

Categorizing and Individuating Others: The Neural Substrates of Person Perception

Malia F. Mason and C. Neil Macrae

Abstract

■ People are remarkably adroit at understanding other social agents. Quite how these information-processing abilities are realized, however, remains open to debate and empirical scrutiny. In particular, little is known about basic aspects of person perception, such as the operations that support people's ability to categorize (i.e., assign persons to groups) and individuate (i.e., discriminate among group members) others. In an attempt to rectify this situation, the current research focused on the initial perceptual stages of person construal and considered: (i) hemispheric differences in the efficiency of categorization and individuation; and (ii) the neural activity that supports these social-cognitive operations.

Noting the greater role played by configural processing in individuation than categorization, it was expected that performance on the former task would be enhanced when stimuli (i.e., faces) were presented to the right rather than to the left cerebral hemisphere. The results of two experiments (Experiment 1—healthy individuals; Experiment 2—split-brain patient) confirmed this prediction. Extending these findings, a final neuroimaging investigation revealed that individuation is accompanied by neural activity in regions of the temporal and prefrontal cortices, especially in the right hemisphere. We consider the implications of these findings for contemporary treatments of person perception. ■

INTRODUCTION

Humans are remarkably adept at understanding other social agents. From only a few visual cues, perceivers are able to formulate detailed impressions and evaluations of others (Fiske & Neuberg, 1990; Brewer, 1988), identify the sex, emotional status, and identity of social targets (Bruce & Young, 1986), and infer the hidden states (i.e., goals, motives, intentions) that give rise to purposive human behavior (Gallagher & Frith, 2003; Baron-Cohen, 1995). When one considers the ambiguities inherent in everyday social exchange, these social-cognitive abilities are striking. But why exactly are perceivers so adroit at understanding others? In particular, how are core aspects of person perception realized in the brain (Adolphs, 2001, 2003)? In the current inquiry, we will explore two basic abilities that are purported to subserve person perception: "categorization" and "individuation" (Fiske & Neuberg, 1990; Brewer, 1988). Focusing on the initial perceptual stages of social-cognitive functioning, the reported research will consider both hemispheric differences in the efficiency of categorization and individuation and the neural activity that supports these operations.

Acknowledging the pivotal status of person construal in social-cognitive functioning (Gallagher & Frith, 2003; Adolphs, 2001, 2003; Baron-Cohen, 1995), researchers in

experimental social psychology have spent much of the last 50 years striving to identify the strategies and tactics that perceivers employ in their dealings with others (Kunda & Spencer, 2003; Bodenhausen & Macrae, 1998; Fiske & Neuberg, 1990; Brewer, 1988; Allport, 1954). The result of this empirical endeavor has been the emergence of two putative cognitive operations that are hypothesized to drive person perception: categorization and individuation (see Fiske & Neuberg, 1990; Brewer, 1988). Broadly speaking, categorization refers to people's propensity to characterize others on the basis of the social groups to which they belong (e.g., men, senior citizens). In so doing, generic category-based beliefs (e.g., stereotypes) guide target appraisal, memorial organization, and response generation (Macrae & Bodenhausen, 2000). Individuation, in contrast, reflects the tendency to view other people not as members of distinct social groups, but rather as unique entities. In this way, people are characterized (i.e., evaluated) on the basis of their idiosyncratic collections of attributes and qualities (Kunda & Spencer, 2003; Fiske & Neuberg, 1990; Brewer, 1988). At least as operationalized in the social-cognitive literature, categorization and individuation are commonly indexed through the differential products of memory retrieval (see Macrae & Bodenhausen, 2000; Macrae et al., 1999). Whereas category-based responding entails the extraction (i.e., generation) of generic stereotype-based information from memory (e.g., as a man, Alan must be ambitious and unemotional),

individuation involves the retrieval of personalized episodic traces from long-term storage (e.g., Alan plays golf and loves champagne). For the most part, therefore, extant work in social cognition has charted how either semantic or episodic memory guide (i.e., enrich, embellish) people's understanding of others (Macrae & Bodenhausen, 2000).

Prior to the retrieval of information from long-term memory, however, a great deal of social-cognitive processing has already taken place. Most notably, perceivers have resolved the perceptual puzzle of identifying social agents from available visual cues (i.e., object recognition). Capturing as they do different solutions or outcomes to the problem of person construal (i.e., group member vs. unique individual), categorization and individuation also operate at these early stages of person perception (Tarr & Cheng, 2003; Haxby, Hoffman, & Gobbini, 2000, 2002; Tarr & Gauthier, 2000; Bruce & Young, 1986). Any object, including a person, can be identified at multiple levels of categorical abstraction (Jolicoeur, Gluck, & Kosslyn, 1984; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). For example, an unfamiliar target can be construed as a woman (i.e., categorization) or as a unique individual, distinct from other members of the group (i.e., individuation). Of relevance herein, these discrete outcomes may reflect the operation of different processing mechanisms or strategies. Unlike other classes of objects for which a coarse analysis of the distinguishing visual features is frequently sufficient to support recognition (Marr, 1982), individuation among faces (i.e., telling group members apart) requires a configural or relational analysis of the available stimulus cues (Gauthier & Tarr, 1997; Moskowitz, Winocur, & Behrmann, 1997; Rhodes, Tan, Brake, & Taylor, 1989). As is the case for object recognition, however, person categorization (i.e., identifying members of a group) is less dependent on configural processing, relying instead on single facial features (i.e., feature-based processing) to determine group membership (Rhodes et al., 1989; Diamond & Carey, 1988). For example, sex categorization is often derived from a person's hairstyle (Brown & Perrett, 1993; Bruce et al., 1993; Burton, Bruce, & Dench, 1993).

Based on these processing differences (i.e., configural vs. feature-based processing), it is possible that categorization and individuation may be supported by distinct neural operations (Tarr & Cheng, 2003; Rossion, Dricot, Devolder, Bodart, & Crommelinck, 2000; Tarr & Gauthier, 2000; Rhodes, 1993; Hillger & Koenig, 1991). It has been noted that the right hemisphere (RH) is more sensitive than the left hemisphere (LH) to configural information, resulting in a RH advantage for face recognition (Rhodes, 1985, 1993; Yin, 1969). Corroborating this observation, neuroimaging studies have identified regions in the right ventral temporal cortex (e.g., fusiform gyrus) that play a functionally important role in face processing (Haxby et al., 2000; Kanwisher, Stanley, &

Harris, 1999; Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997). As it turns out, however, subordinate-level judgments about other stimuli also prompt activity in these areas (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Gauthier, Anderson, Tarr, Skudlarski, & Gore, 1997; Gauthier & Tarr, 1997), thereby suggesting that the ventral temporal cortex may be implicated in the fine-grained discrimination of objects from homogenous categories, such as faces (Tarr & Cheng, 2003; Tarr & Gauthier, 2000). These findings are broadly consistent with the suggestion that there are basic hemispheric differences in the brain's capacity to process global and local aspects of sensory input. Whereas the RH appears to be specialized for global processing (e.g., spatial relations), the LH is better able to process the local aspects of visual stimuli (see Fink et al., 1996; Robertson & Lamb, 1991; Kosslyn, 1987).

In the realm of social-cognitive functioning (i.e., person perception), these findings give rise to specific experimental predictions, at least for the theoretically important task of individuation (Fiske & Neuberg, 1990; Brewer, 1988). At the level of person construal, the RH should be more adept than the LH at individuating social targets (i.e., identity discrimination) as it is better able to process configural visual information (e.g., Rossion et al., 2000; Rhodes, 1993). In contrast, as categorical judgments are typically feature-based (Brown & Perrett, 1993), if anything, the LH should outperform the RH at the task of person categorization (i.e., category discrimination). Given the relative ease with which categorical knowledge can be extracted from faces (Bruce & Young, 1986), however, it is possible that hemispheric differences may fail to emerge on this task. To investigate these predictions, we conducted three experiments. Following the presentation of facial stimuli, participants were required to report if two targets were the same sex (i.e., category-matching), or if two stimuli depicted the same person (i.e., identity-matching). Using a divided visual field paradigm, Experiment 1 and Experiment 2 assessed task performance in healthy individuals (Experiment 1) and a split-brain patient (Experiment 2). Although these studies enabled us to assess hemispheric differences in general task performance, they provided little insight into the functional localization of categorization and individuation in the brain (Haxby et al., 2000, 2002). Accordingly, in Experiment 3, we used functional magnetic resonance imaging (fMRI) to explore the neural substrates of these social-cognitive operations.

RESULTS

Experiment 1: Divided Visual Field Study with Healthy Individuals

In our first experiment, participants made categorical and individuated judgments on faces presented to either

the LH or RH. Accuracy of judgment served as the dependent measure of interest and the data were submitted to a 2 (task: categorization vs. individuation) \times 2 (hemisphere: LH vs. RH) repeated-measures analysis of variance (ANOVA). The results revealed main effects of task [$F(1,15) = 6.20, p < .03$] and hemisphere [$F(1,15) = 10.15, p < .01$] on participants' performance. Judgmental accuracy was higher for categorization than individuation (respective M_s : .73 vs. .69) and the RH outperformed the LH (respective M_s : .73 vs. .69). These effects were modified, however, by a Task \times Hemisphere interaction [$F(1,15) = 5.77, p < .03$; see Figure 1]. Further analyses revealed that performance on the individuation task differed as a function of hemispheric presentation [$t(15) = 3.92, p < .001$], such that performance was better when faces were presented to the RH than to the LH (respective M_s : .71 vs. .66). In contrast, performance on the categorization task was not moderated by hemispheric presentation [$t(15) = 1.349, ns$]. A 2 (task: categorization vs. individuation) \times 2 (hemisphere: LH vs. RH) repeated-measures ANOVA was also undertaken on participants' response times. No significant effects emerged in this analysis.

Experiment 2: Divided Visual Field Study with a Split-Brain Patient

In our second experiment, a split-brain patient (J. W.) made categorical and individuated judgments on faces presented to either the LH or RH. Accuracy of judgment served as the dependent measure of interest and the data were analyzed via a 2 (task: categorization vs. individuation) \times 2 (hemisphere: LH vs. RH) mixed model ANOVA with task treated as a between-subjects factor (see Gazzaniga, 2000). The analysis revealed a significant main effect of task [$F(1,26) = 12.29, p < .03$], such that accuracy was higher on the categorization than the individuation trials (respective M_s : .71 vs. .64). This effect was modified, however, by a Task \times Hemisphere interaction [$F(1,26) = 5.23, p < .03$; see Figure 2]. Further analyses revealed that performance

on the individuation task differed as a function of hemispheric presentation [$t(13) = 2.26, p < .04$], such that performance was better when faces were presented to the RH than to the LH (respective M_s : .65 vs. .61). In contrast, performance on the categorization task was not moderated by hemispheric presentation [$t(13) = 1.14, ns$]. A 2 (task: categorization vs. individuation) \times 2 (hemisphere: LH vs. RH) ANOVA was also undertaken on J. W.'s response times. No significant effects emerged in this analysis.

Experiment 3: The Neural Substrates of Categorization and Individuation

In our third experiment, we used event-related fMRI to explore the neural substrates of categorical and individuated judgments to faces presented at fixation.

Behavioral Results

Behavioral data collected during scanning showed no difference in either the accuracy [$t(13) = 1.26, ns$; categorization = .83, individuation = .81] or latency of participants' responses [$t(13) = 1.77, ns$; categorization = 1286 msec, individuation = 1319 msec]. Consequently, it is unlikely that variability in the neural activity associated with these social-cognitive judgments reflects differences in the difficulty of the respective tasks.

Imaging Results

To examine whether categorization and individuation were associated with different patterns of neural activity, we compared the event-related BOLD response associated with each of these tasks. This comparison revealed distinct patterns of brain activity for each of these social-cognitive operations (see Table 1). The "individuation > categorization" contrast yielded increased activity in several areas in the frontal, parietal, and occipital cortices. Of particular theoretical interest, however, differences were also observed in regions of

Figure 1. Task Performance as as function of hemispheric presentation [healthy individuals - Experiment 1].

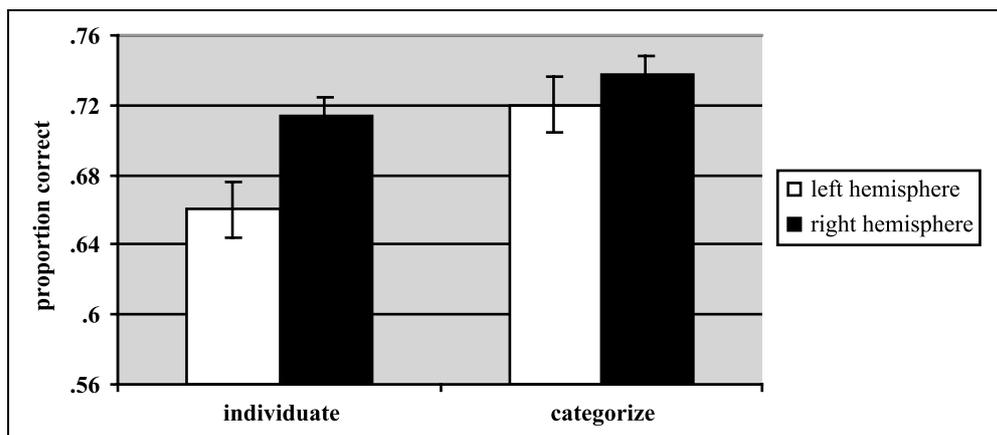
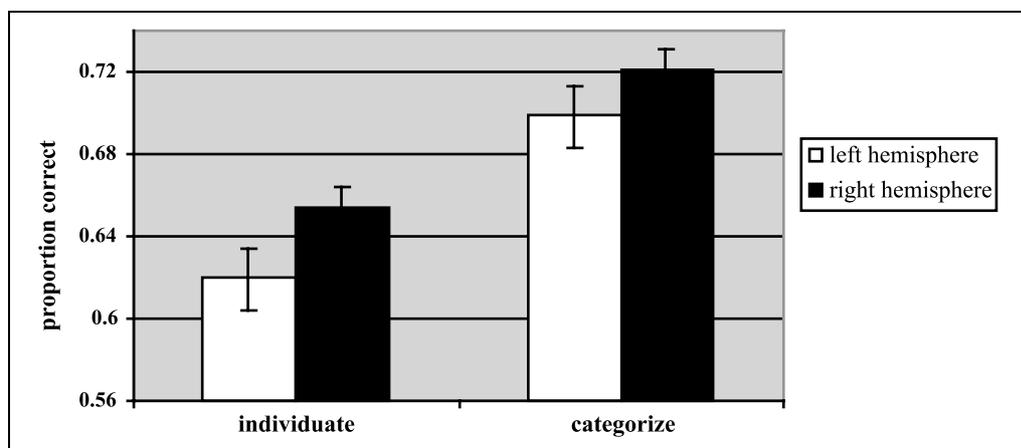


Figure 2. Task Performance as a function of hemispheric presentation [J. W. - Experiment 2].



the ventral temporal cortex. As expected, activity was greater in the right fusiform gyrus (BA 37, 19) and right inferior temporal gyrus (BA 37) during individuation (i.e., identity-matching) than categorization (i.e., category-matching). Figure 3 shows the activations that were observed in these regions during the tasks. The hemodynamic time courses are also shown. Although individuation and categorization showed significant activations above the resting baseline (i.e., fixating a crosshair), this effect was most pronounced for individuation. The “categorization > individuation” contrast revealed activity in areas of the prefrontal and temporal cortices. Of notable interest was the observed difference in activity in the left middle frontal gyrus (BA 8, 9, 10). Figure 3 shows the activation in this region during the tasks, together with the accompanying hemodynamic responses. Although categorization and individuation showed significant deactivations below the resting baseline, this effect was most pronounced for individuation. Thus, the significant difference emerging from the direct comparison was driven by reductions in neural activity relative to baseline.

DISCUSSION

The current inquiry constituted an investigation into the social-cognitive operations that support aspects of person perception; namely, categorization and individuation (Fiske & Neuberg, 1990; Brewer, 1988). Converging behavioral, neuropsychological, and neuroimaging evidence highlighted the importance of processes in the RH, particularly when people strive to individuate other social targets. Experiments 1 and 2 demonstrated a clear enhancement in task performance when faces were presented to the RH rather than to the LH. Extending this finding, Experiment 3 revealed that whereas individuation was accompanied by extensive activation in right inferior frontal and right occipitotemporal areas (Hoffman & Haxby, 2000), categorization yielded activity in the left inferior frontal and left superior temporal gyri

(Martin, 2001). Our attention now turns to a consideration of the implications of these findings for contemporary treatments of person perception.

Reflecting the contribution of distinct component operations (i.e., relational vs. feature-based processing) in their implementation, individuation and categorization may tap into broad hemispheric differences in the efficiency of configural and part-based visual processing. An established literature has confirmed that whereas the RH appears to favor global processing, the LH seems better suited to local processing operations (see Robertson & Lamb, 1991). Many of the studies that have observed this processing asymmetry have investigated people’s ability to identify components of compound stimuli (Navon, 1977), such as a large letter (e.g., T) comprised of several smaller lowercase (i.e., local) elements (e.g., s). Participants’ task is to identify either the global (T) or local letter (s) as quickly and accurately as possible. Of interest is the extent to which the global letter interferes with the identification of its local constituents (Navon, 1977). Using such a paradigm, Lamb, Robertson, and Knight (1990) compared task performance in patients with lesions in either the left or right temporal cortex. The results revealed that whereas patients with lesions in the LH showed an advantage for global stimuli, patients with lesions in the RH were better able to process the local elements of compound letters. These hemispheric differences in processing efficiency have been corroborated by Fink et al. (1996) in a positron emission tomography (PET) investigation. When participants were required to report the global letter of a compound stimulus, cerebral blood flow increased in the right lingual gyrus (see also Martinez et al., 1997). In contrast, when the task was to identify the local letter, increased blood flow was observed in the left inferior occipital gyrus.

At least for the social-cognitive task of individuation, comparable behavioral effects emerged in the current inquiry. Relying as it does on configural processing operations (Haxby et al., 2000, 2002; Rhodes, 1985, 1993; Yin,

1969), individuation was enhanced when faces were presented to the RH rather than to the LH (Tarr & Cheng, 2003; Tarr & Gauthier, 2001; Haxby et al., 2000), an effect that was observed in both normal individuals (Experiment 1) and a split-brain patient (Experiment 2). Hemispheric differences did not emerge, however, when the efficiency of person categorization was assessed. The failure to observe any differences on this task may be a

reflection of the overall ease with which sex can be extracted from facial features (Bruce & Young, 1986), an ability that may be supported by both hemispheres (Brown & Perrett, 1993; Bruce et al., 1993; Burton et al., 1993). Nevertheless, the results of the individuation task are noteworthy and confirm the general observation that basic aspects of face processing are supported by activity in regions of temporal cortex, especially in

Table 1. Regions of Increased Brain Activity Associated with Categorical and Individuated Judgments on Faces

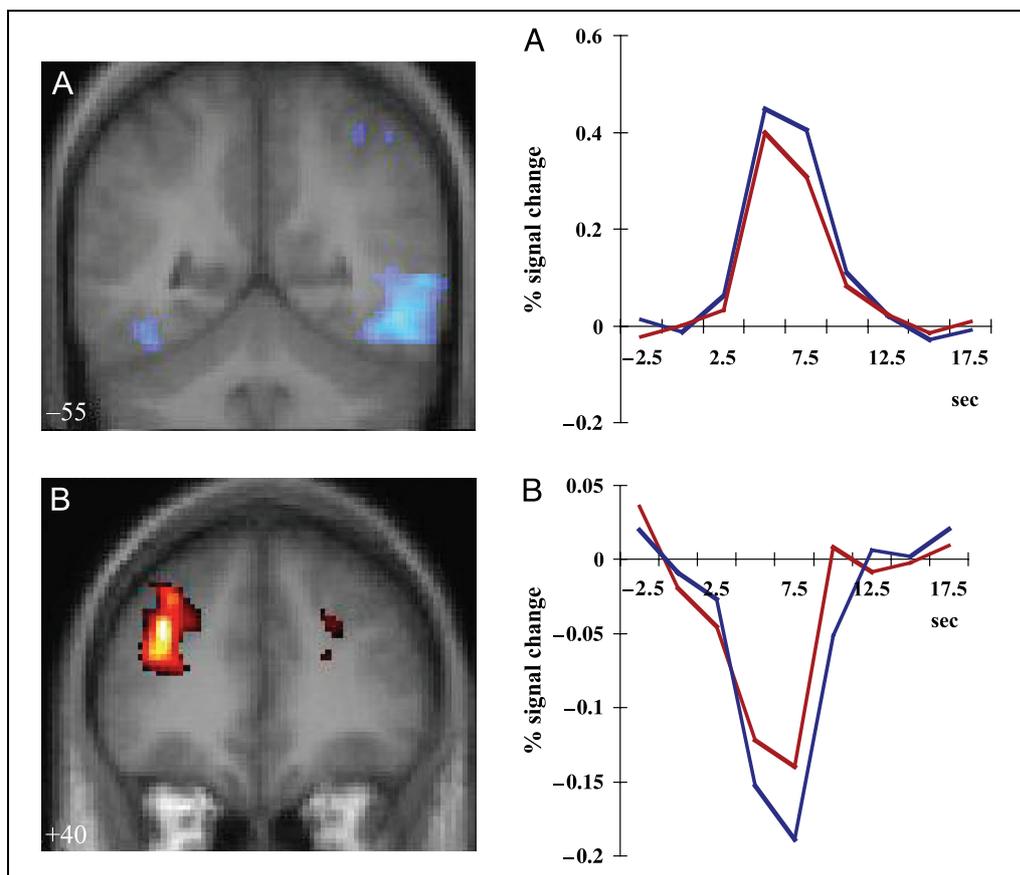
<i>Anatomical Label</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>k</i>	<i>t value</i>	
					<i>Ind</i>	<i>Cat</i>
<i>Individuation > Categorization</i>						
L middle occipital gyrus (BA 18, 19)	-37	-87	17	3507	5.119*	3.022
L inferior temporal gyrus (BA 19, 37)	-52	-70	-8		5.890*	4.296*
R middle occipital gyrus (BA 18, 19)	32	-79	4	1040	9.130*	8.897*
R superior occipital gyrus (BA 19)	30	-74	31		5.229*	3.388*
R fusiform gyrus (BA 37, 19)	45	-64	-7	1480	8.423*	8.300*
R inferior temporal gyrus (BA 37)	50	-56	-6		5.651*	4.430*
L fusiform, parahippocampal gyrus border (BA 20/36)	-30	-10	-37	70	-0.910	-3.881*
R inferior parietal lobule (BA 40)	36	-46	52	167	5.009*	3.638*
R inferior frontal gyrus (BA 47)	40	38	-15	209	0.718	-1.019
R orbital frontal gyrus (BA 11)	30	39	-20		3.773*	.879
R inferior frontal gyrus (BA 47)	30	21	-3	135	3.522*	1.189
R inferior frontal gyrus (BA 46)	46	34	15	152	4.007*	2.397
R inferior frontal gyrus (BA 44)	54	14	29	336	5.104*	3.877*
<i>Categorization > Individuation</i>						
L middle frontal gyrus (BA 9, 10, 8)	-34	40	26	795	-3.422	-1.473
	-38	42	18		-2.413	-0.237
	-32	37	37		-8.246*	-4.858*
R middle frontal gyrus (BA 10)	24	50	14	303	-6.173*	-4.616*
L superior frontal gyrus (BA 6)	-12	5	66	65	1.995	4.228*
L superior, medial frontal border (BA 9, 8)	-4	50	45	51	-9.509*	-7.173*
L cingulate (BA 31)	-8	-20	36	82	-8.207*	-7.500*
B medial frontal gyrus (BA 6)	0	5	55	791	7.327*	9.247*
R cingulate (BA 31)	14	16	42		-0.206	1.579
L cingulate (BA 24/32)	-4	6	44		2.838	3.898*
L superior temporal gyrus (BA 22)	-63	-55	21	128	-8.490*	-7.325*
L superior temporal gyrus (BA 21)	-53	-42	17	343	-6.864*	-5.498*

Coordinates are from the Talairach and Tournoux (1998) atlas. Categorization and Individuation columns display the *t* value associated with the area's peak hemodynamic response relative to passive baseline for individuation and categorization trials, respectively.

L = left; R = right; B = bilateral; BA = Brodmann's area.

**p* < .001.

Figure 3. Time courses and anatomical localization of the hemodynamic responses associated with individuation (A) and categorization (B). Left: Plots representing the mean of the group data for the direct contrasts individuation > categorization (A) and categorization > individuation (B), ($t > 3.5$). Right: The time series representing average signal change in peak voxels within these clusters were obtained for each trial type. Signal from local maxima in (A) right fusiform gyrus (46, -66, -12); (B) left middle frontal gyrus (-32, 37, 37).



the RH (Tarr & Cheng, 2003; Tarr & Gauthier, 2001; Haxby et al., 2000, 2002; Hoffman & Haxby, 2000). These cortical areas appear to be engaged when people make fine-grained perceptual judgments about objects from homogeneous classes, such as faces (Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier, Tarr, et al., 1999; Gauthier, Anderson, et al., 1997). As Haxby et al. (2000) have reported, “Face responsive regions may be . . . characterized as regions that represent perceptual processes for recognizing objects at the subordinate level as unique individuals, rather than at the category level” (p. 226). The results of Experiment 3 supported this viewpoint. Compared to person categorization, individuation yielded increased activity in the right fusiform gyrus and right inferior temporal gyrus, regions that have previously been implicated in the extraction of identity-related information from faces (Haxby et al., 2000, 2002; Hoffman & Haxby, 2000).

The present research has potentially important implications for extant models of person perception, especially those that parse social-cognitive functioning into the operation of two purportedly distinct cognitive processes: categorization and individuation (Fiske & Neuberg, 1990; Brewer, 1988). The question of theoretical interest is as follows. Are categorization and individuation truly discrete (i.e., independent) cognitive processes or simply different products (i.e., outcomes, results) of a

common processing architecture? At least at the perceptual stages of social cognition (i.e., person construal) investigated herein, the current findings tend to favor the latter viewpoint (see Tarr & Cheng, 2003). Inspection of Table 1 reveals that both categorization and individuation are subserved by a common network of cortical regions, including the ventral temporal cortex, the inferior frontal gyrus, and the middle frontal gyrus. That is, relative to baseline (i.e., fixating a crosshair), both categorization and individuation prompt activity in a common network of cortical regions. Differences that emerge between the tasks in these areas can probably be traced to the specific component processes that support categorization and individuation, respectively.

Relying as it does on fine-grained perceptual discrimination, individuation yields greater activity than categorization in areas of the ventral temporal cortex that have repeatedly been implicated in object (and person) recognition (Tarr & Cheng, 2003; Gauthier, Skudlarski, et al., 2000; Haxby et al., 2000, 2002; Hoffman & Haxby, 2000; Tarr & Gauthier, 2000; Gauthier, Tarr, et al., 1999; Kanwisher, Stanley, & Harris, 1999; Gauthier, Anderson, et al., 1997; Kanwisher, McDermott, et al., 1997; McCarthy et al., 1997). In no sense, however, does this imply that areas of temporal cortex are dedicated to the task of individuation. Rather, activity in these regions

indexes fine-grained perceptual discrimination (Tarr & Cheng, 2003; Haxby et al., 2000; Tarr & Gauthier, 2000). As such, if the perceptual difficulty of person categorization was increased in some way, for example, by cropping the hair from the faces (Bruce & Young, 1986), then this task should also prompt increased activity in regions of the ventral temporal cortex. Put simply, whenever a social-cognitive task requires fine-grained perceptual processing (i.e., subordinate-level judgments), activity in regions of the ventral temporal cortex may be expected to emerge (Tarr & Cheng, 2003; Haxby et al., 2000, 2002).

In addition to regions of the extrastriate cortex, individuation was also accompanied by increased activity in areas of the frontal cortex, notably the right inferior frontal gyrus (BA 44, BA 46). These ventral and dorsal areas of the prefrontal cortex are known to play a prominent functional role in spatial working memory (see Cabeza & Nyberg, 2000), specifically the maintenance and manipulation of items in short-term storage (D'Esposito, 2001; D'Esposito et al., 1998). In Experiment 3, these are just the operations that would be required to support individuation, given that participants were shown two faces in different orientations (i.e., full-view vs. 3/4-view) and asked to report if they represented the same individual. As person categorization did not necessitate the representation of items in temporary storage to the same degree, activity in associated regions of the prefrontal cortex was correspondingly less pronounced.

Reflecting the task-related components of person categorization, increased activity was observed in the left middle frontal gyrus (BA 9, BA 10, BA 8), the left superior frontal gyrus (BA 6), and the left superior temporal gyrus (BA 21, BA 22) when participants performed a category-matching task. Activation in prefrontal regions is consistent with an extensive literature documenting the neural substrates of semantic (i.e., rule-based) categorization (Tempini et al., 1998; Thompson-Schill, D'Esposito, Aquirre, & Farah, 1997; Demb et al., 1995; Perani et al., 1995; Kapur et al., 1994; Demonet et al., 1992—for reviews, see Martin, 2001; Cabeza & Nyberg, 2000). As in previous investigations of semantic classification, person categorization was also associated with increased activity in regions of the temporal cortex (Martin, 2001). Regardless of input modality (e.g., words, pictures, faces), regions of the left superior temporal gyrus have been shown to be active during semantic-categorization tasks (Tempini et al., 1998; Martin, Wiggs, Ungerleider, & Haxby, 1996; Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995; Sergent, Zuck, Levesque, & McDonald, 1992), thereby suggesting that this area is involved in generic semantic retrieval operations. As Martin (2001) has noted, “functional neuroimaging studies of object naming suggest that semantic processing may be critically dependent on the left temporal lobe” (p. 156). In the context of person cate-

gorization, the current findings provide further support for this viewpoint.

That categorization and individuation may represent different products of a common processing system is consistent with recent accounts of object recognition (see Tarr & Cheng, 2003; Tarr & Gauthier, 2000). One of the vexing questions in cognitive neuroscience is whether object recognition is accomplished by a single system or multiple, domain-specific modules. In some quarters, it has been suggested that there are separate processing systems that deal with faces and other (non-face) objects (e.g., Kanwisher, 2000; Kanwisher, McDermott, et al., 1997; McCarthy et al., 1997; Moscovitch, Winocur, & Behrmann, 1997). More recent work has challenged this assumption, however, and proposed that recognition across all object categories (e.g., people, cars, birds) is supported by a single processing system that is tuned by a combination of experience and instruction (Tarr & Cheng, 2003; Haxby et al., 2001; Gauthier, Skudlarski, et al., 2000; Tarr & Gauthier, 2000; Gauthier, Tarr, et al., 1999; Gauthier, Anderson, et al., 1997; Diamond & Carey, 1986). Within this system, regions of the ventral temporal cortex are engaged when people make subordinate-level judgments about stimuli for which they have acquired prior perceptual experience (Tarr & Cheng, 2003; Tarr & Gauthier, 2000). This includes, but is not restricted to, faces, such that activation in putative face regions (Kanwisher, McDermott, et al., 1997; McCarthy et al., 1997) is observed when bird and car experts view exemplars from their respective domains of interest (Gauthier, Skudlarski, et al., 2000; Gauthier, Tarr, et al., 1999).

If a single system is sufficient to recognize all types of objects at varying levels of specificity, it seems reasonable to conclude that categorization and individuation may reflect different products or outputs of this system (Tarr & Cheng, 2003). Part of the challenge in person construal is that social targets can be classified at multiple levels of abstraction (e.g., human, women, actress, Gwyneth Paltrow). Given this state of affairs, categorization and individuation can be taken to capture different social-cognitive solutions to the problem of person construal (e.g., group member vs. individuation). Whereas categorization is the product of rule-based (i.e., semantic) processing and a relatively superficial visual analysis of social targets, individuation is the outcome of more elaborate perceptual and working-memory operations (Tarr & Cheng, 2003; Tanaka, 2001). Notwithstanding these differences in the component processes that support the tasks of categorization and individuation, the products of person perception (i.e., categorical vs. individuated responses) are ultimately supported by a common neural architecture (Tarr & Cheng, 2003; Haxby et al., 2000, 2002). Categorization and individuation, at least at the perceptual level, simply make different demands on parts of the distributed cortical network that subserves person perception (e.g., face processing,

working memory, rule-based classification). This viewpoint does not imply, however, that classic dual-process models of person perception are necessarily incorrect in their assertion that categorization and individuation may be discrete cognitive operations (Fiske & Neuberg, 1990; Brewer, 1988). Differences between these tasks may simply emerge later in the information-processing stream (Macrae & Bodenhausen, 2000). For example, it is possible that quite distinct neural operations may support the memorial processes through which people retrieve either stereotype-based (i.e., categorization) or personalized (i.e., individuation) information to enrich their understanding of others.

The emergence of social-cognitive neuroscience has seen researchers turn to the tools and techniques of cognitive neuroscience in an attempt to understand the functioning of the social brain. Given that the mind evolved to solve a raft of essentially social problems (e.g., mate selection, person perception, intergroup living), this new area of inquiry is both timely and important. Borrowing insights from extant work on object recognition and face processing, the current research explored the dynamics of person perception—specifically, the operations that support people’s ability to categorize and individuate others. To capture the richness and diversity of person construal, future research should consider how people’s goals, motives, and prior beliefs and experience impact the neural and cognitive operations that subserve this fundamental facet of social-cognitive functioning. We are clearly skilled practitioners when it comes to the task understanding other social agents, all that remains is to identify how we negotiate the challenges of person perception in such an effortless and flexible manner.

METHODS

Experiment 1

Participants and Design

Sixteen participants (11 women, 5 men) completed the experiment for course credit. All participants were right-handed, reported no significant abnormal neurological history, and had normal or corrected-to-normal visual acuity. The experiment had a 2 (task: categorization or individuation) \times 2 (hemisphere: left or right) repeated-measures design.

Procedure and Stimulus Materials

Participants performed both an individuation and a categorization task. The categorization task required participants to report, via a keypress (i.e., same or different), whether or not two simultaneously presented faces depicted persons of the same sex. In the individuation task, they had to report whether or not the faces depicted the same person. To ensure that the individu-

ation task involved identity-based processing and not simply perceptual matching (Bruce & Young, 1986), one of the faces was displayed in full-view and the other face in a 3/4-pose. The same stimulus configurations were used in the categorization task. The faces were graphics files depicting gray-scale images of 60 men and 60 women displaying neutral facial expressions. The files were standardized to 150 by 150 pixels and matched for luminance and contrast.

Each participant completed two task runs (i.e., individuation or categorization), with 120 trials in each run. The order of presentation of the runs was counterbalanced and stimuli (i.e., two faces) were presented to each participant’s left or right visual field (i.e., RH and LH, respectively). Participants were seated approximately 57 cm from the monitor and instructed to use a chin rest to minimize head movements. A trial consisted of the following sequence of events: A fixation cross appeared in the center of the screen for 500 msec, at which point two faces (full-view and 3/4-view) appeared to either the left or right of the fixation cross and remained on the screen for 200 msec. The faces were aligned horizontally, one above the other, at a distance of 6.5° from the fixation cross. Participants were asked to report if the displayed faces were the same sex (i.e., categorization run) or the same person (i.e., individuation run). Of the 120 trials in each run, 60 were matching trials (i.e., same sex/person) and 60 were mismatching trials (i.e., different sex/persons). Key response mappings (i.e., same/different vs. different/same) were counterbalanced across participants. Participants were instructed to try to keep their eyes fixated on the cross in the center of the screen at all times.

Experiment 2

Participants and Design

We tested J. W., a 50-year-old right-handed male who, at the age of 26, underwent a two-stage callosotomy with sparing of the anterior commissure. The surgery was undertaken as a treatment for pharmacologically intractable epilepsy. Written consent was obtained from J. W. and he was compensated for taking part in the experiment. Our experimental protocol was approved by the Committee for the Protection of Human Subjects at Dartmouth College. The experiment had a 2 (task: categorization or individuation) \times 2 (hemisphere: left or right) design.

Procedure and Stimulus Materials

The study was a conceptual replication of Experiment 1, but with some important modifications. First, in keeping with previous investigations using J. W. (Turk et al., 2002), the number of experimental runs was increased from 2 to 28 (i.e., 14 runs of each type) and the data

were collected over multiple testing sessions. Second, responses were made using four, rather than two, keypresses. J. W. responded “same” or “different” (i.e., category-matching or identity-matching) using his left hand when stimuli were presented in the left visual field (LVF) and his right hand when stimuli were presented in the right visual field (RVF).

Experiment 3

Participants and Design

Seventeen participants (11 women, 6 men) from the Dartmouth College community completed the experiment for course credit or US\$10. All participants were strongly right-handed as measured by the Edinburgh Handedness Inventory (Raczkowski, Kalat, & Nebes, 1974), reported no significant abnormal neurological history, and had normal or corrected-to-normal visual acuity. All participants gave informed consent in accordance with the guidelines established by the Committee for the Protection of Human Subjects at Dartmouth College. Of the 17 participants scanned, 2 were dropped from the analyses due to excessive movement during image acquisition. An additional participant was dropped because of technical difficulties recording the behavioral data. The experiment had a single-factor (task: categorization or individuation), repeated-measures design.

Stimulus Materials and Procedure

Images were acquired using a 1.5 Tesla whole body scanner (General Electric Medical Systems Signa, Milwaukee, WI) with a standard head coil. Visual stimuli were generated with PsyScope 1.2.5 software (Cohen, MacWhinney, Flatt, & Provost, 1993) on an Apple G3 Laptop computer. Stimuli were projected to participants with an Epson (model ELP-7000) LCD projector onto a screen positioned at the head end of the bore. Participants viewed the screen through a mirror. A fiber-optic, light-sensitive keypress interfaced with the PsyScope button box (New Micros, Dallas, TX), was used to record participants' behavioral performance. Cushions were used to minimize head movement.

T1-weighted anatomical images were collected using a high resolution 3-D sequence (SPGR; 128 sagittal slices, TR = 7 msec, TE = 3 msec, prep time = 315 msec, flip angle = 15°, FOV = 24 cm, slice thickness = 1.2 mm, matrix = 256 by 192). Functional images were collected in runs using a gradient-echo EPI sequence (each volume comprised 25 slices; 4.5 mm thick, 1 mm skip; TR = 2500 msec, TE = 35 msec, FOV = 24 cm, 64 × 64 matrix; 90° flip angle).

Experiment 3 used the same stimuli and general methodology as Experiment 1, but with the following modifications. First, all stimuli were presented centrally (i.e., at fixation). Second, the duration of stimulus presenta-

tion was increased to 2000 msec. Each trial lasted 2500 msec and consisted of central fixation (plus sign) for 500 msec, followed by the presentation of the faces for a further 2000 msec. During each of three functional runs, participants performed counterbalanced, jittered blocks of the individuation and categorization tasks. Jitter was introduced into the time series to enable unique estimates of the hemodynamic responses for the trial types of interest to be computed (Ollinger, Shulman, & Corbetta, 2001). In total, participants completed 96 trials of each type (i.e., category-matching, identity-matching).

Image Analysis

Functional MRI data were analyzed using Statistical Parametric Mapping software (SPM99, Wellcome Department of Cognitive Neurology, London, UK; Friston et al., 1995). For each functional run, data were preprocessed to remove sources of noise and artifact. Functional data were corrected for differences in acquisition time between slices for each whole-brain volume, realigned within and across runs to correct for head movement, and coregistered with each participant's anatomical data. Functional data were then transformed into a standard anatomical space (2 mm isotropic voxels) based on the ICBM 152 brain template (Montreal Neurological Institute) which approximates Talairach and Tournoux's (1988) atlas space. Normalized data were then spatially smoothed (8 mm full width at half maximum [FWHM]) using a gaussian kernel. Analyses took place at two levels: formation of statistical images and regional analysis of hemodynamic responses.

For each participant, a general linear model specifying task effects (modeled with functions for the hemodynamic response and its temporal derivative), runs (modeled as constants), and scanner drift (modeled with linear and quadratic trends) was used to compute parameter estimates (β) and *t*-contrast images for each comparison at each voxel. These individual contrast images were then submitted to a second-level, random-effects analysis to obtain mean *t*-images (thresholded at $p = .001$, uncorrected; minimal cluster size = 15 mm³). An automated peak-search algorithm identified the location of peak activations and deactivations based on *z*-value and cluster size.

Regions of interest (ROIs) were defined using the peaks identified in the statistical maps generated by the direct comparisons (individuation > categorization) and (categorization > individuation). All significant voxels ($p < .001$) within 10 mm of a peak location were included in each region. For each participant, the SPM ROI toolbox (SPM ROI Toolbox, <http://spm-toolbox.sourceforge.net>) was used to estimate response functions for both conditions (categorization, individuation) at these 3-D ROIs. Response functions in ROIs were then averaged across participants to generate mean time courses (see Figure 3).

Acknowledgments

We thank Susan Fiske, Dave Turk, Joe Moran, Gagandeep Wig, William Kelley, Jane Banfield, and an anonymous reviewer for their comments and assistance with this work.

Reprint requests should be sent to Malia F. Mason or C. Neil Macrae, Department of Psychological and Brain Sciences, Dartmouth College, Moore Hall, Hanover, NH 03755, or via e-mail: malia.mason@dartmouth.edu or c.n.macrae@dartmouth.edu.

The data reported in this experiment have been deposited in the fMRI Data Center (<http://www.fmridc.org>). The accession number is 2-2004-116WA.

REFERENCES

- Adolphs, R. (2001). The neurobiology of social cognition. *Current Opinion in Neurobiology*, *11*, 231–239.
- Adolphs, R. (2003). Cognitive neuroscience of human social behaviour. *Nature Reviews Neuroscience*, *4*, 165–178.
- Allport, G. W. (1954). *The nature of prejudice*. Reading, MA: Addison-Wesley.
- Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge: MIT Press.
- Bodenhausen, G. V., & Macrae, C. N. (1998). Stereotype activation and inhibition. In R. S. Wyer, Jr. (Ed.), *Stereotype activation and inhibition: Advances in social cognition* (Vol. 11, pp. 1–52). Hillsdale, NJ: Erlbaum.
- Brewer, M. B. (1988). A dual-process model of impression formation. In R. S. Wyer, Jr., & T. K. Srull (Eds.), *Advances in social cognition* (Vol. 1, pp. 1–36). Hillsdale, NJ: Erlbaum.
- Brown, E., & Perrett, D. I. (1993). What gives a face its gender? *Perception*, *22*, 829–840.
- Bruce, V., Burton, A. M., Hanna, E., Healey, P., Mason, O., Coombes, A., Fright, R., & Linney, A. (1993). Sex discrimination: How do we tell the difference between male and female faces? *Perception*, *22*, 131–152.
- Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology*, *77*, 305–327.
- Burton, A. M., Bruce, V., & Dench, N. (1993). What's the difference between men and women? Evidence from facial measurement. *Perception*, *22*, 153–176.
- Cabeza, R., & Nyberg, L. (2000). Imaging cognition: II. An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, *12*, 1–47.
- Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavior Research Methods, Instruments, and Computers*, *25*, 257–271.
- D'Esposito, M. (2001). Functional neuroimaging of working memory. In R. Cabeza & A. Kingstone (Eds.), *Handbook of functional neuroimaging of cognition* (pp. 293–327). Cambridge: MIT Press.
- D'Esposito, M., Aguirre, G. K., Zarahn, E., Ballard, D., Shin, R. K., & Lease, J. (1998). Functional MRI studies of spatial and nonspatial-working memory. *Cognitive Brain Research*, *7*, 1–13.
- Demb, J. B., Desmond, J. E., Wagner, A. D., Vaidya, C. J., Glover, G. H., & Gabrieli, J. D. E. (1995). Semantic encoding and retrieval in the left inferior prefrontal cortex: A functional MRI study of task difficulty and process specificity. *Journal of Neuroscience*, *15*, 5870–5878.
- Demonet, J.-F., Chollet, F., Ramsay, S., Cardebat, D., Nespoulous, J.-L., Wise, R., Rascol, A., & Frackowiak, R. (1992). The anatomy of phonological and semantic processing in normal subjects. *Brain*, *115*, 1753–1768.
- Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, *115*, 107–117.
- Fink, G. R., Halligan, P. W., Marshall, J. C., Frith, C. D., Frackowiak, R. S. J., & Dolan, R. J. (1996). Where in the brain does visual attention select the forest and the trees? *Nature*, *382*, 626–628.
- Fiske, S. T., & Neuberg, S. L. (1990). A continuum model of impression formation from category-based to individuated processes: Influences of information and motivation on attention and interpretation. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 3, pp. 1–74). New York: Academic Press.
- Friston, K. J., Holmes, A. P., Worsley, K. J., Poline, J.-P., Frith, C. D., & Frackowiak, R. S. J. (1995). Statistical parametric maps in functional imaging: A general linear approach. *Human Brain Mapping*, *2*, 189–210.
- Gallagher, H. L., & Frith, C. D. (2003). Functional imaging of “theory of mind”. *Trends in Cognitive Sciences*, *7*, 77–83.
- Gauthier, I., & Tarr, M. J. (1997). Orientation priming of novel shapes in the context of viewpoint-dependent recognition. *Perception*, *26*, 51–73.
- Gauthier, I., Anderson, A. W., Tarr, M. J., Skudlarski, P., & Gore, J. C. (1997). Levels of categorization in visual recognition studied using functional magnetic resonance imaging. *Current Biology*, *7*, 645–651.
- Gauthier, I., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). Expertise for cars and birds recruits brain areas involved in face recognition. *Nature Neuroscience*, *3*, 191–197.
- Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform “face area” increases with expertise in recognizing novel objects. *Nature Neuroscience*, *2*, 568–573.
- Gazzaniga, M. S. (2000). Cerebral specialization and interhemispheric communication: Does the corpus callosum enable the human condition? *Brain*, *123*, 1293–1326.
- Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2002). Human neural systems for face recognition and social communication. *Biological Psychiatry*, *51*, 59–67.
- Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences*, *4*, 223–233.
- Hillger, L. A., & Koenig, O. (1991). Separable mechanisms in face processing: Evidence from hemispheric specialization. *Journal of Cognitive Neuroscience*, *3*, 42–58.
- Hoffman, E., & Haxby, J. V. (2000). Distinct representations of eye gaze and identity in the distributed human neural system for face perception. *Nature Neuroscience*, *3*, 80–84.
- Jolicoeur, P., Gluck, M., & Kosslyn, S. M. (1984). Pictures and names: Making the connection. *Cognitive Psychology*, *16*, 243–275.
- Kanwisher, N. (2000). Domain specificity in face perception. *Nature Neuroscience*, *3*, 759–763.
- Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience*, *17*, 4302–4311.
- Kanwisher, N., Stanley, D., & Harris, A. (1999). The fusiform face area is selective for faces not animals. *NeuroReport*, *10*, 183–187.
- Kapur, S., Rose, R., Liddle, P. F., Zipursky, R. B., Brown, G. M., Stuss, D., Houle, S., & Tulving, E. (1994). The role of the left prefrontal cortex in verbal processing: Semantic processing or willed action? *NeuroReport*, *5*, 2193–2196.
- Kosslyn, S. (1987). Seeing and imaging in the cerebral hemispheres: A computational approach. *Psychological Review*, *94*, 148–175.

- Kunda, Z., & Spencer, S. J. (2003). When do stereotypes come to mind and when do they color judgment? A goal-based theoretical framework for stereotype activation and application. *Psychological Bulletin*, *129*, 522–544.
- Lamb, M. R., Robertson, L. C., & Knight, R. T. (1990). Component mechanisms underlying the processing of hierarchically organized patterns: Inferences from patients with unilateral cortical lesions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 471–483.
- Macrae, C. N., & Bodenhausen, G. V. (2000). Social cognition: Thinking categorically about others. *Annual Review of Psychology*, *51*, 93–120.
- Macrae, C. N., Bodenhausen, G. V., Schloerscheidt, A. M., & Milne, A. B. (1999). Tales of the unexpected: Executive function and person perception. *Journal of Personality and Social Psychology*, *76*, 200–213.
- Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information*. New York: W.H. Freeman and Company.
- Martin, A. (2001). Functional neuroimaging of semantic memory. In R. Cabeza & A. Kingstone (Eds.), *Handbook of functional neuroimaging of cognition* (pp. 153–186). Cambridge: MIT Press.
- Martin, A., Haxby, J. V., Lalonde, F. M., Wiggs, C. L., & Ungerleider, L. G. (1995). Discrete cortical regions associated with knowledge of color and knowledge of action. *Science*, *270*, 102–105.
- Martin, A., Wiggs, C. L., Ungerleider, L. G., & Haxby, J. V. (1996). Neural correlates of category-specific knowledge. *Nature*, *379*, 649–652.
- Martinez, A., Moses, P., Frank, L., Buxton, R., Wong, E., & Stiles, J. (1997). Hemispheric asymmetries in global and local processing: Evidence from fMRI. *NeuroReport*, *8*, 1685–1689.
- McCarthy, G., Puce, A., Gore, J. C., & Allison, T. (1997). Face-specific processing in the human fusiform gyrus. *Journal of Cognitive Neuroscience*, *9*, 605–610.
- Moscovitch, M., Winocur, G., & Behrmann, M. (1997). What is special about face recognition? Nineteen experiments on a person with visual object agnosia and dyslexia but normal face recognition. *Journal of Cognitive Neuroscience*, *9*, 555–604.
- Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, *9*, 353–383.
- Ollinger, J. M., Shulman, G. L., & Corbetta, M. (2001). Separating processes within a trial in event-related functional MRI. *NeuroImage*, *13*, 210–217.
- Perani, D., Cappa, S. F., Bettinardi, V., Bressi, S., Gorno-Tempini, M., Matarrese, M., & Fazio, F. (1995). Different neural systems for the recognition of animals and man-made tools. *NeuroReport*, *6*, 1637–1641.
- Raczkowski, D., Kalat, J. W., & Nebes, R. (1974). Reliability and validity of some handedness questionnaire items. *Neuropsychologia*, *12*, 43–47.
- Rhodes, G. (1985). Lateralized processes in face recognition. *British Journal of Psychology*, *76*, 249–271.
- Rhodes, G. (1993). Configural coding, expertise, and the right hemisphere advantage for face recognition. *Brain and Cognition*, *22*, 19–41.
- Rhodes, G., Tan, S., Brake, S., & Taylor, K. (1989). Expertise and configural coding in face recognition. *British Journal of Psychology*, *80*, 313–331.
- Robertson, L. C., & Lamb, M. R. (1991). Neuropsychological contributions to theories of part/whole organization. *Cognitive Psychology*, *23*, 299–330.
- Rosch, E., Mervis, C., Gray, W., Johnson, D., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, *8*, 382–439.
- Rossion, B., Dricot, L., Devolder, A., Bodart, J.-M., & Crommelinck, M. (2000). Hemispheric asymmetries for whole-based and part-based face processing in the human fusiform gyrus. *Journal of Cognitive Neuroscience*, *12*, 793–802.
- Sergent, J., Zuck, E., Levesque, M., & MacDonald, B. (1992). Positron emission tomography study of letter and object processing: Empirical findings and methodological considerations. *Cerebral Cortex*, *2*, 68–80.
- Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic atlas of the human brain*. (M. Rayport, Trans.). New York: Thieme Medical Publishers.
- Tanaka, J. W. (2001). The entry point of face recognition: Evidence for face expertise. *Journal of Experimental Psychology: General*, *130*, 534–543.
- Tarr, M. J., & Cheng, Y. D. (2003). Learning to see faces and objects. *Trends in Cognitive Sciences*, *7*, 23–30.
- Tarr, M. J., & Gauthier, I. (2000). FFA: A flexible fusiform area for subordinate-level visual processing automatized by expertise. *Nature Neuroscience*, *3*, 764–769.
- Tempini, M. L., Price, C. J., Josephs, O., Vandenberghe, R., Cappa, S. F., Kapur, N., & Frackowiak, R. S. (1998). The neural systems sustaining face and proper-name processing. *Brain*, *121*, 2103–2118.
- Thompson-Schill, S. L., D'Esposito, M., Aquirre, G. K., & Farah, M. J. (1997). Role of left inferior prefrontal cortex in retrieval of semantic knowledge: A reevaluation. *Proceedings of the National Academy of Sciences, U.S.A.*, *94*, 14792–14797.
- Turk, D. J., Heatherton, T. F., Kelley, W. M., Funnell, M. G., Gazzaniga, M. S., & Macrae, C. N. (2002). Mike or me? Self-recognition in a split-brain patient. *Nature Neuroscience*, *5*, 841–842.
- Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, *81*, 141–145.