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Is social categorization based on relational ingroup/outgroup opposition? A meta-analysis

Aleksandr V. Shkurko

Department of Management and Marketing, Moscow State University of Economics, Statistics and Informatics, Nizhny Novgorod branch, Russian Federation

Social categorization is known to be an important part of social cognition. The categorizations we use, despite their multitude, frequently take the form of the general ingroup/outgroup distinction. A meta-analysis of 33 fMRI studies, reporting selective activations to various social groups, was used to identify common neural structures responsible for relational representation of social structure. Activation Likelihood Estimation (ALE) analysis revealed areas in bilateral amygdala, cingulate gyrus, fusiform gyrus, right TPJ and right insula as implementing various aspects of social categorization. Activation of amygdala can be associated with modulation of behavioral response to subjectively significant stimuli. A more ventral part of anterior cingulate cortex (ACC) can be associated with self-referential reasoning about ingroup members while a more dorsal part of ACC is involved in the regulation of emotions toward outgroup members. Right insula can be engaged in the modulation of outgroup avoidance behavior. Fusiform gyrus (FG) appears to be directly involved in social categorization process via top-down modulation of social perception. Yet it is difficult to associate any of the revealed clusters with the relational ingroup/outgroup structure.

Keywords: social categorization; in-group; out-group; social structure; social identity

INTRODUCTION

Social categorization is considered an important part of social cognition (Macrae and Bodenhausen, 2000). Differentiating social world into more or less stable categories helps coping with it by making it graspable and predictable. While psychological interest in social categorization is typically restricted to individual behavior and intergroup relations (Brown and Gaertner, 2003), other fields such as sociology treat it as part of a more complex process of societies' functioning, when the objective social structure, defined by unequal distribution of resources, the division of labor and other macro-level processes, interacts with micro-level representations of social structure and individual choice of strategies to produce and transform this social world (Bourdieau, 1980; Giddens, 1984). Understanding the mechanisms of social categorization is thus important for understanding societies, as well as individuals and groups.

The basic ingroup/outgroup opposition is the most typical way to represent group differences. Since the pioneering works of Lèvi-Strauss (1967), binary opposition is supposed to be the simplest and the basic form of human social cognition underlying many complex social phenomena. The hypothesis of ingroup/outgroup opposition, as the basic relational egocentric form of representing social structure, is fully compatible with this anthropological view. The social differentiations we use, despite their multitude, frequently (although not necessarily) take the form of 'us and them'. This distinction is universally applicable to different social categories and has been intensively studied within social psychology (e.g. Taifel *et al.*, 1971; Brewer, 2007; Bernstein *et al.*, 2007; Krueger and DiDonato, 2008; Dovidio *et al.*, 2009; Miller *et al.*, 2010). These studies reveal the common features of the ingroup/outgroup opposition, such as ingroup favoritism, biases or better memory for various types of social categories: race, age, political affiliation. These effects took place even for contextually defined groups within the so-called 'minimal group paradigm' (Bernstein *et al.*, 2007; Van Bavel and Cunningham, 2009). The existence of such a general form of categorization is plausible from evolutionary perspective as well. An ability to make, maintain and recognize alliances is crucial to survival of collectively living kinds. Categorization is a cognitive basis for dealing with alliances. As a multitude of categorizations are possible, they can use the same mechanism for performing the same function. This hypothesis was partially developed by Kurzban *et al.* (2001), who treated race as the by-product of a more general system evolved for the fast detection of alliances (see also Cosmides *et al.*, 2003). Although this coalition–detection mechanism seems to be less applicable to categorizations based on different biological functions (age, sex), even more general and simple systems can encompass them as well.

This study is an attempt to identify brain structures responsible for this form of social categorization—a relational egocentric binary structure differentiating social world into two universally applicable categories, traditionally labeled 'ingroup' and 'outgroup'.

METHOD

Data selection

Data search was performed in Google Scholar and PubMed using search term 'fMRI' with one of the following terms: 'social categorization', 'social status', 'social group', 'ingroup', 'outgroup'. Additional texts were found through citation analysis. Inclusion criteria for the data set (314 foci from 33 experiments) were the following:

- a study should use fMRI technique;
- subjects are healthy adults;
- experimentation design should include implicit or explicit social categorization (differentiation of targets into social groups or categories) that could be distinguished as ingroup/outgroup; and
- coordinates of activations for the contrasts of interest should be reported in MNI or Talairach and Tournoux space.

Direct comparisons of both ingroup and outgroup members (e.g. Black *vs* White faces), and correlations between brain activations and behavioral measures (e.g. IAT) were included. Studies exploring the differences in social stratification (high *vs* low status) were intentionally excluded to avoid messing of

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Correspondence should be addressed to Aleksandr V. Shkurko, 603146, Russian Federation, Nizhny Novgorod, Norvezhskaya st. 4, ap.123. E-mail: khanovey@rambler.ru

two distinct mechanisms (Fiske, 1992). Studies in which a particular social category was contrasted with the non-social baseline, without further comparisons, were excluded as well.

Coordinates from both whole-brain and ROI analyses were included. Several studies investigating predetermined regions-of-interests were included when corresponding coordinates were available. The rationale for inclusion of ROI-based activations is that, although this approach may result in the loss of relevant data, it should not add to noise data. If a ROI-based study reports effects of interest, it produces relevant input data that can be included in the meta-analysis. When both ROI-based and whole-brain analyses were available, only the latter were included.

Coordinates reported in MNI space were transformed to Talairach space using Lancaster transform implemented in GingerALE 2.1 (UTHSCSA, www.brainmap.org). For every study, information in respect of the following elements was extracted: coordinates of peaks, corresponding relational status of target (ingroup or outgroup), social category involved in experimentation situation (race, age, political affiliation, etc), experimentation task and stimuli (see Appendix Table A1 for details).

The main interest of this meta-analysis is to understand how the brain processes representation of relational social differences. This raises the important methodological question of classifying activations as 'ingroup-sensitive' or 'outgroup-sensitive'. If a study reports differential neural responses for the faces of Black and White targets, it does not point to *social* categorization as such. Social categorization implies that objects in classes are expected to be different in their mental states and behaviors. Such categorization process is not a priory given in any fMRI experimental setting. Differential response to various types of targets with one of which participants can be reasonably associated is, however, a good reason to *hypothesize* categorization process. This may explain the logic of data inclusion.

Take for example a study reporting selective neural response to children and adults in adult participants. It might seem strange to treat 'children' targets as 'outgroup' (as if they were 'enemies'!). In this meta-analysis, however, the In/Out-group distinction is used in a broader sense. If children are expected to be socially different from adults and to have different interests, goals and behaviors, then they can be treated as an outgroup.

Not all possible social oppositions were however included. In studies dealing with gender differences, those that investigated the effects of attractiveness (e.g. Aharon *et al*., 2001; O'Doherty *et al*., 2003) were excluded to decrease the amount of noise data generated from certain aspects of sexual behavior. For the same reasons, I excluded contrasts in which mothers differentially responded to their own and unfamiliar children (Leibenluft *et al*., 2004; Nitschke *et al*., 2004). Although viewing one's own relatives is expected to trigger kinship-based ingroup conception, it can be blurred by reward processing and other emotionally laden processes irrelevant to the goal of this study. I thus left only those kinship-related studies which did not include maternal behavior. Effects of exclusion of these kinship-related contrasts were also investigated.

Data analysis

The meta-analysis was based on activation likelihood estimation (ALE) method (Laird *et al*., 2005). A revised algorithm developed by Eickhoff *et al*. (2009) and implemented in GingerALE 2.1 software was used to find clusters most typically and robustly involved in the representation of social differences. This method's great advantage is that it produces information about each voxel in the brain and can control for sample size and the number of activations reported in each particular study. False discovery rate threshold was set to $q = 0.01$. Brain images were produced in Mango 2.5 (Research Imaging Center, UTHSCSA).

RESULTS

ALE-based analysis revealed several clusters most commonly involved in social categorization: bilateral amygdala and adjacent regions, cingulate gyrus, including anterior cingulate cortex (ACC), left fusiform gyrus and right TPJ (see Table 1 and Supplementary data for figures and clusters found with a more liberal threshold). Ingroup and outgroup activations were also analyzed separately. For the ingroup condition, the largest clusters include ACC, left amygdaloid region, including globus pallidus and putamen, and the posterior part of cingulate gyrus. The outgroup condition revealed left amygdala and right insula as the largest clusters. Smaller clusters were also found in medial frontal gyrus and occipital lobe/precuneus in the ingroup condition.

To test the possible effect of ROI-based activations, they were excluded from the data set. This resulted in only minor changes: clusters in the left FG, right TPJ (ingroup + outgroup condition), as well as three smaller clusters in different conditions, were found when a slightly more liberal statistical threshold $q = 0.02$ was adopted.

To test the possible effect of personal relationship and familiarity with the kinship-based ingroup, activations corresponding to the contrasts in which one's relatives were among targets, were also excluded. This resulted in decreased significance of activations in the cingulate gyrus and ACC in the combined and ingroup conditions. Partially, the main cluster in cingulate gyrus (0, 14, 33) in the main data set, as well as the corresponding cluster in the ingroup condition, was found when statistical threshold was set to $q = 0.02$; the size of this cluster was significantly smaller. A cluster in rostral ACC with coordinates (−12, 43, 1) from the combined condition of the main data set was found when the threshold was set to $q = 0.05$ in the combined condition, and to $q = 0.02$ in the ingroup condition. No changes in the outgroup conditions were found.

Exclusion of 'children *vs* adults' and the opposite contrasts did not significantly change the results.

DISCUSSION

Many aspects of how people represent social relations and structure their social world fit well into one simple and general form of 'us and them' distinction. This opposition and the related effects, such as group preferences and differing evaluations, look very similar for different social categorizations and contexts. This universality leads to a hypothesis of underlying cognitive structure or the set of common mechanisms. It seems plausible, evolutionarily, cognitively and sociologically, that a universal relational structure operating with a general form of ingroup/outgroup distinction exists in human mind/brain.

Although it is difficult to associate any of the revealed clusters with such a universal relational structure, several conclusions can be drawn in this regard to their possible functions in social categorization.

Amygdala

Activations in the left, and less significantly right amygdala and adjacent regions, are the most typically involved in selective response to various social targets. Amygdala has long been considered crucial to implicit processing and fast evaluation of socially relevant information (Lieberman, 2007; Stanley *et al*., 2008; Adolphs, 2009). Activation of the amygdala is more frequent, but not exclusive, in the outgroup condition. The question, however, is whether the amygdala discriminates by itself between targets or receives categorization input from other systems. Cunningham *et al*. (2004) report that amygdala is selective for racial outgroup in the subliminal presentation of faces. This might indicate that amygdala performs categorization function, at least

Table 1 Extrema values and coordinates for ALE-based clusters, $q = 0.01$

Cluster No	weighted center			size, mm^3	Extrema value	Extrema coordinates			Label
	x	y	z			x	y	z	
Ingroup + Outgroup									
1	−20	−5	−13	2976	0.04	−20	−6	−12	L Amygdala
2	0	14	33	472	0.02	−2	12	34	Cingulate Gyrus, BA 24
3	3	37	16	424	0.02	2	36	16	Anterior Cingulate, BA 32
4	15	−7	−8	408	0.02	16	−6	−8	Medial Globus Pallidus
5	−45	−59	−16	248	0.02	−46	−58	−16	L Fusiform Gyrus, BA 37
6	50	−54	33	208	0.02	54	−54	32	R Supramarginal Gyrus, BA 40
					0.02	48	−54	32	R Superior Temporal Gyrus, BA 39
7	39	8	9	192	0.02	40	8	10	R Insula, BA 13
8	−4	−27	34	152	0.02	−4	−28	34	Cingulate Gyrus, BA 31
9	−12	43	1	128	0.02	−12	44	2	Anterior Cingulate, BA 32
10	−20	14	−8	112	0.02	−20	14	−8	L Putamen
11	33	−72	20	104	0.02	34	−72	20	R Occipital Gyrus/Precuneus
Ingroup									
1	3	37	16	592	0.02	2	36	16	Anterior Cingulate, BA 32
2	−21	−5	−8	520	0.02	−20	−4	−8	L Globus Pallidus
3	−3	−27	34	328	0.02	−4	−28	34	Cingulate Gyrus, BA 31
4	−20	14	−8	208	0.02	−20	14	−8	L Putamen
5	−1	26	43	168	0.01	−2	28	42	Medial Frontal Gyrus, BA 8
6	−11	43	0	160	0.01	−12	42	0	Anterior Cingulate
7	28	−28	−17	128	0.01	28	−28	−16	R Parahippocampal Gyrus, BA 36
Outgroup									
1	−19	−4	−14	1816	0.03	−20	−4	−14	L Amygdala
2	39	8	10	504	0.02	40	8	10	R Insula, BA 13
3	−3	10	35	160	0.01	−2	10	34	Cingulate Gyrus, BA 24
4	55	−55	32	152	0.01	56	−54	32	R Supramarginal Gyrus, BA 40
5	−43	−37	−8	136	0.01	−42	−38	−8	L Parahippocampal Gyrus, BA 36
6	15	−7	−8	112	0.01	16	−6	−8	Medial Globus Pallidus

for racial category, but the mechanism of this intellectual operation is not clear. How can it determine to what stimuli one must respond to? Fast response is possible via relatively simple and strict learned associations between particular cues and emotional reaction. This, however, is at best a content-based categorization, not a relational one.

The fact that the amygdala may be inhibited or habituated to particular types of targets (e.g. Hart *et al.*, 2000; Cunningham *et al.*, 2004; Wheeler and Fiske, 2005; Westen *et al.*, 2006) indicates that other brain regions step in deliberately to take decisions about appropriate alertness level and regulate the amygdala activity (Heatherton, 2011).

The idea that the amygdala is especially important for fast processing of visual stimuli, as compared to cortical regions, has been questioned by Pessoa and Adolphs (2010) who proposed its major role is coordination and integration of biologically significant information and modulation of response (see also Sander *et al.*, 2003). This function is too broad to implement social categorization as such but is compatible with the fact that amygdala activation is found both in ingroup and outgroup conditions, for various tasks and stimuli. Amygdala seems to be an important mediating structure but hardly implementing social categorization. Still, it can be partially responsible for content-based categorization via selective response to particular social targets strongly associated with 'salience markers', along with other routs for social categorization.

ACC/cingulate gyrus

Several clusters in ACC and other parts of cingulate gyrus were found for various conditions. ACC has often been considered as composed of two functionally distinct areas, dorsal and rostral/ventral, implementing either automatic and controlled processes or, in an alternative view, appraisal and regulative functions (Lieberman, 2007; Etkin *et al.*, 2011). Among the revealed clusters, a more dorsal one centered at (0, 14, 33) is generally compatible with this distinction. This area is activated primarily in the outgroup condition. Several studies reporting activations in this region treat it as performing self-regulatory functions, including monitoring the need for control and suppression of negative emotions toward outgroup members (Richeson *et al.*, 2003; Cunningham *et al.*, 2004; Kaplan *et al.*, 2007; Knutson *et al.*, 2007). The same region, however, was reported as responding to familiar faces, including kinship ingroup and was linked to personal knowledge (Taylor *et al.*, 2009). Besides, the exclusion of kinship-related activations from the data set resulted in its diminished significance in the combined condition, but has not changed the situation in the outgroup condition. Considering that other studies, investigating the effects of familiarity, have not pointed to this particular region of cingulate gyrus (Gobbini *et al.*, 2004; Leibenluft *et al.*, 2004; Harada *et al.*, 2010), its monitoring/regulatory function seems more stable. Probably, viewing familiar faces activated this region owing to necessity of emotion regulation in response to emotionally salient stimuli.

Other, more ventral portions of ACC extending into ventromedial PFC are activated in the ingroup condition. Activity in these areas were associated with positive emotions during social comparison (Volz *et al.*, 2009; see also Zink *et al.*, 2008), the application of stereotypes (Knutson *et al.*, 2007), mentalizing similar others (Gobbini *et al.*, 2004; Freeman *et al.*, 2010b) and representation of self-relevant information (Northoff *et al.*, 2006; Harada *et al.*, 2010; Ng *et al.*, 2010; Heatherton, 2011). Further, activations in all these clusters, almost exclusively, appear in tasks using semantic stimuli (Rilling *et al.*, 2008; Freeman *et al.*, 2010b; Harada *et al.*, 2010; Ng *et al.*, 2010; Contreras *et al.*, 2012). Taken together, these facts point to a possible mechanism of the ingroup/outgroup distinction processing, based on the similarity assessment and self-referential thinking.

It would be plausible to suppose that the ingroup/outgroup distinction is based on similarity assessment in such a way that similar others are treated as more predictable and understandable, thus enabling them to be included in the 'ingroup' category. This inclusion may result in the application of knowledge about self to ingroup members, up to including them in the self-concept (Volz *et al.*, 2009; Ng *et al.*, 2010) and, consequently, in self-preferential evaluations and reasoning thus implementing ingroup favoritism strongly associated with rACC in the study of Volz *et al.* (2009).

In this interpretation, the causal relations are however not clear. Does the perceived similarity lead to identification of a target as an ingroup member? Or is it a categorization process that turns on reasoning 'by analogy'? Ingroup members may then be considered more similar and mentalizable by reference to one's own position, as is probably the case in the study of Rilling *et al.* (2008). This however does not explain why some targets are represented as ingroups and others as outgroups.

Finally, a cluster in the posterior part of the cingulate gyrus was activated primarily in the ingroup condition. It is reported for various types of targets and tasks (Harada *et al.*, 2010; Hoehl *et al.*, 2010; Falk *et al.*, 2012). A nearby cluster in cingulate gyrus was associated with the application of stereotypes (Mitchell *et al.*, 2008) and with autobiographical memory (Spreng *et al.*, 2008), but the rules controlling activation of this area in social categorization remain unclear.

Fusiform gyrus

Fusiform gyrus is typically associated with visual expertise and, partially, with remarkable sensitivity to human faces (Kanwisher and Yovel, 2006). That it is often activated in social cognition experiments is no surprise considering that human faces are the most typical type of stimuli in the imaging studies of social categorization. But why should FG appear in this meta-analysis, in which every activation included is especially sensitive to various types of social targets all of which are represented as faces? Although more familiar ingroup faces can lead to increased activation of the face-sensitive area (Golby *et al.*, 2001), for the minimal ingroup members, who were not more familiar than outgroup members, the same effect was revealed (Van Bavel *et al.*, 2011). Authors of the latter study considered that this region is more ingroup sensitive owing to motivational factors influencing activity in this region. The results of this meta-analysis support the idea of top-down modulation of the cluster revealed in the FG/inferior temporal gyrus (ITG), but not the idea of its ingroup bias. Indeed, several studies report outgroup sensitivity of this area as well (e.g. Ronquillo, 2010; Vrtička *et al.*, 2009). Moreover, several studies relating to investigating social cognition report selective activation in this area of the FG/ITG or nearby region in the cerebellum to socially meaningful, but non-facial stimuli (Rilling *et al.*, 2008; Marsh *et al.*, 2009; Hein *et al.*, 2010). Almost exactly the same region was associated with visual word perception (McCandliss *et al.*, 2003), and an impressive meta-analysis of Binder *et al.* (2009) reveals a nearby cluster of FG/ITG that is constantly engaged in semantic processing.

A possible explanation can be given if experimental situations in which the FG/ITG is activated are to be compared. In the studies of social categorization, the cluster revealed in FG and adjacent regions in the left, and sometimes in the right hemisphere, is often activated when participant's attention is explicitly directed toward social differences or the changing social context. First, it was often activated in the social categorization tasks, i.e. experimental settings in which participants had to discriminate between social targets: males and females, Black and White, etc. (O'Doherty *et al.*, 2003; Singer *et al.*, 2004; Van Bavel *et al.*, 2008, 2011; Marsh *et al.*, 2009; Farrow *et al.*, 2011). In several other studies, differential activation of FG was found in tasks in which participants had to dynamically update their own and/or the targets' social position (Rilling *et al.*, 2008; Zink *et al.*, 2008; Ronquillo, 2010). In other studies, participants had to explicitly rate the pain experienced by one's own and rivals' football team fans (Hein *et al.*, 2010), explicitly (but not implicilly!) rated attractiveness of faces (Iaria *et al.*, 2008), or explicitly evaluated and classified social targets (Krendl *et al.*, 2006).

Although such tasks can be orthogonal to the process of interest, the fact that FG area is repeatedly involved in explicit social categorization may point to its role in the top-down modulation of social perception, rather than specific visual sensitivity. The preferential engagement of the revealed cluster, centered in the FG in explicit social categorization and in response to the changing social context, may reflect its role in the initial predisposition to social discrimination and indexing of socially significant perceptual input according to pre-existing expectancies and attention to particular aspects of social milieu. This function is compatible with the results of Bollinger *et al.* (2010), who reported that activation in the visual association cortex, including fusiform face area, is dependent on stimuli expectancies. Expected stimulus would affect activity and functional connectivity of these regions *before* the presentation of the stimulus (see also Righart *et al.*, 2010). The particular sensitivity of this area to some types of social targets may reflect the interaction between the expectancies and the actual stimulus presentation. It is worth noting that, in experimental studies of social cognition, participants perform tens and hundreds of trials, so that they can easily produce their own 'theory of an experiment' and their own expectancies and predispositions, probably contributing to the amount of effort invested in social indexing.

The top-down modulation function of this area is also compatible with a recent study of Contreras *et al.* (2012) in which non-social semantic knowledge was compared with that of social categories. The study shows that social categorical information is processed in a different way in comparison with the seemingly equivalent non-social categorical information. This study reports, inter alia, activations in the left FG. Further research may focus on this area as being involved in interactive and bidirectional processing of social stimuli (Amodio and Ratner, in press): a more linear and monotonous bottom-up perception of visual input (Freeman *et al.*, 2010a; Ramon *et al.*, 2010), and more categorical top-down, 'theory-laden' perception and interpretation of social stimuli.

Right temporoparietal junction

This region is known to be crucial to several high- and low-level cognitive processes, including attention modulation and Theory of Mind construction (Decety and Lamm, 2007; Van Overwalle, 2009). No surprise that activation of this region was found in experiments in which mentalizing was necessary or plausible (Rilling *et al.*, 2008; Adams *et al.*, 2010; Cheon *et al.*, 2011; Falk *et al.*, 2012). More interesting is the fact that mentalizing functions are recruited differentially for ingroup and outgroup members in various social contexts. Given that differential mentalizing abilities for ingroup and outgroup members are associated with two radically distinct areas in the ACC/medial prefrontal cortex (mPFC) and right temporoparietal junction, the former being probably based on self-referential reasoning and the latter on simulation; it would be interesting to compare their roles in social inferences (Adolphs, 2009; Van Overwalle, 2009). However, there are no reasons to suppose that the right TPJ plays a role in social categorization as such or that it can discriminate between social targets.

Right insula

Right insula is the only region that demonstrates strong outgroup bias. Several studies dealing with various social categories and tasks report activation of this region in response to racial and political outgroups (Phelps *et al.*, 2000; Richeson *et al.*, 2003, 2008; Kaplan *et al.*, 2007; Falk *et al.*, 2012), unfamiliar faces (Gobbini *et al.*, 2004) and dominant faces (Chiao *et al.*, 2008a), and correlation with discriminating behavior toward minimal outgroup (Rilling *et al.*, 2008). Given that insula damage is associated with difficulties in risky decisions (Weller *et al.*, 2009), and the left insula is associated with response to disgusting stimuli (Harris and Fiske, 2006), it is plausible to suppose the role of this region in modulating avoidance behavior in social context with uncertainty or danger.

Turning back to the main goal of this meta-analysis, namely searching for the brain systems that implement putative relational structure which differentiates social targets into two opposite social categories, it should be mentioned that no union mechanism was found.

In the changing social context found by several studies, the fusiform gyrus is a promising line of further research, especially in the light of its involvement in re-categorization process. It is, however, difficult to say that this structure functions as simple binary relational mechanism of social differentiation and that it associates targets with specific relational social category. Instead, its role is more important for understanding the content-based categorization.

There are several reasons to explain why the neural basis of social categorization remains still unidentified. One is that the studies under question reflect brain activations pointing to different cognitive and affective effects associated with social categorization, but not the categorization itself. In neuroscience experiments, the researcher typically introduces categorization from without, leaving aside mechanisms of categorization as such. Social meaning of group differentiation is in its related evaluations, behaviors and expectations that can be very specific to various contexts. Although many studies declare their findings as dealing with social categorization, reporting differential activations to targets from different social groups or categories, their experimental designs do not often allow distinguishing the representation of social differences from related effects, such as ‘preferential choice to reward ingroup member’ or ‘increasing caution toward other-race person’. While most clusters revealed by ALE analysis are important for various categorization-related effects, such as stereotype suppression, modulating appraisal or avoidance behavior, etc., it is only FG cluster that seems to deal with categorization process as such. The possible role of self-referential region in the rACC/vmPFC, in the production of ingroup/outgroup distinction, is also possible and can be investigated in further research. It would be extremely useful to perform fMRI experiments for studying one sample in various categorization-related tasks and comparing different social classification systems. Till now, to my knowledge, only one fMRI study performed a direct comparison of different social categories, race and gender (Knutson *et al.*, 2007).

Another side of the problem is the interaction of abstract binary classifications with content-based social categorizations. Most social categories we use deal with specific contents associated with them, from the skin color to the expected behaviors. The ingroup/outgroup distinction is, on the contrary, content-free because it is applicable to different social categories. At the same time, being egocentric, it is expected to produce specific effects such as ingroup favoritism or outgroup avoidance. In real life, these relational and substantial, content-based aspects of categorization are interwoven. Relative failure of the search for the ingroup/outgroup distinction in this meta-analysis can partially be explained by the involvement of content-based categorizations.

Several fMRI studies, indeed, found activations that were sensitive to a particular social group (category) in substantial rather than relational manner. This effect was found in the study of Lieberman *et al.* (2005) in which both African-Americans and Caucasian-Americans showed specific brain response to only African-American faces; an even stronger effect was found in a study of Losin *et al.* (2012), in which European-Americans imitated gestures of three racial groups (European, African and Chinese). Two of these outgroups have been processed differently, probably because of the difference in their content.

It is thus possible that a combination of different cognitive mechanisms, or modules, is involved in the processing of information on different social categories (Cosmides *et al.*, 2003; Gil-White, 2006). It is also possible that relational forms, so obviously engaged in the minimal group experiments, interact in real life with other, content-based categorizations.

CONCLUSION

Simple rules and operations can produce complex effects. In the field of societies' functioning such rules can include cognitive mechanisms representing social structure. One such simple mechanism is representation of social differences via ingroup/outgroup opposition. The results of this meta-analysis point to amygdala, ACC, fusiform gyrus and right insula as being most typically involved in differential response to social targets. Most of these brain areas, however, reflect various categorization-related effects, rather than categorization as such. Clusters in the ventral part of ACC appear to be sensitive to the ingroup members, probably indicating dispositional preference toward the ingroup and involvement of self-referential thinking about similar others. A more dorsal part of ACC can be involved in monitoring and/or regulation of emotional tensions raised by observing outgroup members. Right insula is strongly associated with outgroup targets probably modulating avoidance behavior. The fusiform gyrus is sensitive to social categorization tasks and to changing social context urging for re-classification of social objects probably reflecting expectancy-driven bias in category application to visual social stimuli. Further research could focus on direct comparison of neural systems involved in the processing of various social classification systems.

SUPPLEMENTARY DATA

Supplementary data are available at *SCAN* online.

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Table A1 Studies included in the meta-analysis

Study	Social category	Task	Stimuli	Main contrast as defined by authors	Activations	Notes
Adams *et al*., 2010	Ethnic/cultural	Mental state recognition (reading mind in the eyes task)	Visual	(Same culture RME > baseline) > (other culture RME > baseline)	5	
Van Bavel *et al*., 2011	Minimal	Group categorization	Visual	Ingroup > outgroup and novel faces	2	Bilateral activations were identified as an average of the reported ROI coordinates
Van Bavel *et al*., 2008	Minimal	Group or race categorization	Visual	Ingroup > outgroup	6	
	Race				5	
Bruneau and Saxe, 2010	Ethnic	Evaluation of statements about ingroup or outgroup	Semantic	Emotional > nonemotional judgments	2	Pro-outgroup judgments are supposed to trigger strong emotional reaction
Cheon *et al*., 2011	Cultural/ethnic	Rating of empathy toward Korean and Caucasian American targets	Visual	(Ingroup pain > ingroup neutral) > (outgroup pain > outgroup neutral)	12	
Chiao *et al*., 2008b	Ethnic/cultural	Emotion recognition (fear faces)	Visual	Own culture > other culture	8	
Cunningham *et al*., 2004	Race	Face perception	Visual	Black (outgroup) > White	15	
Falk *et al*., 2012	Political	Taking the perspective of one's own and the opposing politician	Visual/aural	Own candidate > opponent	7	
Fischer *et al*., 2004	Gender	Face perception	Visual	Female (outgroup) > male	2	
Freeman *et al*., 2010b	Race	Superficial and individuated judgments about others	Semantic	Individuated > superficial judgments (Covaried with race)	1	
Golby *et al*., 2001	Race	Attention to stimuli	Visual	Same race > other race (Covaried with memory scores)	3	
Harada *et al*., 2010	Kin	Implicit self-recognition task, individualistic and collectivistic priming	Semantic	Father-relevant information > information about strangers	24	It can be hypothesized that father-relevant information not simply enables familiarity processing but serves as a kin-detection mechanism. Those who are not in the kinship ingroup are an outgroup
Hart *et al*., 2000	Race	Gender categorization of faces	Visual	Outgroup > ingroup	11	
Hein *et al*., 2010	Social	Empathy toward members of one's own and rival football teams	Semantic	(High > low ingroup pain) > (high > low outgroup pain)	10	
Hoehl *et al*., 2010	Age	Face perception, response to an ape face presentation	Visual	(Adults > fixation) > (children > fixation), Happy faces; (adults > fixation) > (children > fixation), Angry faces	30	
Kaplan *et al*., 2007	Political	Viewing pictures of politicians	Visual	Opposing candidate > own candidate	18	
Krill and Platek, 2009	Race	Reaction to social exclusion	Visual	Same race > other race	6	
Leibenluft *et al*., 2004	Age	Repetition detection task	Visual	Unfamiliar children > adults	14	
Losin *et al*., 2012	Race	Imitation of gestures of three racial group members	Visual	European (ingroup) > Chinese; African (outgroup) > European	27	Authors link these differences to particular content of each of three groups, see discussion
Mitchell *et al*., 2006	Political	Judgments about (politically) similar and dissimilar others	Semantic	Similar > dissimilar other	7	
Phelps *et al*., 2000	Race	Face recognition	Visual	Black (outgroup) > White male faces (Correlated with behavioral measures of evaluation)	6	
Richeson *et al*., 2003	Race	Face perception	Visual	Black (outgroup) > White faces	10	
Richeson *et al*., 2008.	Race	Face perception	Visual	Black > White	1	
Rilling *et al*., 2008	Minimal	Decision to cooperate in prisoner's dilemma game	Semantic	Interaction with ingroup > with outgroup (covaried with behavioral outcome and functional connectivity with dmPFC)	15	
Ronquillo 2010	Race	Race reversal learning task	Visual	Black (outgroup) > White	8	
Rule *et al*., 2010	Political	Voting decisions	Visual	Voted > not-voted politicians	4	
	Ethnic/cultural		Visual	Voted > not-voted, (covaried with targets' culture)	2	
Taylor *et al*., 2009	Kin	Observation of personally familiar and unknown faces, attention to unusual 'ghost' pictures	Visual	Parents > unknown faces	3	
Volz *et al*., 2009	Minimal	Money distribution among others	Semantic	Ingroup trials > outgroup trials, ingroup bias > fair behavior mixed group trials > ingroup trials, (covaried with subjective identification with the ingroup)	12	
Vrtička *et al*., 2008	Minimal	Virtual game with plus or minus feedback accompanied with smiling or angry faces from two teams	Visual	Smiling > Angry faces in lost/won feedback condition	18	Smiling faces in 'won' condition and angry faces in 'lost' condition designate 'friends' (coalitional ingroup), and the reversed combination are 'enemies' (outgroup)
Vrtička *et al*., 2009	Minimal	Recognition of faces from previously learned in- and out-groups	Visual	Old > new faces (covaried with target's social status, see information on previous study)	5	
Westen *et al*., 2006	Political	Judgments about contradictory statements of Democrat and Republican leaders	Semantic	Same/other party > neutral target	10	
Wheeler and Fiske, 2005	Race	Individuation judgments	Visual	Black (outgroup) > White faces	1	
		Age categorization			1	
Xu *et al*., 2009	Race/ethnic	Empathy (estimation of Other's pain)	Visual	(Pain > No pain) and (Chinese > Caucasian)	2	
Total					314	