

Chapter 6 1

Brain-As-Predictor Approach: An Alternative 2

Way to Explore Acculturation Processes 3

Pin-Hao A. Chen, Todd F. Heatherton, and Jonathan B. Freeman 4

Abstract Chen, Heatherton, and Freeman review the unique strategy of longitudinally assessing the neural changes that occur during the acculturation process. This process differs from the typical research strategy of comparing individuals from two unique cultures or using bicultural individuals and priming them with different cultural cues. The authors use this strategy to determine whether longitudinal study of neural responses can predict acculturation better than typical behavioral measures. 5
6
7
8
9
10

Neuroimaging studies indicate that the ventromedial prefrontal cortex is activated in response to self-judgments in both Western and Eastern cultures and in response to judgments about close others (e.g., one's mother) in Eastern cultures. Longitudinal analysis showed that Chinese immigrants to the USA who displayed greater acculturation had more activation in this brain region for self-judgments than for judgments about close others. 11
12
13
14
15
16

Studies of the reaction to positive emotion expressions of in-group and out-group faces have shown activation of the ventral striatum, a structure in the brain's reward circuit. Longitudinal study of Chinese graduate students who were in school in the USA showed that higher ventral striatum activity to in-group facial expressions showed more in-group friends on a social networking website. Lower ventral striatum activity to in-group facial expressions showed lower number of in-group friends on a social networking website. 17
18
19
20
21
22
23

The authors conclude by offering several ideas for future research, including using diffuse tensor imaging to investigate white matter integrity changes over time and using more cultural specific cues in experimental protocol. 24
25
26

[AU1]

P.-H.A. Chen (✉) • T.F. Heatherton
Department of Psychological and Brain Sciences, Dartmouth College,
6207 Moore Hall, Hanover, NH 03755, USA
e-mail: pin-hao.chen.gr@dartmouth.edu; todd.f.heatherton@dartmouth.edu

J.B. Freeman
Department of Psychological and Brain Sciences, Dartmouth College,
6207 Moore Hall, Hanover, NH 03755, USA

Department of Psychology, New York University,
6 Washington Place, New York, NY 10003, USA
e-mail: jon.freeman@nyu.edu

[AU2]27 Due to increasing globalization within the past decade, immigration has become
28 both more large-scale and frequent. According to a recent report from the
29 International Organization for Migration (2008), more than 200 million immigrants
30 now exist worldwide. Their top destination is Europe, followed by North America
31 and Asia. Among migrant populations, immigrants from Asian countries form the
32 largest majority. An enormous number of intercultural contacts occur between these
33 millions of immigrants. These cross-cultural exchanges result in changes at both
34 group (e.g., cultural) and individual (e.g., psychological) levels (Berry, 1997). At
35 the group level, both the migrant and native group influence changes in their respec-
36 tive cultures. Indeed, intercultural contact inevitably compels incorporation and
37 evolution for every cultural group. However, analysis at the group level is beyond
38 the scope of this review. In this chapter, we will instead focus mainly on the indi-
39 vidual level of intercultural impact.

40 What happens when people move from their native countries and familiar cul-
41 tures to settle in an entirely new environment? Among a vast array of possible adap-
42 tations, they may need to adjust to an unfamiliar language, to understand locals'
43 unfamiliar sayings and jokes, and to change their behaviors in order to be accepted
44 by the new culture. These changes are usually depicted as a progressive process,
45 which is called acculturation (Berry, 2003). Acculturation involves the ways in
46 which people change following immersion within a new culture. It can be defined
47 as a process of cultural and psychological adjustment following intercultural con-
48 tact. Adaptation is another term frequently used in acculturation studies, which can
49 be defined as the extent to which immigrants are able to conform to the accultura-
50 tion process (Sam & Berry, 2010). It can be psychological (for example, well-being)
51 or sociocultural (for example, learning a new language), and often is regarded as the
52 consequence of acculturation.

53 Previous studies have found that individual differences in levels of acculturation
54 can be enormous, even between immigrants who share a cultural origin and settle in
55 the same region (Nauck, 2008). Four major types of acculturation strategies or states
56 contribute to the acculturation outcome. These have been identified as integration,
57 assimilation, separation, and marginalization (Sam & Berry, 2010). Integration can
58 be described as a strategy by which immigrants maintain their own culture while
59 also integrating the parameters of the host culture into their cultural value.
60 Immigrants who use this strategy not only interact with their ethnic group but also
61 show interest in interacting with out-group members. Use of this strategy generally
62 correlates with better psychological and sociocultural adaption than that achieved
63 using other strategies. Assimilation, on the other hand, carries the integrative aspect
64 of the first strategy to an extreme. In assimilating, individuals abandon their original
65 cultural values and try to accept all aspects of the host culture. Under this circum-
66 stance, immigrants will interact for the most part with the out-group members and
67 avoid interacting with people from the same culture. Unlike integration or assimila-
68 tion, separation is defined as a strategy that strongly emphasizes the maintenance of
69 immigrants' own cultural values and identities, with less interest in the host culture.
70 Individuals who use this strategy will interact predominantly with their own ethnic
71 group and avoid interacting with out-group members. Although this seems like a

less adaptive strategy, it actually produces some positive signs of adaptation (Berry, 72
Phinney, Sam, & Vedder, 2006). The least adaptive strategy is marginalization. 73
Marginalization describes immigrants who lack interest in either maintaining their 74
own culture or accepting a new culture. In the end, they become socially isolated 75
and potentially face exclusion by both in-group and out-group members. 76

Although researchers have clearly identified four distinct types of acculturation, 77
the attempt to use behavioral assessment tools to predict immigrants' acculturation 78
styles has not been successful (Sam & Berry, 2010). Developing such predictive 79
tools is important because they may enable governments to provide adequate inter- 80
vention programs for at-risk immigrants at the early stage of acculturation. Previous 81
studies have tried to use the Big Five personality traits (Ward, Leong, & Low, 2004), 82
motivation (Kosic, Kruglanski, Pierro, & Mannetti, 2004), or attachment styles 83
(Bakker, van Oudenhoven, & van der Zee, 2004) to make predictions in accultura- 84
tion, but the results from these studies were inconsistent and failed to make clear 85
predictions. It seems that sticking to behavioral tools as a means of predicting accul- 86
turation simply does not produce accurate results. Using another method, such as 87
the brain-as-predictor approach (Berkman & Falk, 2013), might be an alternative 88
solution to form more precise predictions of immigrants' acculturation outcomes. 89
Hopefully, this could lead to the development of sufficient resources to help immi- 90
grants adapt more healthfully to a new culture soon after arrival. 91

Since the rebirth of cultural psychology in the early 1990s, the number of studies 92
investigating the impact of cultural differences on affective or cognitive processes 93
has grown dramatically (Kitayama & Uskul, 2011). Following in the steps of cul- 94
tural psychology, cultural neuroscience has become an interdisciplinary subfield in 95
cognitive neuroscience. This new field has enabled researchers to explore how cul- 96
tural values influence the neural mechanisms underlying different affective and cog- 97
nitive processes (Han et al., 2013; Kitayama & Uskul, 2011). 98

Among studies in the field of cultural neuroscience, two major approaches exist. 99
The first approach is to compare one group of individuals who live in one type of 100
culture, such as an interdependent culture (e.g., Japan), to another group of indi- 101
viduals who live in another type, such as a collectivist culture (e.g., the USA) (Chiao 102
et al., 2008, 2009b). This can be regarded as the monocultural comparison approach. 103
Findings from such studies support the notion that neural mechanisms subserving 104
the same psychological processes can be modulated by different cultural processes. 105
The second approach is to recruit individuals who grew up under exposure to two 106
distinct cultures, and to prime them with different cultural cues (Chiao et al., 2009a; 107
Ng, Han, Mao, & Lai, 2010). Because bicultural individuals have been influenced 108
by processes from two distinct cultures and have integrated them into their cognitive 109
systems, they tend to show flexibility in neural responses according to which cul- 110
tural values are primed at that moment. This is the bicultural priming approach, 111
which is also another common approach in this field. 112

On the other hand, longitudinal designs, which can be used to answer the key 113
questions surrounding acculturation processes, have rarely been used in cultural 114
neuroscience studies. Based on a recent review (Kitayama & Uskul, 2011), accul- 115
turation is revealed to be not only a learning process but also an adaption process. 116

117 Longitudinal designs are therefore required in order to form a better understanding
118 of what happens in each subprocess. In addition to this advantage, the implementa-
119 tion of longitudinal designs can test whether using neural responses is more accurate
120 than using behavioral measurements to predict immigrants' acculturation outcomes
121 over time. This approach can provide an alternative avenue for cultural psycholo-
122 gists to gain a deeper understanding of dynamic cultural-learning processes.

123 It has long been known that there are prominent cultural differences in both the
124 concept of the self as well as in thinking about the relationship between self and
125 others (Markus & Kitayama, 1991). Furthermore, these cultural differences in self-
126 construal influence almost every aspect of affective and cognitive processing. Thus,
127 understanding how self-construal modulates the neural representations of the self
128 and others may be the first step towards understanding the processes and conse-
129 quences of acculturation (Kitayama & Park, 2010). In the first part of this chapter,
130 we review what brain regions are involved in representations of abstract knowledge
131 of self and others, followed by a review on how cultural differences in self-construal
132 modulate the neural representations of the self and close others. This first section
133 concludes with the findings from our own longitudinal studies on immigrants,
134 which may provide more insight into their acculturating neural systems. In the sec-
135 ond part of this chapter, we review the neural mechanisms involved in social affili-
136 ative and avoidant behaviors, and the brain regions subserving in-group favoritism.
137 Since acculturation is always involved in affiliating with or avoiding in-group or
138 out-group members, understanding these mechanisms will enhance our understand-
139 ing of acculturation processes. Next, we focus on reward-related processing, which
140 may play an important role in in-group favoritism. At the end of this section, we
141 present our recent findings exploring how individual differences in reward reactivity
142 can predict immigrants' friendship patterns. These findings might provide more
143 information about a determining force in the acculturation process. In the final sec-
144 tion of this chapter, we propose an integrated brain-as-predictor approach, which
145 brings together self-referential processing and reward processing at the same time,
146 and uses the data to predict immigrants' acculturation outcomes. We also propose
147 several possible research lines that intercultural neuroscientists could use to gener-
148 ate and test hypotheses in their future studies. We hope that this chapter will provide
149 an alternative approach for cultural neuroscientists who seek a deeper understand-
150 ing of acculturation processes, filling in this critical part of cultural neuroscience.

151 **6.1 Cultural Differences Modulate Neural Representations** 152 **of the Self and Close Others**

153 If you have ever travelled in China or in Chinatown in the USA, you may have
154 noticed the different shape of dining tables at restaurants. The tables are round,
155 which may enable a group of up to ten people to talk to each other clearly, but hardly
156 takes personal space into account. By contrast, the shape of tables in an American
157 restaurant is usually rectangular, which allows for more personal space for

individuals. Under this circumstance, the people whom you interact with most are the ones who sit beside or in front of you. This slight difference in table shape echoes more fundamental differences in concepts of the self and the relationship with others across cultures.

According to a comprehensive review on cultural differences in self-construal, two distinct types of self-construals, namely, independent and interdependent self-construal, have been identified (Markus & Kitayama, 1991). Independent self-construal involves viewing the self as an entity, which is defined by dispositional attributes and is relatively detached from context. As a consequence, individuals with independent self-construal emphasize their autonomy from others and their uniqueness. Their self-esteem is, in large part, dependent upon being better than others. Furthermore, individuals' behaviors are often attributed to personal internal factors rather than contextual factors. The self is regarded as being independent from others, even close others. The boundary between the self and others is solid and clear. By contrast, interdependent self-construal involves viewing the self as enmeshed within the social network. The self is partially defined by the social context and is less differentiated from others. As a consequence, interdependent individuals emphasize the control of personal desires in order to pursue harmonious social interactions, and self-esteem is regarded as synonymous with the capability to exert control over one's own needs. Instead of being attributed to one's internal factors, individuals' behaviors are more readily attributed to contextual factors. Thus, the self is embedded in the social network, and the boundary between the self and others is fuzzier than that of individuals with independent self-construals.

6.2 Neural Substrates for Self-Knowledge

Before reviewing how cultural differences in self-construal modulate neural representations of self and close others, a more general review of studies exploring cognitive and neural representations of self and others is necessary. One of the well-known arguments in social psychology is whether there is a "superordinate schema" for the self in the cognitive system (Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997). The earliest exploration of this issue started with a series of studies examining the mnemonic advantage effect when participants take their selves as a reference point in a memory task. The common finding in these studies was that words associated with one's self would be more easily encoded in the memory system, which showed up in the following memory recall task. In short, using one's self as the reference increases the likelihood of those associated words being encoded in the memory system, which is the mnemonic advantage effect in a nutshell. Although this mnemonic advantage effect is quite consistent across studies, this effect can be perfectly explained by two conflicting interpretations. The first interpretation is that the self is special and has its own superordinate schema in the cognitive system (Rogers et al., 1977). Because of this superordinate schema, "self" has more immediate access to the memory system. Thus, trait words associated with

199 the self would show subsequently mnemonic advantage effect. By contrast, the
200 other interpretation argues that self is not special at all and there is no special space
201 for the self (Klein & Kihlstrom, 1986; Klein & Loftus, 1988). Instead of having its
202 own schema in the cognitive system, this mnemonic advantage effect only reflects a
203 deeper “depth-of-processing.”

204 After decades of attempts to solve this puzzle using behavioral findings, research-
205 ers finally realized that this tactic would be insufficient. It turned out that behavioral
206 results could support either theory perfectly (Symons & Johnson, 1997). Yet where
207 the behavioral tools failed, advancements in neuroscience afforded a different ave-
208 nue for exploration. Neuroimaging techniques allow researchers to directly explore
209 the engagement of particular brain regions in specific tasks. Thus, these techniques
210 enabled researchers to map cognitive processes to brain regions and directly test
211 these two conflicting theories. Based on what we know about the functional neuro-
212 anatomy of social cognition, the medial prefrontal cortex (MPFC) plays a central
213 role in neural representations of self and others (Amodio & Frith, 2006; Mitchell,
214 Macrae, & Banaji, 2006; Wagner, Haxby, & Heatherton, 2012). The MPFC is
215 located at the medial wall of two cerebral hemispheres, and can be divided into a
216 ventral and a dorsal part. The ventral portion of the MPFC, which is also known as
217 Brodmann’s area 10, is named as the ventral MPFC (VMPFC). Another part of the
218 MPFC, which is located at more dorsal portion of the MPFC (including Brodmann’s
219 areas 8 and 9), is named as the dorsal MPFC (DMPFC). Based on a recent review
220 (Wagner et al., 2012), these two regions function differently in thinking about one’s
221 self and others. In short, the VMPFC subserves primarily self-referential process-
222 ing, whereas the DMPFC subserves primarily other-referential processing.

223 The search for the neural basis of the self started with a positron emission
224 tomography (PET) study (Craik et al., 1999), which investigated which regions
225 engage in self-referential memory encoding. The task contained three conditions.
226 Participants had to judge whether different trait words could describe themselves or
227 a familiar figure, or had to think about the semantic meaning of these words. Not
228 surprisingly, the MPFC activity was greater for the self-referential condition than
229 the semantic-judgment condition. However, there were no differences between self-
230 and other-referential conditions, which was inconsistent with the classical self-ref-
231 erential memory advantage effect. Due to this inconsistency and the relatively small
232 sample size used in this study, another group of researchers (Kelley et al., 2002)
233 used another neuroimaging technique, functional magnetic resonance imaging, to
234 re-explore whether self-referential processing is distinct from other semantic pro-
235 cessing. Similarly to Craik et al.’s study, three conditions (self-judgment, other-
236 judgment, and case-judgment) were used in this study. As expected, regions involved
237 in semantic processing, such as the left inferior frontal cortex, showed greater
238 activity for self- and other-judgments than case-judgment. However, the only
239 region that showed selective activity for self-referential processing was the
240 VMPFC. Unfortunately, this study had no memory task after the scanning, which
241 makes the correlational test between VMPFC magnitudes during self-referential
242 conditions and subsequent memory performances impossible. Some researchers
243 (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004) revisited this issue and

found supportive evidence for this correlation, however. Their findings revealed that the MPFC magnitude during self-referential encoding predicts the subsequent memory effect for the trait words being associated with the self during the task. As a consequence, it is obvious that self-referential is not just a deeper type of semantic processing. Instead, self-referential processing is special and one specific brain region, the VMPFC, is engaged in this processing.

6.3 Cultural Differences in Neural Representations of Self and Mother

Since the VMPFC primarily engages in thinking about the self, researchers started to ask whether this region also engages in the moment when individuals think about close others, such as one's mother or best friend. This speculation stems from what psychologists found decades ago when the self-referential processing task was conducted with the reference target as one's close friend or a family member (Bower & Gilligan, 1979; Ferguson, Rule, & Carlson, 1983; Kuiper & Rogers, 1979). A similar mnemonic advantage effect was found for words paired with one's close others, but not a familiar other (e.g., a political figure, like Bush). This finding suggested that it is intimacy, but not familiarity, that contributes to the mnemonic advantage effect. As a result, researchers (A. Aron, Aron, & Smollan, 1992; A. Aron, Aron, Tudor, & Nelson, 1991) proposed that individuals might incorporate close others, such as best friends or family members, into their self-schemas. In order to test the hypothesis that the VMPFC is also involved in representing the abstract knowledge of close others, Heatherton et al. (Heatherton et al., 2006) conducted a pioneer fMRI study by using a classical trait-word judgment task. Participants were asked to judge trait words in three conditions, including self-judgment, best friend-judgment, and a semantic judgment condition. The brain signal changes were extracted from an a-prior region-of-interest (ROI) from Kelley et al.'s VMPFC region. The results revealed that the activity in the VMPFC was greatest for self-judgment, but there was little difference in the activity level for the other two judgments. This evidence revealed that although thinking about close others might show a similar memory advantage effect behaviorally, the VMPFC is only specifically subserved for representing abstract knowledge about one's self.

It seems clear, according to the studies reviewed above, that the VMPFC uniquely subserves representations of abstract knowledge of one's self. Notably, however, the majority of these studies recruited participants solely from independent cultures. Would different patterns be observed in participants from interdependent cultures? Interdependent self-representations feature fuzzier boundaries between one's concept of self and of others. Therefore, it is plausible that the neural representations between one's self and one's closest other (e.g., one's mother) may likewise overlap, specifically in the VMPFC. To test this hypothesis, Zhu and colleagues (Zhu, Zhang, Fan, & Han, 2007) conducted an fMRI study recruiting participants from China, an example of an interdependent culture, and participants from independent Western cultures.

285 Both groups of participants were asked to judge trait words in three conditions,
286 comprising self-judgment, mother-judgment, or font-judgment. Not surprisingly, as
287 Heatherton et al. found, VMPFC activity was significantly higher for judgments of
288 self than for those of one's mother in Western participants. However, the VMPFC
289 showed no self–mother differentiation in Chinese participants. This finding pro-
290 vided supportive evidence that cultural differences in self-construal might not only
291 be reflected at an abstract level but also in neural representations of the self and of
292 close others. Although the sample size was quite small ($N=13$ for each group) in
293 Zhu et al.'s study, a later study (Wang et al., 2012) replicated these findings and also
294 included judgments for one's father and best friends. They found that while no sta-
295 tistical difference in VMPFC activation was observed between self and mother,
296 there was significantly less relative activation for the father judgments and even less
297 for the judgments of a best friend. This finding suggests that mothers may be
298 uniquely incorporated into their children's self-schema, and play an important role
299 in the intimate relationships within Chinese culture. Based on the above findings, it
300 is plausible that differential VMPFC patterns between one's self and mother may be
301 modulated by cultural differences in self-construal.

302 This hypothesized relationship has received support from a recent study (Chiao
303 et al., 2009b) that considered only individual differences in self-construal styles,
304 regardless of participants' country of origin. Participants who possessed independ-
305 ent self-construal styles showed greater MPFC activity for general than for contex-
306 tual self-judgments, whereas participants who held interdependent self-construal
307 styles showed the reverse pattern. This finding demonstrated the modulatory effect
308 of self-construal style upon neural representations of self within the MPFC. Although
309 the focus of this study was not on the neural differentiations between concepts of
310 self and mother, the results provide supportive evidence that individual differences
311 in self-construal might modulate these neural dissociations. Behavioral studies have
312 also found that substantial heterogeneity in self-construal styles can occur within
313 the same culture, even within a culture traditionally defined as more interdependent
314 like that of China (Green, Deschamps, & Paez, 2005). For example, the observed
315 degree of independence and interdependence is quite variable among Chinese par-
316 ticipants (H. Li, Zhang, Bhatt, & Yum, 2006). This phenomenon has been character-
317 ized as within-cultural variance (Freeman, 2013).

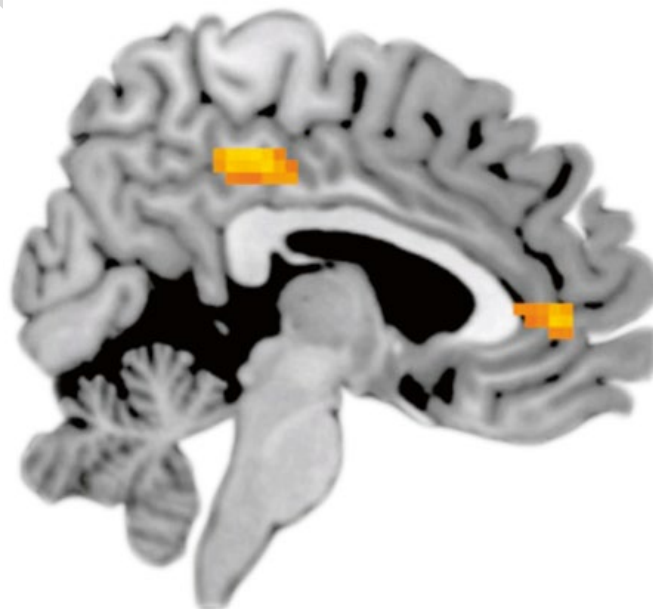
318 One hypothesis related to within-cultural variance is the voluntary-settlement
319 hypothesis, which explains the underlying motives behind immigration (Kitayama,
320 Ishii, Imada, Takemura, & Ramaswamy, 2006). According to this hypothesis, vol-
321 untary immigrants moving to frontiers, such as wilderness regions, foreign coun-
322 tries, or metropolitan cities, have higher independence or lower interdependence
323 than those who stay in their place of origin. For example, individuals who grew up
324 in Japan are generally highly interdependent in self-construal. However, findings
325 have revealed that Hokkaido, the northern territory and the last frontier in Japan,
326 contains more highly independent individuals than other places in Japan.
327 Interestingly, these geographic alterations in autonomy can be observed in a very
328 intimate metric—the names parents give their children (Varnum & Kitayama,
329 2011). Specifically, children in more recently settled regions of Japan are less likely

to have been given popular baby names than are their counterparts in long-settled regions. This trend also holds true in the USA and Canada. In short, it is clear that immigrants generally hold more independent self-construals than do individuals who permanently settle within their place of origin. Thus, immigrants from interdependent cultures, such as China, would likely still show significant self-mother differentiations in the VMPFC.

6.4 Neural Differentiations Between Self and Mother in Chinese Immigrants

In order to test this possibility, our first study (Chen, Wagner, Kelley, Powers, & Heatherton, 2013) recruited 19 newly arrived Chinese immigrants within the first 2 months of their arrival in the USA. None of these immigrants had ever previously lived in a foreign country for more than 2 months. This criterion ensured that these individuals would be free from pre-exposure cultural effects. During four functional imaging runs, participants were asked to judge trait words presented in their native language or in their secondary language in three different conditions (self-judgment, mother-judgment, or font-judgment). Surprisingly, the findings from this study were quite different from what had been found in previous studies done in China. The whole brain analysis revealed significantly greater VMPFC and posterior cingulate cortex (PCC) activity for self-judgments than mother-judgments (Fig. 6.1) regardless of the language used. In order to further confirm our findings in an unbiased way, two independent VMPFC regions-of-interest (ROI) from two previous studies (Kelley et al., 2002; Wang et al., 2012) were used for the ROI analysis.

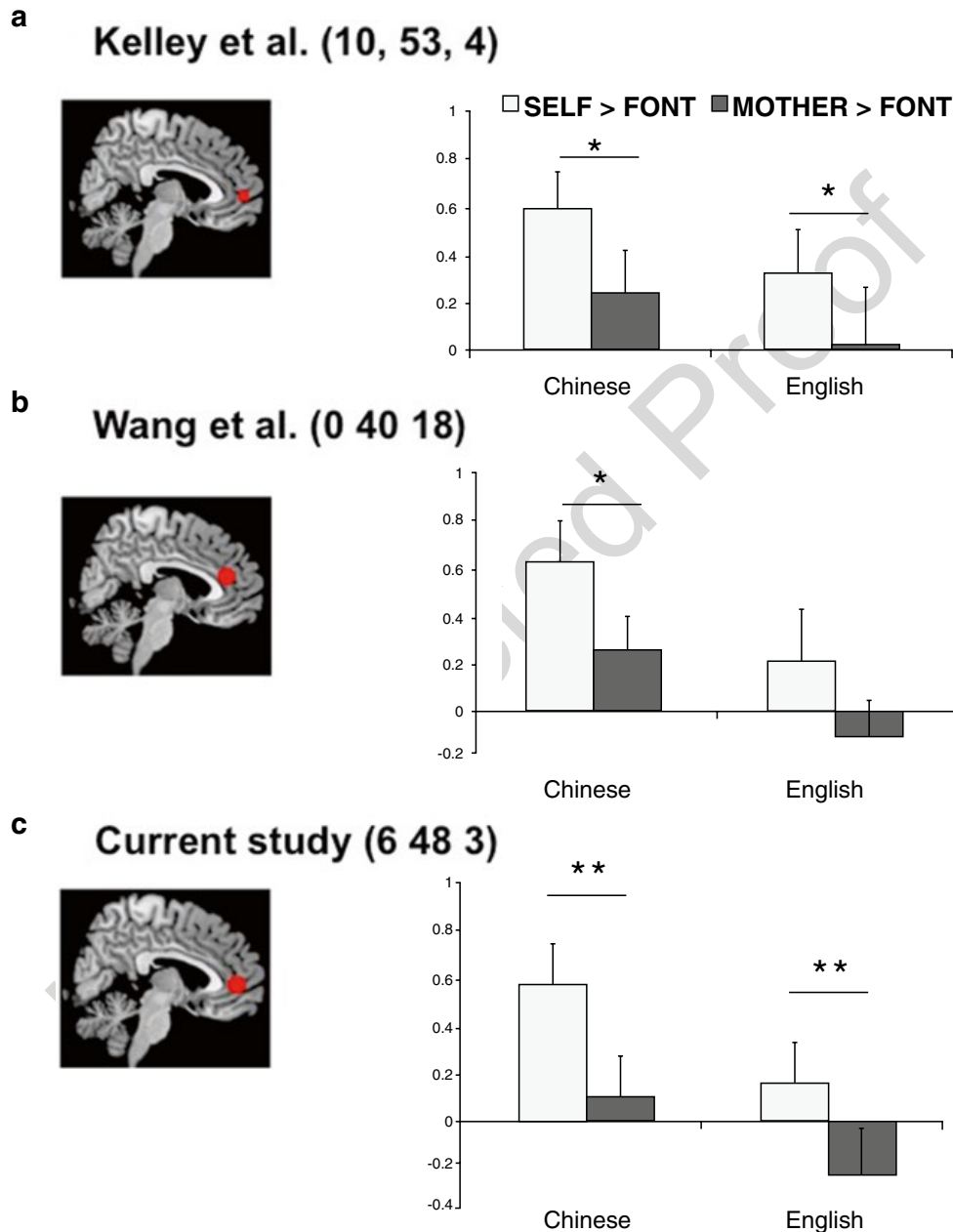
Fig. 6.1 Results from a whole-brain analysis of SELF versus MOTHER-judgments contrast across two languages in newly arrived Chinese immigrants ($P < 0.05$, corrected). Results showed that VMPFC and PCC were more engaged for SELF-judgments than MOTHER-judgments across two languages (adapted from Chen et al., 2013)



this figure will be printed in b/w

352 The VMPFC activity extracted from these two VMPFC ROIs were both greater for
 353 self-judgments than mother-judgments, confirming the findings from the whole
 354 brain analysis (Fig. 6.2). Both the whole brain analysis and the ROI analysis showed
 355 consistently greater VMPFC activity for self-judgments than for mother-judgments

this figure will be printed in b/w



[AU3]

Fig. 6.2 Analysis of differences scores from parameter estimates in three different VMPFC ROIs for SELF>MOTHER contrast in Chinese and in English, respectively. VMPFC activity was significantly greater for SELF- than MOTHER-judgments in both Chinese and English based on the results from three different ROIs. (a) The MPFC ROI defined by Kelley et al. (2002). (b) The MPFC ROI defined by Wang et al. (2012). (c) The MPFC defined in the current study. * $P < 0.05$, ** $P < 0.01$. Bars indicated standard error of the mean (adapted from Chen et al., 2013)

across different ROIs and languages. This finding suggests that these immigrants might possess a more distinct and autonomous self-construal compared to those who choose to stay in China. This speculation was supported by participants' self-construal scores, which were equal in independence and interdependence. Essentially, moving to the USA may have been comparable to moving to a frontier area for most of these immigrants. Therefore, we think it quite possible to generalize that immigrants who choose of their own free will to move can be found to hold more independent or less interdependent self-construals than those who choose to stay in their motherlands. Most importantly, their distinct self-construals are reflected not only at the behavioral level but also in the activity of the VMPFC.

Although the VMPFC self–mother differentiation pattern seems to be a reliable index for assessing individual differences in self-construal, little is known about whether behavioral and psychological changes incurred by acculturation processes manifest in the VMPFC self–mother differentiation pattern. Most of the previous studies employ either the monocultural comparison approach (Wang et al., 2012; Zhu et al., 2007) or the bicultural priming approach (Chiao et al., 2009a; Kitayama & Uskul, 2011; Ng et al., 2010). Further, cultural neuroscientists seldom take a longitudinal approach, which is critical for answering the key questions surrounding acculturation processes (Chen et al., 2013; Kitayama & Uskul, 2011).

6.5 Changes in the Interdependent Self-Construal Modulate Self–Mother Differentiation in the VMPFC

According to what we know about acculturation strategies, some immigrants tend to integrate host cultural values into their identities, whereas others show less interest in taking on host cultural values and instead maintain or enhance their original cultural values. For example, immigrants from China, who are equally high in interdependence and independence (Chen et al., 2013; Kringelbach & Berridge, 2009; Smith, Berridge, & Aldridge, 2011), may show divergent changes in self-construal styles across time. Some of these Chinese immigrants may become less interdependent in self-construal and more like Americans, whereas others may become even more interdependent in self-construal and more like Chinese. Our second study (Chen et al., *in prep*) was designed to examine whether these two different groups of immigrants would show distinct self vs. mother differentiations in the MPFC. We hypothesized that individuals who become less interdependent would show significant self vs. mother differentiation, whereas those who become more interdependent would show no such differentiation 6 months after their arrival. Twenty-seven newly arrived native Chinese-speaking participants were recruited for this study. The same trait-judgment task (self, mother, or font judgments in English or Chinese) from our first study was conducted within the first 2 months of their arrival in the USA (Time 1). After the scanning, the self-construal scale (Singelis, 1994) was administrated and their interdependence scores were calculated. Six months after the initial scan (Time 2), the same participants performed the same self-referential task again, and their interdependence scores were also collected. Their difference scores in the

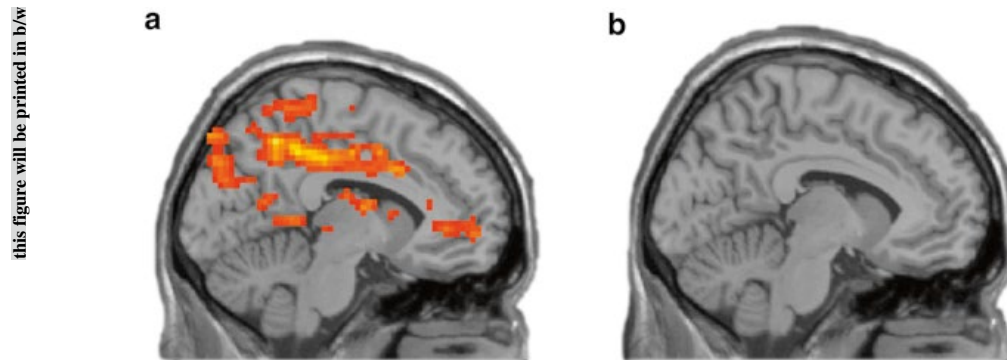


Fig. 6.3 Whole-brain analyses of SELF versus MOTHER-judgments in two groups of immigrants who showed divergent changes in the interdependent self-construal six months later of their arrival ($P < 0.05$, corrected). (a) The immigrants who decreased in interdependent self-construal scores showed prominent SELF–MOTHER differentiations in the VMPFC. (b) The immigrants who increased in interdependent self-construal scores showed no such differentiation pattern in the VMPFC (adapted from Chen et al., in prep)

398 interdependence measure were computed based on the difference in their interde-
 399 pendent scores at Time 2 versus scores at Time 1. We divided participants into two
 400 groups based on whether they showed a decrease or increase in these difference
 401 scores. To test our hypothesis, we analyzed the fMRI data collected at Time 2 only.
 402 The whole brain analysis for the individuals in the decrease group, who become
 403 more like Americans, still showed greater VMPFC activity for self-judgments than
 404 mother-judgment. By contrast, those in the increase group, who become more like
 405 Chinese, showed no such self–mother differentiation pattern in the VMPFC
 406 (Fig. 6.3). The ROI analysis using Chen et al.'s ROI (2013) supported these correla-
 407 tions and our hypothesis (Fig. 6.4). In sum, it seems that changes in the self-construal
 408 can be reflected by changes in this VMPFC self–mother differentiation pattern dur-
 409 ing acculturation processes. These findings also suggest that the neural differentia-
 410 tion patterns between self and mother could potentially yield deeper understandings
 411 of acculturation processes.

412 In the first section, we begin by reviewing two conflicting theories that explain
 413 the self-mnemonic advantage effect, and follow up with an exploration of how func-
 414 tional imaging methods can be used to solve this puzzle. Then, we review which
 415 brain regions are involved in representations of abstract knowledge of self and close
 416 others, and how cultural differences in self-construal modulate these neural repre-
 417 sentations. Lastly, we present findings from our first study, showing that immigrants
 418 may be inherently more independent in self-construal than those who stay in their
 419 motherlands. Their distinct self-construals may be reflected in the self–mother dif-
 420 ferentiations in the VMPFC. Furthermore, in our second longitudinal study, we
 421 demonstrate that immigrants' changes in self-construal could be reflected by
 422 changes in this VMPFC self–mother differentiation pattern during acculturation
 423 processes. These findings suggest that this differentiation pattern could be a poten-
 424 tial tool for understanding the divergent acculturation processes experienced by
 425 immigrants, and for predicting immigrants' acculturation outcomes. We come back
 426 to this topic in the last section of this chapter.

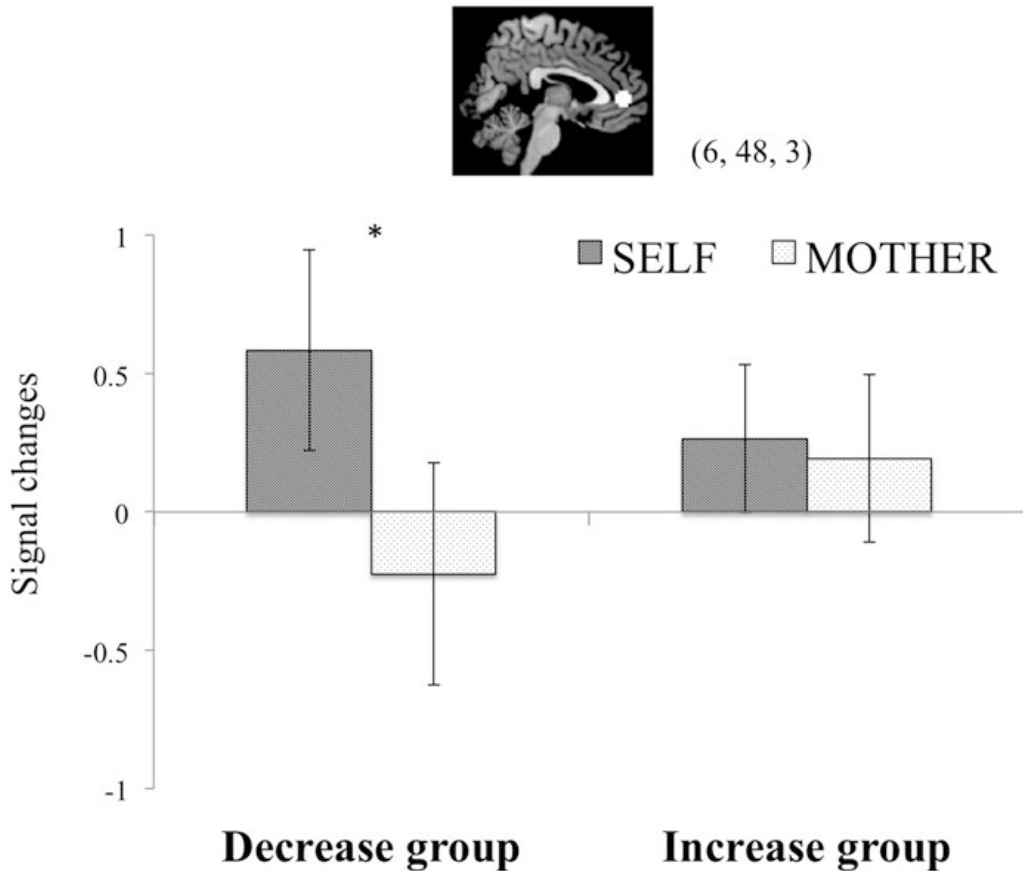


Fig. 6.4 Analysis of differences scores from parameter estimates in Chen et al.'s VMPFC ROI for SELF>MOTHER contrast. The VMPFC activity was significantly greater for SELF- than MOTHER-judgments for immigrants who showed decrease in the interdependent self-construal scores, whereas the VMPFC activity showed no such SELF–MOTHER differentiation for immigrants who showed increase in the interdependent self-construal scores (adapted from Chen et al., in prep)

6.6 Neural Mechanisms for Reward Processing and In-Group Reward Reactivity 427
428

6.6.1 Neural Mechanisms for Reward Processing 429

Before moving on to the reward processes underlying in-group favoritism, we have to review the fundamental neural mechanisms underlying these processes. Reward is critical for motivating incentive-based learning, shaping reactions to different stimuli, and triggering goal-directed behaviors. Researchers have found three distinct aspects within the broad concept of reward, namely, liking, wanting, and learning (Kringelbach & Berridge, 2009; Smith et al., 2011). Among these three aspects, “liking” is a hedonic aspect, and reflects the pleasure component of reward. “Wanting” is a motivational aspect, which reflects the incentive salience component of reward. The last component is “earning,” which reflects the processes of

439 associating, representing, and predicting future outcomes based on past experi-
440 ences. Although these three aspects sometimes can be processed consciously, most
441 of the time they are processed without subjective awareness.

442 Among all of the brain regions, the ventral striatum (VS) is primarily in charge of
443 the liking and wanting components (Delgado, 2007; Kringelbach & Berridge, 2009),
444 and the wanting component is closely related to cue-association learning. Moreover,
445 the VS's anatomical connections with other reward-related brain regions and the neu-
446 rotransmitters it receives (Delgado, 2007) make cue-association learning possible in
447 this region. The VS is a compound structure, which consists of the ventral putamen
448 (VP), ventral caudate nucleus, and nucleus accumbens (NAcc). The VS not only
449 receives inputs from the amygdala, dorsal striatum, and ventral prefrontal cortex but
450 also receives dopaminergic (DA) inputs originating from mesolimbic dopamine
451 regions, such as the ventral tegmental area (VTA). During the early stage of reward
452 learning, the activation of these DA neurons from the VTA is synchronized at the
453 point of time at which the reward is delivered. However, if some specific cues always
454 appear before the reward delivery, after several trials of cues and reward association,
455 the activation of these DA neurons shifts to the point of time at which the cues are
456 presented (Glimcher, 2011). As the result, the activation of these DA neurons syn-
457 chronizes at the presence of cues instead of the delivery of rewards. Due to the fact
458 that the activation of these DA neurons from the VTA results in DA release in the VS,
459 this cue-association activity is also established in the VS. Most importantly, this cue-
460 association characteristic plays an important role not only in the formation of addic-
461 tion but also in different kinds of social learning. The VS is part of the broader
462 cortico-basal ganglia circuitry, which has been described as integrating the motiva-
463 tion and action components into reward processes (Haber & Knutson, 2010). Within
464 this circuitry, the VS primarily subserves for the motivation component (liking and
465 wanting), whereas the dorsal caudate and putamen subserves for moving from motiva-
466 tion to action. By integrating these subcomponents in this circuitry, individuals can
467 execute goal-directed behaviors through incentive-based learning processes.

468 Another line of studies (Demos, Heatherton, & Kelley, 2012) suggests that the
469 neural signals in the VS, especially the NAcc, can predict real-world behaviors,
470 such as eating behaviors and daily sexual desires. By using a classic cue-reactivity
471 paradigm, participants were asked to see different kinds of photographs, including
472 food, people in sexual activity, and scenery, in the MRI scanner, and these partici-
473 pants were asked to judge whether these photographs were shot indoors or outdoors.
474 Because of the indoors and outdoors judgment, participants were unaware of the
475 purpose of this task, which was to measure their incidental brain reward activity
476 toward cues in specific categories. The NAcc activity for food and sexual images
477 were extracted from the NAcc ROI. Individual differences in this NAcc activity for
478 food cues were found to predict participants' weight gain 6 months later, whereas
479 individual differences in this NAcc activity for sexual scenes predicted participants'
480 daily sexual desires 6 months later (Demos et al., 2012). This finding reveals that
481 NAcc activity for specific cues may have a determinant role in real-world behaviors
482 that are linked with these specific cues. Extending from the above finding, it also
483 suggests that brain-as-predictor approach can be applied to acculturation studies
484 when appropriate cues are used in the paradigm.

6.6.2 *Self-Categorization and In-Group Favoritism*

485

A growing number of imaging studies has shown that regions within this cortico-basal ganglia circuitry not only responds to primary rewards, such as food and sex, but also to other secondary rewards, such as money, attractive faces, symbols of status, and social cues (Aharon et al., 2001; Schultz, 2000). Thus, it is not surprising that regions within this circuitry may also play an important role in social interaction. To be more specific, reward processes may motivate in-group or out-group social affiliation behaviors (Powers & Heatherton, 2012).

Differentiating people into in-group or out-group members is an essential ability for human survival, as proven by numerous social psychology studies (Correll & Park, 2005). When there is no other prominent cue, the default cue for this in-and-out-group differentiation is often race (Sporer, 2001; Van Bavel & Cunningham, 2008). Research has shown that people usually show more positive or stronger responses to in-group members than out-group members (Sporer, 2001; Van Bavel & Cunningham, 2008). For example, Elfenbein and Ambady (Elfenbein & Ambady, 2003) have reported in-group advantage in emotional recognition. In this study, Chinese participants showed a shorter reaction time and a better accuracy rate to Chinese emotional expressions than the Caucasian ones. In another study investigating the effect of group membership on the automatic impact of emotional expressions (Weisbuch & Ambady, 2008), participants automatically showed negative responses to in-group fearful expressions, but showed positive responses to out-group ones. However, participants showed a reversed pattern for happy expressions. This in-group vs. out-group difference was not only found at the behavioral level but also at the neural level. Chiao et al. (2008) found that both Japanese and Americans showed greater amygdala responses to in-group fearful expressions than out-group ones, but this effect was not found for either happy or angry expressions. This finding was partially in line with the findings from Weisbuch and Ambady's study, in which participants showed more negative responses to in-group fearful expressions. This response might be reflected in the heightened amygdala responses to the in-group fearful expressions. However, in-group positive responses to in-group happy expressions were not found at the neural level. There are at least two possible explanations. First, the target region in Chiao et al.'s study was the amygdala, which might be more sensitive to negative emotions than positive ones. Instead of the amygdala, regions within the reward circuitry, such as the VS and orbitofrontal cortex (OFC) might subserve for processing this rewarding stimuli (Berridge, Robinson, & Aldridge, 2009; O'Doherty et al., 2003). Second, Chiao et al. used an explicit face-rating paradigm whereas an affective priming paradigm was used in Weisbuch and Ambady's study, which is an implicit priming paradigm. It is possible that the findings in an implicit paradigm might be distinct from the findings in an explicit paradigm.

The other line of research highly relevant to the in-group advantage is in-group bias. In-group bias is not only observed at the behavioral level (Van Bavel & Cunningham, 2008) but also at the neural level (Van Bavel, Packer, & Cunningham, 2008). This novel neuroimaging study found that by assigning Caucasian participants to a classic minimal-group paradigm, several brain regions, especially amygdala and

529 OFC, responded more highly to new in-group faces than to new out-group faces
530 regardless of the race. This finding suggests that the role of amygdala is to process
531 salient and motivationally related stimuli, not just the automatically negative
532 responses to the stigmatized racial group. In this study, the liking rating for the in-
533 group Black faces was much higher than the out-group Black faces, but there was no
534 rating difference in the in-group Caucasian and Black faces. Moreover, this self-
535 reported liking was mediated by the OFC, which was part of the reward circuitry. The
536 researchers concluded that the key process for this in-group bias was self-
537 categorization as a member of a particular group.

538 The effect of self-categorization with a particular group might turn into in-group
539 favoritism. In a recent study (Cikara, Botvinick, & Fiske, 2011) exploring the neural
540 mechanism of intergroup competition, the VS activity was higher when participants
541 saw the positive outcomes in a baseball game (their supporting team won the game
542 or their rival team lost the game) than negative outcomes. The participants' pleasure
543 ratings were also positively correlated with the magnitude of activities in the
544 VS. This finding indicates that regions subserving for primary rewards, such as the
545 VS, might engage in in-group favoritism when in-group members have positive
546 outcomes. It is very possible that the underlying driving force is whether partici-
547 pants consciously self-categorized themselves belonging to a particular group
548 (Balcetis & Dunning, 2006; Sporer, 2001).

549 **6.6.3 Individual Differences in In-Group Favoritism Predicts** 550 ***In-Group Friendship Patterns***

551 This self-categorization process might play an important role in acculturation pro-
552 cesses. According to the four major types of acculturation strategies, integration
553 can be described as a strategy by which immigrants maintain their own culture
554 while also integrating the host cultural value into their identities. On the contrary,
555 assimilation describes the state when individuals abandon their original cultural
556 values, and try to accept all aspects of the host culture. Although these two strate-
557 gies seem different from each other, these two strategies have one common feature,
558 which is that immigrants who use these two strategies are inclined to incorporating
559 host cultural values into their identities. This feature implies that these immigrants
560 may either have no specific tendency to self-categorize into the original or host
561 cultural group, or have stronger tendency to self-categorize into the host cultural
562 group. Compared to these two strategies, immigrants who use the separation strat-
563 egy are those who emphasize only maintaining one's own cultural values and have
564 less interest in integrating host cultural values into their identities. As the result,
565 these immigrants may have a strong tendency to self-categorize themselves as
566 members in the original cultural group, and will still show extreme in-group favor-
567 itism toward their original group members. Based on the above speculation, one
568 possibility is that the determination of whether a group belongs to the in-group
569 does not depend on individual's original cultural group. Rather, it may depend on

this self-categorization process. Once immigrants self-categorize themselves to a particular group, they will automatically show in-group favoritism toward that target group. Thus, this in-group favoritism may lead immigrants into divergent acculturation outcomes.

Our longitudinal study (Chen et al., submitted) was designed to test this possibility, which is that individual differences in in-group favoritism toward the original cultural group may drive immigrants to different acculturation outcomes, specifically friendship patterns. As noted, an early challenge that newly arrived immigrants encounter is determining with whom they should interact. Indeed, new arrivals vary greatly in their friendship formation patterns. Some individuals make more friends among out-group members, whereas others isolate themselves from out-group members and associate mainly with other newly arrived in-group members (Sam & Berry, 2010). Because social affiliation occurs automatically (Powers & Heatherton, 2012), individuals may lack insight into their affiliative processes and behaviors. Therefore, self-reported motives for friendship formations may be biased. Under this circumstance, functional imaging can be used as an alternative means to test the hypothesis that distinct patterns of neural reward reactivity may underlie differential in-group vs. out-group interaction patterns.

Prior imaging studies investigating reward activity provide supportive evidence for the hypothesis that affiliative behaviors are associated with activity in brain reward regions. For example, studies examining facial expressions of happiness as experimental stimuli found activation in the VS (Phan, Wager, Taylor, & Liberzon, 2002). Additionally, a go/no go study that used different emotional expressions as targets found high VS activation in response to happy facial expressions, which also made it more difficult for participants to inhibit responses (Hare, Tottenham, Davidson, Glover, & Casey, 2005). The VS activation induced by happy expressions is likely to motivate approach behaviors. Based on happiness' approach-provoking characteristics, we hypothesized that new arrivals who showed higher reward reactivity for in-group compared to out-group happy expressions would show a preference for approaching in-group members in daily life. In the long run, their percentage of in-group friends might increase. By contrast, those who showed equivalent reactivity for in-group and out-group facial expressions of happiness would be expected to show more balance in their in-group and out-group friendship patterns.

To test this hypothesis, 27 newly arrived Chinese international graduate students were recruited within the first month of their arrivals in the USA. One was excluded from analysis due to excessive movement during scanning. In order to assess how new arrivals expand their social networks with in-group or out-group members in a new culture, percentages of in-group and out-group friends from social networking services (e.g., Facebook) were recorded. Importantly, as Facebook is blocked in China, these Chinese new arrivals had to create a whole new online friendship network in the USA, making it possible to track their changing friendship patterns without contamination from their previous friendship networks. The percentages of in-group friends for each of the participants were recorded immediately after the scanning and again 6 months later, and subsequently changes in the percentage of in-group friends were computed.

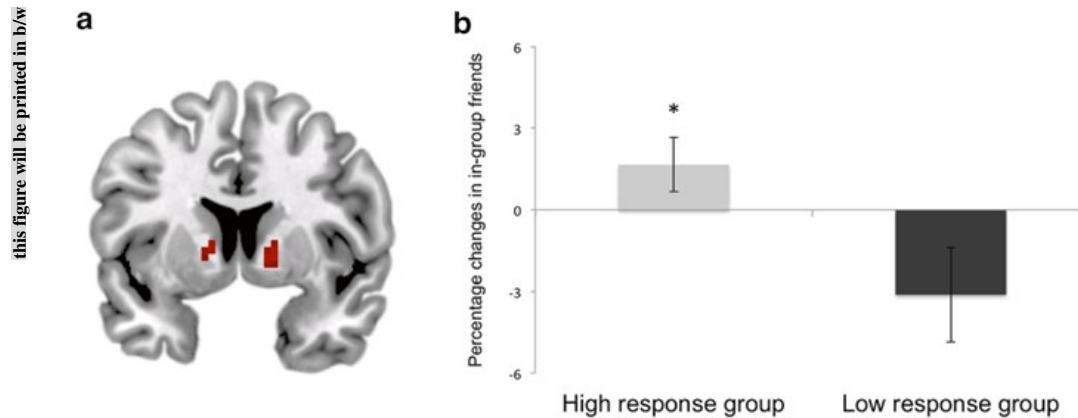


Fig. 6.5 Individual differences in in-group reward reactivity predict changes in the percentage of in-group friends after 6 months. (a) The VS reactivity was greater for in-group than out-group masked happy expressions. (b) New arrivals who were higher in in-group reward reactivity had a significant increase in the percentage of in-group friends than those who were lower in in-group reward reactivity (adapted from Chen, Whalen, Freeman, Taylor, & Heatherton, [under review](#))

615 During three runs of functional imaging, the participants were asked to passively
 616 view blocked presentations of masked faces. In each masked-face block, one of three
 617 in-group and out-group emotional faces (fearful, happy, and surprised) was pre-
 618 sented. Based on previous findings of regional brain activity to emotional stimuli
 619 presented without subjective awareness (Whalen et al., 1998), the current study pre-
 620 sented emotional expressions in a backward masking paradigm. The goal was to
 621 examine whether VS activity in response to in-group and out-group happy expres-
 622 sions in the absence of explicit knowledge of the stimuli could predict new arrivals'
 623 friendship patterns over 6 months. Following the standard procedures of prior work
 624 (Whalen et al., 1998), four participants who indicated subjective awareness of the
 625 masked faces were excluded from further analysis. Based on the above-mentioned
 626 hypotheses concerning VS responses representing reward reactivity to positive affili-
 627 ative stimuli, whole brain analysis focused on the comparison between in-group and
 628 out-group masked-happy conditions in the VS. To examine whether the VS activity
 629 could predict changes in the percentage of in-group friends over 6 month, the param-
 630 eter estimates were extracted from this VS ROI, difference scores were computed,
 631 and then participants were divided into two groups based on the median-split (high
 632 and low VS responses to in-group expressions). The whole brain analysis revealed
 633 higher activity for in-group than out-group masked happy expressions in the bilateral
 634 VS, left medial prefrontal gyrus, right inferior occipital gyrus, left middle occipital
 635 gyrus, and bilateral cerebellum. Interestingly, participants with lower ventral striatal
 636 activity in response to in-group masked happy expressions showed a reduction in the
 637 percentage of in-group friends, whereas those with greater ventral striatal activity
 638 showed an increased in the percentage of in-group friends 6 months later (Fig. 6.5).

639 Our findings support the hypothesis that those with the greatest reward reactivity
 640 to in-group happy expressions subsequently developed more friendships with in-
 641 group members. Importantly, these affiliation processes may occur without subjective

awareness, and this possibility has been proven by post-scan measurements of objective awareness. The increase group and decrease group showed no difference in d-prime difference scores in discriminating in-group and out-group happy expressions, suggesting that this in-group favoritism occurs without subjective awareness and is reflected at neural responses within reward circuitry. Moreover, the new arrivals generally showed greater reward reactivity for in-group than for out-group masked happy expressions, which supports the general idea of in-group favoritism (Cikara et al., 2011; Van Bavel et al., 2008). Individual differences in this in-group reward reactivity, however, predicted divergent friendship patterns 6 months later. This brain-as-predictor approach (Berkman & Falk, 2013) has been used to successfully predict the successful cessation of smoking behaviors (Berkman, Falk, & Lieberman, 2011). Findings from the present study further suggest that this approach might be a useful tool for exploring the acculturation process of immigrants, particularly the dynamics of friendship network formation in a new country.

6.6.4 Linking Individual Differences in Self–Mother Differentiation to In-Group Reward Reactivity

The first section of this chapter reviews how cultural differences in self-construal modulate the neural differentiation between self and mother observed in the VMPFC. Individuals from independent cultures showed a prominent self–mother differentiation in the VMPFC, whereas those from interdependent cultures showed no such differentiation (Heatherston et al., 2006; Wang et al., 2012; Zhu et al., 2007). Moreover, this self-construal modulation effect occurred not only at the cultural level but also at the individual level. We found that newly arrived Chinese immigrants showed this prominent self–mother differentiation, which reflected their unique self-construal, characterized by equivalent independence and interdependence. This finding further supports the voluntary-settlement hypothesis. (As a reminder, this hypothesis states that those who move to the frontiers are inherently different in self-construal from those who stay in their motherlands.) Subsequently, we also found that these self-motivated immigrants showed divergent changes in their interdependent self-construal 6 months later, suggesting that differing degrees of acculturation occurred within a few months. The immigrants who became closer to Americans in their self-construal style showed significant self–mother differentiation in the VMPFC. By contrast, those whose activation patterns became even closer to the Chinese self-construal style showed no such differentiation. This finding suggested that changes in self-construal could be reflected by changes in this VMPFC self–mother differentiation pattern during acculturation processes. Moreover, based on our preliminary findings (Chen et al., in prep), those immigrants who became even more like Chinese revealed fundamental differences during the first fMRI scanning, which was collected within the first months of their arrival. Although they still showed self–mother differentiation in the VMPFC, their differentiation patterns were less prominent than those who became more like

683 Americans. However, their self-construal scores were not significantly different
684 from those who became more like Americans. This discrepancy suggests that
685 behavioral measurements may not be sensitive enough to detect slight individual
686 differences in self-construal, perhaps the reason why previous studies have failed to
687 make successful acculturation predictions. In contrast, neuroimaging techniques are
688 sensitive enough to detect these subtle differences in the neural mechanisms
689 underlying automatic processes.

690 In the second section of this chapter, we describe a study that employed a brain-
691 as-predictor approach to predict immigrants' friendship patterns. Although immi-
692 grants generally showed greater reward reactivity to in-group than to out-group
693 happy expressions presented under subjective awareness, there were substantial
694 individual differences in this in-group reward reactivity. Immigrants with relatively
695 less ventral striatal activity in response to in-group masked happy expressions
696 showed a reduction over time in their percentage of in-group friends, whereas those
697 with greater ventral striatal activity showed an increase in the percentage of in-
698 group friends 6 months later.

699 Based on the above findings, it seems that individual differences in the VMPFC
700 self-mother differentiation and in-group reward reactivity can independently pre-
701 dict different aspects of acculturation outcomes. Is it possible that individual dif-
702 ferences in one domain are correlated with individual differences in the other
703 domain? A recent review (Northoff & Hayes, 2011) proposed that three possible
704 models could be used to explain the relationships between self-processing and
705 reward processing: integration, segregation, and parallel model. The integration
706 model suggests that self and reward processes are highly overlapping, whereas the
707 segregation model suggests that these two processes are distinct. The parallel
708 model presents a compromise between these polar theories, and suggests that cer-
709 tain degrees of overlap exist between self and reward processing. Of these three
710 models, the authors conclude that the parallel model is the best substantiated by
711 existing evidence.

712 Since there are likely certain degrees of overlap existing between self and reward
713 processes, it is rational to hypothesize that individual differences in the VMPFC
714 self-mother differentiation may be correlated with individual differences in in-
715 group reward reactivity. Based on findings from our studies, immigrants who show
716 a greater self-mother differentiation are those who possess a more independent self-
717 construal. This is observed upon their initial arrival in the USA, and also holds true
718 6 months later. Because these immigrants become more like Americans in self-
719 construal style, their acculturation processes may foster the development of a state
720 of integration or assimilation. Thus, they may also show less in-group reward reac-
721 tivity when they first arrive in the USA. As a result, their percentage of out-group
722 friends will increase over time. In contrast to these immigrants, immigrants who
723 show no prominent self-mother differentiation are those who have a more interde-
724 pendent self-construal style. They generally become even more like Chinese in self-
725 construal style 6 months later. Thus, it is possible that they are on the path to the state
726 of separation during acculturation processes. These immigrants may show higher
727 in-group reward reactivity when they first arrive in the USA. In the long run, their

percentage of out-group friends will decrease, while they will show a prominent increase in in-group friendships. Unfortunately, the participants in the self–mother differentiation study and the in-group reward study are recruited from different group of participants, making it impossible to directly test the above hypothesis. Future studies are needed to test this hypothesis, and to develop a better model to understand the complex acculturation processes.

Several limitations exist within our studies. First of all, these studies lack a more comprehensive acculturation battery. We only administered a self-construal scale in these studies, and suggest that other acculturation questionnaires, such as the Suinn–Lew Asian Self Identity Acculturation Rating Scale (Suinn, Rickard-Figueroa, Lew, & Vigil, 1987) and General Ethnicity Questionnaire (Tsai, Ying, & Lee, 2000), should be incorporated in future studies. Secondly, more detailed data regarding friendship patterns should be collected in future studies. In our research, we use a binary approach (in-group vs. out-group) to analyze the friendship patterns. However, this binary assignment might fail to detect subtle affiliation patterns with different ethnic out-groups. Moreover, this study also failed to measure the strength of friendships within their friendship grids. This strength information might be quite meaningful when researchers start doing more detailed analyses. Lastly, we only recruited immigrants who had moved from China to the USA, rather than recruiting from other “Western” populations. Thus, our findings may not be generalizable to immigrants moving from one independent culture to another. In this case, the self–mother differentiation pattern may not have the same predictive power, as the self–mother differentiation pattern is more prominent in immigrants from interdependent cultures. As an alternative, the in-group reactivity paradigm may be used. Future studies must address all of the limitations above.

6.7 Future Directions

6.7.1 *Incorporating Diffusion Tensor Imaging into the Brain-As-Predictor Approach*

A recent study (Chavez & Heatherton, *in press*) using diffusion tensor imaging found that the integrity of white matter tracts between brain regions subserving self-referential processing (i.e., the VMPFC) and regions subserving reward processing (i.e., the VS) predicts individual differences in trait self-esteem. This finding implies that individual differences in traits, which are stable across time, may not reflect differences in brain activation patterns. Rather, they may represent differences in structural integrity between brain regions. According to what we found in one of our studies, immigrants who became more like Americans 6 months later still showed prominent self–mother differentiation not only in the VMPFC but also in one of the reward regions, the VS. Is it possible that those who show an increase in independent self-construal style are those who have more white matter integrity between the VMPFC and the VS? One previous review (Johansen-Berg, 2010) concludes

768 that individual differences in the white matter structures play an important role in
769 individual differences in behavioral consequences. Since immigrants generally
770 show huge individual differences during the acculturation process, some of which
771 are stable across time, it is possible that inherent differences in white matter integrity
772 motivate immigrants to acculturate. Also, due to the fact that learning leads to
773 neural plasticity in the brain (Kitayama & Uskul, 2011), it is possible that white
774 matter integrity will also show dynamic changes during acculturation. Based on our
775 previous findings, the regions likely incurring these changes are the VMPFC, which
776 subserves neural representations of self and close others, and the VS, which sub-
777 serves in-group reward processing. Future studies are needed to test whether white
778 matter integrity between these two regions can predict individual differences in
779 acculturation outcomes, as well as to test whether any changes in white matter
780 integrity are affected by the acculturation process.

781 **6.7.2 Individual Differences in Reward Responses** 782 **to Culture-Specific Cues**

783 Different cultures reinforce different behaviors, and this relationship extends to
784 affect the neural level. For example, American culture reinforces more dominant
785 behaviors, whereas Japanese culture reinforces more subordinate behaviors.
786 Freeman and colleagues (Freeman, Rule, Adams, & Ambady, 2009) conducted a
787 study by recruiting Americans and Japanese to passively view pictorial cues rele-
788 vant to dominant or subordinate behaviors while in the MRI scanner. The findings
789 revealed that the bilateral caudate nucleus, part of the cortico-basal ganglia cir-
790 cuitry, showed greater activity for dominant than for subordinate cues in Americans,
791 whereas the same regions showed greater activity for subordinate than dominant
792 cues in Japanese. Moreover, individual differences in activity in the right caudate
793 nucleus were correlated with individual differences in the self-reported behavioral
794 tendency toward dominant or subordinate behaviors. These findings suggest that
795 reward activity to distinct behavioral cues can be shaped not only by individuals'
796 cultural backgrounds but also by individuals' behavioral preferences. Based on this
797 implication, it will be interesting to test whether individual differences in reward
798 activity to culture-specific cues can predict immigrants' acculturation states. It
799 seems that greater reward activity to one's own culture-specific cues may indicate
800 stronger in-group favoritism and a higher tendency toward the acculturation state of
801 separation. Thus, Japanese who show no reward activity to subordinate cues or
802 show even greater reward activity to dominant cues are those who may move toward
803 the state of integration or assimilation. Conversely, those who show greater reward
804 activity to subordinate cues may move toward the state of separation. The same
805 hypothesis can also be made in relation to Americans and other cultural groups once
806 the appropriate cultural cues are selected. Future acculturation studies may use this
807 paradigm to test the above hypothesis.

6.7.3 Linking Research Using Mouse-Tracking to In-Group Reward Reactivity 808
809

Findings from one of our studies indicate that immigrants have greater reward reactivity to in-group than out-group happy expressions. This heightened in-group reward reactivity represents an approach motivation toward in-group members. However, the avoidance motivation away from out-group members was not tested in this study. To test whether avoidance motivation is also an important factor, mouse-tracking methods could be applied in future work. For example, the MouseTracker software package enables researchers to record and analyze the real-time dynamics underlying a variety of perceptual and cognitive decisions using participants' hand movements en route to specific responses on the screen (Freeman & Ambady, 2010). MouseTracker makes it possible to visualize the time course of an evolving behavioral response by analyzing how participants' hand movements (mouse trajectories) settle into a given response over time—and how they may be partially “pulled” toward alternative responses in parallel (Freeman, Dale, & Farmer, 2011). In the context of approach/avoidance behavior, MouseTracker would allow the recording and analysis of how participants' hand movements may be particularly direct and facilitated toward hypothetical approach-related response options, and particularly indirect and “pushed away” from hypothetical avoidance-related response options.

The setup of this approach/avoidance to in-/out-group members experiment starts with the selection of appropriate emotional expressions for triggering approach or avoidance tendencies. In our previous in-group reward reactivity study (Chen et al., [under review](#)), only the approach tendency was tested. The ideal target for eliciting an approach tendency would be happy expressions (as was done in the previous study), whereas the ideal target for eliciting an avoidance tendency would be angry expressions (Phan et al., 2002). Mouse trajectories that are particularly direct would suggest an approach tendency toward a given face, whereas those that are particularly indirect would suggest an avoidance tendency toward a given face. It would therefore be interesting to test whether approach and avoidance tendencies to angry and happy expressions are at all moderated by a face's in-group/out-group status. MouseTracker in this case would allow us to use motor behavior to gain insight into spontaneous approach and avoidance tendencies toward in-group and out-group faces varying in emotion expressions.

By looking at both of these motivations, particularly the approach tendency toward in-group happy expressions and the avoidance tendency elicited by out-group angry expressions, we may better capture the underlying mechanisms that determine immigrants' acculturation outcomes. Based on a previous meta-analysis of the functional anatomy of emotions (Phan et al., 2002), it is known that angry expressions consistently induce activity in the anterior cingulate cortex (ACC), whereas happy expressions consistently induce VS activity. By combining the mouse tracking data and neural response measures from the VS and ACC, cultural psychologists may be able to form a more comprehensive picture of the acculturation process and make more accurate acculturation predictions for immigrants.

851 **6.8 Conclusion**

852 Acculturation is a complex and multidimensional process. Since previous attempts
853 to use behavioral tools to predict immigrants' acculturation outcomes have not been
854 fully successful (Sam & Berry, 2010), using a brain-as-predictor approach may be a
855 better alternative. Combining neuroimaging with behavioral observations allows us
856 to understand the acculturation process more deeply, to make more precise accul-
857 turation predictions. This is the brain-as-predictor approach as discussed in a recent
858 review (Berkman & Falk, 2013), a means of linking brain imaging data to outcomes
859 beyond the immediate experimental session in the lab setting. By using this
860 approach, neural responses that encode information can be used to make predictions
861 for subsequent real-world behaviors.

862 Although this approach is a promising tool for future studies, it has several flaws
863 that we need to take into consideration. First is the reliability of neuroimaging data.
864 In general, neuroimaging data is easily affected by hardware, the interval length
865 between two imaging scans, and the complexity of the underlying cognitive pro-
866 cesses. Secondly, researchers must choose brain regions carefully based on the
867 results of meta-analyses or prior research. Lastly, discrimination analysis should be
868 used in this approach in order to make more precise predictions before conducting
869 more advanced analyses. Without taking these issues into account, researchers may
870 not be able to make precise and accurate predictions.

871 In this chapter, we first review how cultural differences in self-construal modu-
872 late the neural representations of the self and close others. This is followed by find-
873 ings from our longitudinal studies on immigrants, which may provide more insight
874 into changes in their VMPFC self-mother differentiation during acculturation pro-
875 cesses. In the second part, we review the neural mechanisms subserving in-group
876 favoritism. We also report that individual differences in this in-group reward reac-
877 tivity could predict immigrants' friendship patterns. In the last part of this chapter,
878 we propose an integrated brain-as-predictor approach, which brings together self-
879 referential processing and reward processing to predict immigrants' acculturation
880 outcomes. In this part, we also propose several future directions researchers may
881 want to take in order to gain a better understanding of the acculturation process and
882 foster more accurate predictions. We hope that this exploration into the underlying
883 neural mechanisms involved in the acculturation process will lead to interventions
884 that guide immigrants toward the integration state of acculturation, which allows
885 immigrants from different cultures to gain a better understanding of each other and
886 better communicate across cultures.

[AU4]887 **References**

- 888 Aharon, I., Etcoff, N., Ariely, D., Chabris, C. F., O'Connor, E., & Breiter, H. C. (2001). Beautiful
889 faces have variable reward value: fMRI and behavioral evidence. *Neuron*, 32, 537–551.
890 Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: The medial frontal cortex and social
891 cognition. *Nature Reviews Neuroscience*, 7(4), 268–277. doi:10.1038/nrn1884.

Aron, A., Aron, E. N., Tudor, M., & Nelson, G. (1991). Close relationships as including other in the self. *Journal of Personality and Social Psychology*, *60*(2), 241–253. 892
893

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, *63*(4), 596–612. 894
895

Bakker, W., van Oudenhoven, J. P., & van der Zee, K. I. (2004). Attachment styles, personality, and Dutch emigrants' intercultural adjustment. *European Journal of Personality*, *18*(5), 387–404. 896
897
doi:[10.1002/per.515](https://doi.org/10.1002/per.515). 898

Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology*, *91*(4), 612–625. 899
900
doi:[10.1037/0022-3514.91.4.612](https://doi.org/10.1037/0022-3514.91.4.612). 901

Berkman, E. T., & Falk, E. B. (2013). Beyond brain mapping: Using neural measures to predict real-world outcomes. *Current Directions in Psychological Science*, *22*(1), 45–50. 902
903
doi:[10.1177/0963721412469394](https://doi.org/10.1177/0963721412469394). 904

Berkman, E. T., Falk, E. B., & Lieberman, M. D. (2011). In the trenches of real-world self-control: Neural correlates of breaking the link between craving and smoking. *Psychological Science*, *22*(4), 498–506. doi:[10.1177/0956797611400918](https://doi.org/10.1177/0956797611400918). 905
906
907

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: 'liking', 'wanting', and learning. *Current Opinion in Pharmacology*, *9*(1), 65–73. doi:[10.1016/j.coph.2008.12.014](https://doi.org/10.1016/j.coph.2008.12.014). 908
909
910

Berry, J. W. (1997). Immigration, acculturation and adaptation. *Applied Psychology*, *46*, 5–68. 911

Berry, J. W. (2003). Conceptual approaches to acculturation. In K. Chun, P. Balls-Organista, & G. Marin (Eds.), *Acculturation: Advances in theory, measurement and applied research* (pp. 17–37). Washington, DC: American Psychological Association. 912
913
914

Berry, J. W., Phinney, J. S., Sam, D. L., & Vedder, P. (2006). Immigrant youth: Acculturation, identity and adaptation. *Applied Psychology*, *55*(3), 303–332. 915
916

Bower, G., & Gilligan, S. (1979). Remembering information related to one's self. *Journal of Research in Personality*, *13*, 420–432. 917
918

[AU5] Chavez R. S., & Heatherton T. F. (in press). Multi-modal frontostriatal connectivity underlies individual differences in self-esteem. *Social Cognitive and Affective Neuroscience*. 919
920

Chen, P-H. A., Kelley, W. M., Heatherton, T. F. (in prep). Changes in the interdependent self-construal modulate neural representations between self and mother in the MPFC. 921
922

Chen, P-H. A., Wagner, D. D., Kelley, W. M., Powers, K. E., & Heatherton, T. F. (2013). Medial prefrontal cortex differentiates self from mother in Chinese: Evidence from self-motivated immigrants. *Culture and Brain*, *1*(1), 3–15. doi:[10.1007/s40167-013-0001-5](https://doi.org/10.1007/s40167-013-0001-5). 923
924
925

Chen, P-H. A., Whalen, P. J., Freeman, J. B., Taylor, J. M., & Heatherton, T. F. (under review). Brain reward activity to masked in-group smiling faces predicts friendship development. 926
927

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2009a). Dynamic cultural influences on neural representations of the self. *Journal of Cognitive Neuroscience*, *22*(1), 1–11. 928
929

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2009b). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping*, *30*(9), 2813–2820. 930
931
doi:[10.1002/hbm.20707](https://doi.org/10.1002/hbm.20707). 932

Chiao, J. Y., Iidaka, T., Gordon, H. L., Nogawa, J., Bar, M., Aminoff, E., et al. (2008). Cultural specificity in amygdala response to fear faces. *Journal of Cognitive Neuroscience*, *20*(12), 2167–2174. 933
934
935

Cikara, M., Botvinick, M. M., & Fiske, S. T. (2011). Us versus them: Social identity shapes neural responses to intergroup competition and harm. *Psychological Science*, *22*(3), 306–313. 936
937
doi:[10.1177/0956797610397667](https://doi.org/10.1177/0956797610397667). 938

Correll, J., & Park, B. (2005). A model of the ingroup as a social resource. *Personality and Social Psychology Review*, *9*(4), 341–359. doi:[10.1207/s15327957pspr0904_4](https://doi.org/10.1207/s15327957pspr0904_4). 939
940

Craik, F. I. M., Moroz, T. M., Moscovitch, M., Stuss, D. T., Winocur, G., Tulving, E., et al. (1999). In search of the self: A positron emission tomography study. *Psychological Science*, *10*(1), 26–34. doi:[10.1111/1467-9280.00102](https://doi.org/10.1111/1467-9280.00102). 941
942
943

Delgado, M. R. (2007). Reward-related responses in the human striatum. *Annals of the New York Academy of Sciences*, *1104*(1), 70–88. doi:[10.1196/annals.1390.002](https://doi.org/10.1196/annals.1390.002). 944
945

- 946 Demos, K. E., Heatherton, T. F., & Kelley, W. M. (2012). Individual differences in nucleus accu-
947 bens activity to food and sexual images predict weight gain and sexual behavior. *Journal of*
948 *Neuroscience*, 32(16), 5549–5552. doi:10.1523/JNEUROSCI.5958-11.2012.
- 949 Elfenbein, H. A., & Ambady, N. (2003). When familiarity breeds accuracy: Cultural exposure and
950 facial emotion recognition. *Journal of Personality and Social Psychology*, 85(2), 276–290.
951 doi:10.1037/0022-3514.85.2.276.
- 952 Ferguson, T. J., Rule, B. G., & Carlson, D. (1983). Memory for personally relevant information.
953 *Journal of Personality and Social Psychology*, 44(2), 251–261.
- 954 Freeman, J. B. (2013). Within-cultural variation and the scope of cultural neuroscience.
955 *Psychological Inquiry*, 24(1), 26–30. doi:10.1080/1047840X.2013.767069.
- 956 Freeman, J. B., & Ambady, N. (2010). MouseTracker: Software for studying real-time mental
957 processing using a computer mouse-tracking method. *Behavior Research Methods*, 42(1),
958 226–241. doi:10.3758/BRM.42.1.226.
- 959 Freeman, J. B., & Ambady, N. (2011). Hand movements reveal the time-course of shape and pig-
960 mentation processing in face categorization. *Psychonomic Bulletin & Review*, 18(4), 705–712.
961 doi:10.3758/s13423-011-0097-6.
- 962 Freeman, J. B., Dale, R., & Farmer, T. A. (2011). Hand in motion reveals mind in motion. *Frontiers*
963 *in Psychology*, 2, 1–6. doi:10.3389/fpsyg.2011.00059/abstract.
- 964 Freeman, J. B., Rule, N. O., Adams, R. B., Jr., & Ambady, N. (2009). Culture shapes a mesolimbic
965 response to signals of dominance and subordination that associates with behavior. *NeuroImage*,
966 47(1), 353–359. doi:10.1016/j.neuroimage.2009.04.038.
- 967 Glimcher, P. W. (2011). Understanding dopamine and reinforcement learning: The dopamine
968 reward prediction error hypothesis. *Proceedings of the National Academy of Sciences of the*
969 *United States of America*, 108(Suppl 3), 15647–15654. doi:10.1073/pnas.1014269108.
- 970 Green, E. G. T., Deschamps, J.-C., & Paez, D. (2005). Variation of individualism and collectivism
971 within and between 20 countries: A typological analysis. *Journal of Cross-Cultural Psychology*,
972 36(3), 321–339. doi:10.1177/0022022104273654.
- 973 Haber, S. N., & Knutson, B. (2010). The reward circuit: Linking primate anatomy and human
974 imaging. *Neuropsychopharmacology*, 35(1), 4–26. doi:10.1038/npp.2009.129.
- 975 Han, S., Northoff, G., Vogeley, K., Wexler, B. E., Kitayama, S., & Varnum, M. E. W. (2013). A
976 cultural neuroscience approach to the biosocial nature of the human brain. *Annual Review of*
977 *Psychology*, 64(1), 335–359. doi:10.1146/annurev-psych-071112-054629.
- 978 Hare, T. A., Tottenham, N., Davidson, M. C., Glover, G. H., & Casey, B. J. (2005). Contributions
979 of amygdala and striatal activity in emotion regulation. *Biological Psychiatry*, 57(6), 624–632.
980 doi:10.1016/j.biopsych.2004.12.038.
- 981 Heatherton, T. F., Wyland, C. L., Macrae, C. N., Demos, K. E., Denny, B. T., & Kelley, W. M.
982 (2006). Medial prefrontal activity differentiates self from close others. *Social Cognitive and*
983 *Affective Neuroscience*, 1(1), 18–25. doi:10.1093/scan/nsi001.
- 984 International Organization for Migration. (2008). *Global estimates and trends*. Geneva:
985 International Organization for Migration.
- 986 Johansen-Berg, H. (2010). Behavioural relevance of variation in white matter microstructure.
987 *Current Opinion in Neurology*, 23, 351. doi:10.1097/WCO.0b013e32833b7631.
- 988 Kelley, W. M., Macrae, C. N., Wyland, C. L., Caglar, S., Inati, S., & Heatherton, T. F. (2002). Finding
989 the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, 14(5), 785–794.
- 990 Kitayama, S., Ishii, K., Imada, T., Takemura, K., & Ramaswamy, J. (2006). Voluntary settlement
991 and the spirit of independence: Evidence from Japan's 'northern frontier'. *Journal of Personality*
992 *and Social Psychology*, 91(3), 369–384. doi:10.1037/0022-3514.91.3.369.
- 993 Kitayama, S., & Park, J. (2010). Cultural neuroscience of the self: Understanding the social
994 grounding of the brain. *Social Cognitive and Affective Neuroscience*, 5(2–3), 111–129.
995 doi:10.1093/scan/nsq052.
- 996 Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain: Current evidence and future direc-
997 tions. *Annual Review of Psychology*, 62(1), 419–449. doi:10.1146/annurev-psych-120709-145357.
- 998 Klein, S. B., & Kihlstrom, J. F. (1986). Elaboration, organization, and the self-reference effect in
999 memory. *Journal of Personality and Social Psychology*, 115(1), 26–38.

Klein, S. B., & Loftus, J. (1988). The nature of self-referent encoding: The contributions of elaborative and organizational processes. *Journal of Personality and Social Psychology*, *55*(1), 5–11. 1000
1001

Kosic, A., Kruglanski, A. W., Pierro, A., & Mannetti, L. (2004). The social cognition of immigrants' acculturation: Effects of the need for closure and the reference group at entry. *Journal of Personality and Social Psychology*, *86*(6), 796–813. doi:[10.1037/0022-3514.86.6.796](https://doi.org/10.1037/0022-3514.86.6.796). 1002
1003
1004

Kringelbach, M. L., & Berridge, K. C. (2009). Towards a functional neuroanatomy of pleasure and happiness. *Trends in Cognitive Sciences*, *13*(11), 479–487. doi:[10.1016/j.tics.2009.08.006](https://doi.org/10.1016/j.tics.2009.08.006). 1005
1006

Kuiper, N. A., & Rogers, T. B. (1979). Encoding of personal information: Self-other differences. *Journal of Personality and Social Psychology*, *37*(4), 499–514. 1007
1008

Li, H., Zhang, Z., Bhatt, G., & Yum, Y.-O. (2006). Rethinking culture and self-construal: China as a middle land. *The Journal of Social Psychology*, *146*(5), 591–610. doi:[10.3200/SOCP.146.5.591-610](https://doi.org/10.3200/SOCP.146.5.591-610). 1009
1010
1011

Macrae, C. N., Moran, J. M., Heatherton, T. F., Banfield, J. F., & Kelley, W. M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex*, *14*(6), 647–654. doi:[10.1093/cercor/bhh025](https://doi.org/10.1093/cercor/bhh025). 1012
1013
1014

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*(2), 224–253. 1015
1016

Mitchell, J. P., Macrae, C. N., & Banaji, M. R. (2006). Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron*, *50*(4), 655–663. doi:[10.1016/j.neuron.2006.03.040](https://doi.org/10.1016/j.neuron.2006.03.040). 1017
1018
1019

Nauck, B. (2008). Acculturation. In F. J. Van de Vijver, D. A. van Hemert, & Y. H. Poortinga (Eds.), *Multilevel analysis of individuals and cultures* (pp. 379–410). Mahwah, NJ: Erlbaum. 1020
1021

Ng, S. H., Han, S., Mao, L., & Lai, J. C. L. (2010). Dynamic bicultural brains: fMRI study of their flexible neural representation of self and significant others in response to culture primes. *Asian Journal of Social Psychology*, *13*(2), 83–91. doi:[10.1111/j.1467-839X.2010.01303.x](https://doi.org/10.1111/j.1467-839X.2010.01303.x). 1022
1023
1024

Northoff, G., & Hayes, D. J. (2011). Is our self nothing but reward? *Biological Psychiatry*, *69*(11), 1019–1025. doi:[10.1016/j.biopsych.2010.12.014](https://doi.org/10.1016/j.biopsych.2010.12.014). 1025
1026

O'Doherty, J., Winston, J., Critchley, H., Perrett, D., Burt, D. M., & Dolan, R. J. (2003). Beauty in a smile: The role of medial orbitofrontal cortex in facial attractiveness. *Neuropsychologia*, *41*, 147–155. 1027
1028
1029

Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: A meta-analysis of emotion activation studies in PET and fMRI. *NeuroImage*, *16*(2), 331–348. doi:[10.1006/nimg.2002.1087](https://doi.org/10.1006/nimg.2002.1087). 1030
1031
1032

Powers, K. E., & Heatherton, T. F. (2012). Characterizing socially avoidant and affiliative responses to social exclusion. *Frontiers in Integrative Neuroscience*, *6*(46), 1–5. doi:[10.3389/fnint.2012.00046/abstract](https://doi.org/10.3389/fnint.2012.00046/abstract). 1033
1034
1035

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*(9), 677–688. 1036
1037

Sam, D. L., & Berry, J. W. (2010). Acculturation: When individuals and groups of different cultural backgrounds meet. *Perspectives on Psychological Science*, *5*(4), 472–481. doi:[10.1177/1745691610373075](https://doi.org/10.1177/1745691610373075). 1038
1039
1040

Schultz, W. (2000). Multiple reward signals in the brain. *Nature Review Neuroscience*, *1*, 199–207. 1041
1042

Singelis, T. M. (1994). The measurements of independent and interdependent self-construals. *Personality and Social Psychological Bulletin*, *20*, 580–591. 1043
1044

Smith, K. S., Berridge, K. C., & Aldridge, J. W. (2011). Disentangling pleasure from incentive salience and learning signals in brain reward circuitry. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(27), E255–E264. doi:[10.1073/pnas.1101920108/-DCSupplemental](https://doi.org/10.1073/pnas.1101920108/-DCSupplemental). 1045
1046
1047
1048

Sporer, S. L. (2001). Recognizing faces of other ethnic groups: An integration of theories. *Psychology, Public Policy, and Law*, *7*(1), 36–97. doi:[10.1037//1076-8971.7.1.36](https://doi.org/10.1037//1076-8971.7.1.36). 1049
1050

Suinn, R. M., Rickard-Figueroa, K., Lew, S., & Vigil, P. (1987). The Suinn-Lew Asian self-identity acculturation scale: An initial report. *Educational and Psychological Measurement*, *47*(2), 401–407. 1051
1052
1053

- 1054 Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis.
1055 *Psychological Bulletin*, *121*(3), 371–394.
- 1056 Tsai, J. L., Ying, Y. W., & Lee, P. A. (2000). The meaning of “Being Chinese” and “Being
1057 American”: Variation among Chinese American young adults. *Journal of Cross-Cultural*
1058 *Psychology*, *31*(3), 302–332. doi:[10.1177/0022022100031003002](https://doi.org/10.1177/0022022100031003002).
- 1059 Van Bavel, J. J., & Cunningham, W. A. (2008). Self-categorization with a novel mixed-race group
1060 moderates automatic social and racial biases. *Personality and Social Psychology Bulletin*,
1061 *35*(3), 321–335. doi:[10.1177/0146167208327743](https://doi.org/10.1177/0146167208327743).
- 1062 Van Bavel, J. J., Packer, D. J., & Cunningham, W. A. (2008). The neural substrates of in-group
1063 bias: A functional magnetic resonance imaging investigation. *Psychological Science*, *19*(11),
1064 1131–1139. doi:[10.1111/j.1467-9280.2008.02214.x](https://doi.org/10.1111/j.1467-9280.2008.02214.x).
- 1065 Varnum, M. E. W., & Kitayama, S. (2011). What’s in a name?: Popular names are less common on
1066 frontiers. *Psychological Science*, *22*(2), 176–183. doi:[10.1177/0956797610395396](https://doi.org/10.1177/0956797610395396).
- 1067 Wagner, D. D., Haxby, J. V., & Heatherton, T. F. (2012). The representation of self and person
1068 knowledge in the medial prefrontal cortex. *Wiley Interdisciplinary Reviews: Cognitive Science*,
1069 *3*(4), 451–470. doi:[10.1002/wcs.1183](https://doi.org/10.1002/wcs.1183).
- 1070 Wang, G., Mao, L., Ma, Y., Yang, X., Cao, J., Liu, X., et al. (2012). Neural representations of close
1071 others in collectivistic brains. *Social Cognitive and Affective Neuroscience*, *7*(2), 222–229.
1072 doi:[10.1093/scan/nsr002](https://doi.org/10.1093/scan/nsr002).
- 1073 Ward, C., Leong, C.-H., & Low, M. (2004). Personality and sojourner adjustment: An exploration
1074 of the “Big Five” and the “Cultural Fit” proposition. *Journal of Cross-Cultural Psychology*,
1075 *35*(2), 137–151. doi:[10.1177/0022022103260719](https://doi.org/10.1177/0022022103260719).
- 1076 Weisbuch, M., & Ambady, N. (2008). Affective divergence: Automatic responses to others’ emo-
1077 tions depend on group membership. *Journal of Personality and Social Psychology*, *95*(5),
1078 1063–1079. doi:[10.1037/a0011993](https://doi.org/10.1037/a0011993).
- 1079 Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998).
1080 Masked presentations of emotional facial expressions modulate amygdala activity without
1081 explicit knowledge. *Journal of Neuroscience*, *18*(1), 411–418.
- 1082 Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-
1083 representation. *NeuroImage*, *34*(3), 1310–1316. doi:[10.1016/j.neuroimage.2006.08.047](https://doi.org/10.1016/j.neuroimage.2006.08.047).