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ARE THERE NEURAL GENDER DIFFERENCES IN ONLINE TRUST? AN FMRI STUDY ON THE PERCEIVED TRUSTWORTHINESS OF EBAY OFFERS[1]

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Abstract

Research provides increasing evidence that women and men differ in their decisions to trust. However, information systems research does not satisfactorily explain why these gender differences exist. One possible reason is that, surprisingly, theoretical concepts often do not address the most obvious factor that influences human behavior: biology. Given the essential role of biological factors—and specifically those of the brain—in decisions to trust, the biological influences should naturally include those related to gender. As trust considerations in economic decision making have become increasingly complex with the expansion of Internet use, understanding the related biological/brain functions and the involvement of gender provides a range of valuable insights.

To show empirically that online trust is associated with activity changes in certain brain areas, we used functional magnetic resonance imaging (fMRI). In a laboratory experiment, we captured the brain activity of 10 female and 10 male participants simultaneous to decisions on trustworthiness of eBay offers. We found that most of the brain areas that encode trustworthiness differ between women and men. Moreover, we found that women activated more brain areas than did men. These results confirm the empathizing– systemizing theory, which predicts gender differences in neural information processing modes.

In demonstrating that perceived trustworthiness of Internet offers is affected by neurobiology, our study has major implications for both IS research and management. We confirm the value of a category of research heretofore neglected

in IS research and practice, and argue that future IS research investigating human behavior should consider the role of biological factors. In practice, biological factors are a significant consideration for management, marketing, and engineering attempts to influence behavior.

Keywords: Online trust, trustworthiness, functional magnetic resonance imaging (fMRI), gender, eBay

Introduction

Since the days of ancient civilizations, and continuing as modern societies have emerged, trust has played a key role in the prosperous existence of human society (Gambetta 1988; Luhmann 1979). Trust pervades human society in many domains, ranging from friendship to politics. Most notably, trust is central for successful economic exchange (Zak and Knack 2001). In particular, trust is important for economic prosperity in post-modern societies, where an increased emphasis on technologies heightens a perception of complex and uncertain economic relationships (Resnick and Zeckhauser 2002).

Against this background, it is no surprise that during the last decade an increasing number of technology and information systems studies focusing on trust have been published (e.g., from Hoffman et al. in 1999 to Kim et al. in 2009). Trust has typically been conceptualized as an attitude, belief, intention, or behavior in the existing IS literature (McKnight and Chervany 2001). As a consequence, the existing body of knowledge is primarily focused on the behavioral level of analysis.

In the present article, we borrow concepts, methods, and theories from biology (more precisely, from neuroimaging and neurobiology) in order to gain new insights into trust. In this way, our study adds a significant and expanded view to the question of the nature of trust in IS research. Our approach is in line with other research in human trusting behavior that addresses the role of genes (e.g., Cesarini et al. 2008), hormones (e.g., Kosfeld et al. 2005; Zak et al. 2005), and neurology (e.g., Baumgartner et al. 2008; King-Casas et al. 2005). The ultimate goal of these biological research streams is to explain a maximum of the variance of human trusting behavior (Fehr and Camerer 2007; Kenning and Plassmann 2005).

The present study examines gender differences in online trust. In particular, we investigate the following research question: *Are there neural gender differences in online trust?* This question explicitly addresses (1) the different brain areas that women and men activate in online trust situations and (2) whether women and men utilize a varying number of brain areas.

This research topic is important for a number of reasons. First, IS research has found notable gender effects in IT perception and usage (Gefen and Ridings 2005; Gefen and Straub 1997; Venkatesh and Morris 2000). More recent empirical evidence shows that these differences apply to online trust as well (Awad and Ragowsky 2008). Therefore, understanding how these differences relate to brain activity could shed light on why and how these gender differences occur.

A second foundation for this study focuses on gender as a variable that can be easily integrated into the management of information and communication systems. Hence, if our study reveals neurobiological gender differences in online trust, this knowledge could yield fruitful insights for IT managers, engineers, and marketers. If, for example, the female and male brain process online offers differently (resulting in varying trust levels), and with the knowledge that most Internet platforms identify the gender of registered users, then offers could be tailored to gender-specific requirements in order to increase perceived trustworthiness. A case in point would be developing Internet sites with real-time interface adaptation capacities (e.g., with respect to such factors as content, information presentation, or color) based on the user's gender (Simon 2001; Stenstrom et al. 2008).

A third rationale for our research topic, posing a particularly promising argument, is the key role of gender as a variable in neuroscience research (Bell et al. 2006; Cahill 2006; Cosgrove et al. 2007; Haier et al. 2005). The success of our study, therefore, could indicate an opportunity for neuroscientific findings on human behavior to be integrated into IS research.

Perhaps the strongest reason for choosing this research topic is to use a neurobiological focus to add a new theoretical explanation for the existence of gender-specific differences in IT-related behavior to the current body of literature (e.g., Gefen and Ridings 2005; Gefen and Straub 1997; Venkatesh and Morris 2000). Altogether, our approach is in line with that of the limited number of published NeuroIS papers (Dimoka and Davis 2008; Dimoka et al. 2007), and with that of Gefen et al. (2008), who state that "the trust literature in online environments can substantially benefit from the neuroscience literature and functional neuroimaging studies" (p. 283). In this sense, our study aims to build a bridge between the predominantly independent research fields of IS and neurobiology.

Against this background, the remainder of this paper is structured as follows. In the literature review, we begin with a brief overview of gender differences in general trust behavior. Next, we outline studies focused on general gender differences in the IT realm, before discussing important (though more limited) literature that is focused specifically on gender differences in online trust and related behaviors (e.g., risk perception). In addition to the behavioral literature, we present neuroscience knowledge on gender differences in brain anatomy and functioning. The hypotheses that follow are based on both behavioral and neuroscience work, and are the core concepts that we investigated through functional brain imaging. The next section describes the research methodology in detail. An outline of the research results precedes a more thorough analysis of the results, wherein we connect the IS literature with the neuroscience literature. Finally, we summarize our findings, outline implications, present limitations, and provide concluding comments.

Literature Review and Hypotheses

The expansion of the role of the Internet has led to a recent identification of trust in online environments as a central IS research topic (Steininger et al. 2009). Several research streams have been developing, particularly investigation into (1) trust in virtual teams (e.g., Gallivan 2001; Jarvenpaa et al. 2004; Paul and McDaniel 2004; Piccoli and Ives 2003); (2) trust in interorganizational collaboration (e.g., Allen et al. 2000; Gallivan and Depledge 2003; Nicolaou and McKnight 2006; Welty and Becerra-Fernandez 2001); (3) trust in e-government (e.g., Carter and Belanger 2005; Grimsley and Meehan 2007; Horst et al. 2007; Teo et al. 2008); (4) trust in IT artifacts such as recommendation agents or avatars (e.g., Komiak and Benbasat 2006; Qiu and Benbasat 2005; Vance et al. 2008; Wang and Benbasat 2008); (5) trust in virtual worlds and virtual communities (e.g., Fogel and Nehmad 2009; Johnson and Kaye 2009; Junglas et al. 2007; Oxendine et al. 2003); and, finally, (6) trust in e-commerce (e.g., Ba and Pavlou 2002; Gefen et al. 2003; McKnight et al. 2002a; Pavlou and Gefen 2004).

However, given the focus of the present study, we limit our literature review to gender differences in general trust behavior, general gender differences in the IT realm, and gender differences in online trust and related behaviors (e.g., online shopping risk perceptions). In addition to these gender differences on the behavioral level of analysis, we also discuss gender differences in brain anatomy and functioning. Drawing upon both behavioral and neurological gender research, we deduce two main hypotheses (Hypotheses 1 and 2) and seven sub-hypotheses (Hypotheses 1.1 through 1.7).

Gender Differences in General Trust Behavior

With respect to the literature on trusting others, both survey results and experimental findings show that, in general, *men trust more than do women*. Several surveys found evidence that women are less likely to believe that "most people can be trusted" (Alesina and La Ferrara 2002; Glaeser et al. 2000; Terrell and Barrett 1979). A number of investigations in experimental economics support those findings, concluding that men are more trusting than women. The determination is based on results showing that men sent more money to their opponents in economic games, thereby being more vulnerable to the action of the other party (e.g., Buchan et al. 2008; Snijders and Keren 1999).

In the literature investigating the concept of trusting others in view of gender, empirical evidence shows that, in general, *women are more trusted than are men*. A study of psychological attitudes, using Rotter's (1967) interpersonal trust scale, revealed greater trust toward women than toward men (Wright and Sharp 1979). Moreover, in a study focused on economic behavior, male clients were believed to be less trustworthy than female clients (Shaub 1996).

With respect to a determination that one gender is more trustworthy than the other, both institutional arrangements and scientific evidence indicate that, in general, *women are more trustworthy than men*. *The New York Times* reported that teams of female traffic police were formed in Mexico City, in the belief that female officers are less likely to take bribes. When asked about the reason for this unorthodox arrangement, the police chief responded simply, "I trust them," illustrating the view that women are more trustworthy than men (Treaster 1999). Scientific research corroborates both the notion that women are less likely to take bribes, and the belief that corruption is negatively correlated with the rate of female participation in the public domain (Dollar et al. 2001; Swamy et al. 2001). In line with these results, experimental evidence from economic games shows that women reward trust through financial reciprocation more often than do men, hence, being more trustworthy (Buchan et al. 2008; Croson and Buchan 1999; Snijders and Keren 1999). Table 1 summarizes the studies that investigate gender differences in general trust behavior.

General Gender Differences in the IT Realm

In the IT realm, a substantial number of empirical studies document gender differences in, for example, the use of computers and the Internet, attitudes toward computers, levels of computer anxiety, computer skills, perceptions of communi-

Table 1. Gender Differences (Summary of Literature Review)

Gender differences in general trust behavior	***Sources***
Men trust more than do women.	Alesina and La Ferrara (2002), Buchan et al. (2008), Glaeser et al. (2000), Snijders and Keren (1999), Terrell and Barrett (1979)
Women are more trusted than are men.	Shaub (1996), Wright and Sharp (1979)
Women are more trustworthy than men.	Buchan et al. (2008), Croson and Buchan (1999), Dollar et al. (2001), Snijders and Keren (1999), Swamy et al. (2001), Treaster (1999)
General gender differences in the IT realm	***Sources***
Women and men differ in their perceptions of communication technologies such as virtual communities and e-mail.	Gefen and Ridings (2005), Gefen and Straub (1997)
Computer usage decisions of women are more strongly influenced by a system's ease of use, whereas men's decisions are more strongly influenced by usefulness.	Venkatesh and Morris (2000)
Men use computers and the Internet more often than women.	Seybert (2007)
Women feel less competent and comfortable with the computer and the Internet than men.	Schumacher and Morahan-Martin (2001)
Women exhibit more negative attitudes toward computers and the Internet than men.	Broos (2005)
Women exhibit higher levels of computer anxiety than men.	Broos (2005), Jackson et al. (2001)
More men than women study computer science, are employed in computing jobs, and work in IT-related academic disciplines such as computer science.	Frenkel (1990), Seybert (2007), Van Welsum and Montagnier (2007)
More men than women have basic computer skills.	Seybert (2007), Van Welsum and Montagnier (2007)
Women acquire their computer skills differently than men, that is, they learn from colleagues and friends or from learning-by-doing rather than in formal courses.	Van Welsum and Montagnier (2007)
Women use computers and the Internet for different reasons than men; for example, they search online for health information, and send and receive e-mails, rather than playing games or downloading software.	Jackson et al. (2001), Van Welsum and Montagnier (2007), Weiser (2000)
Women and men differ in their Internet acceptance and usage patterns.	Sánchez-Franco (2006)
Significant gender differences do exist in perceptions of website design and website satisfaction.	Cyr and Bonanni (2005)
Gender differences in online trust and related behaviors	***Sources***
Men are more likely to intend to use the Web for making purchases than women. Men rate the trustworthiness of Web shopping higher, and its complexity lower, than do women.	Van Slyke et al. (2002)
Women are more likely to cue into the more detailed aspects of an online shopping website than men, relying on the extent to which those cues affect them emotionally and drive them.	Rodgers and Harris (2003)
Women, in contrast to men, perceive a higher level of risk in online shopping. Having a website recommended by a friend leads to both a greater reduction in perceived risk and a stronger increase in willingness to buy online for women than for men.	Garbarino and Strahilevitz (2004)
Women perceive a greater risk (i.e., privacy concerns) than do men in online shopping.	Sheehan (1999)
Men are more convenience-oriented and less motivated by social interaction than women in online shopping.	Swaminathan et al. (1999)
Whereas socio-psychological and emotional factors are more important for women than functional concerns in conventional buying, this order reverses when women buy online. Moreover, the functional factors, which have always played an important role for men, are even amplified in the shift from conventional buying to online shopping.	Dittmar et al. (2004)
Men exhibit more positive beliefs about and more positive attitudes toward Web advertising. Men are more likely than women to purchase from the Web, although women are more likely to surf the Web for shopping reasons.	Wolin and Korgaonkar (2003)
The influence of trust on commitment and of commitment on loyalty is stronger for women than men, while the effects of satisfaction on commitment and of trust on loyalty are stronger for men than for women.	Sánchez-Franco et al. (2009)
The effect of trust on intention to shop online is stronger for women than for men. Women value the responsive participation of other consumers to the content they have posted in online word-of mouth systems, whereas men value their ability to post content. (In online word-of-mouth systems, consumers can rate products offered for sale.)	Awad and Ragowsky (2008)

cation technologies such as e-mail, and perceptions of website design. Table 1 summarizes studies from various disciplines (e.g., psychology, marketing, IS) that investigate general gender differences in the IT realm.

In the IS discipline, important milestones in gender research have been set by Gefen and Straub (1997), as well as by Gefen and Ridings (2005); both papers investigate gender differences in the perception and use of communication technologies (e-mail and virtual communities). Major findings revealed by these studies are that women and men differ in their perceptions of e-mail, but not in their actual use of e-mail (Gefen and Straub 1997), and that in virtual communities men communicate to establish superior social standing, while women communicate with an undertone of rapport, compassion, and empathy (Gefen and Ridings 2005). These differences affect the respective perceptions of community quality for men and women. Another influential gender study, conducted by Venkatesh and Morris (2000), investigated differences between men and women in the adoption and use of technology. The study's primary finding is that computer usage decisions of women are more strongly influenced by a system's ease of use, whereas men's decisions are more strongly influenced by usefulness. Building from this research, the following section focuses on gender differences in online trust and related behaviors (e.g., online shopping risk perceptions).

Gender Differences in Online Trust and Related Behaviors

Extensive investigation revealed a very limited number of published studies dealing with gender differences in online trust and related behaviors, indicating an area with significant potential for research. Most notably, the articles we discuss here can be considered as a body of highly fragmented work published in varied fields of research (primarily in IS, marketing, and psychology) and are, thereby, hardly cumulative in nature. Nevertheless, these articles constitute a valuable empirical base for the present study, particularly because the findings substantiate significant gender differences that are important to the focus of our paper.

One study (Van Slyke et al. 2002) investigating gender differences in perceptions of Web-based shopping determined that men, in contrast to women, are more likely to use the Web with intent to make purchases. Their study also found that men's perceptions of the characteristics of Web shopping are more favorable than are women's perceptions. Specifically, men rated the trustworthiness of Web shopping higher, and gave lower ratings to its complexity, than did women in the study.

Another study (Rodgers and Harris 2003) investigated the reasons why women are less satisfied than men with the online shopping experience. The findings indicate that emotion, trust, and convenience are predictors of both women's dissatisfaction with online shopping and men's satisfaction with shopping online, and are predictors of the actual shopping behaviors of men and women. Moreover, the study determined that women, in contrast to men, are more likely to cue into the more detailed aspects of a Web site, relying on the extent to which those cues affect them emotionally and drive them. Conversely, the study found that men are more likely to consider a shopping site in terms of a general attitude than are women, indicating that affective cues do not drive male behavior as much as they do the behavior of women.

In a study investigating the perceived risk of buying online, Garbarino and Strahilevitz (2004) found that, in contrast to men, women perceive a significantly higher likelihood of negative outcomes in online shopping (e.g., credit card misuse or shipping problems). Moreover, the study revealed that women also perceive the consequences of negative events to be more severe. Given the fact that perceived risk is a combination of the perception of the likelihood that something will go wrong and the perception of the seriousness of the consequences if it does (Bettman 1973), the Garbarino-Strahilevitz study concludes that women, in general, perceive a higher level of risk in online purchasing than do men, thereby corroborating findings of a similar study (Sheehan 1999) on gender differences in Internet shopping risk perceptions. Moreover, Garbarino and Strahilevitz's study found that, for women, having a site recommended by a friend leads to both a greater reduction in perceived risk and a stronger increase in willingness to buy online than it does for men, which indicates that trust-building mechanisms (in their study, a site recommendation by a friend) affect trust perceptions of women and men differently.

Gender differences in conventional shopping and online shopping have also been the focus of research, and reveal that shopping generally plays a much more emotionally encompassing role for women than for men (Campbell 2000; Dittmar and Drury 2000). That is, women have highly positive attitudes toward shopping, associating it with a leisure frame, whereas men tend to have more negative attitudes toward buying, viewing it as work that should be accomplished with minimum input of time and effort. Women, therefore, tend to focus on the often enjoyable *process* of buying, whereas men primarily focus on the *outcome* of

obtaining the goods (Dittmar et al. 2004). In other words, men are more functional in their buying attitudes than women who, in turn, are more inclined to emphasize socio-psychological and emotional concerns (Dittmar et al. 1996).[2]

With respect to online shopping, one study (Swaminathan et al. 1999) found that male buyers were more convenience-oriented and less motivated by social interaction than were female buyers, thereby corroborating existing evidence from studies of conventional buying patterns (Dittmar and Drury 2000). In contrast, another study (Dittmar et al. 2004) comparing conventional buying with online shopping found a reversal of buying attitudes. Although in conventional buying socio-psychological and emotional factors are more important than functional concerns for women, the order of significance reverses when women buy online. For men, the functional factors, which typically play an important role, are amplified in the shift from conventional buying to online shopping. In online shopping, women's attitudes become more similar to those of men; that is, both genders consider functional concerns relevant, even though men are comparatively more oriented toward functional factors than women. Given this empirical finding, the shift from conventional buying to Internet shopping implies a much more significant attitudinal change for women, with the possible result that female Internet users experience an increased level of discomfort and arousal. Such an observation might help to explain why women exhibit lower levels of trust in Internet shopping than men (Dittmar et al. 2004; Sheehan 1999; Van Slyke et al. 2002), because arousal and trustworthiness are interrelated (Ravaja et al. 2004). Taken together, the findings of Dittmar et al. (2004) challenge those of Swaminathan et al. (1999). Additional empirical evidence is needed, therefore, to clarify whether socio-psychological and emotional concerns remain most important for women in online shopping, or whether functional factors become the more relevant category.

Another study (Wolin and Korgaonkar 2003) investigated gender differences in consumer beliefs about Web advertising. The results of the study indicate that men exhibit more positive beliefs about and attitudes toward Web advertising than women. Moreover, the study reveals that men are more likely to purchase from the Web than are women, although women are more likely to surf the Web for shopping reasons (rather than to surf the Web for entertainment reasons as do men).

A further study (Sánchez-Franco et al. 2009) investigated online customer loyalty toward an Internet service provider, based on commitment-trust theory (Morgan and Hunt 1994). The study found that the influence of trust on commitment, and that of commitment on loyalty, was significantly stronger for women than men, while the effects of satisfaction on commitment and of trust on loyalty were significantly stronger for men. Finally, another study (Awad and Ragowsky 2008) investigated the effect of gender on the relationship between online word-of-mouth quality and online trust. (In online word-of-mouth systems, consumers can rate products offered for sale.) The results of this study reveal that the effect of trust on intention to buy online is stronger for women than for men. Moreover, the study found that men value their ability to post content online, whereas women value the responsive participation of other consumers to the content they have posted.

Given the combined research on gender differences in general trust behavior, general gender differences in the IT realm, and the gender differences in online trust and related behaviors, evidence supporting substantial behavioral differences between women and men is available. These gender differences on the behavioral level should be associated with differences on the biological level, because all human behavior is—at least partly—determined by biological factors, in particular those related to the brain (Turkheimer 1998). Moreover, recent brain research has revealed notable gender differences with respect to brain anatomy and functioning (Cahill 2006; Cosgrove et al. 2007; Haier et al. 2005). Considering this existing empirical knowledge, there is reason to state the following prediction:

> *Hypothesis 1: Decision making on both trustworthy and untrustworthy Internet offers activates* ***different brain areas*** *in men and women.*

Gender Differences in Brain Anatomy and Functioning

Investigations of neurobiological gender differences have a long history. For example, it is a well-established fact since the 19th century that the male brain is larger than the female brain (Broca 1861; Darwin 1871). Using sophisticated techniques such as magnetic resonance imaging, and correcting for body size, more recent evidence has confirmed this finding (Rushton 1992; Rushton and Ankney 1996), indicating that the cranial capacity of men averages 1,442 cm^3 and that of women averages 1,332 cm^3.

In the recent past, a number of additional gender-specific differences were identified. As an example, the corpus callo-

[2]Important functional factors are, for example, possibilities to compare prices as well as opportunities to save time while buying goods. In contrast, important socio-psychological and emotional factors are possibilities to experience the shopping process as a leisure activity as well as the opportunity to see and touch goods before purchase (Dittmar et al. 2004).

sum, the primary means of communication between the two cerebral hemispheres, is, on average, larger in women. This condition indicates that brain functions requiring connectivity between the two hemispheres (e.g., language) can be better performed by women (Halpern et al. 2007). Other brain regions which are, on average, larger in women include the caudate nucleus and hippocampus. In contrast, men usually have larger amygdalae and hypothalami (Cosgrove et al. 2007). Gender-specific size differences of certain brain regions may affect performance in decision making, memory, and learning tasks (Cahill 2006), thereby being of particular interest for NeuroIS researchers.

With respect to the analysis of gender differences in brain functioning, the *empathizing–systemizing theory* (Baron-Cohen et al. 2005) has gained considerable attention during the past few years. Empathizing is the ability to predict and respond to the behavior of agents (usually people) by inferring the mental states of the agents and responding with an appropriate emotion. Systemizing is the ability to predict and to respond to the behavior of nonagentive deterministic systems by analyzing input–operation–output relations and deducing the rules that govern such systems. The empathizing–systemizing theory predicts that, at a population level, women are stronger empathizers and men are stronger systemizers.

Drawing upon this theory, a number of gender studies in neuroscience (e.g., Mak et al. 2009; McClure et al. 2004; Schulte-Rüther et al. 2008) found that women more often activate emotion-related brain regions in social interaction tasks (in particular *limbic structures* such as the anterior cingulate cortex, thalamus, and hippocampus), whereas men more often activate brain regions associated with cognitive information processing (in particular *prefrontal structures* such as the dorsolateral prefrontal cortex and ventromedial prefrontal cortex). Therefore, in a trustworthiness evaluation task such as was used in the present study, we expect to see that women recruit more limbic structures than men, who in turn should recruit primarily prefrontal structures.

To the best of our knowledge, no published neuroscience study on trust has focused on gender differences. However, the results of the studies available (Baumgartner et al. 2008; Delgado et al. 2005; King-Casas et al. 2005; Krueger et al. 2007; Winston et al. 2002) show that both the limbic and prefrontal systems play a crucial role in trust situations. Moreover, two additional brain regions, the *striatum* and *insular cortex*, were shown to be important in trust situations (e.g., Baumgartner et al. 2008). In the following sections, we discuss brain regions that have been shown to encode human trust, and demonstrate connections between this literature and existing knowledge of gender-specific differences in brain functioning. Drawing upon this evidence, we deduce seven sub-hypotheses about gender-specific brain activation differences in online trust.

Anterior Cingulate Cortex (ACC)

The ACC has been studied intensively in neuroscience since the late 1990s, with demonstrated evidence that its activation is associated with a number of specific cognitive functions. Carter et al. (1998) state that the ACC detects conditions under which errors are likely to occur. Similarly, Botvinick et al. (1999) argue in favor of a conflict-monitoring account of the ACC function. In another investigation, Botvinick et al. (2004) reviewed 80 papers on ACC functions and conclude that "the ACC might monitor conflict as an index of task difficulty (and/or the mental effort it demands), entering this into cost–benefit analysis underlying action or strategy selection" (p. 545).

With respect to online trust, the ACC may have a critical role in processing information displayed on an Internet shopping site, because conflict in information processing and the associated mental effort could result from a comparison of the potential benefits and risks associated with an Internet offer. In line with this view, recent research (Seo and Lee 2007) has found that neurons in the ACC often encode signals related to expected or actual rewards (benefits), whereas another study (Milad et al. 2007) found that cortical thickness within the ACC is positively correlated with skin conductance response, which is a measure for fear expression (risks).

Anatomically, the ACC can be subdivided into dorsal and ventral parts. Brain damage studies and functional imaging studies both indicate separate roles for the dorsal (BA 32, Brodmann area) and ventral (BA 24) part of the ACC (Bush et al. 2000). The dorsal ACC is more involved in a cognitive distributed cortical network, including lateral prefrontal, parietal, premotor, and supplementary motor areas (Bush et al. 2000; Devinsky et al. 1995). The ventral ACC, in contrast, has strong connections to limbic and paralimbic brain regions such as the amygdala and the orbitofrontal cortex (Devinsky et al. 1995). Hence, the ventral ACC, especially, is involved in assessing the salience of emotional stimuli and in regulating emotional responses (Bush et al. 2000) and is, thereby, associated with an affective network of brain structures.

According to the empathizing–systemizing theory, men are stronger systemizers and women are stronger empathizers. This implies that men use more cognitive brain structures during information processing, while women use more affective structures. Drawing upon this argument, we predict

Hypothesis 1.1: Decision making on both trustworthy and untrustworthy Internet offers activates the dorsal ACC (BA 32) in men and the ventral ACC (BA 24) in women.

Thalamus

Research has indicated a role for the thalamus in attentiveness and in the capacity to perform tasks of rapid information processing. Van der Werf et al. (2001), for example, found that the size of the thalamus predicted performance on tasks that require cognitive speed. Further research has shown that the thalamus is also associated with reward processing. It was found that single thalamic neurons can code for the acquired significance of sensory stimuli and can predict future reward value (Komura et al. 2001). Because trustworthy rather than untrustworthy Internet offers are likely to trigger activation in reward regions, there is reason to believe that thalamus activation can be found during the processing of trustworthy Internet offers. With respect to gender differences in thalamus activation, a meta-analysis has determined that in emotional situations the thalamus is activated in women more often than in men (Wager et al. 2003). Considering this evidence, we predict

Hypothesis 1.2: Decision making on trustworthy Internet offers activates the thalamus significantly more in women than in men.

Hippocampus

The hippocampus is well known for its role in processing information to be stored in long-term memory (e.g., Alkire et al. 1998). In addition to this memory function, recent animal experiments show that this brain structure is also associated with the processing of fearful and/or anxiogenic stimuli (Bannerman et al. 2004; McHugh et al. 2004). Although caution is necessary when using results of animal studies for the interpretation of human brain activation and behavior, one study in the trust domain (Winston et al. 2002) found that processing untrustworthy faces may result in parahippocampal activation, thereby creating support for application of the animal experiment findings. Altogether, there is reason to believe that untrustworthy Internet offers may activate the hippocampus and parahippocampus areas, respectively, due to their uncertainty and risk-signaling functions. Anatomically, it is a well-established fact that the female hippocampus is, on average, larger than that of the male (Cosgrove et al. 2007). This neurological gender difference could contribute to women's heightened perception of uncertainty and risk (e.g., Byrnes et al. 1999). Drawing upon the presented evidence, we therefore predict

Hypothesis 1.3: Decision making on untrustworthy Internet offers activates the hippocampus significantly more in women than in men.

Dorsolateral Prefrontal Cortex (DLPFC)

Research revealed brain activation in the DLPFC in trust situations (Krueger et al. 2007). Goal-directed behavior, which plays a crucial role in trust situations (Fehr and Camerer 2007), requires information regarding whether or not implemented actions were successful in obtaining outcomes. For example, if a person makes a decision to trust another person, expected rewards may or may not be realized. The DLPFC was found to play a major role in coupling the information of rewards to actions, thereby controlling behavior and optimizing decision making (Heekeren et al. 2006; Lee and Seo 2007; Van't Wout et al. 2005).

In contrast to women, men usually process information in a cognitive rather than affective manner (Cosgrove et al. 2007; Meyers-Levy 1994; Wager et al. 2003). Coupling information about rewards to actions and, thereby, controlling behavior and optimizing decision making, is a cognitive rather than affective process, because the former implies the deliberate processing of several information cues and not simply the unconscious processing of a few cues, as does the latter. Drawing upon this line of reasoning, we predict

Hypothesis 1.4: Decision making on both trustworthy and untrustworthy Internet offers activates the DLPFC significantly more in men than in women.

Ventromedial Prefrontal Cortex (VMPFC)

In the 1990s, a number of clinical case reports revealed a central role for the VMPFC in human decision making (Bechara et al. 1996, 1997, 1999; Damasio 1996). These reports show that, similar to the patterns of young children (Crone and Molen 2004), patients with VMPFC damage are insensitive to future consequences, positive or negative, and are primarily guided by immediate prospects. Notably, this so-called "myopia for the future" persists even in the face of severe negative consequences such as financial loss or declining future reward (Bechara et al. 2000). Given this finding, the important role of the VMPFC in shopping becomes evident (Deppe et al. 2005). In contrast to ordinary shopping, online shopping is often more risky because of the anonymity afforded by the Internet. Consequently, the deliberate evaluation and anticipation of the consequences of an online transaction (both short- and long-term) are crucial in order to avoid losses as a result of deception.

In addition to the findings of clinical studies, activation in the VMPFC may represent information about value (Gläscher et al. 2009; O'Doherty 2004; Paulus and Frank 2003). Discussing the role of the VMPFC in decision making, Fellows and Farah (2007) stress that the essence of decision making is the weighting of the value of options, and value is not a simple and fixed feature of a stimulus. Rather, it is relative and context-dependent. One such highly important context variable in online environments is uncertainty, which has been shown to be associated with activity changes in the VMPFC (Fellows and Farah 2007). Hence, VMPFC activation may be associated with the processing of untrustworthy Internet offers.

With respect to gender differences in VMPFC activation, one study (Shirao et al. 2005) found that in an emotional decision task, VMPFC was activated in men, but not in women. Shirao et al. (2005) attribute this result to gender differences in neural information processing:

> The gender differences detected in our study may demonstrate differences of cognitive pattern in men and women. Our results suggest the possibility that men processed the emotional decision task including words concerning body image more cognitively rather than emotionally, and activation in the medial prefrontal cortex was prominent; on the other hand, women processed this task more emotionally rather than cognitively, and the medial prefrontal cortex did not exhibit any significant activation (p. 51).

Considering this evidence, which obviously provides strong support for the empathizing–systemizing theory, we predict

> *Hypothesis 1.5: Decision making on untrustworthy Internet offers activates the VMPFC significantly more in men than in women.*

Striatum

It is well known that activation in the human striatum is associated with value and reward, as well as with anticipation of the value and reward (O'Doherty et al. 2004; Tricomi et al. 2004). Previous fMRI studies in neuroeconomics have shown that activations in both the caudate nucleus and putamen—which are major parts of the striatum—are associated with trusting intentions and social cooperation (Baumgartner et al. 2008; Delgado et al. 2005; King-Casas et al. 2005). This result is in line with the striatum's value/reward function, because a major goal of trusting and cooperating with another person is to realize value and reward, respectively.

Dopamine, an important neurotransmitter, is closely associated with the striatum. Dopamine has been found to be correlated with pleasure, value, and reward in the brain, providing positive feelings and reinforcement to motivate proactive behavior to perform certain activities. Furthermore, dopamine is released by naturally rewarding experiences and also by a specific part in the striatum, the nucleus accumbens (e.g., Schultz et al. 1997). With respect to gender differences, it is a well-established fact that the dopaminergic function is enhanced in women, as compared to men (Cosgrove et al. 2007). Moreover, research found that the female caudate nucleus is, on average, larger than that of the male (Cosgrove et al. 2007). Considering these existing research findings, we predict

> *Hypothesis 1.6: Decision making on trustworthy Internet offers activates the striatum significantly more in women than in men.*

Insular Cortex

Research shows that insular activation correlates with (1) the perception of faces that express a feeling of disgust (Phillips et al. 1997, 1998); (2) the anticipation of emotionally aversive visual stimuli such as spiders and snakes (Simmons et al. 2004); and (3) the anticipation of physical pain (Ploghaus et al. 1999). With respect to buying behavior, Knutson et al. (2007) found that excessive prices may activate the insular in purchase situations. Additionally, several studies have found that the insular is activated in uncertain decision situations (Chritchley et al. 2001; Ernst et al. 2002; Paulus et al. 2003), in risky decision situations (Clark et al. 2008; Kuhnen and Knutson 2005; Preuschoff et al. 2006, 2008), and in ambiguous decision situations (Huettel et al. 2006; Krain et al. 2006). Because women, in contrast to men, perceive higher levels of uncertainty and risk (e.g., Byrnes et al. 1999), we predict

> *Hypothesis 1.7: Decision making on untrustworthy Internet offers activates the insular cortex significantly more in women than in men.*

Gender Differences in the Number of Activated Brain Areas

So far, we have discussed brain regions that were shown to play a crucial role in trust situations. We connected these regions to neuroscience knowledge of both anatomical and information-processing gender differences. Drawing upon this evidence, we conceptualized our predictions about gender-related activation differences in specific brain areas in seven sub-hypotheses. In four of these hypotheses, we predict

that the respective brain region is activated significantly more in women than in men (thalamus, hippocampus, striatum, and insular cortex). In two hypotheses, we predict that the region is activated significantly more in men than in women (DLPFC and VMPFC). Finally, in one hypothesis we predict that specific parts of the brain region are activated differently in men and women (ACC). Altogether, we have reason to anticipate that women will recruit more brain areas than men in our trustworthiness evaluation task.

Moreover, women's greater inclination toward risk perception is likely to reveal a gender difference in the number of brain areas activated in trust situations. As discussed, women usually perceive a higher level of risk in online purchasing than do men (e.g., Garbarino and Strahilevitz 2004). A possible strategy for female consumers to cope with this higher level of risk perception is to search for and consider more information, because information can result in a higher level of confidence in a decision (Hall et al. 2007). The deliberate information search and consideration could, however, be reflected in a more sophisticated processing within the human brain.

This theorizing is supported by the *selectivity model* (Meyers-Levy and Maheswaran 1991; Meyers-Levy and Sternthal 1991; Simon 2001), which evaluates gender-specific differences in information processing. This model indicates that men often do not engage in comprehensive processing of all available information, but instead are selective; that is, they consider and rely only on subsets of highly available cues, thereby activating fewer brain areas in contrast to women. Women, comparatively, tend to use more comprehensive information processing strategies, thereby considering a larger number of available cues and engaging in more effortful and particularized analysis of all available information (Simon 2001). In line with this argument, one study (Rodgers and Harris 2003) in the online shopping domain found that men, in contrast to women, typically evaluate a shopping site in terms of a general attitude. Conversely, women typically cue into the more detailed aspects of a Web site, relying on the extent to which those cues affect them emotionally and drive them. This, obviously, accompanies the activation of a greater number of brain regions, that is, a more sophisticated pattern of brain areas. Drawing upon this evidence, we predict

> *Hypothesis 2: Decision making on both trustworthy and untrustworthy Internet offers activates* ***more brain areas*** *in women than in men.*

To the best of our knowledge, no available study investigates the hypotheses presented here. Against this background, the next section describes the research methodology through which we were able to demonstrate that for women the decision to trust an Internet offer can trigger activation in more and in different brain areas than is the case for men, which in turn is reflected in different trustworthiness ratings.

Research Methodology

Stimulus Development

Previous research has demonstrated that trust-assuring arguments, which are formulated on the basis of Toulmin's (1958) model of argumentation, affect consumers' trusting beliefs (Kim and Benbasat 2006). Accordingly, we used Toulmin's model as a basis to create product descriptions, thereby influencing the *perceived trustworthiness of Internet offers*, which we then used as the stimulus material in our fMRI experiment. In line with previous IS research (e.g., Gefen et al. 2003; Kim and Benbasat 2006; McKnight et al. 2002a), we define perceived trustworthiness of an Internet offer as a consumer's trusting belief, which refers to the aggregation of an offer's positive characteristics.

Toulmin's model proposes a layout containing six interrelated components for analyzing arguments (Figure 1): CLAIM (an assertion or conclusion put forward for general acceptance, always having a potentially controversial nature), DATA (statements specifying the particular facts or previously established beliefs about a situation, as a basis on which a claim is made), WARRANT (a statement that justifies or certifies the reasonableness of moving from data to a claim), BACKING (the general body of information or experience that assures the trustworthiness of a warrant), QUALIFIER (articulation of the degree of certainty associated with a claim), and REBUTTAL (an extraordinary or exceptional circumstance that can defeat the warranted claim).

Figure 1 illustrates an example of the interrelationships among the six components. The illustration draws upon a product description text of a fictitious eBay seller. In our experiment, the product for sale was a USB flash drive. We used the text blocks in Figure 1 to create the product descriptions. Considering the various levels of arguments illustrated in Figure 1, several levels of trust-assuring description texts become evident: (1) NO TRUST-ASSURING ARGUMENT (that is, a seller provides no description text), (2) CLAIM ONLY, (3) CLAIM + DATA, (4) CLAIM + DATA + BACKING, and (5) CLAIM + DATA + BACKING + REBUTTAL. Additionally, QUALIFIERS (certainly, presumably, probably, and possibly) may affect the trustworthiness of a product description text.[3]

[3]Note that we did not use the WARRANT to manipulate the product description text, because it is usually not stated explicitly in argumentations; rather, it is substantiated by the BACKING (Toulmin 1958).

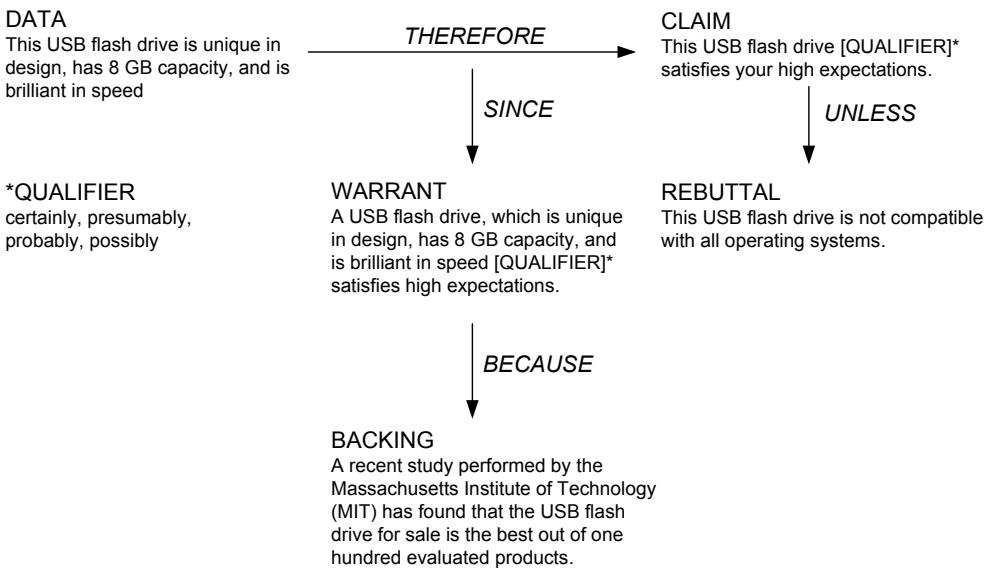

Figure 1. Product Description Text and Toulmin's Model of Argumentation

To enhance the external validity of our experiment, we embedded the elements of Toulmin's model into a realistic eBay site containing the following characteristics (see Figure 2): eBay logo, product name (New USB Flash Drive), picture of the product, selling mode (Buy It Now, indicating our decision to use eBay's online shopping feature rather than a bidding auction), price (EUR 30.00), seller's name (usb-shop-123), seller's experience level (55, with a blue star indicating that 50 to 99 feedback ratings have been posted), feedback (100% positive), duration and location of membership (since October 6, 2004, in Germany), and, finally, the product description. Figure 2 shows a stimulus example with the maximum amount of text allowed in the product description field, that is, 69 words: CLAIM + QUALIFIER (10 w.) + DATA (17 w.) + BACKING (29 w.) + REBUTTAL (13 w.).[4] It is important to note that the seller's name (i.e., usb-shop-123) was designed to eliminate the possibility of any inference concerning gender and subsequent potential for bias, based on the knowledge that women are, in general, more trusted than men (Shaub 1996; Wright and Sharp 1979).

Pretest

Before conducting the fMRI study, we developed 104 different eBay offers (Figure 2 shows one example out of the entire set). We manipulated these offers with respect to the product description (based on Toulmin's model) and the picture of the product. Ten different USB flash drive images were randomly assigned to the various product descriptions. (The complete set of images is presented in the Appendix.) All other elements illustrated in Figure 2 were held constant throughout the study.

To guarantee variance in the trustworthiness of the eBay offers, 39 randomly selected subjects evaluated the developed offers on a scale ranging from 1 = "very low" to 7 = "very high." Afterward, we calculated the mean and standard deviation of each offer. To sharpen contrast, we selected the 10 most trustworthy offers (denoted as T, Trustworthy) and the 10 least trustworthy offers (denoted as U, Untrustworthy) for the fMRI experiment (means: T: 4.41 and U: 2.07).[5] An ANOVA confirmed the selected eBay offers as being significantly different concerning the level of trustworthiness (F (2,29) = 623.742, $p < .01$). *Post hoc* tests (Bonferroni, Tukey Multiple Comparison) showed significant results between the groups ($p < .01$).

[4]In our study, stimulus material was presented in the German language. Hence, the text length presented to our subjects was actually shorter than illustrated in Figure 2: CLAIM + QUALIFIER (8 w.) + DATA (14 w.) + BACKING (21 w.) + REBUTTAL (11 w.).

[5]We also calculated the 10 neutral offers (N = 3.19). However, following an experimental procedure suggested by Stoll et al. (2008), the neutral offers were not included in the fMRI analysis.

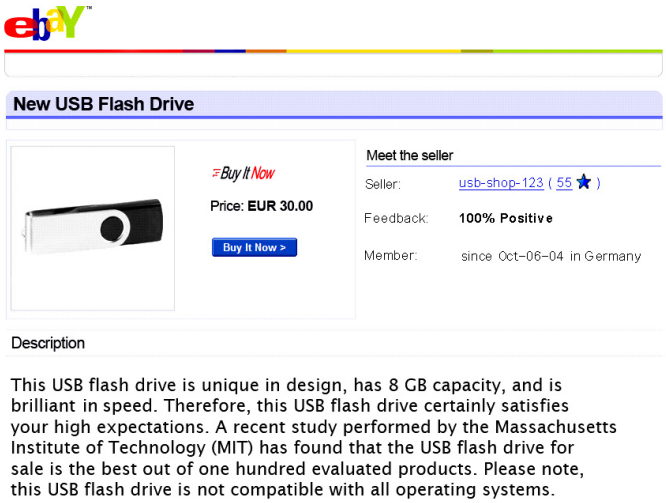

Figure 2. Example for a Trustworthy Internet Offer (eBay)

To ensure that during the fMRI experiment participants would not recognize that they were actually seeing the same eBay offer, we manipulated not only the product descriptions, but also the images of the USB flash drives. We used a nonparametric test (Kruskall-Wallis) to control for confounding influences within the groups T and U due to the images. The test showed no significant differences within each group (T: χ^2 (9) = 3.513, p = .940; U: χ^2 (9) = 3.748, p = .927). Consequently, the trustworthiness of the eBay offers was not affected by the images of the USB flash drives.

With respect to the influence of the product descriptions on the trustworthiness ratings, the pretest revealed that group U was solely comprised of eBay offers consisting of NO TRUST-ASSURING ARGUMENT and CLAIM ONLY. In contrast, group T was comprised only of offers that consist of CLAIM + DATA + BACKING and CLAIM + DATA + BACKING + REBUTTAL. Interestingly, our results show that QUALIFIERS had no influence on trustworthiness ratings.[6]

Main Study

Subjects

For the main study, we selected 10 female and 10 male subjects, all healthy and right-handed. We used fMRI as a method to identify possible gender differences in brain activation and subsequent trustworthiness ratings.[7] With respect to age, research indicates that trust increases almost linearly from early childhood to early adulthood, but stays relatively constant within different adult age groups (Phillips and Stanton 2004; Sutter and Kocher 2007). Hence, to avoid confounding effects due to age differences, we selected subjects from the narrow age group of 30 to 35 rather than using undergraduates or a blend of people from different age groups ($\text{mean}_{\text{female}}$ = 32.4, SD = 1.89, min = 30, max = 35; $\text{mean}_{\text{male}}$ = 31.2, SD = 1.39, min = 30, max = 34).

All participants were familiar with the Internet and eBay. The analysis revealed for duration of Internet usage: $\text{mean}_{\text{female}}$ = 81.6 months, SD = 41.49; $\text{mean}_{\text{male}}$ = 102.7 months, SD = 34.04; duration of eBay usage: $\text{mean}_{\text{female}}$ = 33.89 months, SD = 24.39; $\text{mean}_{\text{male}}$ = 55.56 months, SD = 36.86. An ANOVA showed no significant gender differences (duration of Internet usage: F (1,19) = 1.546, p = .23; duration eBay usage: F (1,17) = 2.162, p = .161).

We asked the participants whether the use of USB flash drives is important in their daily lives (five-point Likert scale with 1 = "totally disagree" and 5 = "totally agree"). As the results show, using USB flash drives is appreciably relevant for our subjects ($\text{mean}_{\text{female}}$ = 3.4, SD = 1.35; $\text{mean}_{\text{male}}$ = 3.5, SD = 1.27). An ANOVA showed no significant gender differences (F (1,19) = .029, p = .866).

[6]Class N included solely eBay offers that consist of CLAIM + DATA. We did not use these offers in our fMRI analysis.

[7]Note that no subject of the fMRI experiment participated in the pretest.

To check for the general trust level regarding the brand eBay, or for an extremely positive or negative attitude toward the company, we asked the participants whether they generally have strong trust in eBay (five-point Likert scale with 1 = "totally disagree" and 5 = "totally agree"), and about their overall attitude toward eBay (five-point Likert scale with 1 = "extremely positive" and 5 = "extremely negative"). The analysis showed for trust in eBay: $mean_{female} = 2$, SD = .94; $mean_{male} = 3.2$, SD = 1.033; and for attitude toward eBay: $mean_{female} = 2.7$, SD = .67; $mean_{male} = 2.4$, SD = .69. An additional ANOVA showed specific gender differences for trust in eBay: $F(1,19) = 7.364$, $p = .014$, but not for the attitude toward eBay: $F(1,19) = .953$, $p = .342$.

Another important trait for which we assessed participants was the level of general trust (trust propensity). We measured general trust by a 25-item questionnaire (Rotter 1967).[8] At a maximum, each subject could score 125 points (high trust), and at a minimum, 25 points (low trust). Although the analysis showed no extreme outliers within the participants ($mean_{female} = 62.2$, SD = 7.97; $mean_{male} = 69$, SD = 7.16), the ANOVA revealed—as expected—a weak significant gender difference ($F(1,19) = 4.026$, $p = .06$). However, there were no arguments for excluding individual participants, because the calculated means for female and male participants are in line with the findings of similar studies (e.g., Kenning 2008).

Table 2 summarizes the descriptive statistics, revealing two important gender differences. First, women have significantly less trust in eBay than do men. Second, as expected, the level of general trust is significantly lower in women than in men. We refer to these differences in the "Discussion" section.

Regarding the fMRI experiment, standard exclusion criteria for MR examinations were applied (Savoy 2005). Because we employed visual stimuli, subjects with strong myopia or other relevant constraints of vision were excluded. All subjects provided written informed consent prior to the scanning sessions. The subjects were informed that the examination could potentially reveal medically significant findings, and they were asked whether they would like to be notified in such a case. An ethics commission approved the study. For their participation, all subjects received 20 Euro in cash and one of the ten USB flash drives (selected randomly).

Experimental Procedure and Stimulus Presentation

The eBay offers selected in the pretest were projected on a transparent screen with an LCD beamer, and viewed from the other side via a 45° mirror mounted on an element phase array coil. Furthermore, the offers were selected for equality in size, position, background, and luminance in order to prevent external confounding visual stimulation (Kenning et al. 2009). Each offer was visible for 12 seconds. The task for the participants was to press one of two corresponding buttons on a magnetic resonance compatible response box to indicate, at the end of the 12-second time frame, whether they considered an offer to be trustworthy or untrustworthy. After the 12-second offer image, participants saw a fixation cross for 3 seconds. Then the next offer was presented, and the displays continued in this way. The sequence of the offers was pseudo-randomized for every subject. In total, every subject had to evaluate 120 offers.

Data Collection and Analysis

The study was executed on a 3T fMRI-scanner (Magnetom Trio, SIEMENS, Erlangen, Germany).[9] fMRI is a noninvasive neuroscientific technique with relatively good spatial and temporal resolution (Huettel et al. 2009). It takes advantage of the blood oxygenation level dependent (BOLD) effect for estimating the neural activity that corresponds with the experimental conditions. The data set used in this study consisted of 36 transversal slices of 3.6 mm thickness without a gap, a field of view of 230 mm × 230 mm, an acquired matrix with 64 × 64 (i.e., isotropic voxels with 3.6 mm edge length). Contrast parameters were a signal response time of 3000 ms, echo time of 50 ms, and a flip angle of 90°.

Data analysis was conducted with the SPM5-freeware (Friston 1996; Friston et al. 1995) using MatLab as a working base, the application followed procedures described in Kenning et al. (2007) and Poldrack et al. (2007). The data preprocessing consisted of three initial steps. First, to correct for artifacts due to participant head movement in the scanner, all images were realigned by a "rigid body" transformation to the first image of the session (realignment). Second, to compare all participants within the group analysis, all images were normalized and re-sampled to the standard Montreal Neurological Institute (MNI) template (normalization). Third, to prepare the data for the statistical analysis, all images were smoothed with a 5-mm Gaussian kernel (Ashburner et al. 1997).

[8]For a recent review on findings yielded by the Rotter scale, see Cook et al. (2005).

[9]The protocol included a 3D isotropic T1-weighted data set of the whole head, with a measured voxelsize of 1.0 mm edge length for anatomical identification and coregistration into the Talairach-Space. Functional images were acquired using a T2* weighted single-shot gradient echo-planar imaging (EPI) sequence, which covered nearly the entire brain.

Table 2. Descriptive Statistics

	Women (*N* = 10) Mean (SD)	Men (*N* = 10) Mean (SD)	ANOVA (Gender Differences)
Age (in Years)	32.4 (1.89)	31.2 (1.39)	F (1,19) = 2.592 p = .125
Duration of Internet Usage (in Months)	81.6 (41.49)	102.7 (34.04)	F (1,19) = 1.546 p = .23
Duration of eBay Usage (in Months)	33.89 (24.39)	55.56 (36.86)	F (1,17) = 2.162 p = .161
Importance of USB Flash Drives in Daily Life[a]	3.4 (1.35)	3.5 (1.27)	F (1,19) = .029 p = .866
Trust in eBay[a]	2 (.943)	3.2 (1.03)	F (1,19) = 7.364 p = .014*
Attitude toward eBay[b]	2.7 (.67)	2.4 (.69)	F (1,19) = .953 p = .342
General Trust[c]	62.2 (7.97)	69 (7.16)	F (1,19) = 4.026 p = .06*

Notes: *Significant gender difference.

[a]Five-point Likert scale with 1 = "totally disagree" and 5 = "totally agree."

[b]Five-point Likert scale with 1 = "extremely positive" and 5 = "extremely negative."

[c]Rotter (1967) scale with 25 = minimum trust and 125 = maximum trust.

For the estimation of the general linear model (GLM), onsets were constructed that constitute a matrix that included one vector for each trustworthiness level (T, U). Realignment parameters were included as additional covariates. The estimation of the GLM was conducted by fitting a reference hemodynamic response function to each event (onset) in the observed data. In order to investigate gender- and trust-dependent activity changes, one- and two-sample t-tests were accomplished on the second-level (group) analysis. All coordinates received by SPM5 were transformed to the Talairach and Tournoux space and were assigned to cortical regions with the T2T-database Java applet.[10]

Results

Behavioral Results

Before we were able to use the two trustworthiness groups from the pretest (T, U), we had to control the evaluation of trustworthiness of the fMRI participants. The analysis showed congruent results between the pretest and the fMRI study. Therefore, as summarized in Table 3, the group classification was confirmed for both female (F (1,79) = 160.17, p < .001) and male participants (F (1,79) = 217.754, p < .001).

Our results show significant gender differences regarding the trustworthiness evaluation of eBay offers. That is, in the T group, on average, women rated 68.5 percent of the eBay offers as trustworthy, whereas only 57.7 percent of male participants, on average, did so (F (1,79) = 6.985, p < .01). In the U group, on average, women rated 20.0 percent of the eBay offers as trustworthy, whereas only 11.0 percent of male participants, on average, did so (F (1,79) = 9.903, p < .001). Consequently, results show that women evaluated the eBay offers significantly higher in trustworthiness than did men. This result is surprising, because the female participants exhibited a lower level of trust in eBay, as well as a lower level of general trust (see Table 2). We refer to this result in the "Discussion" section.

Neuroimaging Results

By contrasting the brain responses of the female and male participants, statistical parametric maps were generated that displayed the t-value of each voxel that reached a p < .001

[10]The applet is available at http://wwwneuro03.uni-muenster.de/ger/t2tconv/.

Table 3. Evaluation of Trustworthiness During the fMRI Experiment

Group		Women (*N* = 10)	Men (*N* = 10)	ANOVA (Gender Differences)
Trustworthy eBay offers	Mean	68.5	57.7	*F* (1,79) = 6.985
	SD	19.2	17.0	*p* < .01
	Median	70.0	60.0	
Untrustworthy eBay offers	Mean	20.0	11.0	*F* (1,79) = 9.903
	SD	14.6	10.5	*p* < .001
	Median	20.0	10.0	
	ANOVA (Group Differences)	*F* (1,79) = 160.17 *p* < .001	*F* (1,79) = 217.754 *p* < .001	

[uncorrected] with an extent threshold of five voxels.[11] We found significant variance in brain activation patterns between women and men, yet also a few similarities (see Table 4).

Trustworthy Versus Untrustworthy Offers

We found significantly higher brain activation in women in the thalamus, striatum (putamen), and fusiform gyrus (BA 37). In contrast, we found higher activation in men only in the DLPFC (BA 9). Interestingly, we noted increased activation in the dorsal ACC (BA 32) in both women and men, although the cluster size (in voxels) was much larger in men (see Table 4 and Figure 3). Moreover, we found increased activation in the lingual gyrus and cuneus (BA 18) for both genders. However, because these two brain regions are not trust-specific—we assume that they are a result of the nature of the experimental task, that is, reading product descriptions (Hagoort et al. 1999; Mechelli et al. 2000; Price et al. 1996)—we do not discuss them in this article.

[11]To identify brain activity changes during certain tasks, it is necessary to construct contrasts in the SPM (statistical parametric mapping) tool. The contrast trustworthy versus untrustworthy offers is defined as +1 (trustworthy) and -1 (untrustworthy) and uses the subtraction method from set theory. Thus, SPM subtracts the neural activity during the processing of untrustworthy offers from the activity during the processing of the trustworthy offers. What remains is the neural activity from the trustworthy offers, which is significantly different from the neural activity of the untrustworthy offers. The contrast untrustworthy versus trustworthy offers is defined as +1 (untrustworthy) and -1 (trustworthy). The neural activity that results from the processing of the trustworthy offers is subtracted from the activity resulting from the processing of the untrustworthy offers. What remains is the positive difference between untrustworthy and trustworthy offers.

Untrustworthy Versus Trustworthy Offers

We found significantly higher brain activation for women in the ventral ACC (BA 24), hippocampus, DLPFC (BA 9), and caudate nucleus (body). In contrast, we found higher activation for men in the VMPFC (BA 10) and ventral posterior cingulate cortex (BA 23). Moreover, we found increased activation in the insular cortex, with exactly the same cluster size, in both women and men (see Figure 4 for the female activation).

In *Hypothesis 1*, we predicted that decision making on both trustworthy and untrustworthy Internet offers activates *different brain areas* in men and women. Our results support this hypothesis (see Table 4).

With respect to our *Hypotheses 1.1* through *1.7*, which predicted gender differences in the activation in seven trust-specific brain regions, we found full support for five of them—ACC (1.1), thalamus (1.2), hippocampus (1.3), VMPFC (1.5), and striatum (1.6). For one hypothesis—DLPFC (1.4)—we found partial support. For another hypothesis—insular cortex (1.7)—we did not find support.

In *Hypothesis 1.4*, we predicted that decision making on both trustworthy and untrustworthy Internet offers activates the DLPFC significantly more in men than in women. We found activation in the DLPFC in men, but also in women (Table 4). In *Hypothesis 1.7*, we predicted that decision making on untrustworthy Internet offers activates the insular cortex significantly more in women than in men. We found activation in both the female and male insular cortex. We refer to these results in the "Discussion" section.

In *Hypothesis 2*, we predicted that decision making on both trustworthy and untrustworthy Internet offers activates *more brain areas* in women than in men. Our results support this

Table 4. Brain Areas Activated During the Presentation of Internet Offers

		Cluster Size (Voxels)	Laterality (Left/Right)	MNI-Coordinates[a] (x, y, z)		
Trustworthy Versus Untrustworthy Offers ([T] – [U])						
Women (*N* = 10)						
Gender Difference	Thalamus	6	R	10	-16	8
	Striatum (Putamen)	5	R	22	20	-2
	Fusiform Gyrus (BA 37)	8	L	-38	-58	-16
Gender Similarity	Dorsal Anterior Cingulate Cortex (BA 32)	5	L	-4	8	26
	Lingual Gyrus[b]	34	R	52	28	16
	Cuneus (BA 18)[b]	30	R	2	-70	42
Men (*N* = 10)						
Gender Difference	Dorsolateral Prefrontal Cortex (BA 9)	25	R	38	32	26
Gender Similarity	Dorsal Anterior Cingulate Cortex (BA 32)	138	R	8	14	57
	Lingual Gyrus[b]	42	L	-8	-90	16
	Cuneus (BA 18)[b]	7	L	-10	-72	12
Untrustworthy Versus Trustworthy Offers ([U] – [T])						
Women (*N* = 10)						
Gender Difference	Ventral Anterior Cingulate Cortex (BA 24)	15	L	-2	38	2
	Hippocampus	12	R	30	-44	-2
	Dorsolateral Prefrontal Cortex (BA 9)	24	L	-18	46	34
	Caudate Nucleaus (Body)	31	L	-12	12	16
Gender Similarity	Insular Cortex	10	L	-40	-16	-4
Men (*N* = 10)						
Gender Difference	Ventromedial Prefrontal Cortex (BA 10)	18	L	-10	46	8
	Ventral Posterior Cingulate Cortex (BA 23)	45	L	-4	-56	18
Gender Similarity	Insular Cortex	10	L	-46	-8	0

Notes: T: Trustworthy eBay offer. U: Untrustworthy eBay offer. BA: Brodmann Area. MNI: Montreal Neurological Institute.
[a]The coordinates of the peak of the activation are given according to MNI-space (Montreal Neurological Institute).
[b]Brain areas are not trust-specific. Rather, we assume that they are a result of the nature of the experimental task (i.e., reading product descriptions) (Hagoort et al. 1999; Mechelli et al. 2000; Price et al. 1996).

hypothesis. Table 4 shows that the contrast of trustworthy versus untrustworthy offers resulted in significant activity changes in *four female* and *two male* brain areas (without considering the lingual gyrus and cuneus, activation of which is not believed to be trust-specific). When contrasting untrustworthy versus trustworthy offers, we found activity changes in *five female* and *three male* brain areas.[12]

Before we discuss our findings regarding the brain activation patterns, it is useful to briefly link our results to previous neuroscience studies in the trust realm. These studies were either conducted in the context of economic games (Baumgartner et al. 2008; Delgado et al. 2005; King-Casas et al. 2005; Krueger et al. 2007) or they concerned the assessment of the trustworthiness of human faces (Winston et al. 2002).[13]

[12]In Table 4, we also report the cluster size (in voxels) and laterality of the various brain activations. However, an in-depth discussion of gender-specific cluster size and laterality issues is not feasible within the scope of the present article. Recent brain research gives insights into this topic (e.g., Cahill 2006; Cosgrove et al. 2007). The topic is a possible avenue for future research.

[13]In most studies, the economic game investigated is the trust game, which has been developed to operationalize trust and trustworthiness (Berg et al. 1995). In a trust game, two players, X (the investor) and Y (the trustee), each have an initial endowment. First, X decides whether to keep his endowment or to send (a part of) it to Y. Then Y observes X's action and decides whether to keep the amount she received or share some of it with X. The experimenter triples X's transfer, so that both players are better off collectively if X transfers money and Y sends back a sufficient amount. This situation mimics a sequential economic exchange in the absence of contract enforcement institutions. Y has a strong incentive to keep all the money and repay none to X. If X anticipates this behavior, however, there is little reason to transfer. Consequently, if X transfers no money, then a chance for mutual gain would be lost. In the trust game, the amount sent by X is used as a quantitative measure for trust, and Y's transfer back is used as a measure for trustworthiness. It should be noted that a recent paper challenges the assumption that the amount sent by X is a reliable measure for trust (Kugler et al. 2009).

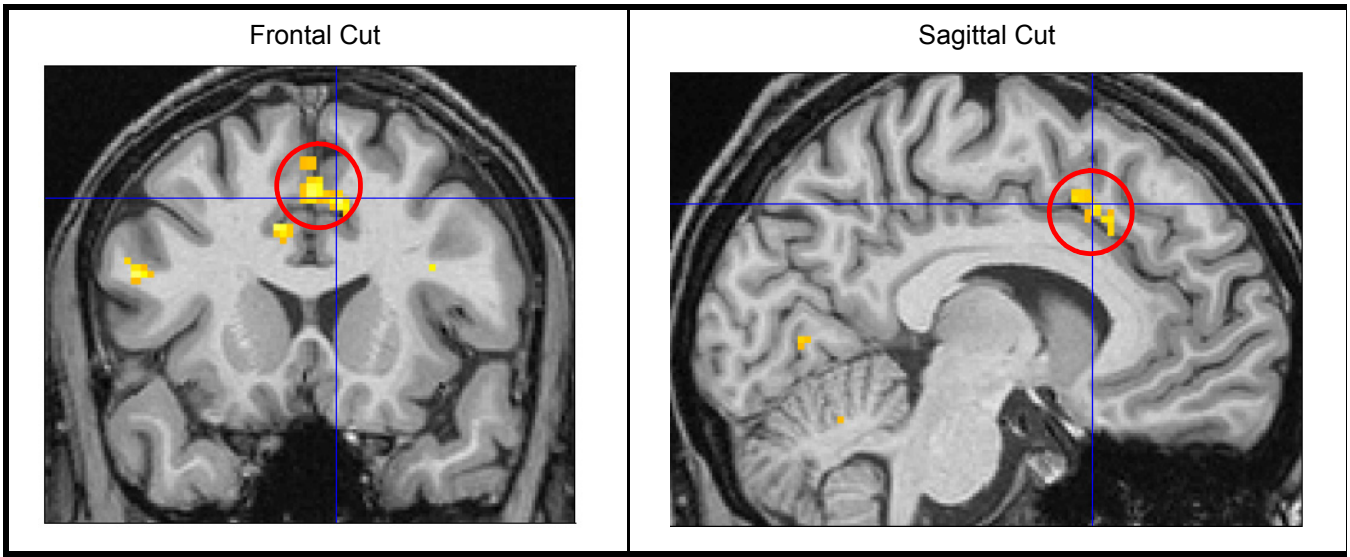

Figure 3. Male Dorsal Anterior Cingulate Cortex (BA 32), Trustworthy Versus Untrustworthy Offers

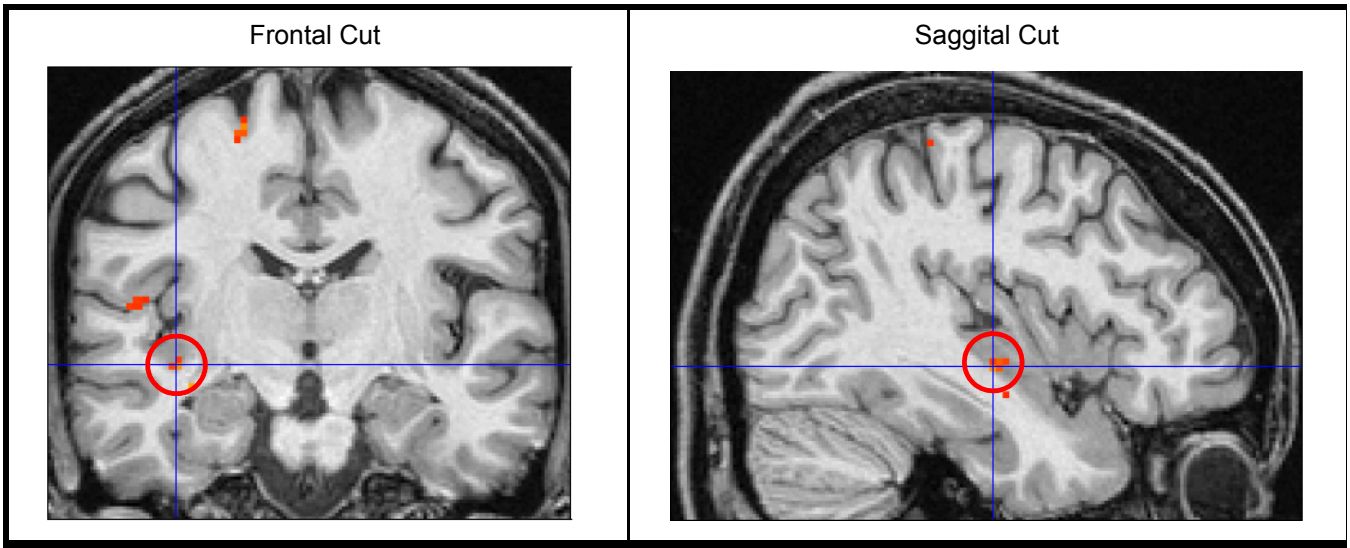

Figure 4. Female Insular Cortex, Untrustworthy Versus Trustworthy Offers

Table 5. fMRI Studies on Human Trusting Behavior and Associated Brain Regions

	Baumgartner et al. (2008) (Trust Game)	Delgado et al. (2005) (Trust Game)	King-Casas et al. (2005) (Trust Game)	Krueger et al. (2007) (Trust Game)	Winston et al. (2002) (Trustworthiness of Human Faces)	Present Study (Trustworthiness of Internet Offers)
Sample Size (Female/Male)	**49 (0/49)**	**12 (5/7)**	**96 (n.a.)**	**44 (22/22)**	**14 (6/8)**	**20 (10/10)**
Amygdala	•				•	
Ventral Anterior Cingulate Cortex (BA 24)	•		•			F
Caudate Nucleus	•	•	•			F
Dorsolateral Anterior Cingulate Cortex (BA 32)		•		•		F/M
Dorsolateral Prefrontal Cortex (BA 9)				•		F/M
Hippocampus and Parahippocampus Gyrus		•			•	F
Insular Cortex	•	•			•	F/M
Putamen	•	•				F
Thalamus	•		•		•	F
Ventral Posterior Cingulate Cortex (BA 23)						M
Ventromedial Prefrontal Cortex (BA 10)						M

Notes: The table lists brain regions that are mentioned in at least two of the six studies. Exceptions are the ventral posterior cingulate cortex (BA 23) and the ventromedial prefrontal cortex (BA 10), which were identified in the present study. Only the present study reports gender-specific results. BA: Brodmann Area. F: Female. M: Male. n.a.: not available.

Table 5 summarizes these investigations, thereby supporting evaluation of whether or not the previous findings are in line with the results of the present study. A marked cell in Table 5 indicates that a study has found this brain region activated in trust-related tasks. Except for the activity results in the amygdala, our study confirms previous research findings.[14] However, although most of the previous studies have used a mixed-gender sample (with the exception of the study of by Baumgartner et al., and with information unavailable in King-Casas et al.), no available study reports specifically on gender differences in brain activation. Therefore, our study makes a substantial contribution to a greater understanding of neuronal gender differences in trust research.

Discussion

To show empirically that decision making on both trustworthy and untrustworthy Internet offers is associated with gender-specific activity changes in certain brain areas, we used fMRI.Altogether, when we contrasted trustworthy versus untrustworthy offers, and untrustworthy versus trustworthy

[14]The amygdala was only marginally activated when the participants were exposed to untrustworthy Internet offers (< 5 voxels, $p < .001$). Lesion studies conducted by the research group of Adolphs, Damasio, and Tranel might explain this finding (Adolphs, Tranel, and Damasio 1998; Adolphs et al. 2005). They conducted three case studies and found that patients with complete bilateral amygdala damage judged other people to look more trustworthy and more approachable than did normal viewers or patients with brain damage in other areas, providing empirical evidence that the amygdala is associated with distrust. Moreover, in their study they also asked the three patients to rate the likeability of different individuals based on single words (i.e., adjectives describing the people) presented visually on a sheet of paper. Intriguingly, the study found that the subjects' impairment does not extend to judging verbal descriptions of people. As a result, Adolphs and his colleagues conclude that the amygdala is necessary to judge the trustworthiness of faces, but it is not necessary to evaluate the trustworthiness of sentences and words. The results of our fMRI study substantiate this theoretical perspective, which has also been confirmed by recent work of Todorov and his colleagues (e.g., Engell et al. 2007; Todorov 2008; Todorov et al. 2008). Additionally, Bechara and Damasio (2005, p. 353) state that the amygdala has evolved for a survival purpose, for example, to be responsive to dangerous animals or persons with untrustworthy faces. Therefore, it might be possible that the role of the amygdala in today's economic decision situations is not the same as it was in former times, because Internet transactions do not require both sellers and buyers to reveal their faces. Rather, conclusions about a transaction partner's characteristics have to be drawn on the basis of other factors, such as feedback profiles (Ghose et al. 2005; Pavlou and Dimoka 2006) or product description texts, as discussed in the present article.

offers, we found some similarities and substantial differences between neural processing in women and men (Table 4). Our study thereby reveals considerable gender differences in neurobiology during decision making on Internet offers, which supports our theorizing in *Hypothesis 1*.

As evidence in support of *Hypothesis 2*, we recognize the significant result that women, in contrast to men, activated more brain areas during the presentation of both trustworthy and untrustworthy Internet offers (Table 4). This result replicates findings from other neuroscience studies in various domains. One study (Canli et al. 2002), for example, investigated gender differences in brain activation patterns of emotional memories and found that women recruited more brain regions than men. In another study (Kucian et al. 2005), it was observed that women activated more brain areas than men in a calculation and mental rotation task. The present study, therefore, extends to the online trust domain the existing finding that women, in contrast to men, activate more brain areas in cognitive tasks (e.g., memory, mathematics, or decision making).

In purchasing online, women, in general, perceive a higher level of risk than do men (e.g., Garbarino and Strahilevitz 2004). Moreover, the descriptive analysis of our survey data shows that women have both less general trust and less trust in eBay (Table 2). To overcome this increased risk perception and the reduced levels of general trust and trust in eBay, elevated levels of information search, and of consideration of that information, could be useful, because this can lead to a higher level of confidence in a decision (Hall et al. 2007). However, given that such deliberate search for and consideration of increased information should be reflected in a more sophisticated brain processing pattern, women's inclination toward a heightened level of risk perception may explain why more brain areas are activated in women than in men.

In the following section, we provide additional discussion of our findings, which outlines gender differences and similarities in brain activation.

Gender Differences

Trustworthy Versus Untrustworthy Offers

By contrasting trustworthy versus untrustworthy offers (upper part in Table 4), we found increased activation

- in the female thalamus, striatum (putamen) and fusiform gyrus (BA 37), and
- in the male DLPFC (BA 9).

With respect to the gender differences in *thalamus*, *DLPFC*, and *striatum (putamen)* activation, these results support our theorizing in *Hypotheses 1.2*, *1.4*, and *1.6*. Moreover, we confirm findings from other neuroscience studies which have also found that these brain regions are activated in trust situations (Baumgartner et al. 2008; Krueger et al. 2007).

In the trust literature, the *fusiform gyrus* is mentioned in only one study (Delgado et al. 2005), and even in this study the area is not discussed as a major trust region. Therefore, we have not formulated a hypothesis about this brain region. However, research has determined an important role of the fusiform gyrus in word and picture processing (e.g., Starrfelt and Gerlach 2007). Therefore, it is possible that this brain region was activated as a result of the experimental task (i.e., visually processing Internet offers). Although recent research (Salloum et al. 2008) has studied gender differences in fusiform gyrus activation in a cognitive task, further research is needed to investigate its role in trust situations and corresponding gender differences.

Untrustworthy Versus Trustworthy Offers

By contrasting untrustworthy versus trustworthy offers (lower part in Table 4), we found increased activation

- in the female ventral ACC (BA 24), hippocampus, DLPFC (BA 9), and caudate nucleus (body), and
- in the male VMPFC (BA 10) and ventral posterior cingulate cortex (BA 23).

With respect to the gender differences in *ventral ACC*, *hippocampus*, *VMPFC*, and *striatum (caudate nucleus, body)* activation, the results support our theorizing in *Hypotheses 1.1*, *1.3*, *1.5*, and *1.6*. Moreover, activation in these four brain areas confirms the findings from other neuroscience studies (Baumgartner et al. 2008; Delgado et al. 2005; King-Casas et al. 2005; Winston et al. 2002). The activation in the male VMPFC is illustrated in Figure 5.

Interestingly, we found increased activity in the *female striatum* (i.e., caudate nucleus, body) during the presentation of untrustworthy offers, as shown in Figure 6. Caudate activation in women conforms to the well-known anatomical fact that the female caudate is, on average, larger than that of the male (Cosgrove et al. 2007). In this case, however, no previous studies showing activation in the caudate nucleus during the presentation of untrustworthy stimuli could be found. We believe that the activation in the female striatum during the presentation of both trustworthy and untrustworthy offers is partly associated with the highly positive attitudes

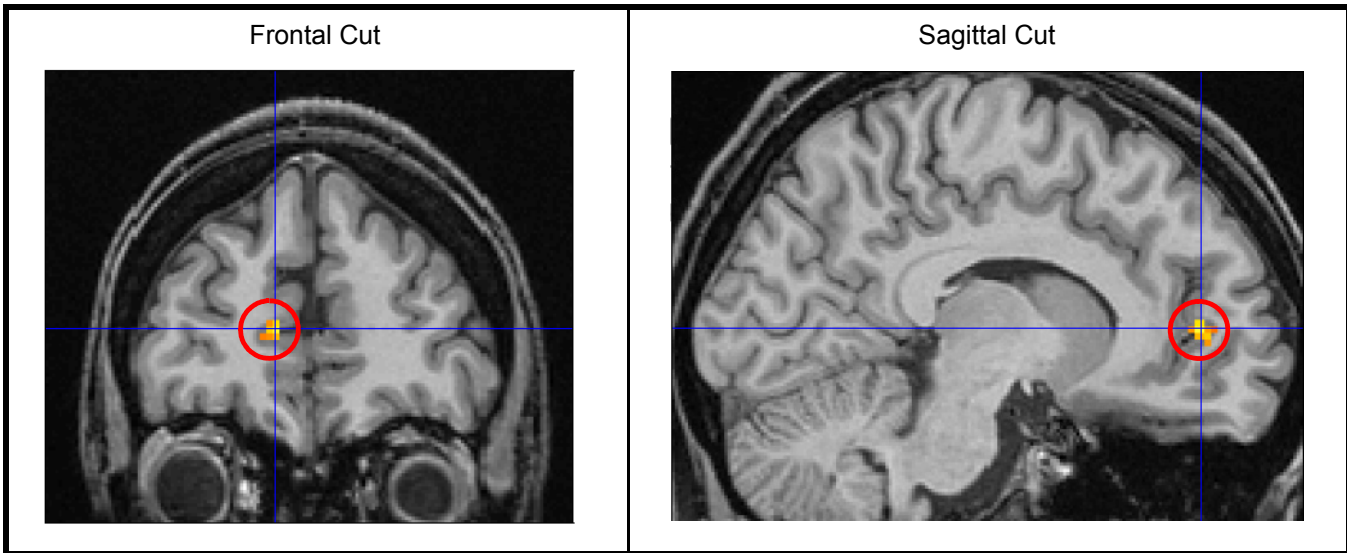

Figure 5. Male Ventromedial Prefrontal Cortex (BA 10), Untrustworthy Versus Trustworthy

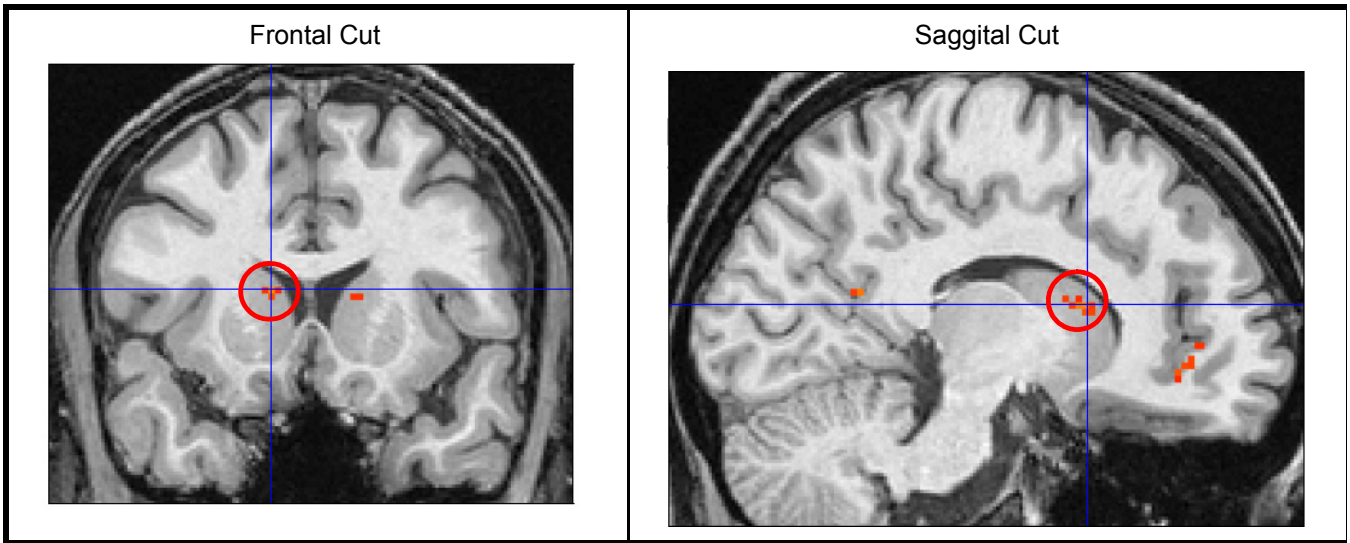

Figure 6. Female Caudate Nucleus (Body), Untrustworthy Versus Trustworthy Offers

toward buying held by women generally (e.g., Campbell 2000). In essence, women tend to focus on the often enjoyable *process* of buying ("shopping feeling") rather than simply on the *outcome*.

In our presentation of gender differences in online trust and related behaviors, we noted that the findings of a study by Dittmar et al. (2004) challenge those of Swaminathan et al. (1999). Specifically, we noted that additional empirical evidence is needed to clarify whether socio-psychological and emotional concerns remain most important for women in online shopping, or whether functional factors become the more relevant category. Our fMRI data (i.e., the striatum activation) provide empirical support that women consider socio-psychological and emotional concerns most relevant in both conventional shopping and online shopping.

Moreover, our behavioral results show that although women have less trust in eBay and a lower level of general trust than do men (see Table 2), their trust in both trustworthy *and* untrustworthy offers is significantly higher than men's trust (see Table 3). The argument that women generally have a more positive attitude toward buying than men (shopping feeling), and as a result show higher activation in the striatum, is a possible explanation for this paradoxical finding. Overall, our data suggest that in shopping situations, women, in general, may have a stronger tendency to activate the striatum (a reward processing area) than men.

Interestingly, a recent study on gender differences in brain activation during computer game playing (Hoeft et al. 2008) found that men, but not women, strongly recruit the striatum. Therefore, men rather than women perceive game playing as rewarding. Considering this finding together with our results, we believe that there is converging evidence that demonstrates that the same task (e.g., either shopping or computer game playing) is perceived differently by women and men, in particular, due to activation differences in the brain's reward area, the striatum.

In *Hypothesis 1.4*, we predicted that decision making on both trustworthy and untrustworthy Internet offers activates the DLPFC significantly more in men than in women. We found support for this prediction during the presentation of trustworthy Internet offers (upper part in Table 4), but we did not find support for this prediction during the presentation of untrustworthy Internet offers (lower part in Table 4). DLPFC was shown to play a central role in coupling the information of rewards to actions, thereby controlling behavior and optimizing decision making (Heekeren et al. 2006; Lee and Seo 2007; Van't Wout et al. 2005). Because coupling information about rewards to actions (and thereby controlling behavior and optimizing decision making), is a cognitive rather than affective process, which empathizing–systemizing theory suggests will be observed in men rather than women (Baron-Cohen et al. 2005), we hypothesized that the DLPFC should be activated significantly more in men than in women.

However, in a study of the neuronal activity of players in an economic game, Sanfey et al. (2003) found increased activity in the DLPFC as a response to unfair offers. Therefore, it is possible that women, but not men, considered untrustworthy offers as unfair offers, which could be associated with the perception of uncertainty and risk. This theorizing is in line with women's increased inclination toward risk perception in online shopping (e.g., Garbarino and Strahilevitz 2004).

In the trust literature, the *ventral posterior cingulate cortex (BA 23)* has not yet been identified as a relevant brain region. We have not, therefore, formulated a hypothesis about this brain area. However, although the posterior cingulate cortex (PCC) has not been studied as intensively as the ACC, its critical role in perception and decision making is established. One study (Maddock et al. 2003), for instance, found that activation in the PCC is associated with emotionally arousing stimuli. Moreover, an animal study (McCoy and Platt 2005) found that neuronal activity in PCC increased when monkeys made risky choices, and scaled with the degree of risk. Due to the interrelationship between risk and trust (e.g., Pavlou 2003), our data suggest that in untrustworthy situations PCC activity is likely to signal both arousal and risk in men, but not in women. Recent research has found that hormonal differences between women and men influence receptor systems in the PCC (Cosgrove et al. 2007), a result that is in line with the gender differences found in the present study.

Gender Similarities

Trustworthy Versus Untrustworthy Offers

By contrasting trustworthy versus untrustworthy offers, we found increased activity in the *dorsal ACC* in both women and men, with a larger cluster size in men (Table 4). In *Hypothesis 1.1*, we predicted that decision making on both trustworthy and untrustworthy Internet offers activates the dorsal ACC (BA 32) in men and the ventral ACC (BA 24) in women. This prediction was based on evidence which shows that, at a population level, men are stronger systemizers (implying more cognitive information processing, which was found to occur in the dorsal ACC) and women are stronger empathizers (implying more affective information processing, which was found to occur in the ventral ACC) (Baron-Cohen et al. 2005; Bush et al. 2000; Devinsky et al. 1995).

In our study, we found that the dorsal ACC was activated not only in men (as predicted), but also in women (Table 4). At a first glance, this result seems to contradict our theorizing in *Hypothesis 1.1*. However, because the cluster size of dorsal ACC activation in men is much larger than in women (Table 4), we believe that this gender difference supports the notion that men, in contrast to women, usually process information in a cognitive rather than affective manner (Cosgrove et al. 2007; Meyers-Levy 1994; Wager et al. 2003). Therefore, our result does not contradict the empathizing–systemizing theory.

Untrustworthy Versus Trustworthy Offers

By contrasting untrustworthy versus trustworthy offers, we found increased activity in the *insular cortex* in both women

and men, with an equal cluster size (Table 4). This finding does not support the hypothesized gender difference in insular activation (*Hypothesis 1.7*). Women, in general, perceive greater risks in a wide variety of domains, including environmental, financial, and medical (e.g., Byrnes et al. 1999), as well as Internet shopping (Garbarino and Strahilevitz 2004; Sheehan 1999). Consequently, we predicted that the insular cortex, a brain area responsible for encoding uncertainty and risk (e.g., Krain et al. 2006), is activated significantly more in women than in men during the presentation of untrustworthy Internet offers. However, because there is no gender difference in insular cortex activation, other brain areas listed in Table 4 must account for the behavioral gender differences in uncertainty and risk perception. In the present study, in particular, we identified the hippocampus as a brain region that signals uncertainty and risk in women, but not in men (Table 4).

The present study identifies the insular cortex as a brain area that is important for both women and men reacting to untrustworthy Internet offers. In the following, we discuss insular activation in the context of *situational normality*, an important behavioral construct in IS trust research (e.g., Gefen et al. 2003), thereby outlining an example of neuroscience findings on human behavior that could be effectively integrated into IS research.

Buying and selling online is inherently different from traditional commerce. First, buyer and seller are physically separated, permitting simultaneous exchange of product and money. Second, a typical online transaction takes place between a buyer and a seller who are unknown to each other, on the basis of a one-time interaction (Resnick and Zeckhauser 2002). Third, in Internet transactions, the medium of communication consists of a complex system of technical components that are not well understood by most users. Fourth, the Internet transaction is influenced by the fact that facial expression, gesture, and similar cues are not available (Brosig et al. 2003). From a buyer's perspective, these characteristics of online transactions may lead to considerable perceptions of uncertainty and risk, both among female and male users (Gefen et al. 2008; Kim et al. 2009; McKnight et al. 2002a; Pavlou 2003; Pavlou et al. 2007).Hence, our results concerning the activation of the insular cortex are in line with behavioral research.

In particular, we believe that insular activation may be associated with situational normality, which signifies a condition in which a person believes that the situation in a risky venture is in proper order and is favorable, and as a result expects that success is likely and failure is unlikely (Baier 1986; Lewis and Weigert 1985).[15] An online buyer who perceives high situational normality would believe that the Internet environment is appropriate, fitting, and favorable for engaging in a transaction. Situational normality, therefore, assures people that everything in the online environment is as it ought to be, and that a shared understanding of what is happening exists (McKnight and Chervany 2001; McKnight et al. 1998; Zucker 1986).

People tend to perceive greater trust when the nature of the interaction is in accordance with what they consider to be typical and, hence, anticipated. Gefen et al. (2003) point out that this is in accord with sociologists such as Luhmann (1979) and Blau (1964), who view trust as the product of fulfilled expectations. In the context of Internet offers, this view is relevant in that an offer represents what customers expect, based on their experience and knowledge of other similar offers. If the expectations are met, then a buyer will be more inclined to trust the seller. However, research suggests that a state of distrust is the mental system's signal that the environment is not normal (Schul et al. 2004, 2008).[16] To be able to recognize that an environment is not normal, experience with that environment is necessary. When exposed to a known environment, it is very likely that humans retrieve their previous experience with that environment. If the perceived environment does not meet the expectations, then distrust is likely to emerge; if it meets the expectations, then distrust is unlikely and an essential basis for the emergence of trust does exist.

Accordingly, the activation of the insular during the presentation of untrustworthy offers can be interpreted as a neuronal signal for distrust. The participants in our fMRI study are highly experienced Internet and eBay users (see Table 2). As a result, it is likely that the participants retrieved their experience with eBay during the visual perception of the stimuli in order to detect abnormalities. Because technical products (e.g., digital cameras, laptops, or USB flash drives) are often described at length on eBay (Bolton et al. 2004; Gregg and Scott 2008), the "abnormality hypothesis" might

[15]Situational normality is discussed as an important antecedent of institution-based trust in the IS literature (e.g., Gefen et al. 2003; McKnight and Chervany 2001; McKnight et al. 1998).

[16]It must be noted that the focus of the present study is not to explicitly distinguish between trust and distrust. However, there is increasing evidence that both constructs are not the two ends of one continuum; rather, they are two separate constructs (e.g., Cho 2006; Lewicki et al. 1998; McKnight and Chervany 2001; McKnight and Choudhury 2006; McKnight et al. 2002b; McKnight et al. 2004; Ou and Sia 2009). Brain imaging could be used to show that trust and distrust are in fact two separate constructs on the neurological level of analysis.

explain why the conditions NO TRUST-ASSURING ARGUMENT or CLAIM ONLY—which included either little or no text—were rated as untrustworthy. Detecting and avoiding threats are two of the most basic human skills, so that the sensitivity to risks of the insular is, in both men and women, considered to be a mechanism that promotes learning in order to avoid loss (Samanez-Larkin et al. 2008).[17]

Summary, Implications, Limitations, and a Concluding Comment

One major goal of our study was to add a new theoretical perspective to the existing IS trust literature. Taking into account the mounting evidence on gender differences in online trusting behavior, we set up a laboratory experiment to explore whether or not these differences are accompanied by neural differences that can be detected by fMRI. In fact, we found a considerable number of neural differences. The following discussion summarizes our results and outlines important implications.

1. We found that there are several gender-specific *trust* regions (Table 4), but there are also two gender-independent trust areas (dorsal ACC and insular cortex). Trustworthy offers are associated with female brain activation in the dorsal ACC, thalamus, striatum (the putamen), and fusiform gyrus (BA 37), whereas in the male brain the dorsal ACC and DLPFC (BA 9) are activated. Untrustworthy offers, in contrast, activated the female ventral ACC, hippocampus, DLPFC, striatum (the caudate body), and insular cortex; in men, the untrustworthy offers activated the VMPFC (BA 10), insular cortex, and ventral PCC (BA 23). Altogether, our study shows that women recruit more limbic structures than do men in a trustworthiness evaluation task.

2. In the "Literature Review and Hypotheses" section and in the "Discussion" section, we link our results to the literature in both IS and neuroscience, thereby providing information about the gender-specific *localization* and *nature* of trustworthiness. For example, we discuss the potential role of the insular in abnormality detection, linking our discussion to both the IS trust literature (e.g., situational normality is discussed in McKnight and Chervany 2001; McKnight et al. 1998; Gefen et al. 2003) and the (social) neuroscience trust literature (Baumgartner et al. 2008; Delgado et al. 2005; King-Casas et al. 2005; Krueger et al. 2007). In our research, we found that the presentation of both trustworthy and untrustworthy Internet offers triggered activation in more brain areas for females than for males, thereby providing neurological evidence for the commonly accepted view that, in general, women process more information, and do so more comprehensively, than men (e.g., Meyers-Levy and Maheswaran 1991). This pattern of female brain activation may occur because women perceive greater levels of uncertainty and risk (e.g., Byrnes et al. 1999).

3. We demonstrated that product descriptions (such as those we embedded in an eBay site) can trigger different brain activation in both women and men, thereby identifying an important *antecedent* of the trustworthiness of Internet offers (Table 4). Our study shows that similar descriptions are processed differently by women and men, which is a finding with considerable implications for online shop managers, engineers, and marketers. In particular, trust-building strategies should differentiate between women and men. This differentiation could, for example, address presentation format, content, and color (Simon 2001; Stenstrom et al. 2008). A related and recent study by Cyr et al. (2009) investigated whether *human images* with facial features would induce a user to perceive a Web site as more trustworthy, but did not find a direct relationship. However, our study revealed that *text* has the potential to induce trustworthiness. Replicating the study of Cyr et al. by means of fMRI would be a useful avenue for future research, because brain activation analysis has the potential to disclose possible reasons for a lack of direct relationship between human images and trustworthiness. For example, the fusiform gyrus is a brain area well known for the processing of human faces (Kanwisher and Yovel 2006; Starrfelt and Gerlach 2007), and holds prospects for developing brain activity studies using fMRI.

4. We showed that increased activation in specific brain regions correlates with women's and men's trustworthiness ratings, thereby providing evidence for the *relationship* between brain activation and behavior (Tables 3 and 4). Consequently, our study demonstrates that gender differences in IT-related behavior, in particular in trust situations, are related to neurobiology. Our study, therefore, corroborates the notions that "all human behavior that varies among individuals is partially heritable and correlated with measurable aspects of brains" (Turkheimer 1998, p. 782) and, moreover, that it is evident that

[17]However, abnormality on eBay does not exist only in cases of missing or very spare product descriptions. Rather, a very long, extremely detailed description, as well, is expected to result in perception of abnormality. Future research could test this hypothesis.

there are sex influences at all levels of the nervous system....The picture of brain organization that emerges is of two complex mosaics—one male and one female—that are similar in many respects but very different in others. The way that information is processed though the two mosaics, and the behaviors that each produce, could be identical or strikingly different, depending on a host of parameters (Cahill 2006, p. 7).

The results of our investigation clearly support this concept.

5. In the present study, our theorizing draws upon the *empathizing–systemizing theory* (Baron-Cohen et al. 2005). Originally, this theory was developed to explain gender differences in autism. In essence, the theory posits that autism represents an extreme of the male information processing pattern (i.e., impaired empathizing and enhanced systemizing). Our study confirms the empathizing–systemizing theory in a trustworthiness evaluation task, because we found that women process Internet offers more emotionally, whereas men do so more cognitively. Hence, we demonstrate that neuroscience theories with original medical implications can have considerable implications for IS research and practice, too. In other words, the present study extends the scope of validity of the empathizing–systemizing theory (from medicine to online trust). This finding is relevant to both IS scholars and physicians.

As is common in research articles, the present study has limitations that should be considered. First, the interpretation of our empirical findings is based on a binary trustworthiness rating task in a controlled laboratory environment. Future studies could use more fine-grained scales, rather than binary ones, to evaluate the trustworthiness of Internet offers. Second, during the experiment, participants were required to lie still and were restrained with pads to prevent small motions during measurement sessions. The fMRI experiment, moreover, required participants to lie supine, within an acoustically noisy scanner. Obviously, such a situation is artificial, because in real life most online shoppers sit in front of their computers in a more or less comfortable and calm environment. Third, the present study investigated one particular product only (USB flash drives) in one specific online-brand frame (eBay). Furthermore, we used only one textual formulation for each component of Toulmin's model of argumentation. The use of different products and text formulations might trigger different brain activations, thereby resulting in different findings.

Despite these limitations, we believe that the present study contributes to a better understanding of the factors influencing perceived trustworthiness of Internet offers and, therefore, of online shopping trust. We now know that neurobiological factors are associated with variance in trustworthiness decisions in online settings, and as a result we can answer the question of *why* there are gender differences in online trust. Such differences exist because women and men recruit different brain areas when facing uncertainty, processing information, and deciding which offer to trust. Consequently, we can conclude that women and men are not only different in observable biological ways, but they are distinct on a deeper neural level as well—which until now has not been investigated in research on the subject of online trust.

The question of why women and men are different on this neural level remains open, however. It is possible, on the one hand, that biological factors such as genes (e.g., Cesarini et al. 2008) and hormones (e.g., Kosfeld et al. 2005) cause these gender differences. It is a well-established fact, for example, that gender differences exist concerning the production of oxytocin, considered to be the "trust hormone" (McLean and Anderson 2009). On the other hand, it is possible that socialization and experience, from both childhood and adulthood, are determinants of brain activation differences, because learning processes affect brain development via brain plasticity (e.g., Hyde 2007).[18] One intriguing study (Maguire et al. 2000) exemplifying this concept found that for cab drivers the size of the hippocampus (the brain region that plays a major role in the recall of complex routes) varied as a consequence of years spent driving taxis. Hence, learning and experience may change brain structure, even in adults. Altogether, we surmise that trust is influenced by both biological and socialization factors, and it will be rewarding to see what insight future research will reveal.

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[18]Socialization and stereotypes have already been discussed in the IS literature as theoretical explanations for the existence of gender-specific differences in IT-related behavior (e.g., Adam et al. 2004; Lockheed 1985; Trauth 2002; Trauth et al. 2008; Truman and Baroudi 1994; Whitley 1997).

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Appendix

USB Flash Drive Images

The USB flash drive images used in the pretest and fMRI study are shown below. All USB flash drive images were selected from eBay and Amazon and they were all black, silver, anthracite, and grey (Eiseman 2006).