ABSTRACT

Product recommendation agents (PRAs) are deployed extensively in e-commerce to give consumers advice on products. Although the design of PRAs has received much attention in the IS literature, the focus has been on the PRA’s functional and utilitarian characteristics, thus potentially ignoring social demographics, such as ethnicity and gender, in their design. In this study, we conducted a functional Magnetic Resonance Imaging (fMRI) study to assess how the design of anthropomorphic PRAs (humanoid avatars) can incorporate ethnicity and gender to enhance the interpersonal interaction between users and PRAs.

Brain activity was captured in an fMRI scanner while users indicated their responses to three key variables – perceived usefulness, social presence, and trust – that were shown in the literature to predict the use of PRAs. Our objective was to offer a neurological explanation to prior behavioral findings that showed that ethnicity (but not gender) similarity is associated with higher perceived usefulness, social presence, and trust in PRAs, particularly in women. Specifically, users who varied on their ethnicity and gender to either match or mismatch the ethnicity and gender of four anthropomorphic PRAs were asked to interact and evaluate these PRAs on their perceived usefulness, social presence, and trust.

The fMRI results help explain earlier behavioral findings by showing that the observed brain activations for the three key variables were evident mainly in women as opposed to men, while certain brain activations were primarily due to ethnicity match and others mainly due to gender match. Besides complementing and extending earlier behavioral findings and shedding light on the neurological nature of perceived usefulness, social presence, and trust, the study uncovers the nature and role of ethnicity and gender match and mismatch, as well as it informs practitioners on how to design PRAs that are more likely to be adopted and used.

Keywords: Online Product Recommendation Agents, Avatars, Anthropomorphic Interfaces, Neuroscience, Ethnicity, Gender, fMRI.
1. INTRODUCTION

Online product recommendation agents (PRAs) are often used by commercial websites to give consumers advice on products. PRAs have taken on some of the traditional roles of salepeople with automated and interactive advice (Alba et al., 1997; Senecal and Nantel, 2004). By eliciting consumers’ needs and then advising them of available products that best match these needs, PRAs improve consumers’ decision-making efficacy and reduce cognitive effort (Haubl and Trifts, 2000). Xiao and Benbasat (2007) offer a detailed discussion on the benefits of PRAs. Thus, a well designed PRA can both increase customers’ satisfaction and loyalty and also offer significant cost savings for online merchants who make them available.

While PRAs have the potential to help increase the utilization of e-commerce, the adoption of PRAs is still in its early stages (Leavitt, 2006). A possible reason impeding the use of PRAs may be the lack of social cues in PRAs (Qiu and Benbasat, 2009), as one would have when interacting with traditional salespeople. Indeed, although the design of online PRAs has received substantial attention in the literature, the design focus has been predominantly on improving the PRA’s functional and utilitarian features. However, by designing anthropomorphic PRAs with humanoid avatars that interact with its users to ask questions about their needs and offer advice, it is possible to enhance the quality of the interpersonal interaction between consumers and PRAs to encourage consumers to adopt and use PRAs (Qiu and Benbasat, 2010).

This study is about how to design and evaluate humanoid avatars that are the interface between the users and the anthropomorphic PRAs. We posit that PRAs could be designed in a way that creates a demographic (gender and ethnicity) match between them and their users. We seek to predict both what the impacts of having such an ethnicity and gender match are, and, more importantly, to understand as to why such a match is influential in a deeper fashion. Therefore, to simultaneously assess the what and the why, a functional Magnetic Resonance Imaging (fMRI) study was undertaken to measure the brain activity while users interacted with PRAs that varied in their ethnicity and gender to match or mismatch those of their users. By directly measuring brain activity, fMRI has been shown to shed light on many unanswered questions in the economics (e.g., Camerer, 2003; Glimcher and Rustichini, 2004), marketing (e.g., Lee et al., 2006), and psychology (e.g., Pessoa, 2008) literatures. The use of fMRI tools has also been extended to the IS literature,
and there is much interest among IS researchers in exploring the potential of NeuroIS (e.g., Cyr et al., 2009; Dimoka, 2010; Dimoka and Davis, 2008; Galletta et al., 2007; Minnery and Fine, 2009; Moore et al., 2005). fMRI was used to measure the neural correlates of three key constructs linked to the adoption of PRAs (perceived usefulness, social presence, and trust) (Qiu and Benbsat, 2009) by capturing the location, timing, and level of brain activity that underlies these constructs. fMRI tools measure the brain’s metabolic activity using the blood’s magnetic properties with superb spatial and temporal resolution. The benefits of using fMRI are described in detail in Dimoka et al. (2010). Two of these benefits of key importance to this study is that fMRI data allow us to do exploratory analyses, especially in cases where theory has not fully been matured, and they are presumed to be more reliable than self-reported scales in a study of socially sensitive topics, such as asking people about their perceptions of others that match or mismatch their ethnicity and gender. Brain data help overcome concerns of subjectivity, social desirability bias and political correctness when users assess PRAs that match or mismatch their ethnicity and gender. Finally, the fMRI study also drew upon the vast neuroscience literature to link the observed brain activations for the three proposed constructs to existing neurological processes, aiming to reveal new neurological insights into their nature in the context of PRAs.

Preliminary behavioral work has identified gender differences in terms of how female and male users interact with PRAs, specifically that women tend to rely more on social cues, such as ethnicity and gender, rather than men (Qiu and Benbasat 2010). To validate these findings by using a method that can provide more reliable data for the questions being asked and also shed light on the neurological origins of these propositions, the fMRI study examined the neural correlates of our three focal constructs in women and men separately, aiming to offer a complementary neurological explanation to the observed behavioral gender differences.

In sum, the following two research questions guided this paper:

1. **What are the neural correlates of the constructs that are already known to be antecedents of consumers’ adoption of PRAs - perceived usefulness, social presence, and trust - and what can we learn from the neuroscience literature in terms of their localization in the brain?**

2. **What are the neurological differences between women and men in terms of evaluating PRAs that match or mismatch their ethnicity and gender? Can we explain these differences across genders in terms of the neural correlates of these three constructs that predict the adoption and use of PRAs?**
The results are summarized as follows: The fMRI study allowed the simultaneous measurement of brain activity while users who differed on their *ethnicity* (Asian, Caucasian) and *gender* (Male, Female) viewed four PRAs that varied in their ethnicity and gender to match or mismatch the users’ ethnicity and gender and responded to psychometric measurement items for perceived usefulness, trust, and social presence while viewing each of these four PRAs. The fMRI results show that ethnicity and gender match and mismatch associated with the neural correlates of three constructs are salient in women (but to a lesser degree in men). These brain activations were primarily due to ethnicity match/mismatch and to a lesser degree due to gender match/mismatch. By specifying the neurological origins of the three key constructs that drive a user’s decision to adopt and use a PRA, the fMRI results offer a neurological explanation as to why women are more likely to favorably evaluate a PRA that matches their ethnicity (and to a lesser degree their gender) as opposed to men.

The paper proceeds as follows: Section 2 reviews the literature, develops the theoretical foundations, and proposes the study’s hypotheses. Section 3 describes the empirical fMRI and behavioral studies. Section 4 presents the study’s results. Section 5 discusses the study’s implications for theory and practice.

2. THEORY DEVELOPMENT

2.1 Underlying Theories: Similarity-Attraction, Homophily, and Social Identity

The importance of social affiliation with a salesperson has long been an important driver of consumer activities (Westbrook and Black, 1985). Extrapolating from human to computer-based agents with an anthropomorphic interface, we expect users to rely on social affiliation when viewing online PRAs. This reasoning is explained by the CASA (Computer are Social Actors) paradigm that posits that people make social inferences about computer artifacts while using them (Reeves and Nass, 1996). Accordingly, three theories - similarity-attraction, homophily, and social identity - have been used to justify the role of ethnicity and gender in the adoption and use of online PRAs (Qiu and Benbasat, 2010). *Similarity attraction theory*, grounded in Byrne’s (1971) work, posits that people are attracted to others who are similar to them in certain aspects, such as demographics, physical appearance, attitudes, economic status, social and cultural background, personality, and activities preferences. More specifically, similarity carries considerable weight in initial attraction (Vinacke et al. 1988). According to the theory, the higher the similarity in demographics, such as ethnicity and gender, the higher the attraction toward another person. Also, the *theory of homophily*,
grounded in Lazarsfeld and Merton’s (1954) work, suggests that most human communication will occur between a source and a receiver who are similar. Demographic similarity among people would result in a better communication and a more comfortable interaction. Finally, social identity theory (Tajfel and Turner, 1986) suggests that membership in a group confers a social identity that spawns a self-categorization process that exacerbates in-group similarities and out-of-group differences (Turner, 1982). As people use these readily observable physical cues to classify others as either in-group or out-of-group (Biernat and Vescio, 1993), ethnicity and gender are principal characteristics involved in self-categorization (Messick and Mackie, 1989). In sum, while ethnicity and gender are only two of many demographic characteristics that contribute to the perception of similarity toward a PRA, they are two salient factors with key implications for the initial interaction and evaluation and eventual adoption and use of online PRAs (Qiu and Benbasat, 2010).

2.2 Ethnicity and Gender

Demographic cues, such as gender and ethnicity, are nonverbal cues that are both non-behavioral and low in individual control due to their inherent and relatively enduring nature (De Meuse, 1987). Thus, similarity on these two demographic attributes can be identified with relative ease. In fact, there is strong evidence that the observable demographic characteristics of ethnicity and gender are the most salient when evaluating a person (e.g, Ng et al., 2006; Qiu and Benbasat, 2010; Taylor et al., 1978).

Ethnicity is a strong demographic characteristic that contributes to similarity-attraction, homophily, social identity, self-categorization, and “in-group” favoritism. The literature has shown that ethnicity similarity can induce increased attention and attraction (Elsass and Graves, 1997), which will make users’ perceptions of coexisting with another social being much more evident (Fontaine, 1992). Similarity perceptions could also enhance enjoyable interactions (Berscheid and Walster, 1978), and also create a sense of consideration, comfort, and supportive behavior toward each other (Tsui et al., 1995). Moreover, ethnicity-similarity is also positively associated with supervisors’ higher performance ratings for subordinates (De Meuse, 1987) as well as higher level of perceived job effectiveness in organizational environments (Tsui and O'Reilly, 1989). Extrapolating the extensive literature of the role of ethnic similarity from people to anthropomorphlhc PRAs, we expect online PRAs who match the user’s ethnicity to be evaluated more favorably by their users.
Gender is also a key demographic characteristic that is associated with positive “in-group” perceptions. For example, salespeople favored prospective customers of the same gender (Dwyer et al., 1998), while both genders had better interactions with people of their own gender in the workplace (Foley et al., 2006). Gender similarity also appears to be positively linked to a buyer-seller dyad’s relationship quality (Smith, 1998). Therefore, we expect gender similarity to also positively affect the evaluation of online PRAs.

2.3 Online Product Recommendation Agents and Ethnicity and Gender Match/Mismatch

As noted earlier, for online PRAs to appeal to their users, their interface is often designed with an anthropomorphic embodiment to imitate human communications (Qiu and Benbasat, 2009). The human-like features of PRAs and their demographic cues are important design considerations with implications for their adoption and use because users perceive a human-like, social, and inter-personal communication when interacting with PRAs (Komiak and Benbasat, 2006). However, the literature has focused on the utilitarian aspects of PRAs (Xiao and Benbasat, 2007), mostly on the quality of their advice and their ability to reduce cognitive effort (e.g., Pereira, 2001). Still, many authors acknowledged the importance of demographic cues in the design of PRAs (e.g., Baylor and Ryu, 2003; Cowell and Stanney, 2005; Nass et al., 1995). This is because demographic cues, namely ethnicity and gender, are the most salient ones and are instinctive characteristics a person observes when looking at a face (e.g., Elsass and Graves, 1997; Phelps et al., 2000). Moreover, Qiu and Benbasat (2010) found that when users evaluate online anthropomorphic PRAs, they use social stereotypes similar to those applied in traditional interpersonal communications. In their research, PRAs that matched the user’s ethnicity (but not gender) were perceived to be more sociable, more enjoyable, and more useful to interact with than mismatched PRAs, thereby resulting in higher users’ intentions to choose a matched PRA. They also showed that women are more likely to favorably evaluate a “matched” PRA than a “mismatched” one in terms of social presence and perceived enjoyment.

2.4 Determinants of Use of Product Recommendation Agents

While similarity due to ethnicity and gender is expected to positively influence the adoption and use of online PRAs, Qiu and Benbasat (2010) showed that the effects of ethnicity- and gender-match are not direct, but they are indirect through a set of perceptions about PRAs. Extending the literature on intrinsic and
extrinsic motivation (Calder and Staw, 1975), Qiu and Benbasat showed that both extrinsic and intrinsic motivations influence a user’s intentions to adopt an online PRA. The extrinsic motivations focus on the utilitarian outcome of the relationship between a user and the PRA while the intrinsic motivations focus on the affective natures of the relationship that are exemplified by feelings of intimacy. Extrinsic motivation was captured by perceived usefulness, while intrinsic motivation by social presence. Further support for using these constructs is found in Kumar and Benbasat (2006) who refer to transactional versus social distinctions (e.g., Clark et al. 1986, Mathwick 2002) that characterize a user’s interactions with other entities, such as PRAs. The transactional focuses on the utilitarian nature of the relationship, while the social on the relational nature exemplified by feelings of intimacy and warmth (Kumar and Benbasat, 2006). Kumar and Benbasat also employed perceived usefulness to assess the transactional aspect and social presence to assess the social aspect of the user-PRA relationship. In this study, we investigated another influential construct, trust, which represents both the utilitarian and the social aspects of the relationship. In fact, besides perceived usefulness and social presence, trust was also shown to be highly influential in the use of PRAs (e.g., Komiak and Benbasat, 2006; Wang and Benbasat, 2007; Qiu and Benbasat, 2009). Extending the behavioral implications of ethnic and gender similarity in the use of PRAs, we seek to examine the neural correlates of the three predictive constructs – perceived usefulness, social presence, and trust – associated with the use of PRAs.

2.5 A Neuroscience Lens to the Study of the Use of Product Recommendation Agents

Our analysis is based on the neuroscience literature that examines the localization of higher-order cognitive, emotional, and social processes onto specific brain areas termed neural correlates (Camerer, 2003). The literature has identified the neural correlates of many such processes by measuring brain activation when subjects perform specific activities (e.g., economic games, experimental tasks, visual stimuli) associated with a certain process, thus mapping social constructs to specific brain areas with already known functional roles. While a straightforward interpretation of a “one-to-one” mapping between a brain area and a social construct is alas assumed, there is a more complex “many-to-many” correspondence between brain areas and constructs

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1 Qiu and Benbasat (2010) examined two factors of intrinsic motivation - social presence and perceived enjoyment. However, because social presence plays a more influential role than perceptions of enjoyment, it was herein retained.
(Price and Friston, 2005). This because both a certain construct may activate one of more brain areas and also that the same brain area may be activated by more than one construct. Therefore, a certain brain activation does not necessarily entail that a certain construct is involved (a misconception termed “reverse inference”) (Miller, 2008). Reverse inference is “not deductively valid” (Poldrack 2006, p. 59), albeit it often offers useful information in an exploratory fashion and helping introduce new hypotheses (e.g., Caccioppo et al., 2008).

Following the call in the neuroscience literature for brain models formed by certain neural correlates that link to social constructs (e.g., Hedgcock and Rao, 2009; Huettel and Payne, 2009; Yoon et al., 2009), we seek to propose explicit hypotheses that link our proposed three constructs in the context of PRAs with brain areas. We derive guidance from recent research that has identified the neural correlates of perceived usefulness (Dimoka et al., 2010) and trust (Dimoka, 2010); for social presence, we rely on work that has identified the neural correlates of social inference, interaction, and attachment (Rilling et al., 2004; Walter et al., 2004). Consistent with the spirit of the neuroscience literature, we pursue an exploratory, data-driven approach that allows the brain data to “speak for themselves” and go beyond what our theory can explicitly hypothesize.

We focus on perceived usefulness, social presence, and trust (as opposed to actual similarity) because they were shown to fully mediate the effects of actual ethnic-and-gender similarity on the adoption of PRAs (Al-Natour et al., 2008; Qiu and Benbasat, 2010). Also, actual ethnic-and-gender similarity, whose neural correlates have been found in the neuroscience literature (e.g., Cunningham et al., 2004; Phelps et al., 2000; Richeson et al. 2003), does not have a direct effect on the intended use of PRAs. Thus, we examine how these mediating constructs are differentially mapped in the brain when interacting with ethnic-and-gender matched or mismatched PRAs, aiming to explore the neurological differences in the underlying factors that determine the subject’s preference toward matched or mismatched PRAs. In other words, our basic premise is that people choose matched or mismatched PRAs because they perceive them to be differentially useful, socially present, and trustworthy, not because they actually have a similar or dissimilar ethnicity and gender. Simply put, ethnicity and gender match or mismatch is expected to be captured in the brain through perceived
usefulness, social presence, and trust, which in turn influence the person’s decision to use a PRA. Therefore, we explore the neural correlates of these three constructs in terms of ethnicity and gender match or mismatch.

### 2.5.1 Perceived Usefulness

Extending the technology acceptance model (Davis, 1989) to online PRAs, perceived usefulness is defined as the user’s expectation that using a PRA will enhance the user’s performance in evaluating and selecting products. Perceived usefulness relates to the user’s extrinsic motivation to use a PRA to reduce her cognitive overload and search costs and improve her product purchasing decisions.

For the neural correlates of perceived usefulness, Dimoka et al. (2010) found the caudate nucleus and anterior cingulate cortex – two brain areas associated with rewards and utility – to be associated with high levels of perceived usefulness, while the insular cortex – an area associated with the probability of loss – to be related to low levels of perceived usefulness. In the neuroscience literature, the caudate nucleus is activated proportionately with the magnitude of an expected reward (Hsu et al., 2005; Knutson et al. 2005), while the anterior cingulate cortex is linked to the probability of an anticipated reward (Bush et al., 2002). The caudate nucleus is innervated by dopamine neurons that are activated when one enjoys a large reward (McClure et al., 2004c), while the anterior cingulate cortex is the “executive” branch of the limbic system that is activated in the anticipation of rewards for decision-making (Delgado et al., 2005). In contrast, the insular cortex is a key sensory area that is typically activated by negative information (Wicker et al., 2003), and it has been associated with the fear of losses (Preuschoff et al., 2008). According to Qiu and Benbasat (2010), ethnicity and gender match with a PRA will enhance the user’s perceived usefulness of a PRA. Therefore, we expect a PRA that matches the user’s ethnicity and gender (due to high perceived usefulness) to be associated with higher activation in the caudate nucleus and the anterior cingulate cortex relative to a PRA that does not match her ethnicity and gender. Further, we expect a PRA that does not match the user’s ethnicity and gender (due to low perceived usefulness) to be associated with activation in the insular cortex relative to a PRA that matches the user’s ethnicity and gender. Thus, we propose:

**H1a:** A user’s perceived usefulness of an ethnicity-and-gender matched recommendation agent is associated with higher activation in the (i) caudate nucleus and (ii) anterior cingulate cortex as compared to a recommendation agent that does not match her ethnicity and gender.
**H1b:** A user’s perceived usefulness of an ethnicity-and-gender mismatched recommendation agent is associated with higher activation in the *insula cortex* as compared to a recommendation agent that matches her ethnicity and gender.

H1 is based on the logic that in-group similarity spawns activation in the proposed brain areas. However, we do not hypothesize differences between ethnic and gender similarity *ex ante* in a confirmatory manner, but we will empirically pursue such potential differences given the exploratory nature of fMRI data.

### 2.5.2 Social Presence

The concept of social presence refers to the feeling of being close to another person (Short et al., 1976), and it is often used to capture how people perceive the degree of intimacy and warmth of other people in distant locations (Biocca et al., 2003). Social presence was shown to play an important role in the adoption of technologies outside the traditional workplace (e.g., Shang et al., 2005; Teo et al., 1999). Social presence was also extended to technological artifacts with anthropomorphic or human-like interfaces, such as humanoid agents (Biocca, 1997; Nowak and Biocca, 2003). For example, Nass et al. (2000) showed that Korean users were more likely to perceive a Korean PRA to be more attractive than a Caucasian PRA, resulting in the adoption of the Korean PRA. Qiu and Benbasat (2010) also found that when users evaluate PRAs, they use social stereotypes similar to those in human communications. The authors found that PRAs that matched the user’s demographics (ethnicity and gender) were perceived to have a higher level of social presence than PRAs that did not match the user’s demographics. Extended to online PRAs, social presence is herein defined as the extent to which a user perceives to be psychologically close to a PRA.

In terms of the neural correlates of social presence, drawing upon the neuroscience literature, it is expected that social presence to be associated with areas related to social inferences and social attachment, namely the *anterior paracingulate cortex* (Rilling et al., 2004). The anterior paracingulate cortex is a brain area in the limbic system that is activated when a person engages in a social interaction (Walter *et al.*, 2004) and predicting how others will act (McCabe *et al.*, 2001). The neuroscience literature has linked the anterior paracingulate cortex as a key area of the “social brain” responsible for predicting the social behavior of others (Gallagher and Frith, 2003). Krueger et al. (2007) also showed the anterior paracingulate cortex to be
activated when inferring another person’s future social intentions. The anterior paracingulate cortex is also associated with social attachment behavior (Walter et al., 2004), and it was shown to predict a person’s engagement in a social relationship (Winston et al., 2002) and build social interactions (Dimoka, 2010). Therefore, we propose that a user’s social presence of a RA that matches the user’s ethnicity and gender to activate the *anterior paracingulate cortex* relative to a RA that does not match her ethnicity and gender.

**H2: A user’s social presence of an ethnicity-and-gender matched recommendation agent is associated with higher activation in the *anterior paracingulate cortex* as compared to a product recommendation agent that does not match the user’s ethnicity and gender.**

In general, it may be possible that PRAs that do not match the user’s ethnicity and gender to activate different brain areas relative to PRAs that match the user’s ethnicity and gender. In terms of social presence, this may be due to brain activation caused by negative feelings that arise from the coldness associated with the lack of social presence. However, as social presence is the positive feeling of being close to another person (that is expected to increase if a PRA matches a user’s ethnicity and gender), we do not expect any particular activation when users do not perceive the sense of social presence with a PRA that is dissimilar to them.

Also, similar to H1, the logic of H2 is that ethnic and gender similarity jointly induce brain activation without explicitly hypothesizing differences between ethnic and gender similarity in a deductive fashion. Potential differences will be empirically pursued in an exploratory fashion using the fMRI data.

**2.5.3 Trust**

Trust in a PRA is based on the user’s evaluation of the PRA’s trustworthiness because of the evaluation of the PRA’s information quality and recommendations. Trust is herein defined as the user’s willingness to be vulnerable to a PRA based on beliefs that the PRA will satisfy the trustor’s confident expectations. Trust in a PRA is expected to be influenced by the match between the user and the PRA in terms of ethnicity and gender (Komiak and Benbasat 2006; Wang and Benbasat 2007). This is because “in-group” members are perceived to be more trustworthy (Clark and Maass, 1988) and competent (Stephan and Beane, 1978) than outgroup members. Similar information sources are viewed more credible than dissimilar ones (Simons et al., 1970). Trust is higher in people who were similar in terms of race and gender to the salespeople (Jones et al., 1998). Thus, we expect a match between the user’s ethnicity and gender with a PRA to be linked to higher trust in
the PRA that ethnicity and gender mismatch. In contrast, mismatch between the user’s and PRA’s ethnicity and gender may result in feelings of distrust. Distrust is defined as the user’s unwillingness to be vulnerable to the PRA on the basis that the PRA will be inept and act against the user’s interests (Dimoka, 2010).

In terms of the neural correlates of trust, Dimoka (2010a) identified the caudate nucleus, putamen, and anterior paracingulate cortex. The caudate nucleus has been linked to of rewards due to dopamine neurons that are activated in anticipation of a positive reward (e.g., Knutson et al., 2001), notably mutual rewards from expected cooperation and reciprocity for joint gain (e.g., King-Casas et al., 2005; Rilling et al., 2008). The putamen is another area associated with positive rewards (Haruno and Kawato, 2006), and similar to the caudate nucleus, it is part of the dorsal striatum that receives dopaminergic input from the midbrain in response to rewards (Knutson et al., 2001). Finally, the anterior paracingulate cortex is also activated when predicting how others will behave (McCabe et al., 2001), another salient component of trust (Dimoka, 2010a) (namely predicting whether the trustee will act cooperatively). The anterior paracingulate cortex also resides in the limbic system, and it is responsible for predicting another person’s intentions (Krueger et al., 2007). Taken together, since a match in terms of ethnicity and gender would be associated with higher trust in a PRA (Jones et al., 1998), we expect higher brain activation in these three brain areas for online PRAs that match the user’s ethnicity and gender than for PRAs that do not match the user’s ethnicity and gender.

In terms of the neural correlates of distrust (for PRAs that do not match the user’s ethnicity and gender), the amygdala and insular cortex have been identified in the literature (Dimoka, 2010a). The amygdala is linked to intense emotional states (e.g., LeDoux, 2003; Todorov, 2008; Winston et al., 2002), while the insular cortex is linked to disgust (Wicker et al., 2003) and fear of untrustworthy faces (e.g., Todorov, 2008; Winston et al., 2002). Adolphs et al. (1998) showed impaired judgment of untrustworthiness in people with lesion in their amygdala. Neuroimaging studies with Caucasian subjects who looked at faces of black people showed higher activation in the insular cortex and amygdala (Cunnigham et al., 2004; Phelps et al. 2000). Also, Hart et al. (2000) showed that amygdala activation deteriorated slower for same ethnicity faces versus faces of other races. Thus, we would expect dissimilar PRAs in terms of ethnicity and gender to be associated with higher activation in the amygdala and insular cortex than PRAs that are similar in ethnicity and gender.
**H3a:** A user’s trust in an ethnicity-and-gender matched recommendation agent is associated with a higher activation in the (i) caudate nucleus, (ii) putamen, and (iii) anterior paracingulate cortex as compared to a recommendation agent that does not match the user’s ethnicity and gender.

**H3b:** A user’s trust of an ethnicity-and-gender mismatched recommendation agent is associated with a higher activation in the (i) amygdala and (ii) insular cortex as compared to a recommendation agent that matches the user’s ethnicity and gender.

Similar to H1 and H2, we do not explicitly hypothesize different brain activations for ethnicity and gender match and mismatch, and would instead rely on exploratory investigations of their neural correlates.

Summarizing the neural correlates of perceived usefulness, social presence, and trust, the three constructs are proposed to activate some common brain areas. This is typical in the neuroscience literature because there is a “many-to-many” relationship among brain areas and mental processes, and a certain mental process can activate several brain areas while a certain brain area can correspond to more than one mental processes. The existence of common brain areas may help explain the behavioral relationship among principal constructs, such as those observed in perceived usefulness, social presence, and trust (Qiu and Benbasat, 2010).

### 2.6 Moderating Role of User’s Gender

The match versus mismatch effects of the PRA’s demographic cues are proposed to vary depending on the user’s gender. Demographic match is a social cue, and we expect that women will pay more attention to social cues than men. Prior research has revealed that women and men are different in their communication abilities: women are generally more expressive and can convey meaning more clearly using nonverbal cues (Briton and Hall, 1995; Burgoon and Dillman, 1995; Spangler, 1995). They are better than men in decoding, understanding, and using nonverbal cues sent by others (Briton and Hall, 1995; LaFrance and Henley, 1994). Also, women tend to pay more attention to social influences, while men focus more on the utilitarian aspects of a communication (Hofstede, 1980). Gefen and Straub (1997), for example, showed that women perceive higher social presence from IT artifacts (e-mail) than men who perceive greater utilitarian benefits. Moreover, research on shopping processes has also reported that women are often more psychologically invested in purchasing than men (Dittmar et al., 2004). Furthermore, it was found that female online consumers are more motivated by social interactions and less convenience-oriented than males (Swaminathan et al., 1999).
In addition to having advantages in decoding and using behavioral non-verbal cues, women are also more inclined to act upon demographic non-verbal cues. For example, favorable same-ethnicity bias in performance was only observed for woman subordinates with woman superiors (Tsui and O'Reilly, 1989). Thus, we expect women to be more sensitive to the non-verbal cues conveyed by an anthropomorphic PRA. In an empirical study, Qiu and Benbasat (2010) found that the matching-up effects of ethnicity are more significant among female users than male users in PRA use. Accordingly, women are expected to value and relate to a PRA with an anthropomorphic interface that is similar to them more so compared to men. Hence, we posit that ethnicity-and-gender match effects would be significantly stronger for women than men, and a set of interaction hypotheses associated with the neural correlates of perceived usefulness (caudate nucleus, anterior cingulate cortex, and insular cortex), social presence (anterior paracingulate cortex), and trust (caudate nucleus, putamen, anterior paracingulate cortex, insular cortex, and amygdala) are hypothesized, with the levels of brain activation to be proposed to be stronger for women than men:

**H4a (Perceived Usefulness Match):** The higher brain activation in the (i) *caudate nucleus* and (ii) *anterior cingulate cortex* induced by an ethnicity-and-gender *matched* product recommendation agent will be stronger for women than men.

**H4b (Perceived Usefulness Mismatch):** The higher brain activation in the *insular cortex* induced by an ethnicity-and-gender *mismatched* product recommendation agent will be stronger for women than men.

**H5 (Social Presence Match):** The higher brain activation in the *anterior paracingulate cortex* induced by an ethnicity-and-gender *matched* product recommendation agent will be stronger for women than men.

**H6a (Trust Match):** The higher brain activation in the (i) *caudate nucleus*, (ii) *putamen*, and (iii) *anterior paracingulate cortex* induced by an ethnicity-and-gender *matched* product recommendation agent will be stronger for women than men.

**H6b (Trust Mismatch):** The higher activation in the (i) *amygdala* and (ii) *insular cortex* induced by an ethnicity-and-gender *mismatched* product recommendation agent will be stronger for women than men.
3. RESEARCH METHODOLOGY

To test the proposed hypotheses, an fMRI experiment was conducted in which the brains of 24 subjects were scanned while responding to a set of stimuli (psychometric measurement items) associated with the antecedents of adoption of RAs. To refine the stimuli and experimental tasks and stimuli for the fMRI study, a behavioral lab experiment with 190 students was also conducted as a pretest. This study followed the procedure of integrating fMRI and behavioral data (e.g., Huettel and Payne, 2009; Yoon et al., 2009).

3.1 Experimental Design

A 2×2 within-subject factorial experimental design (i.e., subject-agent ethnicity match/mismatch × subject-agent gender match/mismatch) was used (Table 1).² Four simulated PRAs were designed with two permutations of ethnicity (Caucasian and Asian) and gender (Male, Female). Accordingly, four groups of subjects were recruited whose gender and ethnicity were also permuted to create four categories (Table 1) - ethnicity and gender match or mismatch (plus two partial mismatches, ethnicity or gender match). We chose Caucasian and Asians as the two ethnicities are consistent with the literature (e.g., Ng et al., 2006). Due to the nature of the within subject design all subjects viewed the exact same stimuli (four PRAs differing on ethnicity and gender and corresponding measurement items), albeit the full match, partial mismatch, and full mismatch varied across subjects (Table 2).³ Therefore, this study first aims to study the effects of similarity in terms of ethnicity and gender (full) match versus full mismatch, and second aims to explore how partial match and mismatch may be different across ethnicity and gender.

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<th>Table 1: Correspondence between Product Recommendation Agents and Users (Within-Subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Caucasian</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Caucasian</td>
</tr>
</tbody>
</table>

² While a between-subject design might have been preferred, it will require four times as many subjects (96 subjects), which would be very difficult to conduct given the cost and time constraints of fMRI studies.

³ Since ethnicity and gender match and mismatch is based on the association between the subjects with the PRAs, the PRA that is matched for certain subjects could be mismatched for others. This counter-balanced design gives control of any systematic differences that may exist among the four PRAs, and it also allows us to explore how different subjects may differentially perceive ethnicity and gender match and mismatch.
Table 2. Combinations between Ethnicity and Gender Match and Mismatch

<table>
<thead>
<tr>
<th>Gender</th>
<th>Ethnicity</th>
<th>Match</th>
<th>Mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Full Match) AA-MM, CC-MM, AA-FF, CC-FF</td>
<td>(Ethnicity Match – Gender Mismatch) AA-FM, CC-FM, AA-MF, CC-MF</td>
</tr>
<tr>
<td>Match</td>
<td></td>
<td>(Ethnicity Mismatch – Gender Match) CA-MM, AC-MM, CA-FF, AC-FF</td>
<td>(Full Mismatch) CA-FM, AC-FM, CA-MF, AC-MF</td>
</tr>
</tbody>
</table>

3.2 Design of Experimental Stimuli

The four PRAs were adapted from Wang and Benbasat (2007). Digital cameras were chosen as the focal product because of the complexity of their product characteristics, the large number of alternative models, and the short lifespan of each product generation. The PRA profiles were designed with Oddcast Sitepal, a software that provides a wide-array of characters that can be modified in terms of their physical appearance. The four PRAs with salient ethnic and gender characteristics (Asian female, Asian male, Caucasian female, Caucasian male) (Appendix 1) were selected after several pretests following Qiu and Benbasat (2009; 2010).

The pre-tests showed that all of the subjects correctly identified the PRA’s ethnicity and gender, and they were no significant differences among the PRAs’ physical attractiveness and professionalism. The screen layout of the PRAs was designed to simulate actual commercial PRAs (Appendix 1). Subjects were asked to select an answer to each question (associated with a certain camera characteristic) and to rate the importance level of each attribute in their answer. If a subject wanted to know more about a characteristic, she could click the “About This Question” button to obtain additional information (Appendix 1).

To elicit brain activation in the brain areas associated with the focal constructs, measurement items in the form of psychometric Likert-type scales were used Dimoka (2010b), which were compared across PRAs. The procedure of using existing well-established psychometric measurement items as stimuli to invoke brain activation associated with our constructs ensures that the stimuli closely correspond to our focal constructs and the resulting brain activation would precisely reflect the neural correlates of these constructs, as outlined by Dimoka (2010b). We thus used validated scales for all three constructs with minor changes in wording.
Perceived usefulness of the PRA was adapted from Davis (1989). The PRA’s social presence was adapted from Gefen and Straub (2003). Trust in the PRA was adapted from Wang and Benbasat (2007).

### 3.3 Experimental Procedures

24 right-handed subjects (6 Caucasian males, 6 Asian males, 6 Caucasian females, and 6 Asian females) who were pre-screened for fMRI safety (no medical implants, no metal objects, no physiological problems) participated in the fMRI study for $35 compensation. The number of subjects in each condition (n=6) was chosen to ensure adequate power of analysis (80%) for statistically-significant brain activations at a threshold of p<.05 (Desmond and Glover, 2002). The subjects were recruited from the population of the metropolitan area of a major US university using an open flyer for an fMRI study. The fMRI protocol and ad were reviewed and approved by the University’s Institutional Review Board. The technical details associated with the fMRI scanner, experimental procedures, and detailed data analysis procedures are reported in Appendix 3.

The fMRI design, experimental procedures, and measurement items were calibrated and refined with a behavioral study with 190 subjects that spanned the four demographic groups (Table 1). The behavioral study replicated the fMRI design besides capturing the subjects’ brain data in the fMRI scanner. Since the fMRI study also collected behavioral data, it was possible to compare the behavioral data with the corresponding behavioral data from a traditional lab experiment to test whether or not the behavioral data differed or not across studies and if they are biased from the constraints of the fMRI scanner, thus inferring external validity.

### 3.3.1 Before the fMRI Session

All subjects were asked to work with each of the four PRAs to get information about a digital camera for themselves. Subjects were told to provide their preferences about a digital camera by answering a common set of 10 questions posed by all four PRAs. Subjects simultaneously saw all four PRAs (Appendix 1) at the top of

Because the ultimate purpose of the PRAs and measurement items was to serve as the stimuli of the fMRI study to induce activation in the areas associated with the focal constructs, special care was taken to ensure that the complexity and length of the measurement items were similar across all five constructs. This is necessary because differences in stimuli (such as extra visual stimuli due to longer measurement items) can cause spurious activations that are unrelated to the focal constructs, such as the visual cortex (occipital lobe). Such spurious activations are highly problematic because they may raise the overall level of brain activity and may suppress statistically significant “true” activations in important brain areas. Thus, fMRI studies must have appropriate controls to cancel out or “subtract” all other brain activations besides the desired activation due to the focal stimulus (trust and distrust). We thus accounted for the complexity and length of the measurement items by adapting them to be similar across the three constructs (Appendix 2).
the screen who together asked attribute elicitation questions on digital cameras. That is, the questions did not come from any single PRA but jointly from all four PRAs. To make the experiment as realistic as possible, subjects were told that they have to evaluate, comment, and act upon the advice of the PRAs to purchase a digital camera after the experiment. After subjects responded to the questions, they were told that each of the four PRAs would show them its best choice for them (during the fMRI session). For added realism, subjects also selected one of three different price ranges presented to them, and the PRA’s recommendations were within the selected price range.

To minimize any differences across the PRAs (besides their ethnicity and gender), the recommended cameras of all PRAs were virtually identical in terms of basic characteristics (e.g., price, resolution, zoom). We slightly modified these characteristics (e.g., picture and model number) so that the recommendations offered by each PRA appear different. Between-subjects pretests revealed that subjects could not distinguish among the characteristics across cameras, and their evaluation of each of the four cameras was not statistically different. For added realism, subjects initially saw three digital cameras from each PRA (which were also virtually identical except picture and model number) followed by each PRA’s top choice in the beginning of the fMRI session, which was clearly superior in terms of all characteristics relative to the other two options.\(^5\)

3.3.2 During the fMRI Session

Subjects entered the fMRI scanner lying comfortably on their back. All visual stimuli were consecutively projected to them through fiber-optic goggles connected to a lab computer. First, each PRA showed its three recommendations followed by its top choice. Then, one randomly-selected PRA was presented together with a randomly-selected measurement item for a randomly-selected variable for the same focal PRA. Each stimulus was shown for 5 seconds without the scale, that was shown to be ample time for subjects to read and process

\(^5\) Besides price that was selected by subjects and used in the PRA’s recommendation, all other characteristics were fixed irrespective of the subjects’ posted preferences. This is to ensure that all subjects saw an identical set of digital cameras to avoid variations across subjects due to looking at different digital cameras. No differences across subjects were observed who selected a different price range and were shown a digital camera to be within their chosen price range. Despite the fact that the recommended cameras were the same across all subjects and did not follow the subjects’ stated preferences, none of the subjects raised concerns that the recommended cameras were unacceptable to them. Moreover, we did not observe any behavioral or neurological differences across subjects due to the fact that the recommended cameras differed from their posted preferences.
(Dimoka, 2010). Then, the 7-point Likert-type scale appeared, and subjects selected their choice by pressing one of the seven buttons with a fiber-optic mouse they held with their right hand. Subjects had unlimited time to make their choice, but the actual time they took in practice was about 2-3 seconds. After clicking on their choice, they were shown a new randomly-selected PRA followed by a randomly-selected measurement item. This procedure was repeated for all PRAs, measurement items, and control items, as shown in Figure 2.

Figure 2. Graphical Description of the fMRI Study and Presentation of Stimuli

Since fMRI studies need some repetition to obtain statistically-significant brain activations, similar to multi-item scales, subjects answered a set of 10 similar, but not identical measurement items (Appendix 2). The total time subjects spent in the fMRI scanner for this study was roughly $3 \times 10 \times 4 \times 10 = 1,200$ seconds (3 constructs X 10 items for each construct X 4 PRAs X about 10 seconds for each cycle) or about 20 minutes (plus 3-4 minutes for obtaining the anatomical brain images in the beginning of the fMRI study).

3.3.3 After the fMRI Session

Upon completion of the fMRI experiment, subjects were asked to rank the four PRAs on a 1-4 scale where 1=highest and 4=lowest in terms of preference. Subjects were then thanked, debriefed, and dismissed.

4. RESULTS

The analysis of the fMRI data was performed with SPM8 freeware. Whole-brain 3Tesla fMRI data were acquired in a time-series of approximately 20 minutes to provide 28 contiguous 5mm thick brain slices

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6 fMRI studies require appropriate control variables to “cancel out” spurious brain activation due to visual stimuli, movement, and other sources of noise, and thereby isolate brain activation only associated with the experimental stimuli. In this study, the comparison was made by comparing the subjects’ brain data across any two PRAs.
allowing subjects to respond to the measurement items with a gap of about 10 seconds between two stimuli (measurement items). All brain activations were obtained during the latter part of the 5-second period where the subjects were reading each measurement item (before posting their response) to minimize confounds (e.g., visual stimuli, movement) when responding to the measurement item and assure temporal separation between the brain activity while reading the measurement item and the response on the Likert-type scale.

The brain images were first analyzed for each subject separately. Then, second-level one-sample t-tests were used on the aggregate data to create random-effect group analyses for all constructs across all PRAs. For each condition at the group level, Statistical Parametric Maps (SPMs) were generated with the z-value of each voxel (3D pixel) that exceeded a p<.05 threshold. Region of Interest (ROI) analysis was used to define an area of interest in the brain within which to observe brain activity (King-Casas et al., 2005).

The first stage of the analysis aimed at identifying the neural correlates of the focal constructs when comparing between matched and mismatched (and vice versa) PRAs. The analysis was undertaken by contrasting the brain activations of each construct for the ethnicity and gender matched PRA relative to the mismatched PRA. The contrast between ‘match’ and ‘mismatch’ image reflects the difference in brain activation due to the measurement item when responding on a PRA that matches versus the PRA that does not match the subject’s ethnicity and gender. From the opposite perspective, the ‘mismatch’ versus ‘match’ contrast reflects the difference in brain activity when responding to the measurement items about a PRA that does not match the subject’s ethnicity and gender versus a PRA that matches the subject’s ethnicity and gender. Because it is not possible to observe negative brain activation when subtracting the two brain images, and we can only observe positive activation that exceeds a certain statistical threshold, the contrast between match and mismatch can be starkly different from the contrast between mismatch and match.

While not hypothesized, we also examined the contrasts between both ethnicity and gender (full) match or full mismatch with ethnicity match/mismatch and gender match/mismatch separately in an exploratory fashion. These exploratory tests help specify whether there are differences between match and mismatch for

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7 The z-values in SPM correspond to the unit normal distribution that renders the same p-values as the t-statistic.
8 Exploratory analysis is an accepted norm in fMRI studies (e.g., Cunningham et al. 2004, King-Casas et al. 2005), and it is an important benefit associated with this method. In fact, it is not common to propose and test explicit hypotheses regarding particular brain areas. This is because a natural, data-driven approach is often preferred, albeit it is advisable to specify the brain areas that are expected to be activated (e.g., Huettel et al., 2009; Yoon et al. 2009).
either ethnicity or gender separately (and not their combination), and whether certain brain activations are specifically due to either ethnicity or gender differences (versus ethnic and gender differences together).

4.1 Neural Correlates of Perceived Usefulness

To test H1a, we compared the brain activations when subjects responded to perceived usefulness for the PRAs who matched their ethnicity and gender versus those who did not match their ethnicity and gender (Figure 3a). The comparison between ethnicity and gender (full) match versus full mismatch for all subjects did not reveal any significant brain activation, implying that the brain activation due to perceived usefulness for the “matched” PRAs was fully cancelled out by the “mismatched” PRAs, thus failing to support H1a.

When performing the analysis by gender, there was significant activation in the two hypothesized areas - anterior cingulate cortex (z=2.85, p<.05) and caudate nucleus (z=2.23, p<.05) - only in women, while there was no significant activation in any brain areas in men (Figure 3a). Moreover, t-tests at the individual brain activations for women versus men showed significant difference (p<.001). Thus, H4a was supported.

| Figure 3a. fMRI Results for Perceived Usefulness (Match Versus Mismatch) |
|---------------------------------|-----------------|-----------------|
| All Subjects                    | Only Women      | Only Men        |
| No significant activation       | Caudate Nucleus | Anterior Cingulate cortex | No significant activation |

We also performed exploratory comparisons between only ethnicity match versus ethnicity and gender (full) mismatch. As in the full match Vs. full mismatch contrast, there was no significant brain activation across all subjects. However, there was significant activation in the anterior cingulate cortex (z=2.33, p<.05) and caudate nucleus (z=2.13, p<.05) in women, but there was no significant activation in men. Moreover, no significant activation was observed for the gender match vs. full mismatch contrast. These results imply that the observed brain activations in the anterior cingulate cortex and caudate nucleus for full match versus full mismatch in women (Figure 3a) are mostly due to ethnicity (and not gender) match. In other words, it is ethnicity match (as opposed to gender match) that is responsible for the brain activations in Figure 3a.
Second, when comparing ethnicity and gender mismatch versus full match (Figure 3b), there was no significant activation across all subjects, thus failing to support H1b. However, when performing the analysis by gender, there was significant activation in the insular cortex \((z=2.30, p<.05)\) only in women (Figure 3b), but there was no significant activation in men, thus supporting H4b.

We also compared the ethnicity and gender (full) mismatch versus ethnicity match (gender mismatch) and gender match (ethnicity mismatch) to explore if ethnicity or gender mismatch is mostly responsible for these brain activations. First, for the full mismatch versus ethnicity match contrast, there was significant activation in the insular cortex \((z=2.95, p<.01)\) in all subjects. There was also significant activation in the insular cortex \((z=2.67, p<.05)\) in women but not in men, implying that the observed activation in the insular cortex was due to ethnicity mismatch in women. Second, for the full mismatch versus gender match contrast (essentially gender mismatch), there was no significant activation in any of the samples (all users, only women, or only men). Taken together, these results imply that for perceived usefulness, it is ethnicity (as opposed to gender) that is predominantly responsible for the observed activation in all three brain areas.

### 4.2. Neural Correlates of Social Presence

Figure 4 shows the comparison between the “matched” and “mismatched” PRAs for social presence. While no significant activation in the anterior paracingulate cortex was observed for all subjects, there was only significant activation for women \((z=1.84, p<.05)\), thus supporting H5 but not H2. Nevertheless, there was no significant activation for either ethnicity match or gender match versus full mismatch, neither for all subjects, women, or men. This implies that the combination of ethnicity and gender (full) match is necessary to spawn significant activation in the anterior paracingulate cortex in women in terms of social presence.
While not hypothesized, a significant brain activation was identified in the caudate nucleus only for men ($z=2.37, p<.05$), a brain area associated with utility. This finding is consistent with Singer et al. (2006) who found that men’s responses are shaped largely by evaluating the utility to be obtained by other people’s social behavior. A significant activation in the caudate nucleus in men was also observed in the ethnicity match versus full mismatch contrast ($z=2.13, p<.05$). However, there was no significant activation in the gender match versus full mismatch contrast, implying that the observed activation for full match was largely due to ethnicity (as opposed to gender) match. Summarizing these results, there is a neurological explanation of the difference between women and men in terms of how women and men map social presence in their brain. Specifically, based on the observed brain activations, women engage in a process of social interaction (anterior paracingulate cortex) that arises from their interaction with matched RAs, while men focus on potential rewards (caudate nucleus) when matched RAs give the sense of social presence to them.

Our hypotheses did not predict any activation for the full mismatch versus full match comparison because lack of a sense of presence (which is expected in the mismatched case) was not expected to spawn any activation in any brain areas. The fMRI results confirmed this expectation because no significant activation was observed for social presence, neither for all subjects, women, or men. However, for the full mismatch versus ethnicity match, there was a significant brain activation in the insular cortex in all subjects ($z=2.03, p<.05$), women ($z=3.05, p<.01$), and a marginally significant activation in men ($z=2.06, p<.10$). Also, there was significant activation in the insular cortex for the full mismatch vs. gender match contrast in all subjects ($z=2.76, p<.05$) and women ($z=3.79, p<.01$), but not in men. While earlier behavioral studies do not reveal
any negative perceptions from the lack of social presence when dealing with PRAs that do not match either the user’s ethnicity or the user’s gender (Qiu and Benbasat, 2010), the fMRI results show an activation in the insular cortex (a brain area associated with disgust and fear of loss) for ethnicity and gender mismatch, especially in women. While behavioral measures capture social presence on a positive continuum from no (zero) to high levels of social presence, the fMRI results suggest the existence of a “negative” (coldness) form of social presence. These unexpected fMRI results attest to the ability of brain data to uncover “hidden” facets of existing constructs (Dimoka et al., 2010) that existing behavioral measures may not be able to uncover.

4.3 Neural Correlates of Trust

In terms of the neural correlates of trust when contrasting “matched” versus “mismatched” PRAs, no significant activation was observed in any of the areas that was earlier associated with trust (Dimoka, 2010a) across all subjects, thus failing to support H3a. In other words, the brain activation in the mismatched PRA fully cancelled any brain activation in the matched PRA in terms of the neural correlates of trust. Similarly, no significant activation was observed when splitting the sample by gender, implying that there was no higher activation in women compared to men in any of these three brain areas, thus failing to support H6a.

To test H3b, we compared ethnicity and gender (full) mismatch versus full match (Figure 5). There was no significant activation in the two hypothesized brain areas across all subjects, failing to support H3b. However, when analyzing the results by gender, in women, there was significant activation in the amygdala (z=3.63, p<.01) and insular cortex (z=3.47, p<.01). However, there was no significant activation in men, thus supporting H6b. Gender t-test analysis of the individual brain activations confirmed that activations in women were significantly higher (p<.001) than men in both areas, further confirming H6b. These results imply that the strong negative emotions associated with lack of trust (or distrust) toward a PRA who does not match their ethnicity and gender versus one that matches these attributes are only evident in women but not in men.

<table>
<thead>
<tr>
<th>Figure 5. fMRI Results for Trust (Ethnicity and Gender (Full) Mismatch Versus Full Match)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Subjects</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
</tbody>
</table>

24
We also ran the analysis by comparing the full mismatch versus ethnicity match or gender match to test whether ethnicity or gender mismatch is mostly associated with the observed brain activations in the amygdala and insular cortex. First, for ethnicity mismatch, there was no significant activation across all subjects. However, there was only significant activation in the insular cortex ($z=2.54, p<.05$) in women (but not in men). Second, for gender mismatch, there was similarly no significant activation in all subjects. However, there was significant activation only in the amygdala ($z=2.54, p<.05$) in women (but not in men).

In summary, while ethnicity and gender (full) mismatch induce activation in the amygdala and the insular cortex only in women, ethnicity mismatch causes activation only in the insular cortex while gender mismatch only causes activation in the amygdala. While the amygdala and insular cortex are both highly emotional brain areas, the insular cortex is typically associated with fear of loss, while the amygdala is associated with intense negative emotions. Therefore, the results suggest that ethnicity mismatch is associated with the potential for loss, while gender mismatch is associated with intense negative emotions.

4.4 fMRI Results - Summary

Table 3 summarizes the identified brain activations for perceived usefulness, social presence, and trust, categorized by match vs. mismatch (and vice versa). Please note that these three constructs share some common brain areas (insular cortex for both perceived usefulness and trust and anterior paracingulate cortex for social presence and trust), consistent with the literature that it is possible for a the same brain area to be associated with more than one construct. These findings are consistent with the literature that has consistently found high correlations among the behavioral measures of these three constructs (e.g., Pavlou et al., 2007).

Table 3 specifies whether these activations are due to ethnicity match or mismatch (bold), gender match or mismatch (bold italics), or both ethnicity and gender (full) match or mismatch (regular). As Table 3 attests,
most observed activations are due to ethnicity match, confirming the literature (e.g., Cowell et al., 2005) that, between ethnicity and gender, ethnicity is generally viewed as the more important demographic characteristic.

Table 3. Summary of Brain Activations for Ethnicity and Gender (Full) Match Vs. Full Mismatch

<table>
<thead>
<tr>
<th></th>
<th>All Subjects</th>
<th>Women Only</th>
<th>Men Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness</td>
<td>Match vs Mismatch</td>
<td>Mismatch vs Match</td>
<td>Match vs Mismatch</td>
</tr>
<tr>
<td>Social Presence</td>
<td>Insular cortex</td>
<td>Anterior Cingulate Cortex</td>
<td>Caudate Nucleus</td>
</tr>
<tr>
<td>Trust</td>
<td>Insular cortex</td>
<td>Anterior Paracingulate Cortex</td>
<td>Insular cortex</td>
</tr>
<tr>
<td></td>
<td>Insular cortex</td>
<td>Caudate Nucleus</td>
<td>Amygdala</td>
</tr>
</tbody>
</table>

Bold: Ethnicity Match/Mismatch – Bold Italics: Gender Match/Mismatch – Regular: Ethnicity and Gender Match

It is important to note that there was no significant activation in the nucleus accumbens, an area linked to attractive faces (Aharon et al. 2001). This implies that the PRA’s relative attractiveness did not spawn any differential brain activation, validating our pretest that all PRA’s were equally attractive. Also, aesthetic evaluation was shown to be distinct from rewards evaluation (Aharon et al., 2001), implying that our results are not driven by aesthetic evaluation. Also, besides breaking down the analysis by the user’s gender, we also performed the analysis by the user’s ethnicity that showed no differences between Caucasian and Asian users.

4.5 Validation of fMRI Results

The fMRI results for trust are supported by the ANOVA analysis (Appendix 4) conducted on the behavioral data that is derived as a by-product of the fMRI data collection process. The overall ANOVA results (Table A4) show a significant “ethnicity and gender (full) match” * “user’s gender” interaction effect but no main effect due to ethnicity and gender match. The ANOVA results from the behavioral data are thus consistent with the fMRI results (which also specify that women are responsible for the gender differences). However, relative to the ANOVA results, the fMRI data also provide a much richer and more nuanced neurological understanding of the behavioral results, as shown in the fMRI images and discussed below.

First, the ANOVA results for perceived usefulness are consistent with the fMRI results (Table A4), which show a significant “ethnicity and gender (full) match” * “user’s gender” interaction effect but no main effect due to gender and ethnicity match. An ex-post cross-gender analysis revealed a significant effect of ethnicity

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9 Activation in the insular cortex across all subjects and in women was evident for either the ethnicity mismatch or the gender mismatch separately but not for the ethnicity and gender (full) mismatch condition.
and gender match (p<.05) only among female users (Table A5). While this is consistent with the fMRI results, the fMRI data also identified that ethnicity (relative to gender) match is more important for women than for men, something that could not be inferred by the behavioral results.

Second, the fMRI results for social presence are consistent with the behavioral ANOVA results (Table A4) that show a borderline significant interaction effect (p=.053) between ethnicity and gender match with user’s gender, supporting the fMRI results that ethnicity match is more important for women than men. However, while the fMRI results denote that gender mismatch reveals differences in the insular cortex between women and men, the ANOVA cross-gender analysis does not detect any significant gender differences (Table A5).

Third, in terms of trust, the fMRI results are also consistent with the ANOVA analysis (Table A4) that show a significant interaction effect (p<.05) between ethnicity and gender (full) match with the user’s gender. An ex-post ANOVA cross-gender analysis suggest that matching effects are marginally significant (p<.10) among female users but not males (Table A5). However, the fMRI results offer further information about the nature of these gender differences, notably that ethnicity mismatch is associated with the fear for loss (insular cortex activation), while gender mismatch is associated with intense negative emotions (amygdala activation).

In sum, while the fMRI and behavioral results are consistent (supporting the study’s ecological validity), the fMRI results not only identify the same basic relationships that behavioral results do, but they also offer additional significant insights not evident from the behavioral results, which are discussed in detail below. We can therefore conclude that fMRI is a method supplements the behavioral data collection approach.

5. DISCUSSION

This study has several major findings: First, although there were no main effects associated with perceived usefulness, social presence, and trust (H1a,b; H2; and H3a, b were all rejected), the fMRI results supported all of the interaction hypotheses for user’s gender (except for H6a for trust) for women. Second, the behavioral results (Appendix 4) are largely consistent with the fMRI results in that the only significant effects are associated with the PRA’s full match x user’s gender interactions while there were no main effects for full match versus full mismatch. Both the behavioral and fMRI data indicate that the interaction effects are due to the fact that ethnicity and gender match is more relevant for women than for men. Third, the
exploratory (non-hypothesized) investigations reveal that the matching effects (for women) are primarily due to ethnicity but not gender match. Finally, the benefits of conducting fMRI studies over behavioral studies only is that we are able to capture the neural correlates associated with the constructs of perceived usefulness, social presence, and trust, as well as the differences between both match vs. mismatch and also mismatch vs. match, giving us a richer neurological understanding as to why different anthropomorphic PRAs that match the user’s ethnicity and gender are evaluated across genders. To our knowledge, this is the first neuroimaging study to examine the neurological bases of the key constructs that drive the adoption of PRAs to shed light onto their nature.

5.1 Theoretical Contributions

The importance of similarity theories in the design of PRAs has been discussed in the IS literature, initiated by the work of Al-Natour, Benbasat, and Cenfetelli (2006; 2008). These authors have theoretically argued and empirically shown that a personality and behavior (decision making strategy) match between a PRA and its users to have positive effects concerning key variables that affect the adoption and use of PRAs.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Behavioral Explanations</th>
<th>Neurological Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived Usefulness</strong></td>
<td>Based on similarity attraction, homophily, and social identity theories, which theorize that membership in a group of similar individuals creates a psychological state that gives a user social identity in a particular group, anthropomorphic PRAs that match the user’s ethnicity and gender are more likely to be viewed as similar to the user, and thus to be perceived as “in-group.”</td>
<td>Perceived usefulness for matched PRAs is associated (only in women) with brain activation in the caudate nucleus and anterior cingulate cortex two areas associated with utility and rewards. Mismatched PRAs activate the insular cortex (only in women) due to negative rewards, implying that the observed gender differences are due to the differential brain activation in the neural correlates of negative usefulness.</td>
</tr>
<tr>
<td><strong>Social Presence</strong></td>
<td>This in-group favoritism makes anthropomorphic PRAs that are similar to their users in terms of ethnicity and gender to be perceived as more useful, sociable, and trustworthy by</td>
<td>Social presence for matched PRAs is associated with brain activation in the anterior paracingulate cortex, an area in the “social” brained linked to social inferences and social attachment behavior. Social presence for mismatched PRAs activate the insular cortex, implying a fear of loss from inferring lack of social attachment. These findings are evident only in women, while brain activity in the caudate nucleus is only evident in men, implying expected utility from engaging in a social relationship with a matched than a mismatched PRA.</td>
</tr>
<tr>
<td><strong>Trust</strong></td>
<td>Trust for matched PRAs does not spawn any significant activation in the expected areas. Mismatched PRAs spawn activation in two brain areas</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Comparison between Behavioral and Neurological Explanations
Qiu and Benbasat (2010) further proposed demographic (ethnicity and gender) match as another type of similarity that is important in the design of PRAs. Accordingly, this study extends and enriches this work by using a methodology (fMRI) not commonly used in IS studies to date to gain complementary benefits with brain data derived from fMRI to extend the theory of similarity in the design of online PRAs. Insights from the fMRI study offer rich neurological explanations on the role of similarity in the design of PRAs that complement and extend existing behavioral explanations about the use of PRAs (Table 4).

The fMRI study not only enriches the behavioral explanations with neurological explanations (Table 4), but it also explains why the behavioral data are observed based on the brain activations that underlie the three focal constructs, and what explains the observed behavioral gender differences. As Table 4 attests to, the brain activations point out to specific psychological processes that enable us to offer more precise explanations for the observed behavioral responses without fear of subjectivity and social desirability bias, thus enabling us to offer more objective and comprehensive explanations for the role of ethnic and gender similarity in the design of online anthropomorphic PRAs that better corresponds to the brain’s functionality. Most interestingly, the fMRI data can identify if the behavior is due to either ethnicity match/mismatch or

| Gender Moderating Effects on Perceived Usefulness | Women are better than men in observing, decoding and using non-verbal cues sent by other people (Briton and Hall, 1995; LaFrance and Henley, 1994). | **Perceived Usefulness:** Mismatched PRAs activate the insular cortex in women, implying that the observed gender differences are due to angst and fear of loss. |
| Gender Moderating Effects on Social Presence | Women were also shown to be more inclined to act upon demographic cues, such as ethnicity and gender in their evaluations of other people (Tsui and O'Reilly, 1989). | **Social Presence:** Mismatched PRAs activate the insular cortex in women and the caudate nucleus in men, implying that men focus on expected utility from interacting with PRAs while women focus on losses. |
| Gender Moderating Effects on Trust | Associated with distrust, specifically fear of loss (insular cortex) from ethnicity mismatch and intense negative emotions (amygdala) from gender mismatch, and only in women. These findings imply that mismatched PRAs in terms of ethnicity and gender are only negatively viewed by women. | **Trust:** Mismatched PRAs elicit activation in two areas in women, fear of loss (insular cortex) from ethnicity mismatch and intense negative emotions (amygdala) from gender mismatch, thus specifying that gender (mismatch) is responsible for strong negative emotions while ethnicity (mismatch) is linked to the fear of loss. |
gender match/mismatch, thus helping specify the particular psychological processes that give rise to the observed behavioral responses. The fMRI data could be viewed as a mediator between the observed stimulus (actual similarity/dissimilarity of the PRA that matches/mismatches the user’s ethnicity and/or gender) and the resulting behavioral responses, thus identifying the neurological processes that occur in our brain when a user observes IT artifacts that vary on their ethnic and gender similarity to match the user’s demographics. The brain data thus enhance the descriptive power of earlier behavioral explanations by identifying the underlying neurological bases that drive the self-reported responses on the three focal behavioral constructs.

Drawing from Table 4 that specifies how the neurological explanations complement and enrich the behavioral data, the study’s first key contribution is to theoretically propose and empirically demonstrate with brain data the differences between women and men in terms of the neural correlates of the three constructs – perceived usefulness, social presence, and trust – which were associated with the adoption and use of PRAs (Qiu and Benbasat 2009). As Table 3 attests to, the brain activations between women and men are starkly different, indicated by the main effects across all subjects where no significant activation was observed when pooling the two distinct gender samples. While the behavioral data also infer gender differences (Appendix 4), the brain data pinpoint the exact differences between women and men in terms of brain activity. Although in women all three constructs that predict the adoption and use of PRAs elicit brain activations (both in terms of match Vs. mismatch and also mismatch Vs. match), in men there is activation in the brain’s reward areas for social presence (caudate nucleus). Notably, women expect both positive (anterior cingulate, caudate nucleus) and negative rewards (insula cortex) to arise from the use PRAs, while they also engage in a social interaction process with PRAs (as suggested by the anterior paracingulate cortex). In contrast, men only seem to focus on potential rewards (caudate nucleus) when matched PRAs give them higher sense of social presene. The observed behavioral differences between women and men can thus be explained by the more pervasive activity that occurs in the women’s “social” brain versus the men’s “utilitarian” brain, implying how brain data can supplement our understanding of gender differences in interacting with PRAs.

The second key contribution of this study is to affirm that ethnicity match is necessary to understand why women prefer demographic matches. While previous literature has argued that ethnicity is regarded as a more
important attribute than gender (e.g., Cowell et al. 2005; Cunningham et al. 2004), it was not clear whether
the importance of ethnicity match was primarily due to women. The observed interaction effects are caused
by women who value ethnicity match higher than gender match. This finding may be explained by Taynor
and Deaux (1973) who argued that gender effects are comparatively weaker relatively to ethnicity effects, and
they are likely to be subordinated. For example, Cowell and Stanney (2005) found that a significant majority
of people chose a character that matched their own ethnicity, but there was no particular preference for gender.
Also, Nass et al. (2000) showed that Korean users were more likely to perceive a PRA that looked Korean to
be more trustworthy, socially attractive, value congruent, and offer higher quality arguments than a PRA that
looked Caucasian, resulting in adopting the Korean PRA. Moreover, Hart et al. (2000) showed that ethnicity
stimuli have an important role when subjects assessed the faces of people from other ethnicities,
recommending that any future studies with face stimuli to include ethnicity. The women’s propensity to stress
ethnic difference could also be behaviorally ascribed to the greater involvement of women in ethnic traditions.
Sociologists have shown that women are more oriented to their ethnic identity than men (e.g, Masuda et al,
1973; Ting-Toomey, 1981; Ullah, 1985). In our study, it is likely that women were more aware of their own
and the PRA’s ethnicity, and they were more prone to use ethnicity as social “in-group” cues that shaped their
motivations to positively evaluate a “matched” PRA. Therefore, we need to extend similarity theory as it
applies to PRA use by adding both the user’s gender as a moderator and possibly having ethnicity match and
gender match as finer gradations of full match Vs. full mismatch in the models to be tested by future research.

The study’s third key contribution is to offer a neurological explanation as to why ethnicity differences are
more influential than gender differences. The fMRI data allow us to understand both the causes for why
certain behavioral constructs are significant and also the finer nuances for these differences (Table 4). The
fMRI results for the construct of trust show stark differences between ethnicity and gender mismatch, notably
that ethnicity mismatch is associated with the insular cortex, while gender mismatch with the amygdala.10

10 While the amygdala and insular cortex are clearly distinct brain areas, Winston et al. (2002) explained that the
amygdala generates sudden changes in bodily states that are subsequently re-mapped onto the insular cortex.
Perhaps the close association between these two brain areas onto which ethnicity and gender biases map may help
explain why it is often behaviorally difficult to perfectly disassociate gender and ethnicity biases from each other.
First, the insular cortex is a primary sensory cortex for autonomic arousal often spawned by negative information (Wicker et al., 2003), and it has been associated with the fear of loss (Preuschoff et al., 2008). Accordingly, interacting with a PRA that does not match the user’s ethnicity causes an aversive behavior toward losses (Sanfey et al., 2003; Rilling et al., 2008). The amygdala activation related to gender mismatch is typically associated with intense negative emotions. While activation in the amygdala tends to be associated with more intense emotions, it is abrupt and short-lived, and this is perhaps why gender mismatch, which is linked to amygdala activation, may be concealed easier. The amygdala is activated due to the secretion of the chemicals epinephrine and norepinephrine that are hormones that are secreted when danger is present, perhaps implying that gender mismatch may imply danger to users. Moreover, since the amygdala has been linked to the interaction between emotion and cognition in decision-making (Phelps, 2006), this emotional activation may be behaviorally contained due to social desirability bias and not appear in the self-reported measures. Thus, it may not be that ethnicity differences are more salient to people, but it may be that gender differences are more easily concealed due to social desirability bias that makes them difficult to uncover with self reports.

A fourth key contribution of this study is to reveal that the reason women prefer to work with PRAs of the same ethnicity is not necessarily because they like an ethnicity match, but because they may have a strong aversion toward ethnically mismatched anthropomorphic PRAs. The fMRI results showed that women are negatively affected by social cues from PRAs that do not match their ethnicity (and gender to a lesser degree), while men are only positively affected by utility cues conveyed by PRAs that match their ethnicity and gender. While one behavioral explanation for these findings is that women are generally more emotionally expressive and can convey their emotions easier than men (e.g., Briton and Hall, 1995; Burgoon and Dillman, 1995; Spangler, 1995), our neurological results show that only women engender strong emotional reactions in their corresponding brain areas (amygdala and insular cortex) in response to PRAs that are not similar to them. That is, it is not that men cannot verbally express or behaviorally convey their emotions that distinguishes them from women, it is simply that men do not engender the same type or level of brain activations in their emotion-laden brain areas as women do. In other words, it does not seem that men cognitively “hide” their emotions (which could be captured by a corresponding activation in more cognitive brain areas that would
“suppress” any emotional activity), but rather there does not seem to be any significant activation in these brain areas, at least for these constructs. In contrast, men seem to draw their behavior from other brain areas mostly associated with utilitarian considerations (caudate nucleus in this study), thus helping explain the behavioral findings in the literature that men are more utility-driven (e.g., Minton and Schneider, 1980).

Lastly, the exploratory investigations afforded by the fMRI data also revealed some interesting results. While our hypotheses only suggested “positive” brain areas to be activated from social presence due to matched PRAs, there was a (non-hypothesized) significant activation in the insular cortex for social presence due to PRAs that did not match the user’s ethnicity and gender, particularly in women. While social presence denotes an intrinsic motivation by being close to a person (or anthropomorphic PRA), perhaps the lack of social presence may spawn negative reactions due to coldness and fear, as reflected in the insular cortex. Also, it may be that social presence is not captured as a continuum from zero to a large degree, as traditional behavioral measures would imply, but there is a “negative” form of social presence caused by entities, such as mismatched PRAs, which are perceived to render a negative perception of social presence, such as coldness. Accordingly, the fMRI results may uncover some interesting but hidden aspects of existing constructs. These unexpected fMRI results underscore the ability of fMRI studies to identify “hidden” aspects of constructs (Dimoka et al., 2010), which may not be possible to uncover with existing behavioral methods.

5.2 Implications for the Design of Online Recommendation Agents

The fMRI results point out to the crucial fact that women are particularly sensitive to mismatched PRAs, which lead to intense negative emotions and fear of loss. This research thus calls for more attention to ethnicity and gender in the design of anthropomorphic PRAs, particularly for women, and we recommend that designers of PRAs provide users with an anthropomorphic interface that matches their ethnicity and gender. While it is quite costly to have traditional salespeople that match the customer’s demographics, IT artifacts in the form of PRAs can be inexpensively designed to match each user’s ethnicity and gender. Although some managers may doubt that the cost for designing customized anthropomorphic interfaces is warranted, it is possible for websites to collect demographic information and present the matched embodiment of a PRA. Still, since we have not studied all possible demographics, there is the possibility that other characteristics of PRAs,
such as age, may also be influential. Otherwise, given the high cost associated with mismatched PRAs, especially for women, until research has investigated an exhaustive set of influential demographics, it may be reasonable to allow users to pick the PRA’s desired demographics from a set of available options.

5.3 Limitations and Suggestions for Future Research

Despite the significant potential of fMRI data to shed light on the neurological processes associated with PRAs, fMRI studies have limitations in terms of the contrained nature of the fMRI scanner, the cost of the fMRI experiments, and the complexity of the fMRI data analysis (Dimoka et al. 2010). While the fMRI and behavioral studies give similar results (Appendix 4), future research could examine whether the idiosyncratic nature of the fMRI scanner raises concerns about external validity relative to traditional behavioral studies.

Besides perceived usefulness, social presence, and trust, there are other constructs that influence the adoption and use of PRAs whose neural correlates may offer further insights on the neurological processes involved in the assessment of PRAs and potential gender differences. For example, enjoyment was shown to influence PRA adoption (Qiu and Benbasat, 2009). Future research could examine the neural correlates of other constructs that could influence the use of PRAs. Besides, more studies are needed to examine the impacts of other non-behavioral cues that might be implemented in PRAs. As proposed by De Meuse’s (1987) model of nonverbal behavior, demographic and physical appearance features of a PRA, including its age, facial and bodily attractiveness, clothing and accessories, voice characteristics and accent, could influence its sociability, credibility, likeability, or usefulness. Results from such research could provide practitioners with more specific design guidelines for embodied PRAs. Researchers could also get more insights into how people react to virtual characters in online shopping environments through the manipulations of other cues. Moreover, the findings of our study can be applied to other non-shopping environments, such as distance learning and e-government, where the use of demographic matching agents might also be preferred by users.

The fMRI study used the Likert-type scales of perceived usefulness, social presence, and trust as stimuli to induce brain activation (Appendix 2), following Dimoka (2010b). Still, there are other means to induce brain activation, such as asking subjects to interact with PRAs and select the one they prefer to transact with.
Although the fMRI data do not suffer from social desirability bias in the same way as behavioral self-reports, future research could include other stimuli to induce brain activation that do not rely on Likert-type scales.

5.4 Concluding Remarks

Since self-reported data may be susceptible to various biases (e.g., subjectivity, social desirability, common methods), brain data were shown to complement and triangulate self-reported measurement scales, particularly for our context that people may be unable, unwilling, or uncomfortable to truthfully self-report due to social desirability bias and political correctness. Opening the “black box” of the human brain has the potential to enhance IS research, as this study attests in the context of the design of anthropomorphic PRAs that vary in terms of their ethnicity and gender similarity. Several new insights on the use of PRAs have emerged from this study, such as the neural correlates of perceived usefulness, social presence, and trust pertaining to ethnicity and gender match/mismatch, and the interesting differences between women and men. This study aims to encourage neuroimaging studies in IS research to explore the nature of IS constructs and their neural correlates to build superior IS theories that better correspond to the brain’s functionality.

REFERENCES
Appendix 1: Experimental Stimuli for Experimental Study

Figure A1 shows the four recommendation agents used for this study’s experiment.

Figure A1: The Four Avatars Used in the Behavioral and fMRI Experiment

Figure A2 shows the recommendation agent interface of the pretest.

Figure A2. Screenshot of the Recommendation Agent Interface

Question 1

How much are you planning to spend on this digital camera?

- A small amount ($100 - $150)
- A medium amount ($150 - $200)
- A large amount ($200 - $250)
- No preference

Importance of this Feature

not important 1 2 3 4 5 6 7 very important

Questions: 1 2 3 4 5 6 7 8 9 10
### Appendix 2: Measurement Items

#### Perceived Usefulness

| 1. | Using this recommendation agent can increase my **productivity** in selecting cameras. |
| 2. | Using this recommendation agent can increase my **effectiveness** in selecting cameras. |
| 3. | Using this recommendation agent can improve my **performance** in selecting cameras. |
| 4. | Using this recommendation agent can improve my **ability** to select cameras. |
| 5. | Using this recommendation agent can enhance my **capability** to select cameras. |
| 6. | Using this recommendation agent can **useful** in selecting cameras. |
| 7. | Using this recommendation agent can be **beneficial** in selecting cameras. |
| 8. | Using this recommendation agent can **helpful** in selecting cameras. |
| 9. | Using this recommendation agent can **valuable** in selecting cameras. |
| 10. | Using this recommendation agent can **effective** in selecting cameras. |

#### Social Presence

| 1. | I felt a sense of **human contact** in this recommendation agent. |
| 2. | I felt a sense of **personalness** in this recommendation agent. |
| 3. | I felt a sense of **human warmth** in this recommendation agent. |
| 4. | I felt a sense of **sociability** in this recommendation agent. |
| 5. | I felt a sense of **human sensitivity** in this recommendation agent. |
| 6. | I felt a sense of **personal touch** in this recommendation agent. |
| 7. | I felt a sense of ‘being together’ with this recommendation agent. |
| 8. | I felt a sense of **human kindness** in this recommendation agent. |
| 9. | I felt a sense of **human warmness** in this recommendation agent. |
| 10. | I felt a sense of **human connection** in this recommendation agent. |

#### Trust

| 1. | In general, this recommendation agent appears to be **competent** about cameras. |
| 2. | This recommendation agent appears to be capable of giving camera recommendations. |
| 3. | In general, this recommendation agent appears to be **knowledgeable**. |
| 4. | I believe that this recommendation agent would in **my best interests**. |
| 5. | I believe that this recommendation agent would do its best to help me. |
| 6. | I believe that this recommendation agent is interested in my well-being. |
| 7. | I believe that this recommendation agent is likely to be **truthful**. |
| 8. | In general, this recommendation agent appears to be **honest**. |
| 9. | In general, this recommendation agent appears to be **unbiased**. |
| 10. | In general, this recommendation agent appears to be **reliable**. |
Appendix 3. Technical Details

**Equipment:** The fMRI scanner was a 3 Tesla, Siemens whole-body scanner with a standard CP head coil. Subjects were scanned with contiguous (no gap) 5 mm axial high-resolution T1-weighted structural slices (matrix size=256×256; TR=600; TE=15 ms; FOV=21cm; NEX=1; slice thickness=5 mm), which were collected for spatial normalization procedures and overlay of functional data. Precise localization based on standard anatomic markers (AC-PC Line) was used for all subjects (Talairach and Tournoux, 1988). Functional scans were acquired with a gradient-echo planar free induction decay (EPI-FID) sequence (T2*weighted: 128×128 matrix; FOV=21 cm; slice thickness = 5 mm; TR = 2s; and TE = 30 ms, slices=28) in the same plane as the structural images. Voxel size was 3.33 mm × 3.33 mm × 5 mm.

**Data Pre-Processing:** The data were processed using SPM5 (Statistical Parametric Mapping, Wellcome Department of Cognitive Neurology, University College of London, UK) under Matlab® (The Mathworks, Inc., Natick, MA). Slice timing correction was performed in order to compensate for delays associated with acquisition time differences among slices during sequential imaging. A 3D automated image registration routine (six-parameter rigid body, sinc interpolation; second order adjustment for movement) was applied to the volume to realign them with the first volume of the first series used as spatial reference. All functional and anatomical volumes were then transformed into standard anatomical space using the T2 EPI template and the SPM5 normalization procedure (Ashburner and Friston, 2005). Next, all volumes underwent spatial smoothing by convolution with a Gaussian kernel of 8 cubic mm full width at half maximum (FWHM) to increase the signal-to-noise ratio (SNR) and account for inter-session differences.

**Statistical Data Analysis:** Subject-level analyses based on changes in Blood Oxygenation Level Dependent (BOLD) contrasts were performed with the General Linear Model (GLM) in SPM5. The four conditions (full match, ethnicity match, gender match, full mismatch) were modeled with a canonical hemodynamic response function (hrf). Contrast maps were obtained through linear contrasts across the four conditions. Group-level random effects analyses for main effects were accomplished by entering whole brain contrasts into one-sample t tests. For the group level analysis, Region of Interest (ROI) analysis was implemented, which involves defining a specific area of interest in the brain within which to make local measurements. A significance threshold based on spatial extent using a height of $t \geq 1.96$ and cluster probability of an uncorrected $p \leq 0.05$ (Forman et al., 1995) was applied to the areas of interest.

Appendix 4. Analyses of Behavioral Results

A behavioral (pretest) study was conducted with the same procedures to refine the experimental design, procedures, and stimuli. Because the behavioral data from the lab and fMRI experiments were very similar, for brevity, we only present the behavioral results from the fMRI study.

Table A1 presents the descriptive statistics for the study’s principal constructs, which closely correspond to the behavioral data from the study’s pretest. Since the behavioral results are similar across the behavioral and fMRI studies, this implies that the fMRI context did not bias the subjects’ responses, implying the external and ecological validity of the fMRI experiment, at least relative to a traditional behavioral study.

**Table A1. Means for Ethnicity and Gender Match versus Mismatch across User’s Gender**

<table>
<thead>
<tr>
<th></th>
<th>Perceived Usefulness</th>
<th>Social Presence</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethnicity &amp; Gender (Full) Match</strong></td>
<td>4.83 (1.09)</td>
<td>3.91(1.16)</td>
<td>4.65 (1.03)</td>
</tr>
<tr>
<td><strong>Ethnicity &amp; Gender (Full) Mismatch</strong></td>
<td>4.65 (1.19)</td>
<td>3.66 (1.02)</td>
<td>4.43 (1.01)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Split by User’s Gender</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethnicity &amp; Gender (Full) Match</strong></td>
<td>5.43 (0.73)</td>
<td>4.24 (1.09)</td>
<td>4.37 (1.28)</td>
<td>3.44 (0.85)</td>
<td>5.02 (0.70)</td>
<td>4.29 (1.20)</td>
</tr>
<tr>
<td><strong>Ethnicity &amp; Gender (Full) Mismatch</strong></td>
<td>4.54 (1.38)</td>
<td>4.77 (1.02)</td>
<td>3.40 (1.27)</td>
<td>3.92 (0.64)</td>
<td>4.21 (1.14)</td>
<td>4.65 (0.85)</td>
</tr>
</tbody>
</table>
Reliability and validity of our constructs were examined first. As shown in Table A2, Cronbach’s alpha reliability coefficients of all dependent variables are above 0.80, exceeding the 0.70 threshold value (Nunnally, 1978). To examine discriminant and convergent validity, we performed exploratory factor analysis with a varimax rotation (omitted for brevity). Three factors were extracted, which accounted for 74% of the total variance. Items that measure a given construct loaded on a single factor, as indicated by high within-factor loadings (generally above .60) and small outside-factor loadings (generally below .30). The factor analysis suggests that perceived usefulness, social presence, and trust are distinct constructs.

Table A2: Reliability and Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>Cronbach’s Alpha</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceived Usefulness</td>
<td>0.96</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Social Presence</td>
<td>0.91</td>
<td>.275(**)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trust</td>
<td>0.90</td>
<td>.841(**)</td>
<td>.423(**)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4. Agent Ranking</td>
<td>-</td>
<td>-.533(**)</td>
<td>-.367(**)</td>
<td>-.581(**)</td>
<td>1</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (two-tailed).

Table A2 also shows that perceived usefulness, social presence, and trust are significantly correlated with how a user ranks PRAs, justifying their selection for inclusion in this study.

A multiple analysis of covariance (MANCOVA) (Hair et al., 1998) was conducted whose results are shown in Table A3. Although the main effect of ethnicity and gender (full) match is not significant (p=0.896), the interaction between ethnicity and gender (full) match with user’s gender is marginally significant (p=0.072). These results suggest that it is appropriate to further examine the moderating effects of user’s gender on each of the three constructs using ANOVA.

Table A3: MANCOVA Results

<table>
<thead>
<tr>
<th></th>
<th>Wilks’ Lambda</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender and Ethnicity Match</td>
<td>.968</td>
<td>.199</td>
<td>.896</td>
</tr>
<tr>
<td>User’s Gender</td>
<td>.819</td>
<td>1.328</td>
<td>.296</td>
</tr>
<tr>
<td>Gender/Ethnicity Match * User’s Gender</td>
<td>.684</td>
<td>2.766</td>
<td>.072</td>
</tr>
</tbody>
</table>

A 2 (full match versus mismatch) X 2 (Male, Female) ANOVA was then used to examine whether full match affects perceived usefulness, social presence, and trust. There were no main effects due to full match or user’s gender (Table A4). However, there were significant interaction effects for all constructs (perceived usefulness, social presence, trust,) showing that match is only important for women but not men (Table A5).

Table A4: ANOVA Results

<table>
<thead>
<tr>
<th></th>
<th>Perceived Usefulness</th>
<th>Social Presence</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity and Gender (Full) Match/Mismatch</td>
<td>F=0.551NS</td>
<td>F=0.485NS</td>
<td>F=0.635NS</td>
</tr>
<tr>
<td>User’s Gender</td>
<td>F=1.506NS</td>
<td>F=0.592NS</td>
<td>F=0.191NS</td>
</tr>
<tr>
<td>Ethnicity and Gender Match * User’s Gender</td>
<td>F=8.334 (p=.009)</td>
<td>F=4.248 (p=.053)</td>
<td>F=4.424 (p=.048)</td>
</tr>
</tbody>
</table>

Table A5: ANOVA Results split by Gender

<table>
<thead>
<tr>
<th></th>
<th>Perceived Usefulness</th>
<th>Social Presence</th>
<th>Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity and Gender (Full) Match/Mismatch: Female Users</td>
<td>F=5.073 (p=.048)</td>
<td>F=2.397NS</td>
<td>F=3.312 (p=.099)</td>
</tr>
<tr>
<td>Ethnicity and Gender (Full) Match/Mismatch: Male Users</td>
<td>F=3.276NS</td>
<td>F=2.251NS</td>
<td>F=1.169NS</td>
</tr>
</tbody>
</table>

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