

Grounding the neuroscience of behavior change in the sociocultural context

Steven Tompson¹, Matthew D Lieberman² and Emily B Falk^{3,4}

Recent work has identified ventral medial prefrontal cortex (vmPFC) as a key region predicting whether people will change their behavior in response to persuasive messages. Moreover, a parallel and complementary area of research has examined sociocultural factors that contribute to successful behavior change. In the current paper we aim to integrate these two distinct lines of research and discuss novel implications for the study of both behavior change and culture. We propose that personally and culturally tailored messages should lead to greater neural activation in vmPFC and this greater neural activation should lead to greater subsequent behavior change; we also consider broader neural systems that may integrate social norms and perspectives into judgments across culture.

Addresses

¹ Department of Psychology, University of Michigan, United States² Department of Psychology, University of California, Los Angeles, United States³ Annenberg School for Communication, University of Pennsylvania, United States⁴ Research Center for Group Dynamics, Institute for Social Research, University of Michigan, United StatesCorresponding authors: Tompson, Steven (tompson@umich.edu) and Falk, Emily B (falk@asc.upenn.edu)

Current Opinion in Behavioral Sciences 2015, 5:58–63

This review comes from a themed issue on **Decision making/ neuroeconomics**Edited by **John O'Doherty** and **Colin Camerer**<http://dx.doi.org/10.1016/j.cobeha.2015.07.004>

2352-1546/© 2015 Elsevier Ltd. All rights reserved.

Introduction

What motivates people to change their behavior? Researchers have long been interested in understanding and predicting changes in behavior in diverse domains [1,2], including health, financial, consumer, and political behaviors. Much of this work focuses on how to develop messages that promote behavior change in a certain direction (e.g. engaging in a specific health behavior, buying a company's product, voting for a particular political candidate, etc.). Recent work in social and communication neuroscience has found that neural activation is a reliable predictor of behavior change, explaining variance

above and beyond a range of self-report measures. For health behaviors as diverse as sunscreen usage [3], smoking cessation [4*,5], and physical activity [6**], activation in the ventral medial prefrontal cortex (vmPFC) in response to health communications predicts whether individuals will subsequently engage in healthier behaviors (or reduce unhealthy behaviors). Additionally, activation in vmPFC has also been shown to predict financial and consumer decisions [7,8].

Why does vmPFC predict behavior change? vmPFC is one of the regions most commonly engaged in studies of self-related processing [9,10], as well as positive valuation [11], and current thinking suggests that these processes may play integral roles driving the effects of social influence on behavior change [12]. In addition, researchers have begun to tease apart the social factors and message characteristics that lead to increased vmPFC activation and subsequent behavior change. As described in more detail below, personal relevance of the message [13], behavior-relevant messages [14], and opportunities for self-affirmation [6**] have all been shown to lead to increased vmPFC activation, which in turn predicts behavior change. Moreover, localizer tasks used to identify a priori ROIs implicated in self-related processing suggest that thinking about the self while evaluating the message may play a key role underlying the link between vmPFC activation and behavior change [4*].

A parallel and complementary area of research in health psychology and health communications also suggests that personally relevant tailored messages are more effective at promoting healthy behaviors [15,16]. Similarly, the cultural match between the message content and personal values influences the effectiveness of health messages [17–19,20**]. Thus, integrating recent neuroimaging evidence regarding the role of vmPFC in promoting behavior change in response to health messages and recent work on personal and cultural message tailoring, we suggest novel implications of these previously distinct areas of research and argue for their combination.

Neuroscience of persuasion and behavior change

Personalized messages that are tailored to the individual are rated as more relevant to the self and congruent with important identities [13,16]. Importantly, more personalized messages also lead to greater goal-consistent behavior change [21*], and increased perceptions of the relevance of the message to the self have been shown

to mediate this effect [22]. For example, people who are trying to quit smoking and are given tailored messages are more likely to succeed in quitting than smokers given non-tailored messages [16] and tailored messages about breast cancer screening lead to greater subsequent intentions to get breast cancer screening [22]. Tailored health messages also activate vmPFC to a greater degree than non-tailored messages and activation in a more dorsal part of mPFC (dmPFC) in response to these health messages predicts subsequent behavior change [23**].

Recently, we used a self-localizer task to identify sub-regions of vmPFC that are recruited when smokers think about the self [4*]. Participants recruited vmPFC more when evaluating whether a trait word described themselves relative to a control judgment (i.e. whether a word was positive or negative). Activation in this same sub-region of vmPFC while our smokers viewed anti-smoking messages predicted changes in smoking behavior [4*].

Additional work has found that vmPFC activation in a small group of participants can also predict the population-level success of a set of health messages [14,24]. Importantly, the relevance of the message content to the behavior being promoted moderates the relationship between vmPFC activation and population-level responses to the health message. vmPFC activation predicted population level behavior (clicks on online anti-smoking ads) when the message content was smoking-relevant, whereas vmPFC activation does not predict click rate for ads containing compositionally similar but behavior-irrelevant images [14].

Another study manipulated activation within vmPFC using self-affirmation priming [6**]. In this study, sedentary individuals were given accelerometers to track their physical activity and then shown health messages promoting the benefits of increased physical activity. Some participants affirmed core values important to the self prior to viewing physical activity health messages, whereas control participants reflected on values rated as personally unimportant. The authors hypothesized that the affirmation manipulation should decrease perceived threat of the messages and increase the ability of participants to internalize the message [6**]. There are three noteworthy findings from this study. First, vmPFC activation was greater for people who had an opportunity to self-affirm prior to seeing the health messages. Second, people who saw the health messages coupled with self-affirmation showed greater improvements in physical activity than people who saw the control messages. Third, vmPFC activation in response to the health messages predicted subsequent changes in behavior, such that people who exhibited greater vmPFC activation while viewing the health messages showed steeper declines in sedentary behavior over the next 30 days.

Research on consumer decision-making provides additional evidence for the role of vmPFC in predicting subsequent behaviors. vmPFC activation predicts whether people will purchase a consumer product [7] as well as the endowment effect (increased valuation of items as a function of object ownership) [25–27], providing evidence that activation in vmPFC may be indexing self-relevance or value of the particular stimuli to the self. More broadly, converging evidence suggests that vmPFC is involved in integrating signals (including self-relevance and value) with both external and internal information to trigger a goal-motivated behavioral response [28–30]. In the context of health messages, vmPFC may therefore be involved in integrating signals about the personal value of a particular message and activating goals related to the health message.

Cultural influences on message effectiveness

There are many ways that culture could influence effectiveness of persuasive messages, but two primary routes include normative influence (changing behavior because of what other people think) and individual values and beliefs. A number of behavior change theories argue that both attitudes and subjective norms influence behavioral intentions [31,32], and culture constitutes a primary source of information about what is sanctioned, valued, and normative. Cultures may reinforce and promote different types of normative beliefs about how people should act and what they should care about; these cultural norms may in turn influence the types of goals, values, and beliefs that people hold [33*,34].

Individualistic cultural contexts are more likely to promote goals, beliefs, and values that emphasize one's individuality, personal achievement, and uniqueness [35–37]. People from individualistic cultures tend to view the self as distinct from others and defined by their personality and personal preferences [34] and as a result, tend to be motivated by the desire to be unique, be the best, and express one's important characteristics through behaviors and decisions [38,39]. In contrast, collectivistic cultures are more likely to promote goals, beliefs, and values that emphasize social harmony and the importance of the group [34–37]. People from collectivistic cultures tend to view the self as intertwined with others and defined by relational attributes and social roles, and as a result primary motivators of behavior include the desire to promote and maintain social harmony, and concern for close others [38,39].

For example, European American children are more motivated and work harder on tasks that are perceived to be freely chosen, whereas Asian and Asian American children are more motivated and work harder on tasks that are chosen for them by close others [38]. Similarly, personally tailored messages are less effective in non-Western cultural contexts [21*,40]. For people from non-Western cultures that are less likely to value individuality and uniqueness, it

may be important to tailor messages more broadly to important cultural identities, beliefs, and values [17].

Recently, social psychologists experimentally manipulated the content of health messages and found that individualistic messages were more effective for European Americans whereas Asians and Asian Americans were more persuaded by collectivistic health messages [20**]. In this research, European Americans, Asians, and Asian Americans read articles that either focused on the personal consequences of excessive caffeine consumption or the social/relational consequences of excessive caffeine consumption. In both cases the article talked about the link between caffeine consumption and fibrocystic disease, but in the self-focused article participants were informed about how the disease could impact them personally, whereas in the relational-focused article participants were informed about how the disease could impact their friends and family. European Americans were more persuaded by the self-focused article, as evidenced by increased endorsement of the message, increased perceived risk associated with excess caffeine consumption, and increased personal relevance of the message. Importantly, European Americans who received the self-focused article also engaged in healthier behaviors immediately following the experiment (i.e. were less likely to choose caffeinated food options). Asian and Asian American participants, on the other hand, believed it was more important to reduce their caffeine consumption, believed the message was more personally relevant, and were less likely to choose the caffeinated food options if they had read the relationship-focused article [20**].

The above research suggests two potential routes whereby persuasive messages can be tailored to the individual. Personalized tailoring leverages important aspects of an individual's identity, matching the message to relevant beliefs, behaviors, and goals. Cultural tailoring enhances the fit between the message and salient cultural identities as well as values and beliefs considered important by that cultural group. To the extent that the individual has internalized the values and beliefs considered important by their cultural group, cultural tailoring and personalized tailoring may appear similar. But, in addition to emphasizing that the behavior change is consistent with the individual's beliefs and values (employing a similar route as personalized tailoring), cultural tailoring also emphasizes normative information that other in-group members care about the behavior being promoted and compare their current self to normative goals and idealized self [41]. In fact, research has found that, for individuals with a strong cultural identity, cultural tailoring can actually be more effective than personalized tailoring [19].

Toward a contextual understanding of persuasion and behavior change

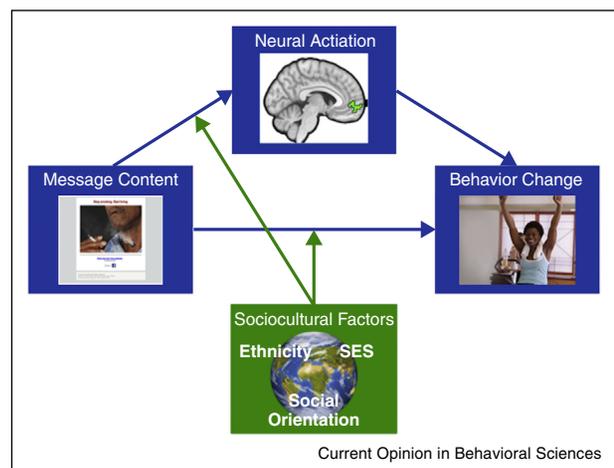
Growing evidence suggests that vmPFC plays a crucial role in promoting behavior change (especially in response

to persuasive messages), but the way in which people respond to different types of health messages might vary across cultures [20**,40], and the types of messages, goals, and reasons that recruit vmPFC and promote behavior change may be fundamentally different across cultures. Moreover, messages that are tailored to the individual's important characteristics lead to greater vmPFC activation and subsequent behavior change [13,23**]. But, the type of characteristics and judgments that activate vmPFC should be influenced by one's chronic cultural frame and other sociocultural factors [42,43**,44,45].

These predictions are reinforced by cultural neuroscience research, which has identified vmPFC as a key region in mediating cultural differences in various types of social judgments (including evaluating the self — [46,47,48*,49]; and empathizing with others — [50]). Moreover, the neural mechanisms that support persuasion seem to be consistent across cultures [51]. Because cultural context is known to influence both what types of persuasive messages lead to behavior change [20**], as well as what types of stimuli activate vmPFC [48*,49] we suggest that combining these insights to explore culturally moderated vmPFC activation in response to persuasive messaging will lend new insight into culturally relevant, persuasion-induced, behavior change (see Figure 1).

This model leads to a number of testable predictions. First, activation in vmPFC should mediate the relationship between message content and behavior change; messages that are perceived as more important to the self and fit with important and salient identities should lead to increased vmPFC activation and subsequent behavior change. Second, sociocultural factors including ethnicity, socioeconomic status, and chronic cultural frame (e.g. individualistic versus collectivistic) should

Figure 1



The effect of message content on behavior change should be mediated by neural activation and moderated by sociocultural factors.

moderate the links between message content, vmPFC activation, and behavior change. Messages that fit with values and beliefs that the individual considers important or that the individual perceives as being important to their cultural group should lead to greater vmPFC activation and subsequent behavior change. For example, personal messages should lead to greater vmPFC activation and subsequent behavior change for people with individualistic cultural frame (versus collectivistic cultural frame) and social messages should lead to greater vmPFC activation and subsequent behavior change for people with collectivistic cultural frame (versus individualistic cultural frame).

Implications for future research

This framework has novel implications for future research directions. For example, our argument focuses on studies of vmPFC and the value that individuals from different backgrounds find in messages; however, additional studies have found that dmPFC is also predictive of behavior change under some circumstances [23^{**},52]. Recent meta-analyses suggest a distinction between the roles of vmPFC and dmPFC in social judgments, such that vmPFC is thought to compute the degree to which an object is relevant, valued, or important to the self, whereas dmPFC is involved in evaluating social information about relevant goals, social norms, and contextual factors in order to make a judgment or decision [9,28] and is recruited by both Americans and Koreans when evaluating persuasive messages [51]. People from collectivist cultures, however, also recruit dmPFC and TPJ when making judgments about the self [43^{**},48^{*}].

One tentative interpretation of this body of work is that vmPFC may index whether the message being presented is relevant and important to the self, which includes cultural cues (e.g. about the individual in Western cultures; about the collective in East Asian cultures). To the extent that social norms and societal expectations are internalized and valued more by people in collectivistic cultures, vmPFC should be more active for people from individualistic cultures presented with personal messages and more active for people from collectivistic cultures presented with social messages. dmPFC may instead evaluate whether the persuasive message fits with relevant social norms, expectations, and information about others' thoughts and opinions and may be recruited whenever people from any culture think about social norms and societal expectations; however, activation in this region may more strongly influence behavior change for people from collectivistic or tight cultures where norms and expectations are paramount. Thus, different types of messages may recruit vmPFC to differing degrees across culture, whereas the importance of dmPFC for evaluating social information and promoting behavior change might be stronger in East Asian cultures than Western cultures.

The extent to which this argument is supported empirically can also help to address a prominent open question in the study of the neuroscience of behavior change; namely, what cognitive processing roles are regions of mPFC playing when people are exposed to persuasive messages that ultimately leads to greater subsequent behavior change? To the extent that vmPFC increases in response to culturally congruent messages (e.g. personal messages in Western, and social messages in East Asian cultures), it would highlight a role for vmPFC as assessing broad fit between personally motivating factors and behavioral outcomes. By contrast, if vmPFC only increased to personal messages across cultures, it would suggest a focus on a more narrow definition of 'self' within vmPFC.

Second, this framework can extend recent work in cultural neuroscience to health behaviors and health decisions, addressing the types of stimuli and contexts that are likely to activate vmPFC and lead to subsequent behavior change across individuals from diverse cultural backgrounds. In the current paper we focused on individualism and collectivism as promising dimensions by which cultural differences in responses to persuasive messages might emerge, although other dimensions may also be involved. Tightness of social rules and norms [53], motivation to avoid uncertain outcomes [54,55], and orientation toward long term versus short term goals [55] have been shown to vary across cultures and may also influence how people respond to health messages (and the degree to which their vmPFC activates in response to these messages).

Conclusions

Combining research on personally and culturally tailored messages with neuroscience research on behavior change suggests fruitful levers through which health advocates and others interested in changing behavior can build interventions. Integrating multiple methods and linking neuroscience with health communications and other data on sociocultural context promises to improve our understanding of what makes some persuasive messages more effective than others [2,56,57] and will enable health advocates to optimize the personal and cultural fit of persuasive messages. Using brain data will increase understanding of not only which messages work better, but why they work better, whether it is through influence of cultural norms and beliefs, group pressure, or match with internalized values, beliefs, and goals. This has the potential to improve health outcomes for individuals from disadvantaged groups currently encountering stark health disparities. Finally, to the extent that sociocultural factors influence the types of persuasive messages that activate dorsal versus ventral mPFC, this could inform our understanding about how the brain works and how cortical structures integrate both internal and external information.

Conflict of interest

Nothing declared.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. Ajzen I: **From intentions to actions: a theory of planned behavior**. In *Action Control*. Edited by Kuhl J, Beckmann J. Springer; 1985:11-39.
2. Berkman ET, Falk EB: **Beyond brain mapping: using neural measures to predict real-world outcomes**. *Curr Dir Psychol Sci* 2013, **22**:45-50.
3. Falk EB, Berkman ET, Mann T, Harrison B, Lieberman MD: **Predicting persuasion-induced behavior change from the brain**. *J Neurosci* 2010, **30**:8421.
4. Cooper N, Tompson S, O'Donnell MB, Falk EB: **Brain activity in self- and value-related regions in response to online antismoking messages predicts behavior change**. *J Media Psychol* 2015. (in press).
Highlights two potential neurocognitive mechanisms by which messages may lead to behavior change. Namely, activation in subregions of vmPFC linked to self and value-related processing predicts subsequent reductions in smoking behavior. Individuals who process the messages as more self-relevant and valued by the self are more likely to subsequently change their behavior.
5. Falk EB, Berkman ET, Whalen D, Lieberman MD: **Neural activity during health messaging predicts reductions in smoking above and beyond self-report**. *Health Psychol* 2011, **30**:177.
6. Falk EB, O'Donnell MB, Cascio CN, Tinney F, Kang Y, Lieberman MD, Taylor SE, An L, Resnicow K, Strecher VJ: **Self-affirmation alters the brain's response to health messages and subsequent behavior change**. *Proc Natl Acad Sci USA* 2015, **112**:1977-1982.
This study provides experimental evidence that self-processing plays a key role in mediating the link between vmPFC activation and behavior change. Specifically, self-affirmation prior to being exposed to health messages promoting increased physical activity led to greater vmPFC activation (relative to presenting the messages without the self-affirmation) and greater subsequent behavior change.
7. Knutson B, Rick S, Wimmer GE, Prelec D, Loewenstein G: **Neural predictors of purchases**. *Neuron* 2007, **53**:147-156.
8. Kuhnen CM, Knutson B: **The neural basis of financial risk taking**. *Neuron* 2005, **47**:763-770.
9. Denny BT, Kober H, Wager TD, Ochsner KN: **A meta-analysis of functional neuroimaging studies of self- and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex**. *J Cogn Neurosci* 2012, **24**:1742-1752.
10. Martinelli P, Sperduti M, Pjolino P: **Neural substrates of the self-memory system: new insights from a meta-analysis**. *Hum Brain Mapp* 2013, **34**:1515-1529.
11. Bartra O, McGuire JT, Kable JW: **The valuation system: a coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value**. *Neuroimage* 2013, **76**:412-427.
12. Cascio CN, Scholz C, Falk EB: **Social influence and the brain: persuasion, susceptibility to influence and retransmission**. *Curr Opin Behav Sci* 2015, **3**:51-57.
13. Chua HF, Liberzon I, Welsh RC, Strecher VJ: **Neural correlates of message tailoring and self-relatedness in smoking cessation programming**. *Biol Psychiatry* 2009, **65**:165-168.
14. Falk EB, O'Donnell MB, Tompson S, Gonzalez R, Dal Cin S, Strecher V and An L: **Functional brain imaging predicts public health campaign success**. *Social Cogn Affect Neurosci* (conditional acceptance).
15. Noar SM, Benac CN, Harris MS: **Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions**. *Psychol Bull* 2007, **133**:673-693.
16. Strecher VJ: **Computer-tailored smoking cessation materials: a review and discussion**. *Patient Educ Couns* 1999, **36**:107-117.
17. Davis RE, Resnicow K: **The cultural variance framework for tailoring health messages**. In *Health Communication Message Design: Theory and Practice*. Edited by Cho H. Sage; 2011: 115-136.
18. Kreuter MW, Lukwago SN, Bucholtz DC, Clark EM, Sanders-Thompson V: **Achieving cultural appropriateness in health promotion programs: targeted and tailored approaches**. *Health Educ Behav* 2003, **30**:133-146.
19. Resnicow K, Davis RE, Zhang G, Konkel J, Strecher VJ, Shaikh AR, Tolsma D, Calvi J, Alexander G, Anderson JP *et al*: **Tailoring a fruit and vegetable intervention on novel motivational constructs: results of a randomized study**. *Ann Behav Med* 2008, **35**:159-169.
20. Uskul AK, Oyserman D: **When message-frame fits salient cultural-frame, messages feel more persuasive**. *Psychol Health* 2010, **25**:321-337.
Demonstrates that the match between an individual's chronic cultural orientation (i.e. independence or interdependence) and message content is an important factor predicting subsequent behavior change. European Americans primed with independence and exposed to self-focused messages were more persuaded and more likely to subsequently change their behavior, whereas Asians primed with interdependence and exposed to relationship-focused messages were more persuaded and more likely to subsequently change their behavior.
21. Lustria MLA, Noar SM, Cortese J, Van Stee SK, Glueckauf RL, Lee J: **A meta-analysis of web-delivered tailored health behavior change interventions**. *J Health Commun* 2013, **18**:1039-1069.
This meta-analysis examines personally tailored health messages and finds that web-based tailored interventions are significantly more effective than non-tailored interventions. Interestingly, the effect of personal tailoring appears to be stronger in US samples than non-US samples, suggesting some cultural differences in the effectiveness of personalized messages.
22. Jensen JD, King AJ, Carcioppolo N, Davis L: **Why are tailored messages more effective? A multiple mediation analysis of a breast cancer screening intervention**. *J Commun* 2012, **62**:851-868.
23. Chua HF, Ho SS, Jasinska AJ, Polk TA, Welsh RC, Liberzon I, Strecher VJ: **Self-related neural response to tailored smoking-cessation messages predicts quitting**. *Nature* 2011, **20**:426-427.
One of the first studies to use fMRI to predict behavior change in the health domain, this study found that people trying to quit smoking cigarettes showed greater dorsal mPFC activation in response to tailored anti-smoking messages (relative to non-tailored messages). Importantly, this increased activation to tailored messages predicted whether the smokers were successful at quitting smoking.
24. Falk EB, Berkman ET, Lieberman MD: **From neural responses to population behavior: neural focus group predicts population-level media effects**. *Psychol Sci* 2012, **23**:439-445.
25. Knutson B, Wimmer GE, Rick S, Hollon NG, Prelec D, Loewenstein G: **Neural antecedents of the endowment effect**. *Neuron* 2008, **58**:814-822.
26. Kim K, Johnson MK: **Extended self: medial prefrontal activity during transient association of self and objects**. *Social Cogn Affect Neurosci* 2010, **7**:199-207.
27. Kim K, Johnson MK: **Extended self: spontaneous activation of medial prefrontal cortex by objects that are 'mine'**. *Social Cogn Affect Neurosci* 2013, **9**:1006-1012.
28. van der Meer L, Costafreda S, Aleman A, David AS: **Self-reflection and the brain: a theoretical review and meta-analysis of neuroimaging studies with implications for schizophrenia**. *Neurosci Biobehav Rev* 2010, **34**:935-946.
29. McNamee D, Rangel A, O'Doherty JP: **Category-dependent and category-independent goal-value codes in human ventromedial prefrontal cortex**. *Nat Neurosci* 2013, **16**:479-485.

30. Hare TA, Malmaud J, Rangel A: **Focusing attention on the health aspects of foods changes value signals in vmPFC and improves dietary choice.** *J Neurosci* 2011, **31**:11077-11087.
31. Fishbein M, Ajzen I: *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research.* Reading, MA: Addison-Wesley; 1975.
32. Cialdini RB, Kallgren CA, Reno RR: **A focus theory of normative conduct: a theoretical refinement and reevaluation of the role of norms in human behavior.** *Adv Exp Soc Psychol* 1991, **24**:1-243.
33. Riemer H, Shavitt S, Koo M, Markus HR: **Preferences don't have to be personal: expanding attitude theorizing with a cross-cultural perspective.** *Psychol Rev* 2014, **121**:619-648.
- The authors propose a model of attitudes, preferences, and norms, and suggest that culture may influence the degree to which personal preferences, descriptive norms, and situational context predict real-world behavior.
34. Markus HR, Kitayama S: **Culture and the self: implications for cognition, emotion, and motivation.** *Psychol Rev* 1991, **98**:224-253.
35. Kim HS, Markus HR: **Deviance or uniqueness, harmony or conformity? A cultural analysis.** *J Pers Soc Psychol* 1999, **77**:785-800.
36. Kim HS, Sherman DK: **"Express yourself": culture and the effect of self-expression on choice.** *J Pers Soc Psychol* 2007, **92**:1-11.
37. Markus HR, Schwartz B: **Does choice mean freedom and well-being?** *J Consum Res* 2010, **37**:344-355.
38. Iyengar SS, Lepper MR: **Rethinking the value of choice: a cultural perspective on intrinsic motivation.** *J Pers Soc Psychol* 1999, **76**:349-366.
39. Na J, Kitayama S: **Will people work hard on a task they choose? Social-eyes priming in different cultural contexts.** *J Exp Soc Psychol* 2012, **48**:284-290.
40. Davis S: **The influence of collectivistic and individualistic value orientations on the acceptance of individually tailored Internet communications.** *Interface* 2008, **8**:17-32.
41. Hecht ML, Choi HJ: **The communication theory of identity as a framework for health message design.** In *Health Communication Message Design: Theory and Practice.* Edited by Cho H. Sage; 2011:137-150.
42. Han S: **Understanding cultural differences in human behavior: a cultural neuroscience approach.** *Curr Opin Behav Sci* 2015, **3**:68-72.
43. Han S, Ma Y: **Cultural differences in human brain activity: a quantitative meta-analysis.** *Neuroimage* 2014, **99**:293-300.
- The authors conducted a meta-analysis of fMRI studies that employed a comparison of individuals from different cultures. They found that, across different types of social, cognitive, and affective tasks, people from Western cultures were more likely to recruit ventral medial prefrontal cortex and anterior cingulate cortex whereas people from Asian cultures were more likely to recruit dorsal medial prefrontal cortex, lateral prefrontal cortex, and temporoparietal junction.
44. Hyde LW, Tompson S, Creswell JD, Falk EB: **Cultural neuroscience: new directions as the field matures.** *Cult Brain* 2015, **3**:75-92.
45. Kitayama S, Tompson S: **Envisioning the future of cultural neuroscience.** *Asian J Soc Psychol* 2010, **13**:92-101.
46. Chen PHA, Wagner DD, Kelley WM, Heatherton TF: **Activity in cortical midline structures is modulated by self-construal changes during acculturation.** *Cult Brain* 2015, **3**:39-52.
47. Huff S, Yoon C, Lee F, Mandadi A, Gutches AH: **Self-referential processing and encoding in bicultural individuals.** *Cult Brain* 2013, **1**:16-33.
48. Ma Y, Bang D, Wang C, Allen M, Frith C, Roepstorff A, Han S: **Sociocultural patterning of neural activity during self-reflection.** *Soc Cogn Affect Neurosci* 2014, **9**:73-80.
- This study scanned Danish and Chinese participants while they made judgments about whether trait words described themselves (versus control judgment). The authors found that Chinese participants were more likely to recruit temporoparietal junction to make these judgments whereas Danish participants were more likely to recruit medial prefrontal cortex, and these cultural differences were mediated by differences in interdependence.
49. Zhu Y, Zhang L, Fan J, Han S: **Neural basis of cultural influence on self representation.** *Neuroimage* 2007, **34**:1310-1317.
50. Meyer ML, Masten CL, Ma Y, Wang C, Shi Z, Eisenberger NI, Han S: **Empathy for the social suffering of friends and strangers recruits distinct patterns of brain activation.** *Social Cogn Affect Neurosci* 2012, **8**:446-454.
51. Falk EB, Rameson L, Berkman ET, Liao B, Kang Y, Inagaki TK, Lieberman MD: **The neural correlates of persuasion: a common network across cultures and media.** *J Cogn Neurosci* 2010, **22**:2447-2459.
52. Wang AL, Ruparel K, Loughhead JW, Strasser AA, Blady SJ, Lynch KG, Langleben DD: **Content matters: neuroimaging investigation of brain and behavioral impact of televised anti-tobacco public service announcements.** *J Neurosci* 2013, **33**:7420-7427.
53. Gelfand MJ, Raver JL, Nishii L, Leslie LM, Lun J, Lim BC, Duan L, Almaliaich A, Ang S, Arndottir J et al.: **Differences between tight and loose cultures: a 33-nation study.** *Science* 2011, **332**:1100-1104.
54. Hofstede G: *Organizations and Cultures: Software of the Mind.* McGraw-Hill; 1991.
55. Aaker JL, Lee AY: **"I" seek pleasures and "we" avoid pains: the role of self-regulatory goals in information processing and persuasion.** *J Consum Res* 2001, **28**:33-49.
56. O'Donnell MB, Falk EB: **Linking neuroimaging with functional linguistic analysis to understand processes of successful communication.** *Commun Methods Meas* 2015, **9**:55-77.
57. O'Donnell MB, Falk EB: **Big data under the microscope: using brains, networks and language to link individual and population level data.** *Ann Am Acad Pol Soc Sci* 2015, **659**:274-289.