relations (Ondrus and Pigneur 2006; Ondrus and Yves 2007), and 4) the transaction transfer formula (Ruiz 2009). The current study focuses on the last and most widespread of these criteria, and distinguishes between "credit and debit systems" and "virtual payment systems."

Credit and debit systems are founded on the consumer use of a bank card for transaction payments. The amount of a purchase in a debit card transaction is withdrawn from the available balance of the cardholder's account. If the available funds are insufficient, the transaction is not completed (except where an overdraft option is in place). In the case of credit cards, the expense is assumed directly by the bank allowing the consumers to maintain a balance of debt subject to interest charges. Two important issues associated with debit systems are security and privacy, as consumer transaction records can be tracked through their debit cards (Yu, Hsi, and Kuo 2002).

Virtual payment systems or e-wallets, in turn, use a customer account within a general system which is linked to a bank or card account necessary for the payment. This paper focuses on the most widespread wallet, namely Paypal (Worldpay 2016) which is the general term for a Paypal account where customers link bank accounts or credit or debit cards. The Paypal system is what is known as a "staged" wallet, meaning that it processes a transaction in two stages. It first collects money from the purchaser before remitting it to the business without necessarily passing along card details to the issuer or the credit card network. Paypal therefore constitutes a quickly growing payment alternative as the system is considered by itself as secure and offers consumers choice and convenience since they can either revert to stored value or take funds from a payment type linked to Paypal (Yu, Hsi, and Kuo 2002). Accordingly, the perception is that Paypal could be safer, more protective of data and more convenient than debit cards (Sukoco 2012). Debit cards, in turn, could be easier to use (Suhuai et al. 2010). Table 1 presents a rapid listing of the differences between debit cards and Paypal, the two e-payments in which this work is targeted.

According to a recent report (Worldpay 2016), 31% of the worldwide transactions in 2015 reverted to e-wallet systems such as Paypal, whereas 25% and 17% used credit and debit card systems. In Spain, the country of the current study, the

Table 1
Comparison of the characteristics of debit card and Paypal payment systems.
(Adapted from Yu, Hsi, and Kuo 2002.)

Characteristic	Debit card	Paypal
Privacy	Poor: uses actual card number to make transaction. Risk of data theft	Good: uses only Paypal account number without revealing card number on the Internet
Authority	Good: card number and PIN serve to check identity	Good: Paypal account number/mail and PIN serve to establish identity
Bank account involvement	Debit card account makes the payment	No involvement as Paypal makes the payment
Users	Any legitimate debit card user	Anyone with a Paypal account and a bank or debit/credit bank account
Real/virtual world	Can be used in real and virtual worlds	Can be used in real and virtual worlds
Current degree of popularity	17% of transactions around the world	31% of transactions around the world
Consumer transaction risk	Medium: appears to be vulnerable to fraud and identification theft	Low: only Paypal account number is vulnerable to fraud
Ease of using	Very easy, only card number and PIN is necessary	Great ease as only an active Paypal account is necessary without using bank information. Yet there are difficulties among low-experienced users
Speed of transaction	Limited to time necessary for filling out card information	Limited to time of "acceptance" of the payment (if client possesses a Paypal account)
Cost of transaction	Regular debit card transaction costs paid by buyers	Apart from regular debit card costs, a fee is paid in general by the seller to Paypal and no fees to the customer. However, at times the seller charges a fee to the consumer

Note: "Privacy" refers to the protection of information sent via Internet and to prevention of unauthorized personnel or company employees from accessing confidential information. The purpose of the characteristic "Authority" is to verify the identities of all parties involved and to prevent third parties from sabotaging information. "Cost of transaction" refers to the cost paid by the seller and buyer.

payment system breakdown of 2015 is very similar as 24% and 25% reverted to credit and debit cards, whereas 21% to e-wallets such as Paypal. Furthermore, Spain's e-commerce market is expected to expand significantly in the next five years by about 25% (Cetelem 2016) and, similarly, new online payment systems (such as Paypal, debit cards or ApplePay) will become critical factors for successful business (Cotteleer, Cotteleer, and Prochnow 2007). Indeed, a recent study carried out by Indra (2017) revealed that, compared to 2016, the amount of electronic transactions using debit cards increased 25% in 2017 in Spain, whereas this growth has been much lower in the case of credit cards (7%). Trying to reflect the tendency of e-payments usage in Spain, our study focused the analysis only on debit cards (and not credit cards) and Paypal, the most widely used e-payments in Spain.

Despite the enormous projections of growth of online payment systems, they have not achieved the expectations regarding level of performance and diffusion for the most part because of issues of risk/security (Hong, Zulkiffli, and Hamsani 2016; Linck, Pousttchi, and Wiedemann 2006; Steinhart et al. 2013; Suki and Suki 2017; Tsiakis and Sthephanides 2005; Xu and Riedl 2011), trust (Chen et al. 2016) and complexity of use (Chou, Lee, and Chung 2004). Recent research in fact concludes that *perceived risk* and *security*, together with product involvement and consumer characteristics, could be the most important determinants of use of e-payment systems (Faqih 2016; Kim, Mirusmonov, and Lee 2010; Kim et al. 2010).

Perceived Risk and Security

The concept of perceived risk in online consumer behavior research was originally proposed by Harvard scholar Bauer (1960). This author defines it through two components: uncertainty (lack of knowledge about what could happen after the purchase) and the likely negative consequences after shopping. The most widely accepted definition is by Cunningham (1967) who detailed that perceived risk can be divided into six dimensions: performance risk, financial risk, social risk, psychological risk, time risk and privacy risk (see Chiu et al. 2014; Pires, Stanton, and Eckford 2004 for definitions of each type of risk). In the context of online payment, perceived risk is defined by He and Mykytyn (2008) as the "… customer's subjective evaluation of the e-payment system's risk during a purchase in a web-site." Some studies have indeed measured perceived risk (He and Mykytyn 2008; Ho and Ng 1994; Liébana-Cabanillas 2012; Liébana-Cabanillas, Muñoz-Leiva, and Sánchez-Fernández 2017; Pagani 2004) by enquiring as to agreement or disagreement among subjects about statements such as: "Other people could gather information about my online transactions when I use this tool," "There exists a high potential of monetary loss if I purchase through this tool on the Internet," "There exists an important risk when purchasing on the Internet through this tool" or "I consider that shopping on the Internet is a risky choice."

Perceived security, conversely, refers to a customer's subjective evaluation of the e-payment security system (Linck, Pousttchi, and Wiedemann 2006). Since consumers possess different experiences and expectations, they can adopt different attitudes toward the security of online transactions. Some researchers indicate that security is closely related to trust when referring to the level of confidence generated by a secure option (Tsiakis and Sthephanides 2005). Other authors such as Kim, Ferrin, and Rao (2008) or Kim, Mirusmonov, and Lee (2010) and Kim et al. (2010) developed a series of items to measure participant agreement or disagreement regarding e-payment security: "I feel secure about this electronic payment system," "I am willing to use my… on this site to make a purchase" or "Information and transactions through websites are trustworthy." Some literature suggests that a high level of perceived security toward an e-payment transaction is tantamount to low risk (Hartono et al. 2014). However, no research to date has explored whether perceived risk and security toward e-payments are ends of a single continuum or different constructs. In any case Tsiakis and Sthephanides (2005) indicate that high levels of perceived risk or low levels of perceived security trigger consumers to not adopt the online payment system and, consequently, not participate in the transaction until solutions are implemented to allay their fears. This notion thus affects purchase and "repurchase" online behavior (Kousaridas, Parissis, and Apostolopoulos 2008).

In sum, the level of risk and security of an online payment system can significantly affect its acceptance and, consequently, the purchase of online goods. It is therefore essential to delve deeper into establishing the brain reactions toward risky and secure online payment systems, as well as explore consumer processing of the two types of online payment systems (debit card and Paypal). Understanding the results of the self-report and neural correlates of risky and secure payment systems, and clarifying which payment system (Paypal or debit card) is thought to be more secure, provides invaluable insight into the most appropriate means to achieve online repurchase behavior.

Neural Correlates of Perceived Risk and Security

Recent advances in cognitive neuroscience are uncovering the neural bases of cognitive, emotional, and social processes, as well as offering new insights into the complex interplay between Innovation Technology (IT) and information processing, decision making, and behavior among consumers, organizations, and markets. Specifically, certain studies (e.g. Dimoka, Pavlou, and Davis 2011; Riedl, Davis, and Hevner 2014; Venkatraman et al. 2015) have recently introduced the idea of drawing upon cognitive neuroscience literature in the framework of marketing research and online consumer behavior. These studies identify a set of opportunities that marketing researchers can exploit to inform marketing phenomena, namely localizing the neural correlates of marketing constructs (such as perceived trust, risk or privacy) or capturing hidden mental processes among consumers.

The empirical fMRI study of Dimoka (2010) in the field of online consumer behavior concluded that trust and distrust activate different brain areas and have distinct effects on price premiums. This helps explain why trust and distrust are distinct constructs associated with different neurological processes. In Dimoka and Davis (2008) also identified the brain areas activated when users interact with websites that differ in their level of usefulness and ease of use. In a similar context, Riedl and Javor (2012) revealed the neural correlates of trust. Other authors

(Riedl, Hubert, and Kenning 2010) went so far as to analyze whether there are neural differences in online trust from the gender standpoint. Apart from these studies, no research to date has singled out the neural correlates of risk and security in an online payment environment. In view of this research gap, the current study intends i) to objectively approach the constructs of risk and security that are very often related to unconscious and automatic processing mechanisms (Dimoka et al. 2010), and ii) complement the results of traditional self-report tools that do not capture low-order emotions, are susceptible to social desirability and subjectivity, and may include sensitive issues.

Neuroimaging studies bring to light consistent evidence of involvement of several brain areas in risk perception. Specifically, two meta-analyses focusing on decision-making, Krain et al. (2006) and Mohr, Biele, and Heekeren (2010), suggest that risky decisions are associated with activity in the orbito- and inferior frontal cortex, the superior parietal cortex, and the middle occipital gyrus. Similar results are advanced by Gonzalez et al. (2005) and Häusler et al. (2016) when exploring neural correlates associated with risky gambles.

Less attention, however, has been paid to neural reactions to secure choices. Building upon the definition of security and its related concept of trust, the confident expectations generated by a secure option would first involve the anticipation of positive rewards. Cognitive neuroscience literature has identified the middle frontal gyrus, precuneus, postcentral gyrus and left insula as key areas associated with increasing reward prediction (Chaudhry et al. 2009; Häusler et al. 2016; Wittmann et al. 2005). In her study assessing the neural correlates of trust and distrust, Dimoka (2010) concludes that trust is also associated with activations in areas such as the caudate nucleus related to the magnitude of those expected rewards. Finally, on the basis that the trustee will act according to the trustor's level of expectation, the notion of trust could lead to predicting how the trustee will perform in the future. In this regard, affective neuroscience literature has found activation in an area of the limbic system responsible for social inferences, namely the anterior paracingulate cortex, when perceiving trustworthy websites (Dimoka 2010; Riedl and Javor 2012).

Research Objectives

Following recent neuroscience research capturing hidden mental processes of marketing constructs, this paper aims to: i) identify neural differences between risky and secure online payment systems, ii) explore whether the two widespread online payment systems (Paypal and debit cards) elicit the same or different brain mechanisms, and iii) assess whether the corresponding areas elicited by online payment systems covary with use intentions toward those e-payments.

Although the studies above assess risk and security in different fields, the findings serve to formulate the following hypotheses: Hypothesis 1 is the expectation of activations related to decision-making in situations of risk (orbito- and inferior frontal cortex, superior parietal cortex or the middle occipital gyrus) when processing self-reported risky versus secure online payment systems. Hypothesis 2 supposes that areas involved with reward prediction (middle frontal gyrus, precuneus, postcentral gyrus and left insula), magnitude of the expected rewards (caudate nucleus), and social inferences (anterior paracingulate cortex) are more strongly activated in response to secure as opposed to risky online payment systems. Given that Paypal could be considered a more protected, simpler and convenient payment method (as opposed to debit cards), Hypothesis 3 supposes whether brain areas related to the security processing (such as the middle frontal gyrus, postcentral gyrus or left insula) are strongly activated when comparing Paypal with debit card systems (Mohr, Biele, and Heekeren 2010). Conversely, Hypothesis 4 supposes activation of brain areas associated with risk perception (the superior parietal cortex or the middle occipital gyrus) when comparing debit card with Paypal payments. Given the importance from the interactive marketing perspective of understanding the role of specific brain areas in predicting self-report responses such as use intention toward e-payments, this study also delves into the question of which brain regions activated during viewing Paypal covary with use intentions toward such online payment system. As in the case of earlier studies in this field, the authors of the current study presume activation in the areas most commonly involved in value encoding and reward-sensitive areas such as the posterior cingulate cortex (Bartra, McGuire, and Kable 2013) or the cerebellum (Kühn and Gallinat 2012).

To test these hypotheses, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that offers an indirect measure of brain activation (Solnais et al. 2013).

Method

Stimuli and Procedure

The main objective of the experimental design was to simulate the online purchase process of low-involvement products through a well-known website. The choice was narrowed down to entertainment tickets (concerts, musicals, theater and festival) as the leading sectors in Spanish online transactions are tourism, clothing, accessories and entertainment (ONTSI 2017). The simulated website selected was “Ticketmaster,” one of the main ticket sellers in Spain (Datanize 2017).

Participants arrived at the laboratory 1 hour prior to the fMRI task. After receiving instructions and verifying that all study procedures were understood, they completed an informed consent questionnaire. They were then subject to four conditions during the fMRI task: i) four low-involvement products accompanied by the Paypal symbol, ii) the same products accompanied by a debit card, iii) a *judgement* slide in which participants were asked to express “How risky or secure do you think the purchase of the previous product is by paying with Paypal or by debit card?,” and iv) a *choice* slide offering the online payment system to acquire the products. In the *judgement* slide, participants expressed their opinion by pressing one of four buttons: 1. Very risky, 2. Risky, 3. Secure, and 4. Very secure. In the *choice* slide they were asked to press their choice of 1. Paypal or 2. debit card. In addition, there was a baseline condition requiring participants simply to observe a fixation asterisk.

Consumer neuroscience studies tend to have a relatively small sample size (due to the cost, healthy or availability issues, Hedgcock and Rao 2009), which could offer reproductible results only whether few experimental conditions are compared (e.g. no more than two). Investigations of that field, furthermore, are prone to extensively homogenizing as variables included in the study as possible, aiming to control the number of stimuli that could affect the brain mechanisms. Along this line, the authors of this paper focus on comparing only two main e-payments (the most widely used, debit cards and Paypal) in a specific low-involvement purchase online environment.

Each block of trials began with a randomly selected slide of one of the four products accompanied by one of the online payment systems displayed for 8.1 s. This was followed by the *judgement* slide and a 12 s response time, which was shown to be ample time for subjects to read and process the information (Dimoka and Davis 2008). Next, a white screen with a centered black fixation was displayed for an average of 3 s, jittered from 2 to 4 s in 1-s steps. This white screen has a double function: first, to allow for the stabilization of the brain signal (the so-called Bold oxygenation level dependent, BOLD[1]); second, it works as a control item.[2] Afterward, the same product with the other online payment system was displayed for 8.1 s. Again, the *judgement* slide ran for 12 s. Next, a fixation condition was viewed (3 s) after the *choice* slide (9 s). There were 12 blocks of trials and, therefore, the subjects viewed the same condition 12 times but with different products. In total, they only were exposed three times to the same condition with the same product. The repetition of the same condition in several points in the task is highly recommended in fMRI tasks, aiming to perform an average brain response for each trial. The same products were never repeated consecutively, the order of the blocks was randomized, and finger assignments were counterbalanced across the subjects. The fMRI stimuli were presented via E-Prime Professional 2.0 and lasted 12.5 minutes (see Fig. 1). The timing of each trial was adapted from previous fMRI studies (Dimoka 2010; Riedl and Javor 2012) and the randomization of first type of slide of each block (i.e. the product accompanied by an e-payment) was also implemented by using the "Random" option in the layout of the software E-Prime Professional 2.0. Please, see the SPM manual's website for completeness (http://step.talkbank.org/materials/manuals/users.pdf).

After the scanning, the participants responded to questions about use intentions toward e-payments for each product, as follows: "If you had the choice of using a debit card or Paypal for the purchase of tickets for a concert, indicate your level of agreement, with 1 = totally disagree and 7 = totally agree: i) I would use debit cards in the next months if I wanted to buy tickets for a concert on the Internet; ii) I would use Paypal in the next months if I wanted to buy tickets for a concert on the Internet" (scale adapted from the study of Venkatesh and Bala 2008). After completion of the session, participants were thanked, paid and given one of four entertainment tickets (selected randomly).

Participants

Thirty right-handed subjects were recruited via social networks and the institutional website of the University of Granada between February and April 2017. Given that their computer expertise, access to debit cards and Paypal, online purchase experience and various other sociodemographic characteristics (e.g. age and gender) can influence online payment system processing and use intention (Riedl, Hubert, and Kenning 2010), the authors of the study selected participants showing characteristics with similar levels. Hence the initial survey included questions about those variables as well as other issues related to health.

Specifically, only participants with a high-medium computer expertise were retained as the average expertise level was 5.6 (*SD*: 0.8) on a seven-point scale (anchored at 1 = low expertise to 7 = high expertise). All of the sample population responded to fully possess access and knowledge of the function of debit cards and Paypal. Furthermore, all stated having used both e-payments in the past. In addition, 68% spent more than 10 hours per week using the Internet, and 100% had purchased products or services on the Internet at least once, with 65% purchasing at least once each semester. Collectively, the samplings were good proxies for Spanish online consumers (Statistical National Institute 2017) as 46.66% were female and 53.33% male. In addition, 40% were under the age of 35, 50% between 35 and 55, and 10% between 55 and 65 (average = 36.59 years, *SD*: 10.55).

Participants also assessed the involvement of the four products by expressing their opinions (7-point Likert scale, 1 = nothing and 7 = very) toward the adjectives defined by Zaichkowsky's involvement scale (1986) as follows: important, boring, irrelevant, exciting, means much to me, attractive, trivial, worthy or thrilling. After averaging the scores for each adjective of the involvement index, all subjects reported that tickets for concerts (mean = 2.52 and *SD* = 1.02), theater (mean = 2.85 and *SD* = 1.25), musicals (mean = 2.98 and *SD* = 1.36) and cinema (mean = 2.14 and *SD* = 1.05) were perceived as low-involvement products.

To check for the general familiarity and attitude toward the brand "Ticketmaster," the subjects were asked about their usage duration and about their overall attitude (seven-point Likert scale with "1 = extremely negative" and "7 = extremely positive"). The analysis indicated buying tickets with Ticketmaster for 53.2 months (*SD* = 14.5) and a medium attitude toward the brand (means = 3.92, *SD* = 1.15).

The participants were also assessed for the important trait regarding their level of general risk (risk propensity). The

[1] Blood oxygenation level dependent (BOLD) signal refers to the concentration of deoxyhemoglobin in the blood of the brain. The BOLD effect is based on the fact that when neuronal activity is increased in one part of the brain, there is also an increased amount of cerebral blood flow to that area which is the basis of hemodynamic response. This increase in blood flow produces an increase in the ratio of oxygenated hemoglobin relative to deoxygenated hemoglobin in that specific area.

[2] fMRI studies require appropriate control variables to "cancel out" spurious brain activation due to visual stimuli, movement, and other sources of noise, and thus isolate brain activation only associated with the experimental stimuli.

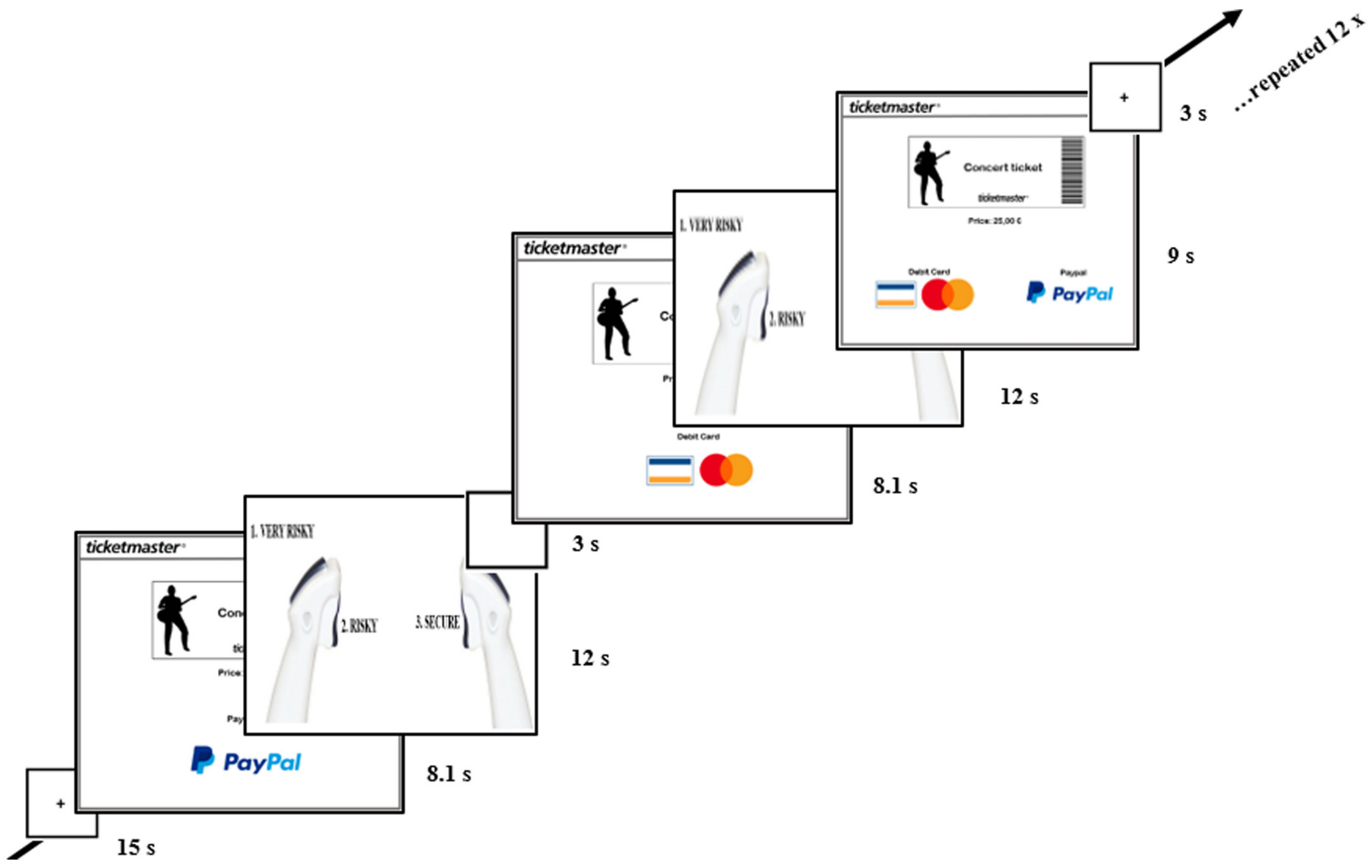

Fig. 1. The fMRI task structure. The order corresponds to the first block. The conditions 'ticket for a concert with Paypal' and 'ticket for a concert with a debit card' are presented in random order in the subsequent eleven repetitions. Please, see Appendix for a complete view of stimuli.

authors measured this by a 7-point Likert scale of one item: "I am willing to take substantial risks when online shopping" (adapted from Cho and Lee 2006) with "1 = Totally disagree" and "7 = Totally agree." The analysis revealed no extreme outliers as the risk propensity of all participants was at a relatively medium mean (3.45, *SD* = 1.25).

All participants also were in good health. They took no medication or were afflicted by any neurological disease, did not abuse drugs and had a normal (or corrected to normal) vision and hearing. The experiment also applied the common fMRI exclusion criteria of claustrophobia, pregnancy and metal implants in the body. For access to their private medical information, an ethical commitment consent form was obtained from each participant. Moreover, the study was approved by the local ethical committee following the protocol of the World Medical Association Declaration of Helsinki (2013).

The fMRI Analyses

Statistical maps were generated for each participant by fitting a boxcar function to the time series, convolved with the hemodynamic response function. Data were high-pass filtered[3] with a cutoff of 128 s. The following five conditions were modeled in a general linear model defined for each participant: a) Risky blocks, that is, "1. Very risky" and "2. Risky" self-reported e-payments; and b) Secure blocks including "3. Secure" and "4. Very secure" self-reported e-payments according to the opinions expressed in the *judgement* slide; c) debit card blocks; d) Paypal blocks; and e) inquiries about which online payment system participants would choose to purchase the products (*choice* slide). Six rigid body motion correction parameters (the parameters from the realignment) were also included as nuisance covariates. The rest periods (fixation points) were treated as the baseline on the general linear model (GLM) implemented in SPM12. Please, see the explanation of a GLM in fMRI analyses in Appendix.

To perform the analysis of brain data, brain images are first analyzed and localized for each subject (first level analysis). Then, second-level one-sample t-tests are performed on the aggregate data to create random-effect group analyses for the experimental conditions. On the first level (single subject analysis), the following contrasts were generated: i) risky vs. secure e-payments; and ii) debit card vs. Paypal periods (and the reverse). On the second level, one sample t-tests were carried out to examine the significant brain activation of the group during the contrasts mentioned above. The cp_cluster_Pthresh (https://goo.gl/kjVydz) tool served to set the cluster extent threshold to a meaningful value. This tool offers a non-arbitrary uncorrected threshold and cluster extent equal to $p < 0.1$ corrected for multiple comparisons (FWE) across the

[3] Neuroimaging studies use high-pass filtering aiming to remove the very low frequencies of the hemodynamic response signal and "pass through" the high frequencies, the latter being the most interesting for the analysis.

whole brain. In the Risky versus Secure and Debit card versus Paypal analyses (and vice versa), the threshold resulted in $p < 0.001$ uncorrected with a cluster (k). A rigorous explanation of the procedure of cluster extent thresholding can be consulted in Appendix.

In addition, a stricter analysis (small volume family-wise error (FWE) corrections at $p < 0.05$) was applied to a priori regions of interest (ROIs) according to our hypotheses. The ROIs were defined according to the Automatic Anatomical Labeling[4] (AAL) atlas (Tzourio-Mazoyer et al. 2002) as implemented in the WFU Pickatlas (Maldjian, Laurienti, and Burdette 2004) integrated in SPM12: orbitofrontal gyrus ROI, AAL frontal superior orbito; inferior frontal gyrus ROI, AAL inferior frontal; superior parietal ROI, AAL parietal superior; occipital middle ROI, AAL occipital middle; middle frontal gyrus ROI, AAL frontal middle left; precuneus ROI, AAL precuneus; postcentral ROI, AAL postcentral; left insula ROI, AAL insula left; caudate nucleus ROI, and AAL caudate nucleus. Please, see Appendix for a detailed overview of the preprocessing and image acquisition procedures. Appendix includes, furthermore, the main regions and functions of interest for risky and security processing.

Predicting Use Intentions Toward E-payments

After averaging the intention of each participant toward debit card and Paypal usage while purchasing online entertainment tickets, we ran a subtraction analysis[5] of use intentions (i.e. use intentions toward Paypal − Debit card). This was followed by a multiple regression analysis to examine whether the neural response (peak level activations) in the brain regions related to Paypal (vs. Debit card) were associated with the subtraction between the rating of use intention of Paypal (Int Paypal Debit) and the scores toward debit card use (Int = Int Paypal − Int debit card). In other words, the brain areas found to be correlated with use intentions toward Paypal will covary with use intention toward Paypal. Using the peak level of brain activation is a standard practice in fMRI studies (Dimoka 2010). A more liberal threshold was applied in this exploratory analysis since it enquired into the most important areas involved in value and reward (e.g. posterior cingulate cortex or cerebellum). In this case the study resorted to a threshold of $p < 0.001$ uncorrected with a cluster extent of minimum 5 voxels.

Results

Self-report Results

The statistical software IBM Statistical Package for the Social Sciences (IBM SPSS Version 20) served to evaluate whether there are differences in the use intentions toward Paypal and debit cards when purchasing online entertainment tickets in general, and within each typology of tickets in particular. A Paired-samples t-test indicates that use intentions toward Paypal (mean = 4.87, *SD* = 1.37) yield significantly more positive scores than use intentions toward debit cards (mean = 5.80, *SD* = 1.37) across the subjects (t (29) = −2.44; p = 0.021). Looking at those differences within each type of performance, the findings reveal consistencies with the general trend as use intentions toward Paypal when buying tickets for a concert (mean = 5.72, *SD* = 1.46) are significantly higher (t (29) = −2.70, p = 0.009) than those toward debit cards (mean = 4.98, *SD* = 1.54); similar trend when buying tickets for a musical (t (29) = −2.69, p = 0.012), tickets for the theater (t (29) = −2.52, p = 0.018) and tickets for a festival (t (29) = −2.32; p = 0.027).

Functional Imaging Results

Risky and Secure E-payment Contrasts

Clusters in the right middle occipital gyrus are more strongly activated when responding to self-reported risky as opposed to secure online payment systems. In turn, when comparing secure with risky e-payments, the study identified activations in the left middle frontal gyrus, right precuneus, left postcentral gyrus, right superior parietal gyrus and left insula (see results in Table 2 and Fig. 2). Several of those areas survived $p < 0.05$ small volume correction (FWE) over a priori ROIs, namely the middle occipital gyrus, the middle frontal gyrus, the precuneus, the insula and the postcentral gyrus.

Debit and Paypal Contrasts

The comparison of debit card with Paypal e-payment systems reveals a strongly activated cluster in the left calcarine and right middle occipital gyri. By contrast, several clusters in the right Rolandic operculum and right postcentral gyri elicited strong reactions when contrasting Paypal with debit cards (see results in Table 2, Fig. 3). Two of those areas, notably the middle occipital and postcentral gyri, survived $p < 0.05$ small volume correction (FWE) over a priori ROIs.

Relation Between Neural Responses and Use Intentions Toward E-payments

Activation in the right cerebellum and left fusiform gyrus during the viewing of Paypal minus debit card covaried significantly (positive) with a difference of score of use intentions toward Paypal and debit cards ($r_{cerebellum} = 0.51$; $r_{fusiform} = 0.48$). Thus, participants with higher use intentions toward Paypal showed significantly stronger activation in these areas while viewing the Paypal online payment system (see Fig. 4 and Table 3).

Discussion and Conclusions

This is the first study combining neuropsychological tools and self-reports shedding light on how consumers process online payment systems in a purchase environment. Specifically, the study explores differences in brain activation patterns toward risky and secure e-payments, and compares the processing of two

[4] AAL is a digital human brain atlas containing labels that indicate names of the macroscopic brain areas.

[5] A subtraction analysis implies to test the significance of the difference between two means. In the current manuscript, it points to reach the difference between the average scores of intentions toward Paypal and the average scores of intentions toward Debit card.

Table 2
Peak coordinates of brain regions when responding to Risky versus Secure e-payments contrasts and when responding to debit card versus Paypal contrasts.

Brain region	Peak MNI coordinates (mm)			Z	T	Cluster size	Effect size
	x	y	z				
Risky > Secure							
L middle occipital gyrus	−27	−91	7	3.81	4.39	45	0.70
	−20	−95	18	3.71	4.24		
Secure > Risky							
R postcentral gyrus	−41	−21	49	5.35	7.08	297	0.98
L insula	−38	−4	−4	3.80	4.37	14	0.70
L middle frontal gyrus	−34	42	14	3.53	3.98	13	0.64
R precuneus	12	−67	32	3.43	3.85	10	0.63
R inferior parietal gyrus	47	−32	42	3.43	3.85	19	0.63
Debit > Paypal							
L calcarine	−17	−98	−4	4.93	6.24	39	0.90
R middle occipital gyrus	33	−88	14	4.04	4.74	15	0.74
Paypal > Debit							
R Rolandic operculum	47	−11	18	3.69	4.21	11	0.67
R postcentral	57	−14	25	3.39	3.80	9	0.62

Note: Peak of clusters significant at p uncorrected <0.001, k ≥ 10 voxels are reported. This uncorrected threshold and cluster extent is equal to $p < 0.1$ corrected for multiple comparisons. L = left side of the brain; R = right side of the brain. Peak MNI coordinates refer to the specific location of the activated cluster of voxels on the x, y and z axes, according to the Montreal Neurological Institute (MNI) template. Cluster size refers to the number of voxels that contiguously survive to a specific threshold of significance. Effect size = $Z/\sqrt{N}$, which constitutes a quantitative measure of the strength of voxel or cluster activation.

widespread online payment systems (debit card and Paypal). At the behavioral level, the findings advance higher intentions toward Paypal usage during online entertainment ticket purchasing. At the brain level, the study shows that risky e-payments elicit different brain activations when compared to secure e-payments, as well as distinct activation patterns when comparing reactions to Paypal and debit cards. Interestingly, this study also reveals that more positive use intentions toward Paypal correlate with the cerebellum responses to this e-payment system, an area responsible for value and reward encoding.

As regards the self-report responses, this study infers higher use intentions toward Paypal (vs. debit cards) when purchasing low-involvement products, e.g. entertainment tickets. Previous research in this field explored the characteristics (popularity, possibility to move, database safeguarding…) of several e-payment systems, including Paypal (Yu, Hsi, and Kuo 2002), and revealed that Paypal receives higher perceived usefulness, control and confidentiality than debit/credit cards (Suhuai et al. 2010). The higher use intentions toward Paypal in the purchase environment advanced in this study could be indeed derived from the higher usefulness, confidentiality and control offered by this e-payment, thus supporting the relationship of causality between use intentions and variables identified in other studies (Slade et al. 2015; Yang, Qing et al. 2015; Yang, Yongqing et al. 2015).

At the neural level, the findings advance that perceived risk and security are not opposite ends of a single continuum but constitute different constructs associated with different neurological processes. Specifically, fMRI data evidence that the middle occipital gyrus is more strongly activated in response to risky as opposed to secure e-payments. This activation is consistent with the conclusions of several studies analyzing risky decisions (Krain et al. 2006; Mohr, Biele, and Heekeren 2010). A great number of investigations find the middle occipital gyrus specifically responsible for anticipating events of negative emotional valence and risk. For example, Herwig et al. (2011) advanced middle occipital gyrus activation when exploring neural correlates of a ‘pessimistic’ attitude in anticipating events of emotional valence. Similarly, Matthews et al. (2004) revealed that deliberation prior to selection of risky as opposed to safe responses generated greater activation in the middle occipital cortex. Along the same line, Cunningham, Raye, and Johnson (2005) suggested that the left middle occipital gyrus is involved with preventive behavior toward negative valenced events. The literature also largely corroborates the role of the occipital gyrus in human visual processing (Hummel et al. 2013). Taken together, our results suggest the involvement of a typical visual brain area, namely the middle occipital gyrus, in anticipation of self-reported risky e-payments. The results therefore reflect that risky e-payments are processed as more negative given the previous links between the activation of the middle occipital gyrus and anticipation of negative valenced events. This reasoning is in agreement with the conclusions of Brühl et al. (2011) that the temporo-occipital associative visual areas are activated in anticipation of negative emotional stimuli.

Contrary to expectations, the orbito-inferior frontal and superior parietal areas were not strongly triggered by risky e-payments. These areas were found to be activated in economic decision-making studies (e.g. Schonberg, Fox, and Poldrack 2011; van Bömmel et al. 2014) while participants choose between options with different levels of risk (e.g. to bet 100€ and win 10% if the decision is correct versus betting 50€ and win 5% if the decision is correct). Yet, contrary to the results of those studies, participants in this analysis do not make (risky) decisions but expressed their opinion about perceived risk according to the type of e-payment they viewed. The higher involvement of the orbito-inferior frontal and superior parietal areas in risky choice tasks (as opposed to reporting an opinion about perceived risk) could be a potential explanation for the absence of activation. In this sense it is comprehensible that only the middle occipital gyrus, related to deliberation prior to self-reported perceived risk opinion, is activated in response to the self-reported risky e-payments. Consequently, Hypothesis 1 could only be partially retained.

Secure e-payments, in line with Hypothesis 2, are strongly elicited in the middle frontal gyrus, precuneus, postcentral gyrus and insula. Previous research has linked those brain regions to reward prediction (Chaudhry et al. 2009; Häusler et al. 2016; Wittmann et al. 2005). Therefore, the activations observed in response to secure e-payments suggest that online payment systems are processed as more rewarding than risky ones. However, secure e-payments did not trigger the expected activations of areas previously involved with the magnitude of the rewards (such as the caudate nucleus) or social inferences (such as the anterior paracingulate cortex), cognitive processes found in response to trustworthy websites (Dimoka 2010; Riedl and Javor 2012). The absence of those activations could reveal

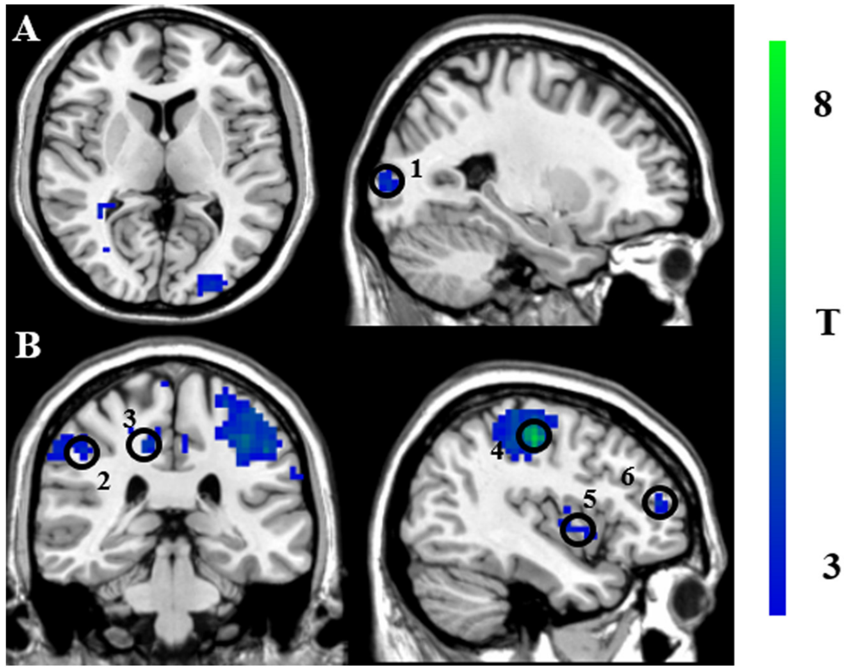

Fig. 2. Illustration of the brain regions activated during (A) risky > secure e-payments: (1) middle occipital gyrus; (B) secure > risky e-payments: (2) inferior parietal gyrus, (3) precuneus, (4) postcentral gyrus, (5) insula and (6) middle frontal gyrus.

that security and trust in e-payments are distinct constructs associated with different neurological processes. Specifically, it seems that trust in e-payments constitutes a wider construct as it does not activate only brain areas related to reward prediction (similar to security), but also other regions involved with the magnitude of the rewards and social inferences. This aligns with the results of behavioral research considering security as one of the determinants of trust in e-payments (Kim, Mirusmonov, and Lee 2010; Yoon 2002).

Parts of the brain eliciting stronger activation while perceiving Paypal, in contrast to those of debit cards, are the postcentral gyrus and the Rolandic operculum area. Together with the insula, the middle frontal gyrus and the precuneus, the postcentral gyrus is one of the areas mentioned above involved with reward prediction (Schonberg, Fox, and Poldrack 2011). In the framework of this paper, an increase of activation of the postcentral gyrus during Paypal visualization could indicate that participants perceived this e-payment as slightly more secure and

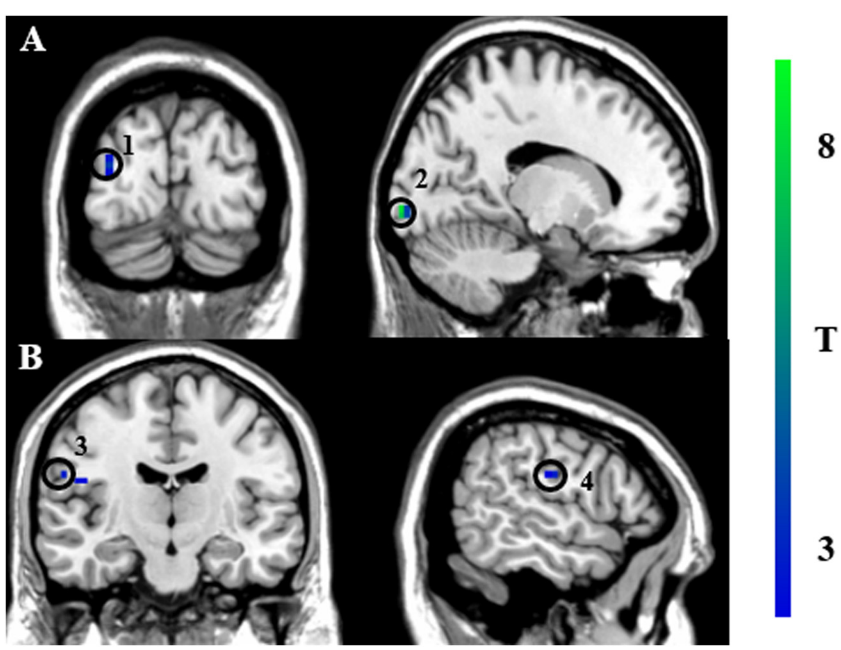

Fig. 3. Illustration of the brain regions activated during viewing of (A) debit card > Paypal: (1) calcarine, (2) middle occipital gyrus; (B) Paypal > debit card: (3) postcentral gyrus, and (4) Rolandic operculum.

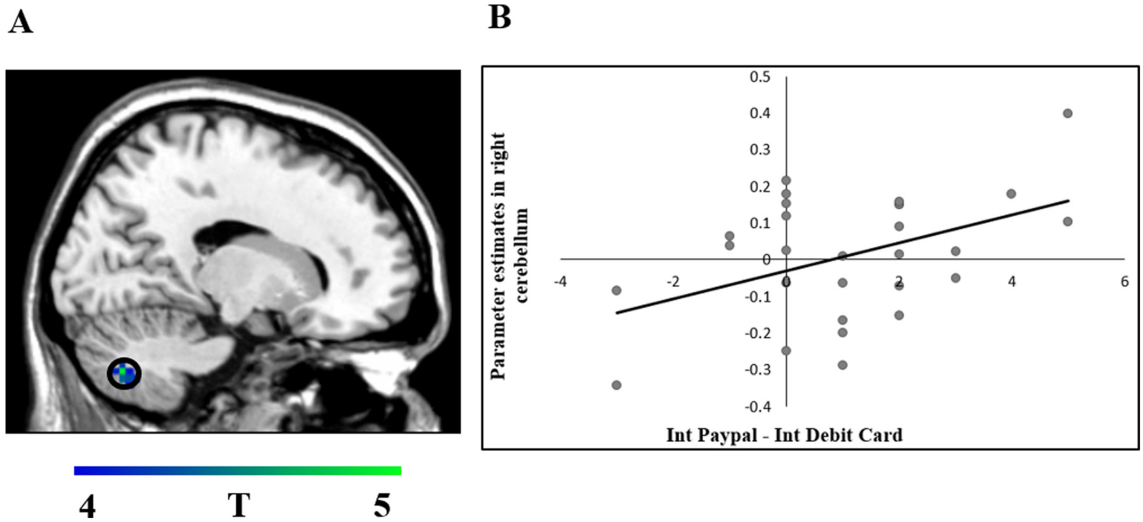

Fig. 4. Activation in the right cerebellum during Paypal (versus debit card) correlates with use intention of Paypal. (A) Brain regions in which activation during viewing Paypal (versus debit card) strongly covaries in use intentions toward Paypal. Circle indicates right cerebellum cluster. (B) Plot showing the correlation between the parameter estimate of Paypal vs. debit cards in the cerebellum cluster and the use intention toward Paypal (vs. debit card).

rewarding than that of debit cards. The Rolandic operculum is a part of the frontal lobe involved with preference judgements. Specifically, Chaudhry et al. (2009) found activation in the Rolandic operculum among participants making choices based on affectively driven judgements compared with those driven cognitively. Together, these findings reveal that when consumers are purchasing low-involvement products on the Internet, they process Paypal as a more secure, rewarding and affective payment system than debit cards, thus supporting Hypothesis 3.

In line with the expectations of Hypothesis 4, we observed a stronger triggering of the middle occipital gyrus when participants viewed debit cards (versus Paypal). As noted previously, the middle occipital gyrus is traditionally linked to anticipation of emotional negative-valenced and risky events (Matthews et al. 2004). Indeed, the findings reveal middle occipital gyrus activation when participants were exposed to risky versus secure e-payments suggesting that debit cards are processed as a riskier payment system than Paypal. Given that the participants did not make a (risk) decision while viewing debit cards, it is also reasonable not to identify, in this case, activations in the orbito-inferior frontal or superior parietal areas. What is more, activation of the calcarine gyrus, a brain area related to visual processing (Ishai 2002) in response to debit cards, corroborates prior findings regarding the presence of visual areas when subject to risky and negative emotional stimuli as in the case of debit cards.

Finally, an intention of this study is to determine the regions in the brain linked to Paypal activation that covary with use intentions. In line with these expectations, the findings reveal that participants expressing higher use intentions toward Paypal showed stronger activation during Paypal (vs. debit cards) in several brain regions, including the right cerebellum. The cerebellum is traditionally associated with attentional processes, and value and reward encoding. Martin-Sölch et al. (2001) identified differences in cerebellum activation of non-smokers when responding to reinforcement and reward stimuli. Similarly, the findings of Nieuwenhuis et al. (2005) indicate activity of cerebellum suggesting strong sensitivity to the magnitude of monetary rewards and value. Kühn and Gallinat (2012) also found positive correlates of subjective pleasantness in the cerebellum. On the whole, the more pronounced right cerebellum activation while processing Paypal reveals that preferences, subjective values and attentional processes are key factors for the formation of use intention toward e-payments, e.g. Paypal (vs. debit card).

Theoretically, these findings contribute to the literature examining the factors that influence the consumer attitudes or intentions toward online purchases such as the risk and trust (Yang, Qing et al. 2015; Yang, Yongqing et al. 2015), personal innovativeness (Kalinic and Marinkovic 2016; Kim, Mirusmonov, and Lee 2010; Molinillo and Japutra 2017), convenience (Chiang and Dholakia 2003) or perceived usefulness (Shin 2009). This study clarifies the effects of very common variables affecting

Table 3
Peak coordinates of brain regions in which response to Paypal against Debit Card contrast covaried with use intentions toward Paypal (as opposed to Debit Card).

Brain region	Peak MNI coordinates (mm)			Z	T	Cluster size	Effect size
	x	y	z				
Paypal > Debit card							
R cerebellum	15	−70	−42	4.07	4.81	9	0.74
L fusiform gyrus	−41	−46	−21	3.74	4.30	5	0.68

Note: Peak of clusters significant at p uncorrected <0.001, k ≥ 10 voxels are reported. This uncorrected threshold and cluster extent is equal to p < 0.1 corrected for multiple comparisons. L = left side of the brain; R = right side of the brain. Peak MNI coordinates refer to the specific location of the activated cluster of voxels on the x, y and z axes, according to the Montreal Neurological Institute (MNI) template. Cluster size refers to the number of voxels that contiguously survive to a specific threshold of significance. Effect size = $Z/\sqrt{N}$, which constitutes a quantitative measure of the strength of voxel or cluster activation.

use intention toward Paypal and debit cards, namely perceived risk and security. It also represents an advance in the research comparing the characteristics of online payment systems (Yu, Hsi, and Kuo 2002) as no study to date has specifically focused on the differences in use intentions toward Paypal and debit cards in a low-involvement online environment. Furthermore, it constitutes a new step in the application of neurological tools to analyze the processing of IS constructs and to capture hidden consumer mental processes. Previous fMRI research has focused on the neural correlates of trust, distrust, usefulness and ease of use (Dimoka 2010; Dimoka and Davis 2008). This work goes further and sheds light on the neural correlates of little studied constructs, namely perceived risk and security in e-payments. Through the use of fMRI, this study corroborates that risk and security are not opposite ends of a single continuum, but they are different constructs associated with different neurological processes. This study also defines the neural differences between security and trust in e-payments.

The findings of the current study have considerable managerial implications as they suggest: first, that professionals interested in selling online products should go to great lengths to offer secure online payment systems as e-payments perceived as risky are processed in the brain as emotionally negative and unrewarding. In line with Harvard scholar Bauer's study (1960), risky e-payments not only are perceived as uncertain, but the customer's subjective evaluation on a risky online payment system is also subconsciously processed as disgusting and could even force the consumer to avoid the e-purchase (Featherman and Hajli 2016). Accordingly, all efforts made by companies on offering high-quality products or services, promoting the advantages of their usage or investing huge sums in innovation may be worthless whether the proper e-payment is not included in the website. The current paper goes further to propose, secondly, the inclusion of Paypal, as opposed to debit card systems, in websites as Paypal not only obtains more intentions to use but is perceived by consumers as a secure, valuable, rewarding and affective choice. Purchasing entertainment tickets online via Paypal elicits brain mechanisms similar to those involved with the maternal love (Noriuchi, Kikuchi, and Senoo 2008), organically desired food (Linder et al. 2010) or valuable advertising (Casado-Aranda, Martínez-Fiestas, and Sánchez-Fernández 2018). Therefore, Paypal is subconsciously perceived as a secure and emotional tool that enhances the online purchase process and may convey consumers' complementary benefits to those offered by the purchased product. It may become, therefore, an inherent feature of the product that could play a key role in creating value to consumers and obtaining long-term competitive advantages. To increase trust and security, businesses intending to include debit card systems in their websites, should offer complementary trustee signals, such as seals of approval, rating systems or business policies (Hu et al. 2010). Indeed, our research concluded that perceived security is one of the determinants of trust in e-payments. Consequently, designing secure websites constitutes a highly advisable strategy, together with others such as offering high accessibility, security statements or comprehensibility (Kim, Mirusmonov, and Lee 2010; Kim et al. 2010), to increase the perceived trust on websites.

It is noteworthy that links are established between brain activation and behavioral measures indexed by use intentions toward e-payments. Future e-payment research should link neural responses with actual usage to more fully understand which brain regions predict consumer use intention. Secondly, only risk and security constructs were considered as potential determinants of e-payment choice. E-payment research requires future studies applying fMRI to clarify the neural correlates of other variables including privacy, confidentiality or cost of transactions within several online payment systems. What is more, the modulation of brain activations by sociodemographic variables should constitute a key element in such research to fully understand consumer behavior in the online purchase environment. Furthermore, the specific environment required by neurological studies (control of experimental conditions or relatively small sample size) has allowed only the contrast of two e-payments, Paypal and debit cards; further research at that point may investigate the effects on cognitive and affective processing of credit cards or digital wallets (Akram, Markantonakis, and Sauveron 2016). Finally, the conclusions of this paper should be interpreted with caution due to selection only of participants with medium risk propensity and relatively high use intention toward Paypal, and due to the presentation of only one low-involvement product.

Despite these limitations, the present study represents a first step toward understanding consumer neural and behavioral responses to online payment systems in a real purchase environment. Shedding light on a traditional gap in research, the current behavioral findings highlight higher use intention toward Paypal (vs. debit card use) when purchasing online low-involvement products. This project is also the first to advance neural responses to risky and secure e-payments and to compare the processing of two widespread online payment systems, Paypal and debit cards. The findings are the following: i) self-reported risky e-payments activate areas of the brain linked to anticipations of emotional negative-valenced and risky events meaning that they are perceived as more negative than secure e-payments; ii) only the brain areas involved with reward prediction are strongly triggered by secure e-payments, suggesting that perceived security in e-payments constitutes a different and narrower construct than trust; iii) Paypal is processed as a more secure, rewarding and affective payment system, while the debit card system elicits brain activations related to the anticipation of negative and risky events; and iv) the right cerebellum response to Paypal covaries with more positive use intention toward that type of e-payment.

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Appendix. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intmar.2018.03.001.

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