Consumer Processing of Online Trust Signals: A Neuroimaging Study

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Abstract

The growth of online transactions coupled with the worldwide expansion of Internet-based information exchange has triggered fear, distrust and risk among online consumers. Despite the well-proven benefits to retailers when they include assurance services (e-Assurances) such as seals of approval, rating systems or assurance statements in their websites, there is no consensus as the most trustworthy type. To fill this research gap, the current study reverts to neuroscience (fMRI) to compare the underlying brain mechanisms linked to each type. **Twenty-nine** subjects participated in an experiment simulating a low-involvement online purchase. The **functional neuroimaging** analysis reveals that seals of approval are the most trustworthy as they elicit activation of brain areas linked to reward and expected values. Although assurance statements reveal lower scores of trust than seals of approval, they do not arouse negative brain areas. By contrast, products accompanied by rating systems elicit brain areas linked to ambiguity, negativity and risk. Interestingly, more positive trust and purchase intentions toward seals of approval were predicted by the activation of value-computation areas, whereas higher scores of risk associated with rating systems were predicted by negative-related activations. These results offer invaluable insight into the psychological origin of trust conveyed to different types of e-Assurances.

Keywords: e-Assurance, seals of approval, rating systems, assurance statements, trust, risk, fMRI.

Abbreviations:

fMRI: functional Magnetic Resonance Imaging

DMPFC: dorsomedial prefrontal cortex

Pre-SMA: prefrontal supplemental motor area

SVC: Small Volume Correction

ROI: Region of Interest

1. Introduction

The exponential increase in online shopping and the unprecedented rate of growth of online retailers has led to an extremely competitive marketplace. The relative ease in which vendors can enter this global environment means that many firms offering products remain unknown to consumers. “Unknown” online vendors hope to build a favorable reputation and seek ways to convince consumers that they are legitimate and trustworthy (Chang, Waiman, & Mincong 2013). In their attempt to increase purchase intention, these vendors search for ways to reduce concerns as to online transactions (Wang, S., Beatty, S. E., & Foxx 2004).

Previous literature examining the main deterrents in business to consumer commerce (B2C) indicates that trustworthiness, reputation, perceived risk and accessibility can dramatically influence online commerce (Aljukhadar, M., Senecal, S., & Ouellette 2010; Li et al. 2010). Whereas reputation may constitute a great advantage to well-known firms, several studies claim that unknown online vendors can enhance consumer willingness to buy by reverting to trust mechanisms (Bahmanziari, T., Odom, M. D., & Ugrin 2009; Karimov, F. P., Brengman, M., & Van Hove 2011). An initial improper use of trust tools will blemish subsequent efforts as initial trust is thought to lower perceived risk and, consequently, increase purchase intentions and expectations (D'Alessandro, Girardi, & Tiangsoongnern 2012).

There are many mechanisms available for vendors to build trust. E-commerce studies point to three types of online trust mechanisms (e-Assurances hereafter) that increase trust in e-commerce retailers: *seals of approval* (assurance provided by a third-party vendor only after an independent evaluation of the retailer's website and related activities), *rating systems* (that rate Web sites with "stars" based on customer feedback) and *assurance statements* (vendor statements with information about returns, privacy and security policies). While each of those mechanisms is designed to enhance trust and reduce perceived risk, they revert to different sources. Seals use independent verification through third parties, ratings use customer feedback, and assurance statements are the vendor's self-reported statements about their policies and procedures.

E-commerce literature, deriving from these differences, has evaluated the effects of internal and external e-Assurance signals on initial trust conferred to products sold in B2C e-commerce. The conclusions of these studies are far from consistent. Certain authors point to a greater trust linked to assurance statements (Pennington et al. 2003; Bahmanziari, Odom & Ugrin 2009), while others strongly posit a greater impact on trust of rating systems (Li & Lorin 2008; Wu & Wu 2016) or third-party assurances (Kim & Kim 2011; Nöteberg, Christiaanse & Wallage 2003). Instead of resolving the discordant findings, recent research has focused on analyzing the effects on trust of different modalities of assurance statements, such as privacy disclosure (Bansal et al. 2016), return policies (Wang et al. 2004) or ethical performance (Yang et al. 2009). Though the implications of such studies are undoubtedly remarkable, it is vital first to properly test the effects of seals of approval, rating systems and assurance statements on trust by controlling several essential variables such as product involvement, risk propensity or consumer level of experience. Furthermore, no research in this field to date has resorted to **functional neuroimaging** tools that are more appropriate as trust and risk formation are associated with automatic information processing mechanisms that are not easily addressed through self-reports (Author2 et al. 2010). **The current study precisely resorts to neuroscience aiming to identify (different) affective and cognitive processes involved in the comparison of** the three most widely spread e-Assurances (seals of approval, rating systems and assurance statements)**, so that the**

neurological origin of the likely higher intentions toward the products accompanied by each type could be elucidated.

2. Conceptual Background and Hypotheses

2.1. Behavioral Research on E-Assurances: Trust and Risk

The growth of online transactions coupled with the worldwide expansion of Internet-based information exchange, social networking, profusion of mobile devices, and e-commerce is accompanied by consumer fear, distrust and high levels of perceived risk (Hille, Walsh, & Mark Cleveland 2015). This is especially the case in the case of un-known companies leading consumers to refrain from conducting online transactions. Im-plementing mechanisms to increase online trust and reduce risk play a key role these days, as these two variables are widely considered as important antecedents of inten-tion to purchase and price willingness to pay (Kaplan, & Nieschwietz 2003). Thus, with-out favorable initial trust or low sense of risk, new e-commerce retailers will not sell products and customers will migrate to other websites they deem more trustworthy.

Psychology literature defines trust as an individual's (the trustor) willingness to be vulnerable to another person (the trustee) on the basis that the trustee will act in accor-dance with the expectations of the trustor (Mayer et al. 1995). In buyer-seller relation-ships, trust is defined as the buyer's willingness to be vulnerable to a seller based on the belief that the seller will transact in a manner consistent with the buyer's expecta-tions (Author2 2010). Following this definition, trustworthy environments (e.g. a trustwor-thy online marketplace) correspond to the anticipation of positive rewards and highly valuable expectations. Lower levels of trust, on the other hand, are tantamount to high risk (Hartono et al. 2014) which refers to the uncertainty (lack of knowledge about what could happen after the purchase) and the likely negative consequences after shopping (Bauer 1960). Accordingly, riskier online marketplaces provoke ambiguity and negative feelings among consumers.

Based on these two concepts, a great number studies have focused on the mechanisms available to online vendors to build trust and reduce the notion of risk. Most e-commerce publications point out that the main tools affecting perceived trust, risk, the willingness to pay and purchasing intentions are e-Assurances (online signals included that guarantee returns, privacy and security; Yoon 2002), seller accessibility (easy access to information; Li et al. 2010), reputation of seller (positioning that guarantees that the seller has honored or met its obligations toward other consumers; Urban, Amyx, & Lorenzon 2009) and familiarity with the website (degree of acquaintance including knowledge of online sellers and understanding their relevant procedures and interfaces; Kim & Kim 2011). **Rested on this theoretical framework, Figure 1 outlines the main tools available for online vendors to increase the performance effects of online marketplace on consumers' perceptions of trust and risk, as well as their influence on the willingness to pay and purchase intentions.**

[Please, insert Figure 1 about here]

Following the mainstream currents of e-commerce literature, this study proposes that higher levels of trust and lower levels of perceived risk toward new e-commerce retailers may be bolstered by the characteristics of the website and its e-Assurances.

Web assurance services represent a form of institutional-based trust formed through externally provided e-Assurances (such as seals of approval and rating systems) and internally provided e-Assurances (such as assurance statements). As business transactions on the Internet go relatively unregulated, Web assurance services constitute a way to generate institution-based trust. Specifically, s*eals of approval* refer to an assurance provided by a third-party vendor only after an independent evaluation of the retailer's website and related activities. This type of e-Assurance involves a large amount of testing and is accompanied by a certificate from a third party. It stands to reason that third-party certification from independent sources should offer assurance over and above the internally provided assurance structures on the website, and thus result in more trust. *Rating systems* provide Web sites different quantities of “stars” according to customer feedback and serve to rate a vendor's performance in terms of privacy policies, fee shipping, ease to usefulness and guarantees. *Assurance statements*, in turn, are e-Assurances managed by the online retailer through the use of different combinations of statements referring to privacy policies, guarantees, free shipping, return policies, contact information and frequently-asked-questions (Kaplan & Nieschwietz 2003; Bahmanziari, Odom & Ugrin 2008). In sum, while each mechanism is designed to enhance trust and reduce risk, they do so in different ways. Seals use independent verification through third parties, ratings use customer feedback, and assurance statements are vendor’s self-reported statements about their policies and procedures. Appendix A lists examples of the three most widely used e-Assurances.

Interactive marketing literature concurs that the presence of a Web seal affects perceived trust, risk and judgment behavior. The study by Nöteberg et al. (**2003**), for example, examined the effect of different Web assurance signals (accountant, bank, computer association, consumer union, self-reported, and none) on likelihood of purchase. The results reveal that the presence of any e-Assurance resulted in greater trust, likelihood of purchase, price willing to pay and less perceived risk. Moreover, studies carried out by Lala et al. (2002) and Kaplan and Nieschwietz (2003) highlighted the same tendency. Nevertheless, there is no consensus as to the effectiveness of each e-Assurance (seals of approval, rating systems or assurance statements) on an increase of trust, willingness to pay, purchase intentions and reduction of perceived risk among potential consumers. Pennington et al. (2003) concluded that only self-reported vendor statements (vs. seals of approval and rating systems) affect system trust and enable successful e-commerce. Similar findings are derived from the studies of Bahmanziari et al. (2009), Lee and Turban (2001), and Milne and Culnan (2004) that reveal that the presence of third-party certifications did not affect consumer trust or purchase intentions. Reversely, Nöteberg, Christiaanse and Wallage (2003) found that third-party assurances (vs. self-proclaimed assurance) significantly increased purchasing likelihood and reduced consumer concern about privacy and transaction integrity. Along the same line, Portz, Strong, and Sundby (2001) found that web seals increase perceived trustworthiness.

In sum, although it is commonly accepted that there is an impact of e-Assurances on perceived trust, risk and purchase intentions in online environments, more research is needed to clarify the effectiveness of each. The inconsistencies found in the literature may be due to the automatic and automatic nature of the processing of the trust or risk conveyed by e-Assurances. This would therefore deem crucial to delve deeper into establishing the brain reactions elicited by e-Assurances. Understanding the results of the self-report and neural correlates of trust or risk associated with each e-Assurance, and clarifying which e-Assurance is thought to be more trustworthy, will provide invaluable insight into the most appropriate means of developing secure and encouraging online purchase environments.

2.2. Neural Correlates of E-Assurances: Trust and Risk

Current advances in cognitive neuroscience are unveiling the neural bases of cognitive, emotional, and social processes, as well as offering insight into the complex interplay between Innovation Technology (IT) and information processing, decision making, and behavior among consumers, organizations, and markets. Certain recent enquiries (e.g. Author2 et al. 2011; Riedl, Davis & Hevner 2014) have introduced the idea of drawing upon cognitive neuroscience literature in the framework of Information Systems research (hence the term “NeuroIS”). These studies identify a set of opportunities that IS researchers can exploit to gain knowledge on IS phenomena, namely identifying the neural correlates of IS variables or capturing hidden mental processes among consumers.

One of the main benefits of resorting to neuroscience in information systems research is that it facilitates exploring the neural origin of media effects (e.g. trust, risk, int willingness to pay, purchase intentions) provoked by specific media features (e.g. e-assurances). In other words, it sheds light on the underlying mechanisms of media effects (Author2 et al., 2010; Weber, Mangus, & Huskey, 2015)**. While traditional self-report tools give answer “to what extent an e-assurance pro-**

vokes better performance on consumers", neuroscientific techniques respond to "why" or "how" that e-assurance triggers such effect on consumers. This new information offered by neuroscience could be of high interest for managers desiring to include on their website the e-assurance that encourages the highest automatic mechanisms involved with trust and reward.

Some studies have investigated the effects of online stimuli on consumers. An fMRI study carried out in 2010 by Author2 in the field of e-commerce, for example, revealed that trust and distrust activate different brain areas and give way to distinct effects on price premiums. This helps explain why trust and distrust are distinct constructs associated with different neurological processes. The same author and colleagues (2008) also identified the brain areas activated when during interaction with websites that differ in level of usefulness and ease of use. Other academics (Riedl, Hubert, & Kenning 2010) went so far as to analyze whether online trust shows neural contrasts from the gender standpoint. Apart from these studies, no research to date has singled out the neural effects of e-Assurances on online product evaluation. Neurological tools, in fact, offer an outstanding means to objectively study the effectiveness of each e-Assurance as the comparison of brain activations elicited by seals of approval, rating systems or assurance statements during product evaluation **can reveal the neurological basis of the self-reported levels of trust and risk.**

The likely higher *positive rewards* conferred to products accompanied by one or another e-Assurance may convey positive information and hence lead to involvement of the brain regions linked to reward. Across the wide range of contexts, a broad neural circuit is involved in reward processing. This includes the ventral striatum, brainstem, septal area and ventral tagmental area (Bartra, McGuire, & Kable 2013; Krueger et al. 2007; Riedl & Javor 201**2**). Specifically, neuroimaging studies exploring product preferences in the field of consumer behavior have shown that the ventral striatum is linked to anticipation of a pleasant primary taste reward (O'Doherty et al., 2002) during the visual inspection of preferred foods (Stoeckel et al., 2008). Similarly, Bartra et al. (2013) carried out a meta-analysis examining the neural correlates of subjective value and found that the ventral striatum is highly involved with positive effects in the reward domain. The authors also advanced that the posterior part of the brain (brainstem) is highly elicited by reward stimuli. Studies exploring the neural processing of rewarding obese participants with food corroborate the brainstem's reward-related function (Volkow et al. 2011; Ralph, Taylor & Picciotto 2012). Krueger et al. (2007) carried out an fMRI study aiming to elucidate the brain regions essential in building a trust relationship. Their findings point to the septal area (which includes the anterior paracingulate cortex) and the ventral tegmental area. Moreover, previous research confirmed the connection of those two areas to reward and trust (Author2 2010; Reimann et al. 2011).

In addition to rewarding and positive properties, more trustworthy e-Assurances may also convey greater *valuable expectations***.** Neuroimaging studies offer consistent evidence of involvement of two brain areas in value computation, namely the ventral striatum and the pre-superior motor area (pre-SMA hereafter). In their meta-analysis examining the neural correlates of subjective value, Bartra et al. (2013) found that a specific portion of the right ventral striatum and the pre-SMA responds significantly to expected values of outcomes. Campos et al. (2005) and Linder et al. (2010) concurred that these areas encode value expectancy respectively in eye-movement and in product valuation tasks.

When comparing purchase environments accompanied by distinct e-assurances, opposite constructs of trust, such as loss, intense negative emotions, risk or ambiguity, can also be elicited by one assurance signal (Author2 2010). The presence of areas involved with such mechanisms could be illustrative of the lower trust and higher perceived risk conveyed by one e-Assurance. Consequently, these brain regions may constitute automatic antecedents of aversive experiences (e.g. insecure online environment). Indeed, several studies linked the activation of brain areas related to loss, negative emotions and ambiguity with repulsion and non-choices (Christopoulos, Tobler, Bossaerts, Dolan, & Schultz, 2009; Huang, Soon, Mullette-Gillman, & Hsieh, 2014)**. Accordingly,** a negative value that is likely conveyed during a purchase by riskier e-Assurances may elicit brain regions linked to risk, ambiguity and negative feelings. The dorsomedial prefrontal cortex (DMPFC), among other brain regions (such as the middle occipital gyrus or orbitofrontal gyrus), has been extensively related to danger (Liddell et al., 2005) and the *penalty domain* (Bartra, McGuire, & Kable 2013). Krain et al. (2006) carried out a meta-analysis on decision-making tasks aiming to clarify the neural mechanisms of *risk* and *ambiguity*. Their results confirm that while the middle frontal gyrus, superior frontal gyrus, cingulate gyrus and inferior parietal gyrus are strongly related to the processing of ambiguous stimuli, the superior parietal gyrus and precentral show more response to risky tasks.

This theoretical framework linking brain activity with trust, risk, willingness to pay and purchase intentions can be seen in Figure 2[1].

[Please, insert Figure 2 about here]

2.3. Research Objectives

Implicit processes are possibly present during the reception of e-Assurances that are inaccessible to conscious awareness, as well as conscious processes that are simply not identified in ratings following reception of the signals. These, in fact, might explain inconsistencies in e-Assurances effectiveness in interactive marketing literature. Following recent neuroscience research capturing hidden mental processes of IS constructs, this paper aims to overcome previous limitations and objectively: i) elucidate the neural differences between seals of approval, rating systems and assurance statements during evaluation of low-involvement products, ii) and assess whether the corresponding areas elicited by e-Assurances predict self-reported trust, risk, purchase intention and the price customers are willing to pay for products.

Although the studies above assess trust, reward, ambiguity, risk and penalty in different fields, the findings serve to formulate the following hypotheses which are tested in the current study. Hypothesis 1: We hypothesize stronger activation in areas related to reward (ventral striatum, brainstem, septal area and ventral tagmental area) and value expectations (ventral striatum and the pre-SMA) when

[1] In Figure 2, the neural correlates of mechanisms involved in e-assurance processing (namely, reward, trust, penalty, risk and ambiguity) precede their corresponding psychometric measures because the measurement of brain activity when subjects evaluate online products temporally precedes when the subjects are instructed to respond to the psychometric measurement items.

processing e-Assruances perceived as more trustworthy. Hypothesis 2: We hypothesize that areas involved with risk (superior parietal gyrus and precentral), ambiguity (middle frontal gyrus, superior frontal gyrus, cingulate gyrus and inferior parietal gyrus) and negative feelings (DMPFC) are more strongly activated in response to riskier e-Assurances. Furthermore, given the importance from the interactive marketing perspective of understanding the role of specific brain areas in predicting self-report responses such as trust, risk, purchase intentions or price willingness to pay, this study also delves into the question of which brain regions activated during viewing e-Assurances covary with levels of trust, purchase intentions and prices toward products. As in the case of earlier studies in this field, the authors of the current study presume activation in the areas most commonly involved with value encoding and in the reward-sensitive areas such as the superior frontal gyrus, middle frontal gyrus or inferior frontal gyrus (Bartra, McGuire, & Kable 2013). Reversely, the authors expect that risk scores covary with brain regions related to risk and negative evaluations such as thalamus (Aleman, & Swart 2008) or the superior parietal gyrus (Krain et al. 2006). It is worth noting that this latter constitutes an exploratory covariation analysis whose results should be corroborated in further studies in the field. To explore these research questions, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that offers an indirect measure of brain activation (Author1, Author2, & Francisco J. Montoro-Ríos 2017; Solnais et al. 2013).

3. Method

3.1. Participants

Thirty right-handed participants (15 females) averaging 25.04 (SD: 4.32) years of age were selected to participate in the experiment via social networks and the institutional website of XXX University (July - September 2017). The experiment applied standard fMRI exclusion criteria such as claustrophobia, pregnancy and metal implants. Access to private medical information and an ethical commitment consent form were obtained from each participant. Furthermore, the study was approved by a local ethical committee following the Protocol of the World Medical Association Declaration of Helsinki (2013). A total of **29 participants did finally take part** in the fMRI analysis as one individual did not adhere to the **technical** standards.

From an initial sample of 120 subjects, only participants with a high-medium computer expertise **took part on the 29 afore-mentioned subjects** and their average expertise level was 5.4 (SD: 1.2) on a seven-point scale (anchored at 1 = low expertise to 7 = high expertise). In addition, 72% **of 29 participants** spent more than 10 h per week using the Internet, and 85% had purchased books on the Internet at least once, with 67% purchasing at least once each semester. Collectively, the sampling was representative of Spanish online consumers (Statistical National Institute 2017) as 46.66% were female and 53.33% male. All were also keen on reading books, as 89% of them reported reading more than three times a week.

The 29 subjects were also assessed according to the important trait of level of risk (risk propensity) by means of a 7-Likert scale of one item: “I am willing to take substantial risks when online shopping” (adapted from Cho & Lee 2006) with “1 = Totally disagree" and "7 = Totally agree." The analysis revealed no extreme outliers as the risk propensity of **all 29** participants lined up along the medium mean of 3.32, *SD* = 0.97.

3.2. Stimuli

The main objective of the experimental design was to simulate the online purchase process of low involvement products, specifically books. Participants viewed six different types of books (four times each) corresponding to a total of 48 trials (in total, 24 books, 18 e-Assurances and 6 controls). The subjects were explained that all books were written by fictitious authors and shared identical page numbers. The color of the books was also uniform (white and black) and they included similar cover page illustrations. In line with previous studies, distinct images of books were selected to avoid monotony during the scanning. The authors purposely simulated the realistic website layout of a fictitious book seller: Bookler.com.

After each book, participants were shown one of the three e-Assurances (rating systems, seals of approval and statements, 18 trials in total) in the fictitious Bookler.com website and were asked to imagine the purchase of the book in function of the e-Assurance. An empty slide in the layout of Bookler.com at times served as a control item and was shown to simulate the absence of e-Assurances during the purchasing process (the remaining 6 trials). 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 linked to the experimental stimuli. The set of the e-Assurances was designed in a way that the authors homogenized both the number of words explaining the e-Assurance (between 20 and 24) and their visual complexity. The seal of approval selected was "Confianza Online," the most well-known logo in Spain provided by an independent evaluator firm to businesses that “have decided to make a commitment to promoting good practices on the Internet.” The rating system revealed high scores by previous customers regarding privacy disclosure, web security, delivering and return, as well as financial guarantees when doing business with Bookler.com. The assurance statements included the Bookler.com logo together with a description of the returns, privacy and security policies of the seller.

Following previous research (Garbarino & Strahilevitz 2004), books were chosen as the product of study because buyers view them as low involvement. The authors, in an independent sample (n = 80), corroborated the level of involvement of the books by asking participants to express their opinions (7-point Likert scale, 1 = none and 7 = very) of the adjectives included in Zaichkowsky's involvement scale (1986): important, boring, irrelevant, exciting, means much to me, attractive, trivial, worthy or thrilling. After averaging the scores of each adjective of the index, all subjects reported that they considered books as low involvement products (mean = 2.52 and SD = 1.02).

3.3. Task

Participants arrived at the laboratory one hour prior to the fMRI task. After receiving instructions and verifying that all the procedures were clear, they completed an informed consent form. They then attended a session to identify the differences between the three e-Assurances. They then began the experiment with a short practice session on a computer to familiarize themselves with the stimuli.

The fMRI experiment consisted of 48 trials (Figure **3**). Each began with the display of a short period of fixation[2] (1-2 s) followed by observation of the layout of Bookler.com including a 3.5 seconds viewing of a randomly selected book. The subjects were then required to reflect on the previous purchase taking into consideration an e-Assurance displayed randomly (9 seconds[3]). This was followed by the display of a fixation cross (1-**3** s). The order of the e-Assurances was counterbalanced among the subjects. At the end of the task the subjects received a 30 € payment. The fMRI stimuli were presented via E-Prime Professional 2.0 and lasted about 14 minutes. The timing of each trial was adapted from previous fMRI studies (Author2, 2010; Riedl & Javor 2012) and randomization of the books and e-Assurances were implemented by using the "Random" option in the layout of the E-Prime Professional 2.0 software. For more information see the SPM manual's website (http://step.talkbank.org/materials/manuals/users.pdf).

[Please insert Figure **3** about here]

3.4. Questionnaires

After the scanning, the participants responded to questions regarding trust, risk and intentions gleaned from the purchase of a book in Bookler.com and taking into consideration each e-Assurance. Along the same line, the authors formulated the following inquiries: "After seeing the seal of approval/rating system/assurance statement accompanying the purchase of the book, what is the trust/risk/purchase intention toward

[2] This white screen has a double function: 1) to stabilize the brain signal (the so-called Bold oxygenation level dependent, BOLD); 2) to serve as a control item.
[3] This period was shown to be ample time for subjects to read and process the information (Author2 & Davis, 2008).

the acquisition of this product?" (with 1 = low levels of trust, risk and purchase intentions, and 7 = the highest levels of trust, risk and purchase intentions). The authors also asked the participants the following open question as to the price they would be willing to pay for the book based on its e-Assurances: "After seeing the seal of approval/rating system/assurance statement accompanying the purchase of the book, what is the price you are willing to pay for the book?" The reported price corresponds to a value above and below an average price given to the book during the scanning (i.e. 15 €).

3.5. fMRI Participant Level Analyses

Statistical maps were generated for each participant by fitting a boxcar function to the time series convolved with the canonical hemodynamic response function. Data were high-pass filtered with a cutoff of at 128 s. Neuroimaging studies use high-pass filtering with the aim 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. A general linear model (GLM) was estimated for each participant with the following regressors of interest:

i) Onset picture in the book

ii) Onset picture in the seal of approval

iii) Onset picture in the rating system

iv) Onset picture in the assurance statement

v) Onset picture in the non-assurance slide

Furthermore, each GLM included a constant session term, six covariates to capture residual movement-related artifacts, and fixation crosses as regressors of no interest.

To establish the brain regions that reveal contrasts of responses to seals of approval, the current study carried out a mean subtraction analysis between seals of approval and rating systems together with assurance statements conditions. This resulted in a contrast image of seals of approval minus rating system and assurance statement evaluation periods and a contrast image of the last two e-Assurances as opposed to seals of approval (ii vs. iii + iv, and vice versa). The study also separately contrasted the seals of approval time periods with rating systems and assurance statements (i.e. ii vs. iii and ii vs. iv). To ascertain the brain differences between rating systems and the remaining e-Assurances, four contrasts were calculated: rating systems vs. seals of approval and assurance statements (iii vs. ii + iv) and vice versa, rating systems vs. seals of approval (iii vs. ii), and rating systems vs. assurance statements (iii vs. iv). To test the brain differences between assurance statements and the remaining two e-Assurances, four subtractions were carried out: assurance statements vs. seals of approval and rating systems (iv vs. ii + iii) and vice versa, assurance statements vs. seals of approval (iv vs. ii) and assurance statements vs. rating systems (iv vs. iii).

3.6. fMRI Group Level Analyses

To determine the brain regions revealing different types of activations as to seals of approval vs. rating systems vs. assurance statements, the following contrast images were subject to a one-sample t-test analyses. To examine the brain areas that correlate with a likely incremental trust, purchase intention and price toward books accompanied by seals of approval over the same products accompanied by rating systems or assurance statements, the contrast images of seals of approval vs. rating systems and seals of approval vs. assurance statements were subject to one-sample t-tests with as covariate the subtraction of the individual scores of trust, purchase intention and price between the seals of approval, assurance statements and rating systems.

The analyses were carried out by means of a Region of Interest (ROI) approach using small volume correction (SVC) as implemented in SPM, which means that the selected regions of interest were developed based on the coordinates of previous similar research[4]. Brain activations were labeled according to the automated anatomic labeling tool implemented in the MRIcron and reported using MNI coordinates.

Five reward- and trust-related areas were selected as ROI, namely the striatum, brainstem, septal area and ventral tagmental area. Specifically, the authors applied 10 mm spheres around the coordinates in the striatum (x = 12, y = 6, z = -8) and brainstem (x = 0, y = -20, z = 6) as reported by Bartra, McGuire and Kable (2013) in a metanalysis about the positive effects of stimuli in the reward domain. The authors also applied 10 mm spheres around the coordinates in the septal (x = 1, y = 2, z = -4) and the ventral tagmental areas (x = 2, y= -20, z = -13) as reported by Krueger et al. (2007) in a specific

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[4] **Neuroscience studies commonly run either two types of brain analyses involved with the evaluation of any media effect (e.g. e-assurances in the current study):**

1. Whole brain analysis, with no mask. This is just an exploratory analysis where for each of the contrasts, it can be seen which brain areas are activated by reporting corrected (Family Wise Error, commonly) or uncorrected results (generally, $p_{uncorrected}$ >.001).

2. Whole brain, with mask (SVC analysis). This is when it is defined a subset of the brain as a mask, based on a priori expectation on what it is hoped to find according to previous studies evaluating similar media effects of constructs. This approach allows to correct the results only within the mask and not the whole brain, thus it constitutes a stricter method of analysis. This second type of analysis (which is mostly used in the current paper) corresponds to a hypothesis-driven approach, which constitutes a useful strategy to partially avoid concerns of reproducibility of the results.

study about the neural correlates of trust. Given the higher value most likely conveyed by the most trustworthy e-Assurances, the authors selected two areas typically linked to value computation as ROI, specifically those reported by Bartra, McGuire and Kable (2013): the ventral striatum (x = 12, y = 10, z = -6) and the pre-SMA (x = -2, y = 16, z = 46).

The e-Assurances psychologically perceived as less rewarding are likely to elicit an area that Bratra et al. (2013) reported to be associated with a penalty domain, namely the DMPFC (x = 4, y = 22, z = 44). The authors applied 10 mm spheres around those coordinates in the SVC analysis and carried out similar analysis with four ambiguous-related areas which were selected as ROI, namely the middle frontal gyrus (x = 28, y = 2, z = 60), superior frontal gyrus (x = 40, y = 40, z = 30), cingulate gyrus (x = -4, y = 22, z = 37) and inferior parietal gyrus (x = 12, y = -66, z = 61) based on the meta-analysis of mechanisms of risk and ambiguity in decision-making tasks carried out by Krain et al. (2006). Finally, 10 mm spheres were applied around the superior parietal gyrus (x = 30, y = -51, z = 55), precentral gyrus (x = 40, y = 5, z = 36) and anterior cingulate gyrus (x = -20, y = 39, z = 14) that were reported by Krain et al. (2006) to be involved with risky decision making. For regions other than those of *a priori* interest, the study reports the significant clusters at a stricter statistical threshold of $p < 0.001_{\text{uncorrected}}$ and a cluster extent k > 20 in line with other research in the field (Author1 et al., 2018) (see Appendix B for a detailed overview of the preprocessing and image acquisition procedures and see Appendix C for the main regions and functions of interest for risky and security processing).

4. Results

4.1. Self-report Results

The statistical software IBM Statistical Package for Social Sciences (IBM SPSS Version 20) served to evaluate trust, risk, purchase intentions and prices willing to pay for books accompanied by each type of e-Assurance. Paired-sample t-tests indicate that the trust conferred to books accompanied by seals of approval (mean = 5.03; SD = .95) yielded significantly more positive scores than the remaining e-Assurances (mean = 4.27; SD = 0.98) in general ($t(28) = 4.52$; $p < .001$), and specifically more than those accompanied by rating systems (mean = 4.48; SD = 1.4) and assurance statements (mean = 4.07; SD = 1.16). However, participants showed significantly lower levels of trust toward books accompanied by assurance statements than the joint results of the other e-Assurances ($t(28) = -3.02$; $p = .005$).

Along the same line, Paired-sample t-tests indicate that books accompanied by seals of approval elicited significantly lower levels of perceived risk (mean = 2.25; SD = 0.91) when compared to the joint results of the other e-Assurances (mean = 2.74; SD = 0.92), and specifically when compared to rating systems (mean = 2.63; SD = 1.18).

Following the tendency of perceived trust, participants also revealed significantly higher intentions to purchase books accompanied by seals of approval (mean = 6.00; SD = 0.65) as opposed to the other e-Assurances (mean = 5.13; SD = 1.01) in general ($t(28) = 5.12$; $p < .001$), and specifically, as opposed to rating systems (mean = 5.28; SD = 1.01) and assurance statements (mean = 5.00; SD = 1.22). The subjects also revealed significantly lower levels of purchase intentions toward books accompanied by assurance statements than the joint results of the other e-Assurances ($t(28) = -3.67$; $p < .001$).

Finally, Paired-sample t-tests indicate that participants were willing to pay higher prices for books accompanied by seals of approval (mean = 14.28 €; SD = 2.54 €) as opposed to the remaining e-Assurances conjointly analyzed (mean = 13.38€; SD = 2.40€; $p < .001$), and specifically when compared to assurance statements (mean = 13.01 €; SD = 2.92€).

4.2. Functional Imaging Results

Seals of Approval vs. Rating Systems and Assurance Statements

The whole brain analysis ($p_{uncorrected} < .001$, $k > 20$ voxels) indicates that clusters in the Rolandic operculum, calcarine, angular gyrus and SMA were more strongly activated in response to seals of approval vs. the remaining e-Assurances. When restricting this analysis to the ROIs (at an FWE-corrected threshold of $p < .05$) reported by Bartra, McGuire, and Kable (2013), Krueger et al. (2007) and Riedl et al. (2010), the previously hypothesized pre-SMA fell in line with that comparison (Figure **4A**). The opposite contrast (rating systems + assurance statements vs. seals of approval) revealed supra-threshold activations in the anterior cingulate (ROI's, Krain et al. 2006) and in the superior parietal and inferior parietal gyri for $p_{uncorrected} < .001$, $k > 20$ voxels. See Table 1 for all peak coordinates.

[Please, insert Table 1 about here]

Furthermore, when comparing seals of approval vs. rating systems, the ROIs striatum and septal area (among other regions that survived to the whole-brain analysis) show greater activation (Figure **4**B). The contrast seals of approval vs. statements, in turn, yielded more supra-threshold activations in the superior frontal gyrus for $p_{uncorrected} < .001$, k > 20 voxels. Table 2 lists all the peak coordinates.

[Please insert Figure **4** about here]

[Please insert Table 2 about here]

Assurance Statements vs. Seals of Approval and Rating Systems

The comparison of the assurance statements with the two remaining e-Assurances, and vice versa, did not yield any supra-threshold activations either at the whole brain or ROI level. Neither did the assurance statement vs. seals of approval contrast (American vs. Spanish products) reveal supra-threshold activations. Nevertheless, clusters in the previously hypothesized ROIs brainstem and ventral tagmental area showed significant activation when confronted with assurance statements, as opposed to rating systems at an FWE-corrected threshold of $p <.05$. The whole brain analysis of that contrast also revealed significant activations of the middle temporal and fusiform regions ($p < .001$ uncorrected, k > 20) (See Table 3 for an overview of all the peak coordinates).

[Please insert Table 3 about here]

Rating Systems vs. Seals of Approval and Assurance Statements

Among the other regions activated at the whole brain level, the comparison of ratings vs. seals of approval + assurance statements elicited an increase in activation in the ROIs as reported by Krain et al. (2006) in the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus at an FWE-corrected threshold of p <. 05 (Figure **5**; Table 4). Specifically, at the whole brain level, the contrast rating system vs. seals of approval reflected higher activations in the hypothesized ROIs DMPFC, superior parietal gyrus, precentral gyrus, middle frontal gyrus, cingulate gyrus and inferior parietal gyrus. The contrast rating systems vs. assurance statements also significantly activated the same coordinates of the ROI superior parietal gyrus, as well as other clusters found at the whole brain level. See the remaining peak coordinates in Appendix D and E.

[Please insert Figure **5** about here]

[Please insert Table 4 about here]

Relation between neural responses and trust, risk, purchase intention and price

Activation in the medial portion of the superior frontal gyrus (x = 3, y = 46, z = 47) during the evaluation of seals of approval minus rating systems covaried significantly (positively) with an incremental trust conferred to books accompanied by seals of approval over the same products with rating systems (r = .361; **p = .049**). Along the same line, the incremental intention reported toward the purchase of books accompanied by seals of approval versus rating systems was associated (r = .432; **p = .**

019) with the activation of the middle frontal gyrus (x = 38, y = 7, z = 61) during the evaluation of seals of approval (vs. rating systems).

The higher levels of perceived risk elicited by rating systems when compared to seals of approval were significantly linked (r = .357; **p =.044**) with an increase in activation in the thalamus (x = 17, y = -18, z = 2) during the evaluation of books accompanied by ratings as opposed to seals of approval.

Finally, activation in the medial superior frontal gyrus (x = -1, y = 46, z = 47) during the evaluation of products accompanied by seals of approval (vs. the remaining e-Assurances) covaried significantly (r = .443**; p = .016**) with an higher price conferred to books followed by the seals of approval (vs. the remaining e-Assurances).

A more liberal threshold was applied in this exploratory analysis since it enquires as to the most important brain 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. Figure **6** shows the associations of trust and risk scores with brain activations.

[Please insert Figure **6** about here]

5. Discussion

The growth in online transactions coupled with the worldwide increase in Internet-based information exchange and e-commerce is nowadays accompanied by consumer fear, distrust and high levels of perceived risk (Hille, Walsh, & Mark Cleveland 2015). As a consequence, online retailers are looking for ways to reduce ambiguity and increase trust, intentions, price willing to pay and actual purchases. E-commerce literature widely concurs on the positive impact that Web services exert on those variables. There is no consensus, however, on the relative effectiveness of different e-Assurances, namely seals of approval, rating systems and assurance statements. This is the first study that resorts to neurological and self-report tools to objectively examine this gap and ascertain the origin by which e-Assurance conveys more trust in a controlled purchase environment (i.e. low involvement environment) and hence lead to involvement of brain regions linked to reward and value computation. This research also assesses whether the corresponding areas elicited by e-Assurances can predict self-reported trust, risk, purchase intention and price willing to pay for products. The behavioral findings unveil that certificates provided by third-party vendors (i.e. seals of approval), as opposed to rating systems and assurance statements, yield a higher perception of trust, purchase intentions and price desiring to pay, as well as lower levels of perceived risk. The later, furthermore, constitute the web assurance that provokes lower perceived trust during the purchase of books. Interestingly, the fMRI scans reveal that: i) seals of approval give rise to stronger activation in value- and reward-related areas when compared to the other e-Assurances, but above all, when compared to rating systems; ii) assurance statements strongly elicit reward- and trust-related areas when compared to rating systems, and iii) rating systems provoke negative and ambiguous-related activations, showing higher levels when compared to seals of approval. This study also brings to light for the first time that higher perceived trust afforded to books accompanied by seals of approval was predicted by value-computation brain areas while evaluation of this e-Assurance, and higher perceived risk provided to rating systems (vs. seals of approval), correlated with areas involved with negative processing.

As regards self-report responses, this study infers that seals of approval yield a significantly more trustworthy online environment than other e-Assurances given the higher scores received in perceived trust. These findings line up with those of the studies of Nöteberg, Christiaanse and Wallage (2003) and Portz, Strong, and Sundby (2001) in that the presence of the web seal increases the perception of website trustworthiness. What is more, the lower levels of perceived risk, as well as the willingness to pay a higher price and purchase intentions afforded to books accompanied by seals of approval, corroborate the key role that the characteristics of the website play as an antecedent of valuation and purchase intentions toward online products (Featherman, & Pavlou 2003; Kim & Peterson 2017). In addition, participants did not show significant differences between trust, risk, price and purchase intentions toward products accompanied by assurance statements versus rating systems. This could suggest that the trustee sources of the retailer and previous customers may be similarly perceived. Consequently, it could be suggested that not all the external (e.g. customer opinions or seals) or all internal (e.g. privacy or return policies) e-Assurances exert the same impact on e-commerce outcomes, but depend on the source of the e-Assurance (contrary to the reasoning of Bahmanziari et al. 2009). Interestingly, when compared simultaneously to seals of approval and rating systems, assurance statements did provoke significantly lower scores in perceived trust, a notion in line with the findings of Pennington et al. (2003) and Lee and Turban (2001).

The neurological analyses carried out in this study amount to a step in the right direction as they reveal the underlying brain mechanisms that trigger trust and risk toward products accompanied by different e-Assurances. On the one hand, brain regions eliciting stronger activation during evaluation of seals of approval, as opposed to the remaining e-Assurances, include the pre-SMA at the ROI level, and the rolandic operculum, calcarine, angular gyrus and superior motor area at the whole-brain level. The role of the pre-SMA in value computation during decision making is largely evidenced as a great amount of research confirms that this brain area encodes the expected values of outcomes (Bartra, McGuire, & Kable 2013; Pisauro et al. 2017). The rolandic operculum is a part of the frontal lobe involved with preference judgements (Chaudhry et al, 2009). Together with the angular gyrus, the calcarine has been traditionally related to enhancements of endogenous attention to relevant information (Cate et al. 2009). These results are supported by the brain areas elicited by the reverse contrast (rating systems + assurance statements vs. seals of approval), namely the ROI anterior cingulate together with the middle temporal gyrus, as well as the superior and inferior parietal gyri. In the meta-analysis on decision-making, Krain et al (2006) indicate that the anterior cingulate is linked to risky decisions. The same authors also concluded that the inferior parietal gyrus is an ambiguous-related area whereas the superior parietal gyrus is more in line with risky tasks. Overall, these results suggest that the higher trust conferred to products accompanied by seals of approval (vs. the remaining e-Assurances, see section 4.1.) originates with higher expected values and attention paid to the third-party certificates, thus supporting **Hypothesis 1**.

More specifically, the analysis comparing seals of approval with rating systems and assurance statements, when considered individually, reveals that third-party certificates are far more trustworthy than rating systems given the activation in previously hypothesized ventral striatum and septal areas. In line with the findings of Bartra et al. (2013), previous studies exploring product preferences have shown that the ventral striatum is activated during anticipation of a pleasant primary taste reward (O'Doherty et al., 2002), as well as during the visualization of aesthetic packages. Furthermore, it is an area also known to encode the subjective value of a decision (Bartra et al., 2013) and constitutes a key element in trustworthy environments (e.g. Author2 2010). Krueger et al. (2007) resorted to an fMRI study to clarify if the brain regions critically involved in building a trust relationship. Their findings indicate that the septal area satisfies their purposes and is connected to reward and trust (Author2 2010; Reimann et al. 2011). The middle temporal gyrus, furthermore, is found to be activated in secure and safe circumstances (Matthews et al. 2004). Despite the higher scores that participants consciously conferred to products accompanied by seals of approval (when compared to assurance statements), brain data reveal that only one area, the superior frontal gyrus, is more strongly elicited by seals of approval vs. assurance statements. Previous research has also linked the left superior frontal gyrus to rewarding tasks (Rushworth et al. 2004). Taken together, these findings constitute a step forward as they evidence that despite the fact that seals of approval consciously yield more trust than rating systems and assurance statements, neural data reveal that brain activations related to reward and value computation are mostly found when contrasted to rating systems (i.e. to a lower extent when contrasting to assurance statements).

Interestingly, assurance statements only elicited greater brain activations when compared to rating systems. Particularly, the ROIs relate to reward and trust building, namely the brainstem (Bartra, McGuire & Kable 2013) and ventral tagmental (Krueger et al. 2013) respectively showed an increase in activation in response to the above contrast. The middle temporal and fusiform gyri also were strongly elicited at the whole brain level. The former is found to be activated in secure and safe circumstances (Matthews et al. 2004) while the latter is a visual area typically involved with endogenous attention (Cate et al., 2009). Accordingly, despite the fact that the self-report findings did not show significant differences between trust, risk, price and purchase intentions conferred to products accompanied by assurance statements versus rating systems, participants did reveal different types of processing of assurance statements and rating systems at the neurological level. The retailer's statement (vs. rating systems) conveyed a more positive online frame as it led to involvement of the brain regions linked to reward and attention.

Areas previously thought to be involved with the processing of risk, ambiguity and negative feelings (the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus) show greater activation in response to rating systems as opposed to the other e-Assurances (analyzed conjointly and individually), thus in line with **Hypothesis 2**. The DMPFC is widely linked to danger (Liddell et al., 2005) and penalty domains (Bartra, McGuire, & Kable 2013). In their meta-analysis on decision making, Krain et al. (2006) found the middle frontal gyrus and superior parietal gyrus to be strongly related to processing ambiguous stimuli. Similarly, the same authors concluded that the superior parietal gyrus and precentral show greater responses to risky tasks, findings that are bolstered by earlier research (Lin et al. 2015). In our study, the stronger activation in the risk, negative and ambiguity-related areas during rating systems (vs. seals of approval and vs. assurance statements) may be the reflection of a riskier online environment which could negatively affect the trust conferred to the retailer website and, consequently, to purchase intention. These findings are of great interest as neural data bring to light differences inaccessible at the conscious level between trust conveyed by rating systems and assurance statements.

The last goal of this study is to evaluate whether the areas elicited by e-Assurances predict self-reported trust, risk, purchase intention and price willing to pay for products. The findings indicate a consistent tendency: the higher scores of trust, price and purchase intentions afforded to products accompanied by seals of approval (vs. rating systems) were predicted by increases in areas previously involved with value encoding and reward such as the superior frontal gyrus, middle frontal gyrus or inferior frontal gyrus (Bartra, McGuire, & Kable 2013; Author1, Martínez-Fiestas and Author2, 2018). Higher levels of perceived risk elicited by rating systems when compared to seals of approval, in turn, were greatly linked to an increase in activation in the thalamus during the evaluation of books accompanied by ratings (vs. seals of approval). The thalamus is traditionally associated with risky and negative tasks (Aleman, & Swart 2008; Preuschoff, Bossaerts & Quartz 2006). The greater superior, middle and inferior frontal activation during seals of approval among participants who granted a higher level of trust, price and purchase intentions to the books accompanied by seals of approval in the current study may reflect a higher subjective value and preference for online environments which include seals of approval (vs. rating systems). This reasoning is supported by the covariation found between the thalamus and the higher scores of risk conferred to rating systems.

Theoretically, the current findings contribute to the literature challenging the effects of web assurances on trust building in online environments. Earlier studies along these lines focus on the impact of general external and internal e-Assurances on initial trust (Bahmanziari, Odom & Ugrin 2009), the influence of user review volume on consumer willingness-to-pay (Wu, Yinglu, & Jianan Wu 2016) and trust of different modalities of assurance statements such as privacy disclosure (Bansal et al. 2016), return policies (Wang et al. 2004) or ethical performance (Yang et al. 2009). To our knowledge, the study of Pennington et al. 2003 is the only paper that explores the effectiveness of the three most widely used e-Assurances. However, the lack of control of the stimuli (colors, shapes, number of letters) and of the type of involvement of the online purchase environment, together with the psychological nature of the processing of trust and risk associated with e-Assurances, indicate the need of further research to clarify the inconsistencies regarding the differences between the three types of e-Assurances. The current study constitutes a first step in this direction as it resorts to consumer neuroscience tools and controls for the number of letters, colors, type of retailer (fictitious) and involvement of the online marketplace. Unlike preceding studies resorting to self-report tools to generate data about the levels of trust/risk/purchase intentions triggered by different e-Assurances, the neuroscience techniques adopted by this study lead to reflections based on underlying cognitive, emotional, and social processes. Along this line, the current study advances that the higher levels of trust consciously conferred to products accompanied by seals of approval stem from the higher expected values, reward and attention triggered by the e-Assurance. Neurological tools also are known to offer evidence of the implicit processes (Author2 2010) present during the receipt of e-Assurances but inaccessible to conscious awareness. In this sense, the current study reveals differences at the brain level in the processing of assurance statements and rating systems, despite participants conferring similar levels of trust, risk and price to both e-Assurances. Finally, this paper constitutes a new step in the application of neurological tools to explore consumer processing of innovation technology constructs such as distrust (Author2 2010), usefulness and ease of use (Author2 et al. 2008). Hence, this study spells out the processing of trust, risk, ambiguity and reward conveyed by e-Assurances accompanying the purchase of low involvement products. **Table 5 illustrates the advance that neuroscientific tools offer over self-report techniques in measuring consumers' responses to assurance signals.**

[Please, insert Table 5 about here]

These findings offer remarkable managerial implications as they firstly indicate that the source of trust of web assurance is key to implement rewarding and satisfying online purchase environments (Pennington, Wilcox, & Grover 2003). They also offer evidence based on brain activations related to reward and value computation that assurance signals provided by external evaluators after checking the online retailer websites and related activities (i.e. seals of approval) trigger the highest trust and lowest risk. Hence the findings indicate the importance for e-retailers to make an accurate choice of a well-known and widely renowned website evaluator to act as a trustee (Hu et al. 2010). Secondly, the returns, privacy and security policies included by the retailer on the website (i.e. assurance statements) trigger less self-reported trust during the product evaluation when compared to seals of approval. As its inclusion does not elicit more negative-related brain activations (vs. seals of approval), it will not damage the trust of the online environment. Rating systems, however, not only are consciously perceived as riskier than other e-Assurances, but their inclusion, when compared to others, may elicit brain regions related to ambiguity and negativity during the purchase process. Taken together, professionals interested in selling online products should go to great lengths to discriminate between the assurance they include in their web site. The findings of this study therefore strongly recommend the inclusion of seals of approval in a highly visible place within web site as they may serve as an external reward that can benefit and encourage the overall purchasing process. Furthermore, the inclusion of assurance statements in conjunction with seals of approval will at least not be negative, and may in fact be beneficial to sales, when pertinent marketing strategies are implemented. Finally, more trustworthy signals should be considered by online retailers to include in the website together with e-Assurances. These include a proper e-payment system (Slade, Williams & Dwivedi 2013), personal innovativeness information (Kalinic & Marincovic 2016; Molinillo & Japutra 2017) or efficient seller accessibility (Wells, Joseph, & Hess 2011).

It must be taken into consideration that the current study only measured self-reported intentions and prices desiring to acquire products and not actual purchasing behavior. Although it is widely demonstrated that more positive intentions toward products are linked to an increase in purchase behavior (Ajzen, 1991), future research should link neural responses to product valuation with actual purchasing behaviors.

Secondly, and following previous research, this study only resorts to a low involvement purchase environment (i.e. books) to explore the effects of e-Assurances. Further research, in turn, should replicate the findings in high involvement frames and thus corroborate the key role of seals of approval in increasing online trust. Further research exploring the relative trust conveyed by different mechanisms (such as e-payments or website quality) is also needed to advance in the understanding of the effects of the web layout on trust building. **Finally, the brain inferences carried out in this paper should be received with caution due to the effect of the reverse inference problematic. Using the location of brain activations to infer the underlying mental processes (Plassmann, Venkatraman, Huettel, & Yoon, 2015) could be misleading as a brain region X could be activated by a cognitive process P, as well as other processes L, M, N. Similarly, a cognitive process P could trigger not only region X, but also regions W, Y and Z (so-called "reverse inference problem"). Despite performing an hypothesis-driven approach in the fMRI analysis constitutes an useful strategy to partially avoid the reverse inference problem (Poldrack et al., 2017; Weber et al., 2015), the reader should be careful when generalizing the conclusions of the current paper. The replication of this study in different (online) purchase environments could aid at corroborating the current findings.**

Despite the large amount of literature analyzing the effects of web assurances on trust building in online environments, it is surprising to observe how most studies omit comparing the effectiveness of the three most widely spread e-Assurances in controlled online environments. This is the first study that applies a multimethodological approach to face this research gap and advances that seals of approval are the most trustworthy assurance service due to the increase in expected values and reward they induce during product valuation. By contrast, the other e-Assurances, when compared with rating systems, are perceived as riskier as they psychologically convey ambiguity and negative processes during the online purchase. Therefore, this exploratory study constitutes an advance in the understanding of the origin of trust and risk induced by e-commerce web sites and marks the first step in revealing the effects of e-Assurances by the use of more objective neurological tools.

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Table 1.
Brain regions revealing different activations in response to the conjoint analysis of seals of approval and the other e-Assurances.

Seals of approval	Peak MNI coordinates (mm)			Cluster size	T	Study
	x	y	z			
Seals of approval > Rest						
ROIs [a]						
Pre-SMA	-2	16	46	3	3.72	Bartra, McGuire, & Kable (2013)
Whole brain [b]						
Rolandic operculum	45	-4	9	271	7.89	
Calcarine	10	-88	-6	110	6.59	
Angular gyrus	-36	-63	44	92	6.18	
Superior motor area	-5	0	58	181	5.72	
Rest > Seals of approval						
ROI [a]						
Anterior cingulate	-20	39	14	5	4.14	Krain et al. (2006)
Whole brain [b]						
Superior parietal	-26	-46	72	20	4.57	
Inferior parietal	55	-35	51	21	4.53	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 20$ voxels are reported.

Table 2.

Brain regions revealing different values of activation in response to seals of approval as opposed to rating systems (as compared to assurance statements).

a

Seals of approval	Peak MNI coordinates (mm)			Cluster size	T	Study
	x	y	z			
Seals of approval > Rating systems						
ROIs [a]						
Striatum	12	6	-8	3	3.94	Bartra, McGuire, & Kable (2013)
Striatum	12	10	-6	4	3.94	Bartra, McGuire, & Kable (2013)
Septal area	1	2	-4	2	3.94	Krueger et al. (2007)
Whole brain [b]						
Middle temporal gyrus	-57	-42	9	185	5.77	
Middle temporal gyrus	59	-11	-13	43	4.45	
Seals of approval > Assurance Statements						
Whole brain [b]						
Superior frontal gyrus	-15	32	58	20	3.89	

Peaks reported are significant at p <.05 FWE-corrected on ROI level.

[b] Peaks of clusters significant at p <.001 uncorrected, k > 20 voxels are reported.

Table 3.
Brain regions revealing different activations in response to assurance statements vs. rating systems.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Assurance statement > Rating systems						
ROIs [a]						
Brainstem	-2	-22	-12	3	3.81	Bartra, McGuire, & Kable (2013)
Ventral tagmental area	2	-20	-13	3	3.81	Krueger et al. (2007)
Whole brain [b]						
Middle temporal gyrus	59	-11	-13	85	6.04	
Fusiform gyrus	-40	-39	-20	39	5.60	

[a] Peaks reported are significant at p <.05 FWE-corrected on ROI level.
[b] Peaks of clusters significant at p <.001 uncorrected, k > 20 voxels are reported.

Table 4.
Brain regions revealing different activations in response to rating systems as opposed to the results of the conjointly analysis of the other e-Assurances.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Rating systems > Rest						
ROIs [a]						
DMPFC	4	22	44	10	4.04	Bartra, McGuire, & Kable (2013)
Superior parietal gyrus	30	-51	55	55	6.30	Krain et al. (2006)
Precentral gyrus	40	5	36	33	5.27	Krain et al. (2006)
Middle frontal gyrus	28	2	60	11	4.33	Krain et al. (2006)
Whole brain [b]						
Middle occipital gyrus	31	-91	12	1559	8.07	
Inferior parietal gyrus	-33	-46	44	83	6.39	
Precentral	52	11	37	77	5.48	
Precuneus	-19	-70	47	35	4.61	

[a] Peaks reported are significant at p <.05 FWE-corrected on ROI level.
[b] Peaks of clusters significant at p <.001 uncorrected, k > 20 voxels are reported.

Table 5.
Illustration of the advance that neuroscientific results offer over self-report findings in measuring consumers' responses to assurance signals.

Effect on consumers / e-Assurance	Seals of approval	Rating systems	Assurance Statements
SELF-REPORT			
Risk	+	+++	+++
Trust	+++	++	++
Willingness to pay	+++	++	++
Intentions to purchase	+++	++	++
NEURAL CORRELATES			
Underlying brain mechanisms	**Reward** and **trust** when compared to rating systems and assurance statements	**Risk, negativity** and **ambiguity** when compared to seals of approval and assurance statements	**Risk, negativity** and **ambiguity** when compared to seals of approval **Reward** and **trust** when compared to rating systems

Note: Based on the results of the current study, "+" refers to low means scores, "++" involves medium means scores, and "+++" indicates higher means scores given by participants in the questionnaire to the risk, trust, willingness to pay and intentions to purchase in relation to each e-assurance.

Figure 1. Illustration highlighting the effects of the main available tools for online vendors on consumers' reactions [1.5-column fitting image]

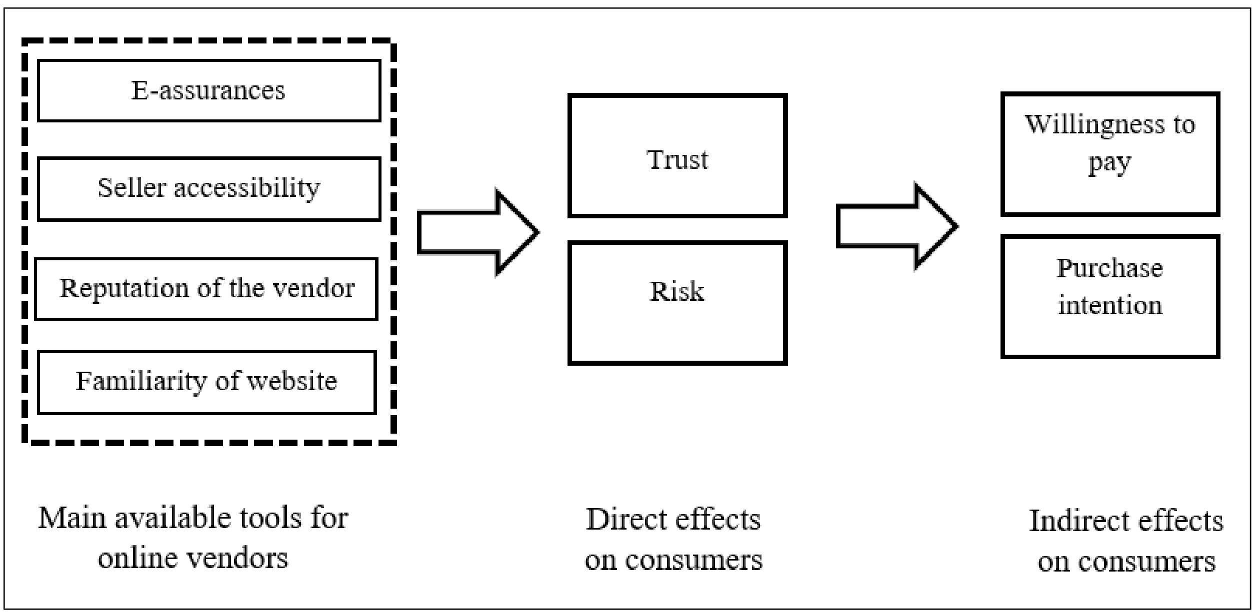


Figure 2. Theoretical framework linking brain activity with trust, risk, willingness to pay and purchase intentions [2-column fitting image]

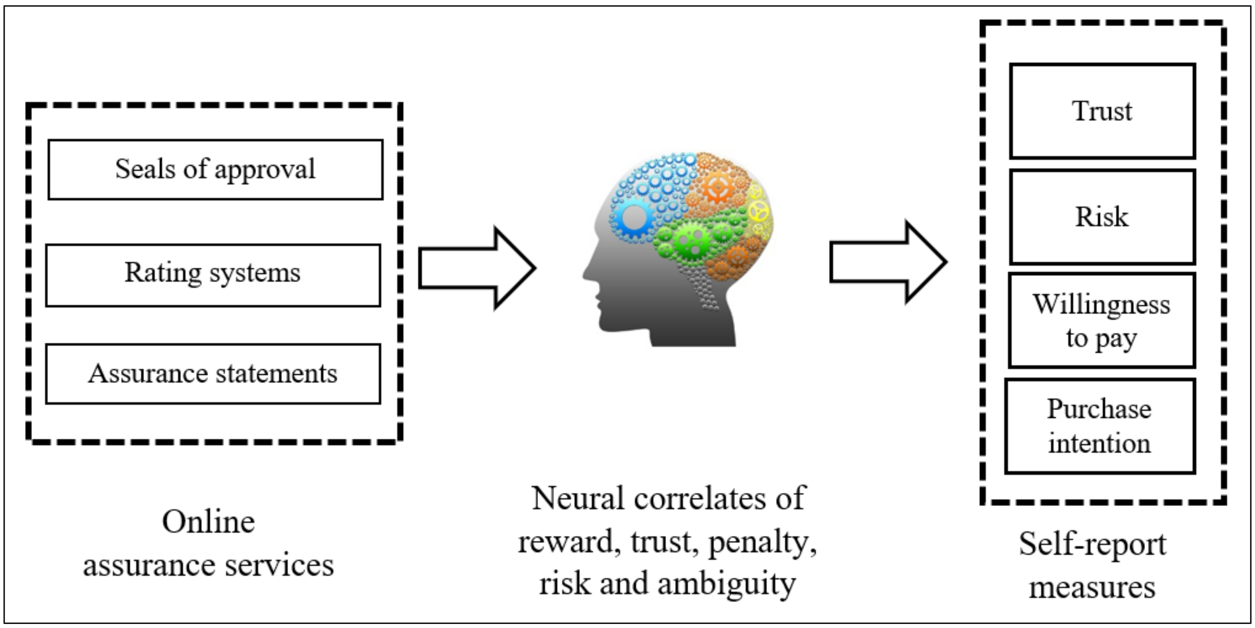


Figure 3. Depiction of the experimental design of the fMRI task. The order corresponds to the first block of trials. The order of the subsequent trials is random and counterbalanced. [2-column fitting image]

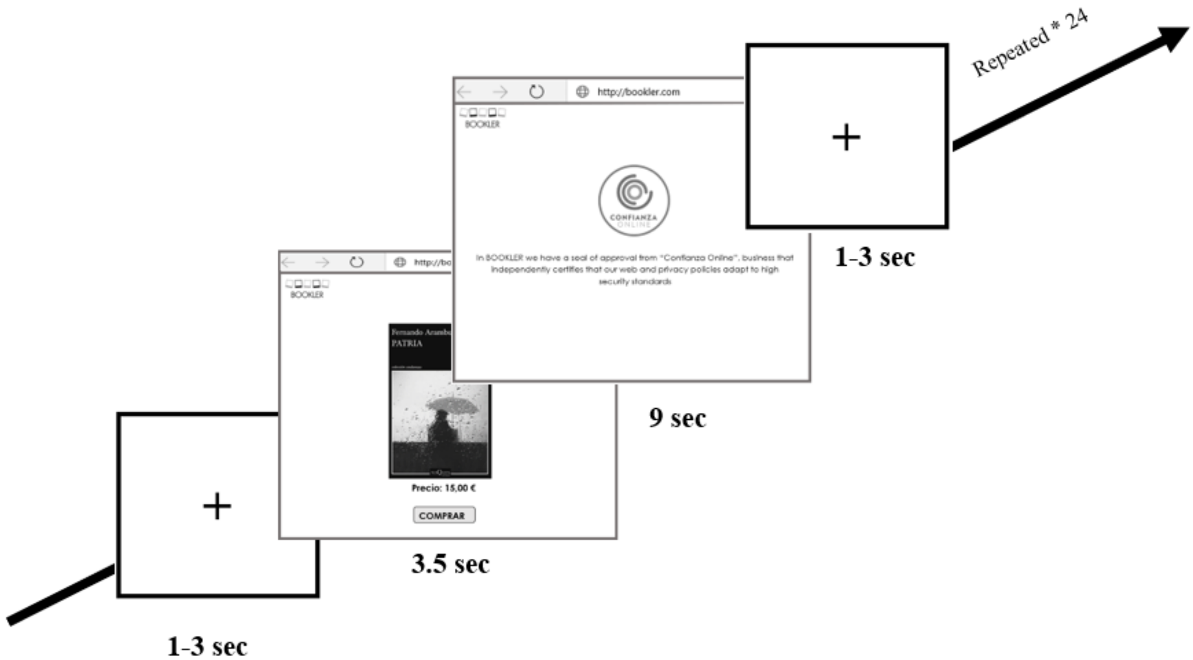


Figure 4. Main effect of the evaluation of book websites accompanied by Seals of Approval. A) view of the increase of activity in the pre-MSA (ROI analysis), the rolandic operculum, calcarine, angular gyrus, superior motor area and inferior parietal gyrus (whole brain analysis) at the moment of Seals of Approval vs. the other e-Assurances; B) view of the increase in activation in the striatum and septal areas (ROI analysis) and middle temporal areas (whole brain analysis). The images are depicted at T-map thresholded at $p < .001_{\text{uncorrected}}$, superimposed on the mean anatomical image of all subjects (MNI-space).

[1.5-column fitting image]

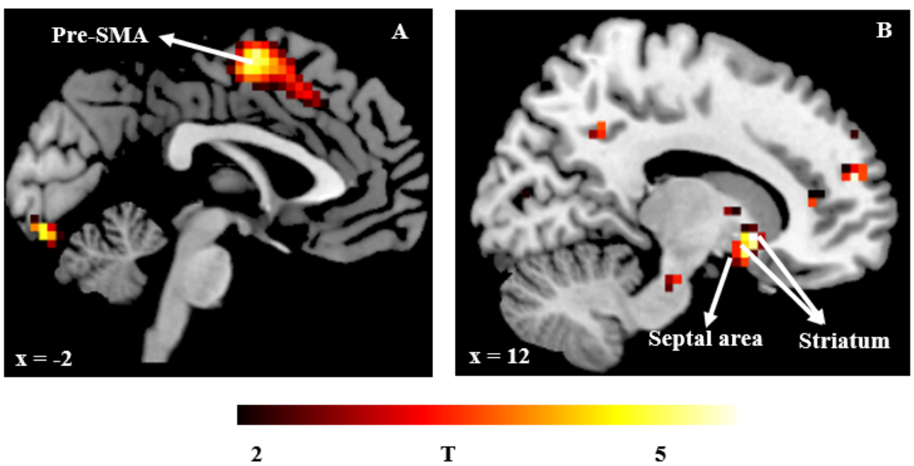


Figure 5. Main effect of the evaluation of book websites accompanied by Rating Systems. An increase of activity is recorded in the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus (ROI analysis) as well as in the middle occipital gyrus, inferior parietal gyrus, precentral and precuneus (whole brain analysis) when rating systems, as opposed to evaluation of the other e-Assurances. The image is depicted at T-map thresholded at $p < .001_{\text{uncorrected}}$, superimposed on the mean anatomical image of all subjects (MNI-space).

[1.5-column fitting image]

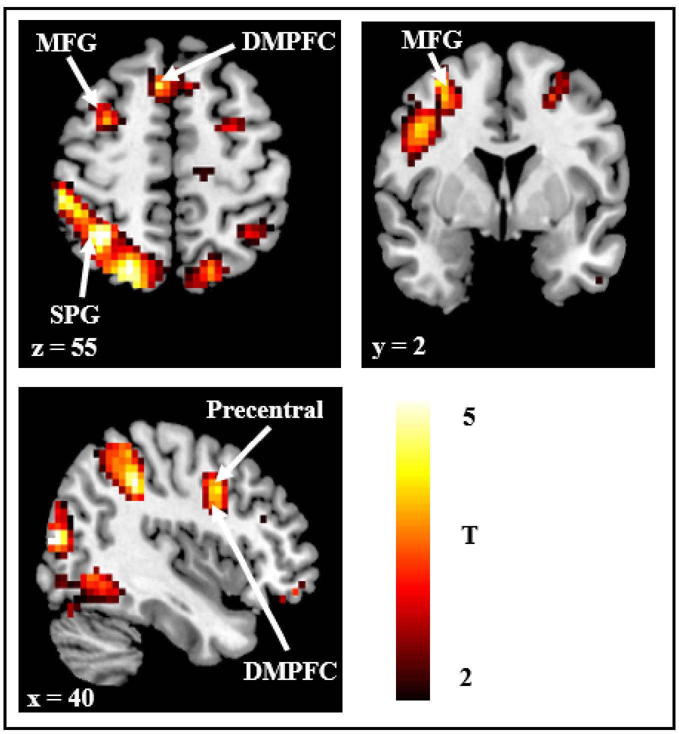
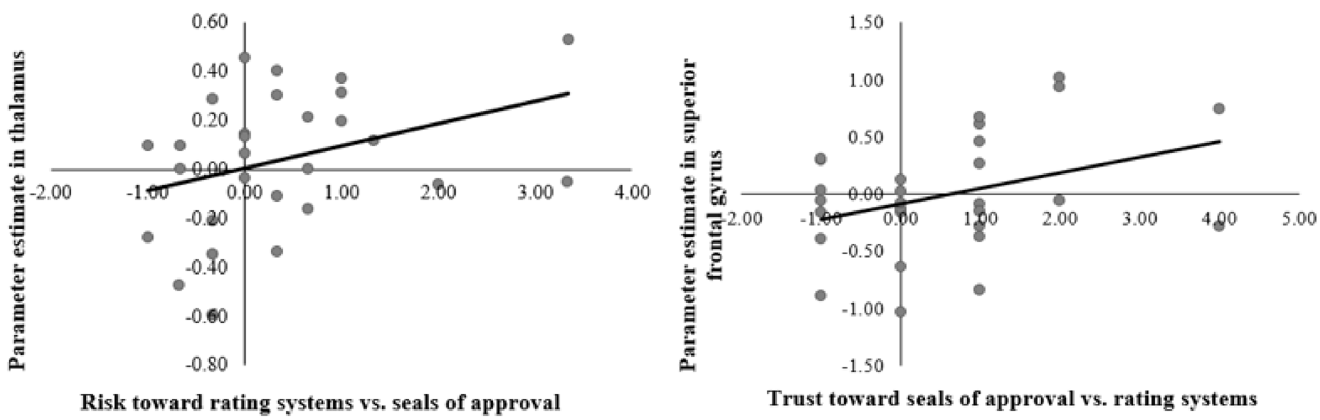


Figure 6. Relation between neural responses and trust and risk scores. **(A)** Plot of the correlation between the parameter estimate of rating systems vs. seals of approval in the thalamus cluster and differences between the levels of perceived risk between rating systems and seals of approval; (B) Plot of the correlation between the parameter estimate of seals of approval vs. rating systems in the superior frontal gyrus cluster and the differences between levels of perceived trust between seals of approval and rating systems.

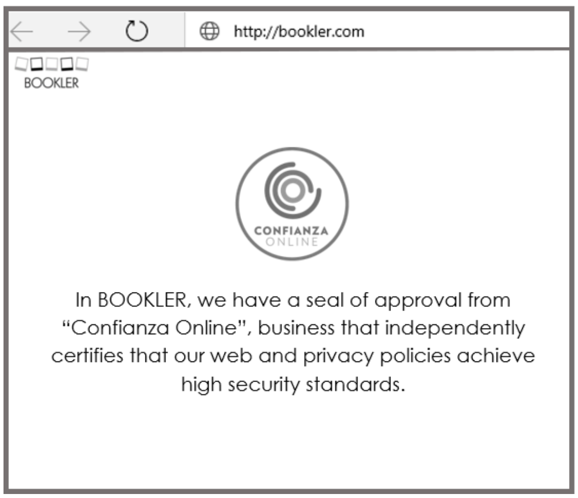
[2-column fitting image]



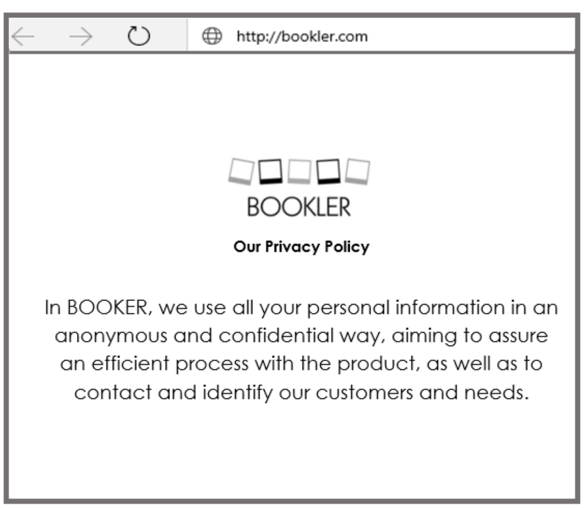
Appendices

Appendix A. e-Assurances

A. Seals of Approval ("Confianza Online")



B. Assurance statement



C. Rating systems

Appendix B. fMRI Data Acquisition and Preprocessing

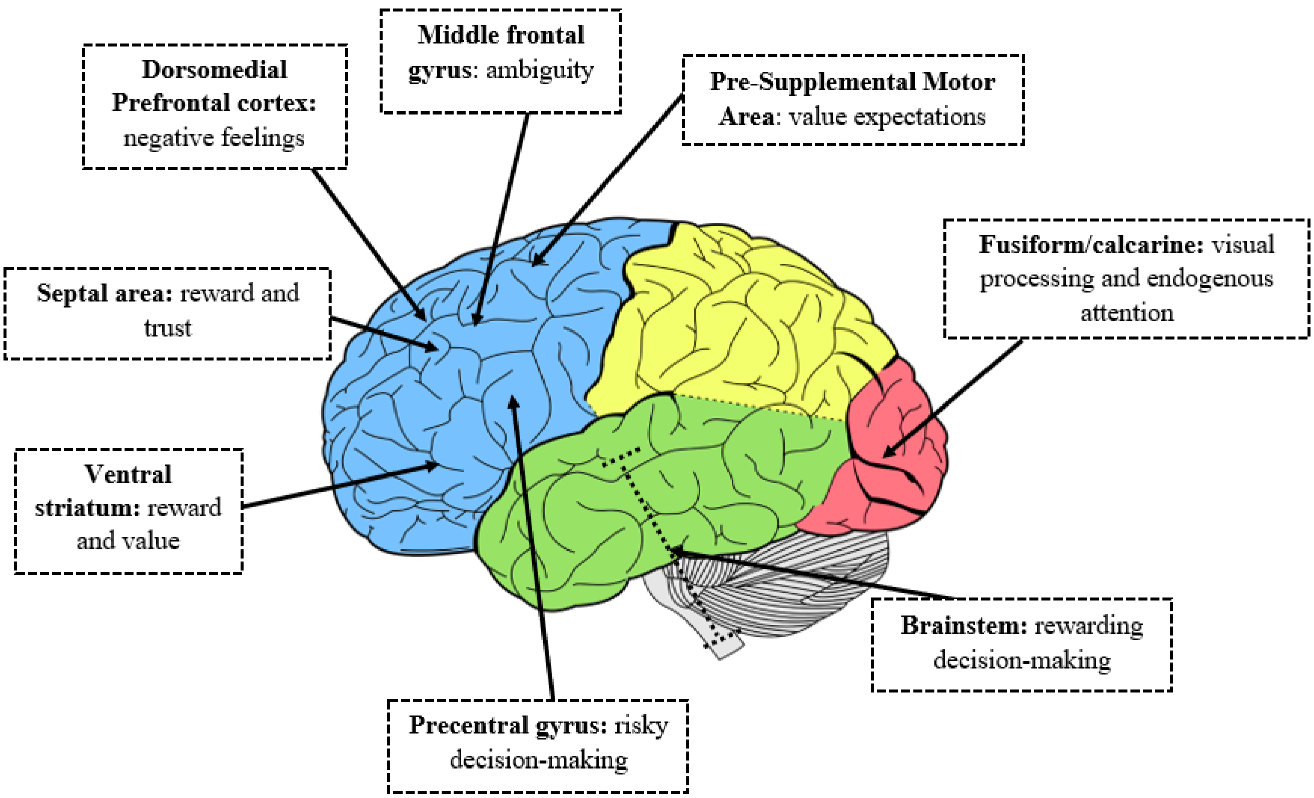
MRI scanning was carried out in a 3 Tesla Trio Siemens Scanner equipped with a 32-channel head coil. The structural image T1 was acquired by a 3D MP-RAGE sequence with a sagittal orientation and a 1 mm x 1 mm x 1 mm voxel size (TR = 2300 ms, TE = 2.96 ms). Functional scans were acquired with a T2*-weighted echo-planar imaging (EPI) sequence (TR = 2000 ms, TE = 25 ms, flip angle 90° and a plane reduction of 3.5 x 3.5 x 3.5 mm corresponding to the slice thickness, slice order: descending). The distance factor was 20% so as to attain a total of 35 slices, a slice matrix of 64 x 64 mm, and a field of view of 238 mm with an axial orientation. The task resulted in the acquisition of a total of 1090 functional scans.

The data were preprocessed and analyzed using Statistical Parametric Mapping software (SPM12, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) run with MATLAB R2012a (The MathworksInc, Natick, MA). Default settings were used unless stated otherwise. To allow stabilization of the BOLD signal, the first seven volumes (14 seconds with a "cross" on the screen) of each run were discarded prior to analysis. Corrections were then applied by means of interpolation as to the differences in the time of slice acquisition with the initial slice serving as the reference. Functional images were realigned to the first image of the time series. Functional and structural images were co-registered and normalized (retaining 3.5 x 3.5 x 3.5 mm voxels) according to the Montreal Neurological Institute (MNI) template. Finally, functional images were smoothed with the Gaussian kernel (FWHM = 7 mm). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined.

Appendix C.

Main regions and functions of the brain of interest to the e-Assurances processing.

Blue: frontal lobe; green: temporal lobe; yellow: parietal lobe; red: occipital lobe.



Appendix D. Brain regions revealing different activations in response to rating systems as opposed to seals of approval.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Rating systems > Seals of approval						
ROIs [a]						
DMPFC	4	22	44	28	5.12	Bartra et al. (2013)
Superior parietal gyrus	30	-51	55	55	6.34	Krain et al. (2006)
Precentral gyrus	40	5	36	53	5.42	Krain et al. (2006)
Middle frontal gyrus	28	2	60	22	4.91	Krain et al. (2006)
Cingulate gyrus	-20	39	14	10	4.10	Krain et al. (2006)
Inferior parietal gyrus	-33	-46	44	58	5.23	Krain et al. (2006)
Whole brain [b]						
Occipital gyrus	24	-95	2	1658	8.07	
Precentral gyrus	45	7	37	184	5.42	
Superior motor area	3	21	47	54	5.12	
Inferior triangulus frontal gyrus	38	32	23	23	4.28	

[a] Peaks reported are significant at $p <.05$ FWE-corrected on ROI level.
[b] Peaks of clusters significant at $p <.001$ uncorrected, $k > 20$ voxels are reported.

Appendix E. Brain regions revealing different activations in response to rating systems as opposed to assurance statements.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Rating systems > Assurance Statements						
ROIs [a]						
Superior parietal gyrus	30	-51	55	38	5.57	Krain et al. (2006)
Whole brain [b]						
Middle occipital gyrus	27	-91	12	464	7.22	
Fusiform	-26	-74	-9	298	6.62	
Inferior parietal	27	-56	44	194	6.15	
Inferior temporal	48	-56	-9	22	4.28	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.
[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 20$ voxels are reported.