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RESEARCH REPORT

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The neural correlates of trustworthiness evaluations of faces and brands: Implications for behavioral and consumer neuroscience

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Abstract

When we buy a product of a brand, we trust the brand to provide good quality and reliability. Therefore, trust plays a major role in consumer behavior. It is unclear, however, how trust in brands is processed in the brain and whether it is processed differently from interpersonal trust. In this study, we used fMRI to investigate the neural correlates of interpersonal and brand trust by comparing the brain activation patterns during explicit trustworthiness judgments of faces and brands. Our results showed that while there were several brain areas known to be linked to trustworthiness evaluations, such as the amygdalae, more active in trustworthiness judgments when compared to a control task (familiarity judgment) for faces, no such difference was found for brands. Complementary ROI analysis revealed that the activation of both amygdalae was strongest for faces in the trustworthiness judgments. The direct comparison of the brain activation patterns during the trustworthiness evaluations between faces and brands in this analysis showed that trustworthiness judgments of faces activated the orbitofrontal cortex, another region that was previously linked to interpersonal trust, more strongly than trustworthiness judgments of brands. Further, trustworthiness ratings of faces, but not brands, correlated with activation in the orbitofrontal cortex. Our results indicate that the amygdalae, as well as the orbitofrontal cortex, play a prominent role in interpersonal trust (faces), but not in trust for brands. It is possible that this difference is due to brands being processed as cultural objects rather than as having human-like personality characteristics.

KEYWORDS

amygdala, consumer behavior, fMRI, orbitofrontal cortex, trust

Abbreviations: ANOVA, analyses of variance; BOLD, blood-oxygen-level dependent; EPI, Echo planar imaging; fMRI, functional magnetic resonance imaging; FOV, field-of- view; FWHM, Full Width at Half Maximum; Hz, Hertz; OFC, orbitofrontal cortex; ROI, region of interest; SD, standard deviation; TE, echo time; TR, repetition time; T, Tesla.

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1 | INTRODUCTION

Trust in a certain brand leads us to expect good experiences with a product we intend to buy. Trust in brands is therefore a major determinant of consumer behavior (Chaudhuri & Holbrook, 2001). Similarly, interpersonal trust leads us to expect prosperous, reliable and safe transactions with other humans in the future. Therefore, trust plays a major role in social life and in economic decisions. Consequently, trust has been researched in several disciplines including neuroscience, economics, medicine, psychology, marketing and computer science (Chaudhuri & Holbrook, 2001; Fehr, 2009; Gefen, Karahanna, & Straub, 2003; Javor, Koller, Lee, Chamberlain, & Ransmayr, 2013; Javor, Ransmayr, Struhal, & Riedl, 2016; Javor, Riedl, Kirchmayr, Reichenberger, & Ransmayr, 2015). It is unclear, however, how trust in brands relates to interpersonal trust. This question is important for social neuroscience as it clarifies whether the processing of trust is specific to human-to-human interactions. Alternatively, trust processing might generalize to other goals of trust (towards brands, animals, objects etc.). For marketing theory, a comparison of brand and interpersonal trust might shed some light on the question whether it really makes sense to generalize the consequences of high and low trust in interpersonal relationships to brand-consumer relationships.

One possible way of investigating trust is through trustworthiness evaluations. Riedl and Javor (2012) described the relationship between trustworthiness evaluations and trust behavior: First, beliefs about the other person's trustworthiness are formed based on, for example, appearance or facial expression. This, in turn, affects the attitude towards the individual, subsequent behavioral intentions and ultimately actual behavior (e.g., trust/distrust and approach/avoidance). The importance of trustworthiness evaluations for subsequent behavior is further underlined by evidence showing the highly predictive value of trustworthiness evaluations for trust behavior (van't Wout & Sanfey, 2008). As trustworthiness evaluations are processed, at least partly, on a subconscious level (Todorov, Pakrashi, & Oosterhof, 2009) and therefore cannot be directly observed, most research in this field relies on neuroscientific methods, mainly functional brain imaging. In the following we will summarize some key findings of this research on trustworthiness evaluations of faces and neuroscientific findings regarding brand processing.

1.1 | Neural correlates of trustworthiness evaluation of faces

Functional magnetic resonance imaging (fMRI) has given us insight into the neural correlates of trustworthiness evaluations of faces (Engell, Haxby, & Todorov, 2007; Said, Baron, & Todorov, 2009; Todorov & Engell, 2008; Winston, Strange, O'Doherty, & Dolan, 2002). As the most consistent finding, the amygdalae were identified as being centrally involved in trustworthiness processing of faces (Bzdok et al., 2011; Said, Dotsch, & Todorov, 2010; Said et al., 2009; Todorov, Said, Engell, & Oosterhof, 2008; Winston et al., 2002). A recent meta-analysis of 29 different neuroimaging studies of trustworthiness evaluations of faces (Mende-Siedlecki, Said, & Todorov, 2013) revealed activation in the bilateral amygdalae for negative trustworthiness evaluations. For positive trustworthiness evaluations of faces, activations were observed in the frontal and insular cortex as well as in the basal ganglia (Mende-Siedlecki et al., 2013). Finally, other brain areas that were found to play a role in trustworthiness evaluations are the medial prefrontal cortex, the pregenual anterior cingulate cortex, the medial orbitofrontal cortex, as well as the left caudate and nucleus accumbens (Mende-Siedlecki et al., 2013).

1.2 | Neural correlates of brand processing

Trust research has been extended beyond the interpersonal setting by business researchers as trust in a brand is essential for brand loyalty and consumption behavior (Chaudhuri & Holbrook, 2001). However, is this type of trust really the same as trust in the interpersonal domain? On the one hand, it is a common view in marketing theory that consumers may assign personality qualities to brands and think about them as if they were human characters (Levy, 1985), which leads to a concept called brand personality — a set of human characteristics associated with a brand (Aaker, 1997). On the other hand, trust in brands might be processed differently than trust in faces. There are some studies that investigated the neural correlates of brand processing using fMRI. Some focused on a brand's impact on product perception (McClure et al., 2004; Reimann, Zaichkowsky, Neuhaus, Bender, & Weber, 2010), brand categorization (Schaefer & Rotte, 2007b), brand judgments (Yoon, Gutchess, Feinberg, & Polk, 2006), the impact of brand relationship (Reimann, Castaño, Zaichkowsky, & Bechara, 2012) and brand preference (Plassmann, O'Doherty, & Rangel, 2010; Santos, Seixas, Brandão, & Moutinho, 2011; Schaefer & Rotte, 2007a). Plassmann, Ramsøy, & Milosavljevic, 2012 tried to summarize these findings and concluded that the most prominent brain regions relevant to brand decisions are the anterior cingulate cortex, the dorsolateral prefrontal cortex, the lateral and medial orbitofrontal cortex (OFC), the nucleus accumbens, the ventral striatum and the ventromedial prefrontal cortex.

Although, there is ample evidence on brain regions involved in trustworthiness evaluations of faces, evidence on how trustworthiness evaluations of brands are processed in the brain is missing. So far, the literature on the neural processes underlying other types of brand processing indicates a certain degree of overlap in the neurobiology of face and brand processing. Differences might exist with regard to the role of the amygdalae. The amygdalae were consistently found activated in the processing of the trustworthiness of faces, however, so far, not in tasks with brands. To date, no study has investigated trustworthiness judgments in brands. It is therefore unclear, whether the activation of the amygdalae in the case of faces would also be observed for brands in a trustworthiness judgment.

We conducted an fMRI experiment where subjects had to explicitly evaluate the trustworthiness and familiarity (as a control task) of human faces and brands (logos). We then compared the brain activation pattern between the two tasks for both faces and brands and correlated behavioral data of trustworthiness ratings (Likert scale 1–7) and brain activation. As the amygdalae and the OFC seem to play a crucial role in processing trustworthiness, we performed an additional ROI (region of interest) analysis of these regions.

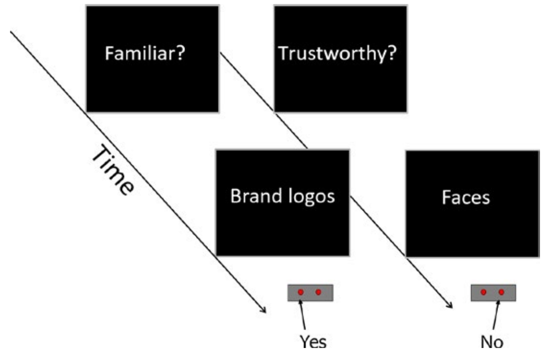

FIGURE 1 Illustration of the judgment tasks (familiarity and trustworthiness). The second screen represents the stimulus material consisting of brand logos and faces. [Colour figure can be viewed at wileyonlinelibrary.com]

2 | MATERIALS AND METHODS

2.1 | Subjects

Forty healthy young adults took part in the fMRI experiment. Three had to be excluded from analysis due to technical problems, leaving 37 (19 male, with a mean age of 24.5 years, range: 18–41, SD: 4.78). All participants had normal or corrected to normal vision and reported no history of neurological or psychiatric illness. The participants received 10 € compensation for their participation and gave written informed consent prior to the experiment. The study was approved by the ethics committee of the Karl-Franzens University Graz. All experimental procedures were carried out in accordance with the approved guidelines.

2.2 | Design and materials

In the fMRI experiment, pictures of familiar and unfamiliar faces, as well as the logos of familiar and unfamiliar brands, were presented to participants in two tasks. In the control task (familiarity judgment), participants were instructed to indicate by button press whether or not the picture or logo was familiar to them. In the task of interest (trustworthiness judgment), they had to indicate whether or not they trusted the person or brand depicted (see Figure 1). Stimulus materials consisted of 15 pictures of familiar faces, 15 pictures of unfamiliar faces, 15 logos of familiar brands, and 15 logos of unfamiliar brands. Known and unknown stimuli were used (1) to implement the control task (familiarity ratings) and (2) to achieve generalizability of our results for both initial (memory independent) and ongoing trust (memory dependent). Care was taken to match the familiar faces to the selected unfamiliar faces with regard to age, gender and overall appearance. In the case of the logos, pictures of unfamiliar and familiar brands were matched with regard to the presence of text, colouring and image complexity. The trustworthiness and familiarity of faces and brands were assessed in a pilot study with 67 participants (mean age 22.4, SD: 4.21) before the fMRI experiment. Familiar faces and brands with comparably high (e.g., Barack Obama, BMW) and comparably low (e.g., Silvio Berlusconi, Fiat) trustworthiness ratings were selected to achieve a greater variability of trustworthiness judgments. In the fMRI experiment, faces and brands were presented twice in each task, yielding 240 trials in total. Each task and stimulus category was presented separately in eight blocks of 30 trials each, to avoid task switching costs.

2.3 | Procedure and apparatus

Before entering the scanner, participants were given written instructions for their task. In one task, they were asked to press a button indicating whether they trusted the face or brand depicted or not. In the other task, they had to indicate whether or not the face or brand was familiar. There was no practice session. The main experiment consisted of 240 picture presentations. The eight blocks were presented alternatingly for both judgment tasks and stimulus categories. At the beginning of the experiment, a short instruction was presented for 25 s, which reminded the participants of their two tasks: "Please judge the following pictures with regard to their trustworthiness or their familiarity". Before each block, an instruction was shown for 20 s that indicated the type of the current task: "Trustworthiness?" or "Familiarity?" Instructions were shown in white against a black background. Each trial started with the presentation of a face or a logo, which was centrally presented on the screen for 2 s. The background was black. After a variable waiting time between 5- and 7 s (step size: 500 ms, mean waiting time: 6 s) the next trial was presented. Reaction times were measured from the onset of the presentation of the picture. Participants had 5 s to respond (see Figure 1 for a trial timing schema). To allow a better estimation of the hemodynamic response function, 80 null events were randomly interspersed (10 per block). Null events were trials that were identical in timing to the experimental trials. Instead of a picture, only a black screen was presented to participants for 2 s. The main experiment took approximately 45 min. Stimulus presentation and scanner triggering were controlled by a computer outside the scanner room using Presentation software (Neurobehavioral systems). Stimuli were projected on a screen mounted at the foot end of the scanner and viewed by the participant over a mirror mounted on top of the head coil. After leaving the scanner, participants rated all picture stimuli with regard to trustworthiness and familiarity using a computer in a separate room. Here, a 7-point Likert Scale was used, with low numbers indicating high familiarity or trustworthiness. Stimuli were shown once. The trustworthiness ratings were later used as a parametric predictor in the analysis of the functional images.

2.4 | fMRI data acquisition

Imaging was performed using a 3T whole-body system Siemens Trio scanner with an echo planar capable gradient system and a Siemens-issued 32-channel bird cage head coil. For the anatomical images a T1-weighted MPRAGE sequence was used (TR/TE = 1560 ms/2.07 ms, matrix = 256 × 256, FOV = 256 mm, 176 sagittal slices, inplane resolution: 1 × 1 mm, slice thickness: 1 mm, 0.5 mm gap), and for the functional images a T2*-weighted echo planar imaging (EPI)-sequence was used (TR = 2130 ms TE = 31 ms, matrix = 64 × 64, FOV = 192 mm, 32 axial slices, inplane resolution: 3 × 3 mm, slice thickness: 3 mm, 1 mm gap), which is sensitive to brain oxygen-level dependent (BOLD) contrasts. Participants lay supine in the scanner. Their head was stabilized with foam paddings. Participants were protected from the scanner noise by earplugs. The anatomical three dimensional (3-D) scan was conducted before the functional measurements.

2.5 | fMRI data analysis

Data analysis and preprocessing were performed with SPM12 (Wellcome Department of Cognitive Neurology, London, UK). The first two functional scans of each participant were discarded to allow for signal stabilization. The functional scans were first motion corrected and unwarped. Then, they were non-linearly normalized to correspond more closely to the Talairach and Tournoux coordinate system (Talairach & Tournoux, 1988) using the MNI functional (EPI) template. Images were finally smoothed with a Gaussian kernel of 8 mm full width at half maximum (FWHM). Statistical analysis was performed on the basis of the general linear model, as implemented in SPM12. A model with eight conditions in total (familiarity judgment: familiar faces, unfamiliar faces, familiar brands, unfamiliar brands; trustworthiness judgment: familiar faces, unfamiliar faces, familiar brands, unfamiliar brands) was estimated. The delta-function of the trial onsets for each condition was convolved with the canonical form of the hemodynamic response and its first temporal derivative. The off-line ratings of the trustworthiness judgment were entered into the model as parameters of interest (linear and quadratic term). The motion parameters derived from the realignment procedure were entered into the model as parameters of no interest. A high-pass filter (cut-off frequency: 1/120 Hz) was used to remove low frequency drifts. The contrast images calculated for individual subjects were entered into a second level or random effects analysis (Friston, Holmes, Price, Büchel, & Worsley, 1999). The resultant statistical parameter maps were thresholded using an initial uncorrected p-value threshold of less than 0.001, reporting only clusters with a family-wise error-corrected p-value of less than $p < 0.05$ for the cluster level.

2.6 | ROI analysis

To evaluate the activation of the amygdalae in all eight conditions, a ROI analysis was performed. This analysis was based on the amygdala and OFC ROIs mapped within the MATLAB Toolbox AAL (Anatomical Automatic Labeling, Cyceron; Tzourio-Mazoyer et al., 2002). For the amygdalae, we extracted the contrast estimates for each of the eight conditions, as well as for the linear and quadratic parametric terms. These values were then entered into a repeated-measures analysis of variance with the factors task (familiarity, trustworthiness), stimulus type (faces, brands) and familiarity (familiar, unfamiliar). For the ROI analyses, the MATLAB Toolbox Marsbar was used (Brett, Christoff, Cusack, & Lancaster, 2001) (http://marsbar.sourceforge.net). We extracted the contrast estimates of each condition against the implicit baseline averaged over all voxels of the ROI per participant. Contrast estimates have the advantage that they can be entered into a second-level statistical analysis. The contrast estimates represent effect sizes; they are related, but not equivalent to percent signal change or activation.

2.7 | Behavioral data analysis

We analyzed only the data of the 37 participants that were used in the fMRI analysis. There were 84 trials with no response, leaving 8796 out of 8880 data points in total for analysis. To assess task difficulty, the reaction time data from the fMRI measurement were entered into a repeated measures ANOVA with the within-subjects factors task (familiarity judgment vs. trustworthiness judgment) and type (faces vs. brands). No distinction was made between yes and no answers. Outside the scanner, participants rated all items with regard to familiarity and trustworthiness. There were no missing values. This yielded 4440 total data points for analysis. Note that low rating values indicate high familiarity/trustworthiness. The rating data for the familiarity and trustworthiness judgments were entered into two separate repeated measures ANOVAs with the within-subjects factors type (faces vs. brands) and familiarity (familiar vs. unfamiliar).

3 | RESULTS AND STATISTICAL ANALYSES

In the scanner, we asked our young healthy adult participants to judge pictures of known and unknown faces as well as the logos of known and unknown brands in two tasks. In a familiarity judgment task, they were instructed to indicate whether or not the picture or logo was familiar to them. In a trustworthiness judgment task, they had to indicate whether or not they trusted the person or brand depicted (Figure 1). After scanning, we asked our participants to rate all items once with regard to familiarity and once with regard to trustworthiness on a 7-point scale. Based on the reaction times and the ratings, faces and brands were well matched with regard to the two tasks (see below).

3.1 | fMRI Results

3.1.1 | Trustworthiness vs. familiarity judgments

We first assessed activations in the trustworthiness task compared to the control task (familiarity judgment) and found the following: trustworthiness judgments activated the left amygdala, the right amygdala and the left fusiform gyrus more strongly than familiarity judgments. The control task activated the right and left angular gyrus, the precuneus and the posterior cingulum more strongly than trustworthiness judgments. These results are presented in Table 1 and Figure 2a.

3.1.2 | ROI analysis of the amygdalae

Due to the reported importance of the amygdalae in trustworthiness judgments of faces (Bzdok et al., 2011; Said et al., 2009, 2010; Todorov & Engell, 2008; Todorov et al., 2008), we conducted an additional ROI analysis based on the amygdala ROIs given by the AAL atlas (Tzourio-Mazoyer et al., 2002). The activation of both ROIs for all eight conditions is shown in Figure 2B. In the left and right amygdala, faces activated more strongly than brands (left amygdala: $F(1,36) = 33.23$, $p < 0.001$, $\eta^2 = 0.48$; right amygdala: $F(1,36) = 44.89$, $p < 0.0001$, $\eta^2 = 0.55$). The amygdalae were also more activated in the trustworthiness judgment than in the control task (left amygdala: $F(1,36) = 14.79$, $p < 0.0001$, $\eta^2 = 0.29$; right amygdala: $F(1,36) = 13.48$, $p = 0.001$, $\eta^2 = 0.27$). However, faces elicited more activation in the amygdalae in the trustworthiness evaluation compared to the familiarity judgment (interaction between stimulus type and task: left amygdala: $F(1,36) = 8.74$, $p = 0.005$, $\eta^2 = 0.20$; right amygdala: $F(1,36) = 7.04$, $p = 0.012$, $\eta^2 = 0.16$). We had also entered the trustworthiness ratings per item and per subject into the analysis as a parameter of interest with a linear and a quadratic component. The quadratic component was entered into the fMRI analysis because the relationship between the valence of emotional stimuli and amygdala activation was reported to be nonlinear rather than linear (Said et al., 2009; Todorov et al., 2008). However, an analysis of variance on the beta-values of the quadratic parameter did not yield any significant main effects or interactions in the left and right amygdala. The

TABLE 1 The brain areas activated for the familiarity vs. trustworthiness judgment

Side	Region	*x*	*y*	*z*	*k*	*Z*
	Trustworthiness > Familiarity					
Right	Amygdala	20	6	−16	510	4.78
Left	Amygdala	−20	4	−10	349	4.50
Left	Fusiform Gyrus	−30	−48	−16	418	3.97
	Familiarity > Trustworthiness					
Left	Angular Gyrus	−40	−60	46	1395	5.26
Left	Precuneus	−10	−68	30	1718	5.15
Right	Angular Gyrus	46	−58	56	765	4.55
Right	Posterior Cingulum	−4	−46	30	565	4.07

Note. Statistical parameter maps were thresholded at $p < 0.001$ uncorrected, $p < 0.05$ FWE-corrected at the cluster level. Coordinates are reported as given by SPM12 (MNI space), corresponding approximately to Talairach & Tournoux space (Brett et al., 2001; Talairach & Tournoux, 1988). k = cluster size, Z = Z value for the maximally activated voxel of the cluster.

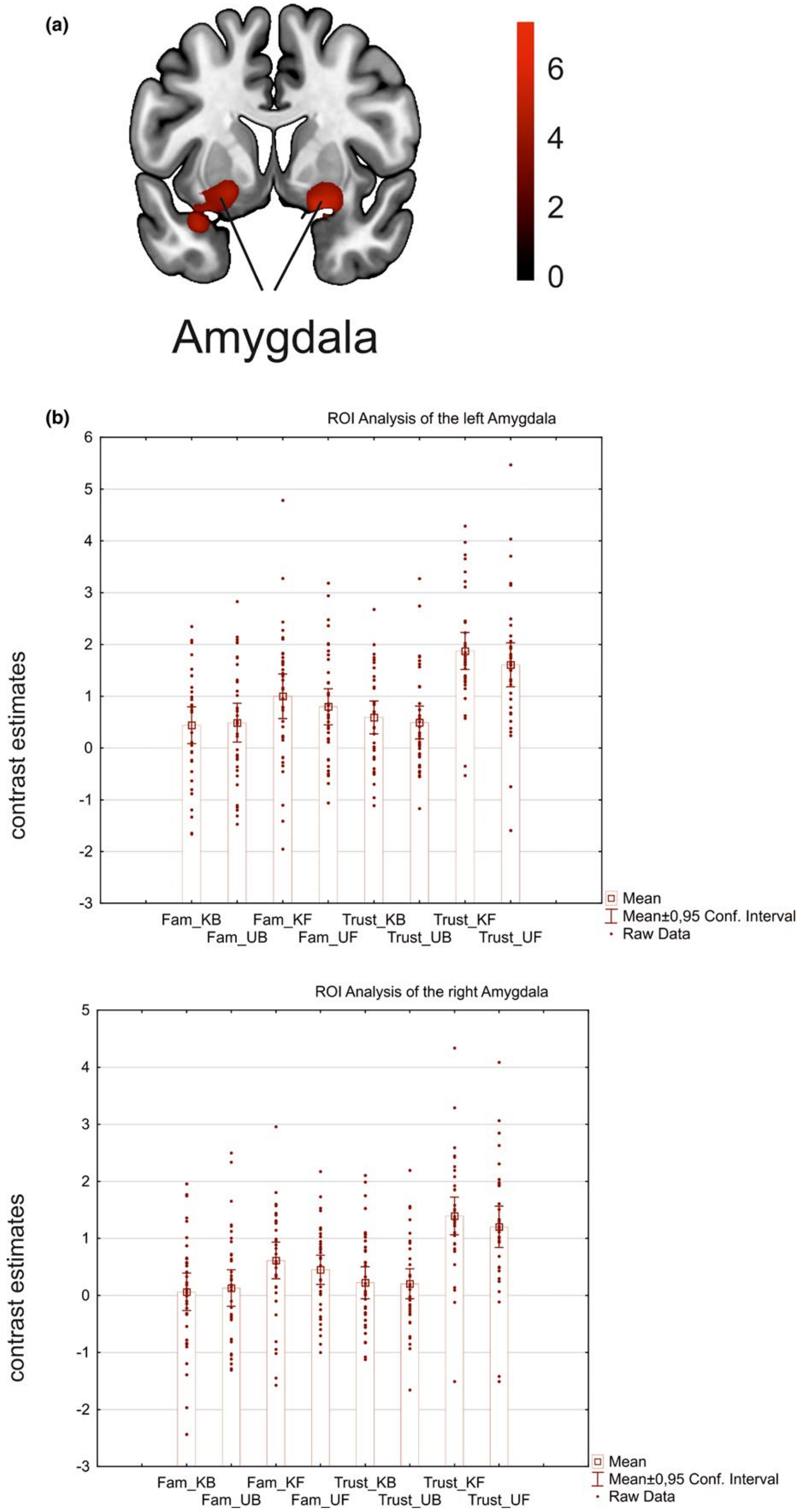

FIGURE 2 fMRI-results: A Amygdala activations for the trustworthiness judgment > familiarity judgment B ROI-analysis results of the right and left amygdala for all eight conditions. Notes: Fam.: familiarity judgment task, Trust: trustworthiness judgment task, K: known, U: unknown, B: Brands, F: Faces. The fMRI data depicted in A were thresholded with $p < 0.001$ uncorrected, showing only clusters with a FWE-corrected p-value of less than 0.05. [Colour figure can be viewed at wileyonlinelibrary.com]

quadratic and the linear component were not significantly different from zero (intercept not significant; left amygdala: linear: $p = 0.59$, quadratic: $p = 0.30$; right amygdala: linear: $p = 0.32$, quadratic: $p = 0.57$). This indicates that the activation in the amygdala was not modulated significantly by the off-line trustworthiness ratings.

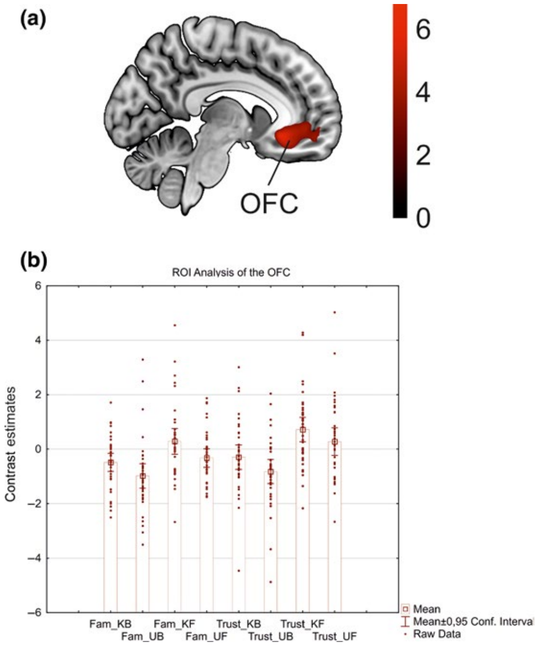

FIGURE 3 fMRI-results: A Activation in the OFC correlates significantly with the off-line trustworthiness ratings for faces in the trustworthiness judgment task. B ROI-analysis results of the OFC for all eight conditions against baseline. Notes: Fam.: familiarity judgment task, Trust: trustworthiness judgment task, K: known, U: unknown, B: Brands, F: Faces, OFC: orbitofrontal cortex. The fMRI data depicted in A were thresholded with $p < 0.001$ uncorrected, showing only clusters with a FWE-corrected p-value of less than 0.05. [Colour figure can be viewed at wileyonlinelibrary.com]

3.1.3 | Brain activation correlating with trustworthiness

To investigate which brain areas were specifically sensitive to different degrees of trustworthiness, we entered the off-line trustworthiness ratings for each item in the trustworthiness task as a regressor into the statistical analysis of the fMRI data. For the trustworthiness judgment, a positive correlation between trustworthiness and brain activation was obtained for faces in the OFC (coordinates: −2 34 −10, $k = 502$, $Z = 4.32$), see Figure 3a. We also conducted a ROI analysis of this activated cluster to explore this activation in more detail. We found that the cluster in the OFC was activated more strongly for trustworthiness judgements than for familiarity judgements (main effect task: $F(1,36) = 5.62$, $p = 0.023$, $\eta^2 = 0.14$), more strongly for faces than for brands (main effect type: $F(1,36) = 25.36$, $p < 0.0001$, $\eta^2 = 0.41$), and more strongly for familiar than for unfamiliar stimuli (main effect familiarity: $F(1,36) = 20.06$, $p < 0.0001$, $\eta^2 = 0.40$), see Figure 3b. No other effects were significant. For brands in the trustworthiness judgement, there was a negative correlation between trustworthiness and activation within the left and right supramarginal gyrus (coordinates: left: −56 −22 26, $k = 1301$, $Z = 4.49$; right: 64 −26 40, $k = 266$, $Z = 3.78$). No other significant correlations were observed. Specifically, no significant correlations were observed for faces or brands in the familiarity judgment task.

TABLE 2 Mean reaction times for faces and brands

Reaction times	Familiarity	Trustworthiness
Faces	1.437 (0.406)	1.508 (0.391)
Brands	1.436 (0.372)	1.377 (0.389)

Note. Reaction times are given in seconds. Standard deviation is given in brackets.

3.2 | Behavioral results

There was no overall difference in difficulty as measured with reaction times with regard to the two tasks ($F(1,36) = 0.13$, $p = 0.72$, ns.). This indicates that both tasks were of comparable difficulty. In the trustworthiness task, it took longer to judge faces compared to brands (interaction $F(1,39) = 17.13$, $p = .0002$, $\eta^2 = 0.32$, main effect of stimulus type $F(1,39) = 11.31$, $p = 0.0018$, $\eta^2 = 0.24$), but not in the familiarity task. Mean reaction times are given in Table 2. As we presented our stimuli twice, it is possible that they became more familiar with the second presentation. However, there was no significant increase in the number of “familiar” answers for faces and brands from the first to the second presentation ($p = .667$).

In the familiarity ratings obtained after scanning, there was no difference between faces and brands (main effect type: $F(1,36) = 0.366$, $p = 0.55$, ns). There was, of course, a significant difference between familiar and unfamiliar stimuli ($F(1,36) = 1020.40$, $p < 0.0001$, $\eta^2 = 0.97$). In the analysis of the trustworthiness ratings, ratings for faces were higher (meaning lower trustworthiness) than for brands (main effect stimulus type: $F(1,36) = 11.22$, $p = 0.002$, $\eta^2 = 0.24$). Overall, there was no difference between the trustworthiness ratings for familiar and unfamiliar stimuli ($F(1,36) = 2.35$, $p = 0.13$, ns). However, familiar faces were judged as being more untrustworthy than unfamiliar faces, whereas familiar brands were judged as being more trustworthy than unfamiliar brands, which is reflected in a significant interaction

TABLE 3 Mean trustworthiness and familiarity ratings for faces and brands

Ratings	Familiarity	Trustworthiness
Familiar faces	1.67 (0.53)	4.67 (0.60)
Unfamiliar faces	6.12 (0.76)	4.03 (0.73)
Familiar brands	1.60 (0.54)	3.59 (0.93)
Unfamiliar brands	6.13 (0.65)	4.61 (0.92)

Note. Rating scale from 1 (high familiarity/trustworthiness) to 7 (low familiarity/trustworthiness). Standard deviation is given in brackets.

between type and familiarity ($F(1,36) = 49.61$, $p < 0.0001$, $\eta^2 = 0.58$). Mean ratings are given in Table 3.

Trustworthiness ratings and familiarity ratings also did not correlate. There were no significant correlations between familiarity and trustworthiness ratings for all four stimulus categories (familiar faces: $r = 0.19$, $p = 0.491$, ns; unfamiliar faces: $r = 0.25$, $p = 0.376$, ns; familiar brands: $r = 0.30$, $p = 0.277$, ns; unfamiliar brands: $r = 0.31$, $p = 0.267$, ns).

4 | DISCUSSION

In this study, we used fMRI to investigate the neural correlates of explicit trustworthiness evaluations of brands and faces to elucidate possible processing differences between interpersonal trust and trust in brands. First, we compared the brain activation pattern during trustworthiness judgments with the brain activation during familiarity judgments of both faces and brands, to specifically study brain areas involved in trustworthiness evaluations while subtracting away brain areas generally activated in face and brand perception. Second, we performed ROI analyses of the amygdalae and the OFC to investigate processing differences in brands and faces. Third, we correlated the brain activation with the offline trustworthiness ratings for each stimulus.

Our results showed that trustworthiness judgments activated the amygdalae more strongly than familiarity judgments. The ROI analysis additionally showed that this finding is mainly due to trustworthiness judgments of faces rather than brands. Taken together, these two findings are in line with current literature emphasizing the importance of the amygdalae in trustworthiness evaluations of faces (Engell et al., 2007). Third, we searched for brain activity correlating with the trustworthiness ratings for faces after the scanning session. We found that activation in the OFC correlated significantly with trustworthiness, whereas no significant correlation was observed for trustworthiness judgments of brands in this area. In the OFC, the activation was higher for faces that were judged as more trustworthy. Additionally, the direct comparison of the brain activation patterns during the trustworthiness evaluations between faces and brands in our ROI analyses showed that trustworthiness judgments of faces activated the OFC more strongly than trustworthiness judgments of brands.

The OFC is considered a key region in the intersection of affective and cognitive processing. It has been associated with the representation of the affective value of stimuli, influencing subsequent behavior (Rolls & Grabenhorst, 2008). The OFC has also been associated with fast visual processing: it is assumed to generate a prediction about an object's identity before the object is actually recognized (Bar, 2004). This finding fits well with the rapid trustworthiness evaluations that occur within milliseconds and might therefore depend largely on "first guesses" about the identity of a face created by the OFC. Other fMRI and lesion studies also showed that the OFC is implicated in trustworthiness evaluations (Bos, Hermans, Ramsey, & van Honk, 2012; Heberlein, Padon, Gillihan, Farah, & Fellows, 2008; Hornak, Rolls, & Wade, 1996).

Prior studies on the correlation of trustworthiness ratings of faces and amygdala activation are inconsistent. Several studies have shown that there is no linear correlation between amygdala activation and trustworthiness ratings (Engell et al., 2007; Said et al., 2009). While some researchers reported increased responses for untrustworthy faces in a linear fashion (Winston et al., 2002), others observed non-linear U-shaped or quadratic activation for both trustworthy and untrustworthy faces with less activation for neutral faces (Said et al., 2009; Todorov et al., 2008). Moreover, the activation of the amygdala has been shown to increase when atypical faces, either more positive or negative, are shown (Said et al., 2010). These findings indicate that the relation of the amygdala activation to trustworthiness is complex. In our study, trustworthiness ratings for faces did not correlate in a linear nor in a non-linear fashion with amygdala activation. Nevertheless, our results underline the role of the amygdala for the processing of socially relevant information, in contrast with the earlier interpretation of the amygdala response being primarily due to the negative affective content of stimuli (Bzdok et al., 2011). The exact activation pattern of the amygdalae during face trustworthiness judgments needs, in our view, further research.

For brands, different results were observed, indicating a difference in trustworthiness processing between faces and brands. First, there was significantly less activation in the amygdalae for brands than for faces, especially in the trustworthiness judgment. Furthermore, the activation of the OFC did not correlate significantly with brand trustworthiness ratings in our study. This finding is supported by our result of stronger activation of the OFC in the trustworthiness judgements of faces when directly compared to trustworthiness judgements of brands. We acknowledge the fact that negative results might be a result of insufficient sample size. As a consequence of the lack of availability of published effect sizes of similar experiments in the literature, a formal calculation of sample size was not possible. Nevertheless, we want to emphasize that the sample size in this study exceeds that of most fMRI studies (Oosterhof & Todorov, 2008; McKone, Crookes, Jeffery, & Dilks, 2012; Szucs & Ioannidis, 2017; Poldrack et al., 2017). The large sample size of our study leads us to believe that the results of this study could nevertheless be cautiously used for theoretical considerations. Our negative result with regard to the OFC is somewhat surprising because higher activation during brand processing was observed in several reward-related regions including the OFC (Schaefer & Rotte, 2007a). The OFC was also found to be involved in reward expectations and predictions during decision-making (Knutson & Cooper, 2005; Plassmann et al., 2010). One possible reason for the difference between our study and other studies investigating brand processing might be the task. Whereas former studies instructed participants to imagine the use of the product (Schaefer & Rotte, 2007a), to choose a product (Reimann et al., 2012), or to rate the valence of a brand (Esch et al., 2012), we explicitly asked subjects to rate the trustworthiness of the brand and contrasted this to explicit familiarity ratings within subjects. Furthermore, some studies used brands in combination with the corresponding product, while our study offered only brand logos as stimulus materials. Another reason for the modulation of OFC activation according to the trustworthiness ratings of faces, but not of brands might be that face evaluation is possible within milliseconds (Willis & Todorov, 2006) enabling a "first guess" mediated by the OFC while this might not be true for brands.

In light of these findings, our results indicate that trustworthiness evaluations of brands do not activate the amygdalae in the same way as trustworthiness evaluations of faces. Although these results should be interpreted cautiously and validated by future research, we think that our findings have important implications for behavioral neuroscience and marketing.

It is highly probable that faces are processed differently from brands. The human brain is specialized in face perception, even though it is unclear, whether these skills are developed through practice during infancy and childhood or due to evolutionary selection (for a review see McKone et al., 2012). Either way, the social evaluation of a face as a predictor of future behavior is a major determinant for our survival as social beings. It has been proposed that two major axes, trustworthiness and dominance, characterize the social dimensions of face evaluation (Oosterhof & Todorov, 2008), which makes trustworthiness evaluations crucial for social behavior. In contrast, the trustworthiness evaluation of brands, even though important for consumption behavior, has not had the same impact on survival or social behavior. As brands have not been around for as long as humans have, it seems plausible that no specialized brain network has developed for processing brand trustworthiness. Moreover, it is possible that the difference between interpersonal trust and trust in brands is due to social vs. value-based decision-making. Our results can thus contribute to this very recent debate among decision and social neuroscientists (for a review see Ruff & Fehr, 2014).

Our results could be useful to advance marketing theory by contributing to the discussion about the nature of brands and how they are perceived by consumers. A concept that has drawn much attention in the field is "brand personality", where it is assumed that consumers perceive brands as having human-like characteristics and form different types of relationships with brands (Fournier, 1998). Marketing practitioners thus try to anthropomorphize brands and induce the consumer to express his or her personality through the use of a brand (Belk, 1988). Another stream of marketing theory assumes that brands are perceived as cultural objects (Schroeder, 2009). This view is strengthened by the results of the present study. Trustworthiness judgments of faces activate the amygdalae more strongly than trustworthiness judgments of brands. This indicates that trust in brands is processed differently than interpersonal trust.

The reward system, including the OFC, has been found to be involved in interpersonal trust (Erk, Spitzer, Wunderlich, Galley, & Walter, 2002) as well as for brands, though in different tasks (Schaefer & Rotte, 2007a). Greater activation of the reward system was also observed during exchanges with individuals previously experienced as fair when compared to unfair individuals (Rilling et al., 2002; Singer, Kiebel, Winston, Dolan, & Frith, 2004). The authors hypothesized that the social saliency of fair and therefore trustworthy cooperators promotes mutual cooperation in human societies by inherent reward. In other words, trustworthy individuals evoke reward anticipation in the sense that trust will not be betrayed in the future. This result is in line with our findings of a significant correlation between trustworthiness ratings of faces and OFC activation, whereas we did not observe a similar correlation for brands and supported by a stronger OFC activation in the trustworthiness judgments of faces when compared to brands. The trustworthiness of a brand might not imply a lower risk of betrayal in the same way as a trustworthy face, because betrayal aversion is inherent to social risk-taking (Fehr, 2009; Fehr, 2008). Therefore, this result also indicates that brands are perceived as cultural objects.

Despite these conclusions, our results should be interpreted with some caution. Generally, it is difficult to infer cognitive processes from brain activation patterns (reverse inference). There is an ongoing debate regarding the possibilities and limits of such conclusions (Hutzler, 2014; Poldrack, 2006). One further limitation of our study is that we did not achieve a perfect match between familiar and unfamiliar faces and brands with regard to the off-line trustworthiness ratings. Trustworthiness of familiar stimuli depends heavily on individual preexisting experiences with the respective person, while trustworthiness of unfamiliar faces (and possibly brands as well) depends more on perceptible attributes (see Todorov, 2008). This limitation, however, should not affect the finding of the amygdala activation in the trustworthiness judgment compared to the familiarity judgment as we had entered the trustworthiness ratings into the fMRI analysis, regressing out the influence of differences with regard to trustworthiness ratings from this contrast. Another aspect that is possibly important for trustworthiness evaluations of faces and brands might be attractiveness. We have not evaluated attractiveness in the present study. In the case of unfamiliar stimuli attractiveness might play a greater role than for familiar stimuli, where trustworthiness might depend more on past experiences with the respective person or product. Future studies should address the influence of attractiveness on trustworthiness judgments.

In conclusion, we have shown that trustworthiness evaluations of faces and brands are processed differently. We interpret these findings as indicating a difference between interpersonal trust and trust in brands. Brands might be perceived as cultural objects rather than as human-like personalities. Future research could address the question of implicit vs. explicit trustworthiness evaluations. We only investigated explicit trustworthiness evaluations of faces and brands, but there is evidence of automated brain activation during implicit trustworthiness judgments of faces (Winston et al., 2002). It is unclear whether similar results would be obtained for brands. Another interesting avenue for future research is the use of brain imaging methods with higher temporal resolution than fMRI, such as electroencephalography. With this method, it would be possible to explore how fast the trustworthiness of faces is processed compared to brands. This topic would be of interest, given the evidence that 100 ms suffices for faces to be rated in terms of trustworthiness (Willis & Todorov, 2006). Our behavioral data show that brands can be assessed as quickly as faces, but it remains unclear whether a similar fast "first guess" route also exists for brands.

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COMPETING INTERESTS

The authors do not have any competing interests. AJ has moved to Biogen International GmbH, Zug, Switzerland since completion of this work.

DATA ACCESSIBILITY

The article's supporting data and materials will be shared by the corresponding author upon request.

AUTHORS CONTRIBUTION

AJ, HK and AI conceptualized and designed the study. AJ and AI wrote the main manuscript text; HK and KK revised the manuscript. KK and AI performed the experiments and analyzed the data. All authors approved the final version of the manuscript.

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