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Culture, Mind, and the Brain:

Current Evidence and Future Directions

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INTRODUCTION

The history of the study of culture in psychology can be traced back at least to the very early days of empirical psychology (Cole 1996; Jahoda 1993). As a modern discipline, however, cultural psychology was re-discovered and re-born around the year 1990. Jerome Bruner (1990) emphasized canonical cultural scripts as a source of meanings that are deeply ingrained in every human action. Further, Richard Shweder (1991) brought together several strands of thought related to the interface of culture and the mind, and memorably observed that "culture and the psyche make each other up." Around the same time, the field also witnessed some highly influential reviews of empirical evidence for cultural influences on human psychology (Markus & Kitayama 1991; Triandis 1989). These reviews demonstrated substantial cross-cultural variation in psychological processes, thereby showcasing the possibility that many psychological processes might be linked systematically, and much more closely than had ever before been imagined, to certain aspects of socio-cultural contexts (Campbell, 1975).

As seen in several Annual Review chapters on culture and psychology published since the year 1990 (see e.g., Heine & Buchtel 2009; Gelfand et al. 2007a for the most recent chapters), the last two decades have seen a considerable progress. Much of this work initially focused on systematic comparisons between Western cultures (as exemplified by North American cultures) and Eastern cultures (as exemplified by East Asian cultures) (e.g., Kitayama et al. 2006a; Markus & Kitayama 1991; Nisbett et al. 2001). Unlike its predecessors that used surveys as the primary instrument (e.g., Hofstede 1980), this new work relied much more heavily on experimental methods and suggested that some fundamental aspects of basic psychological processes such as cognition, emotion and motivation can be systematically

influenced by culture. Although this work was guided by the general hypothesis that social orientation of independence vs. interdependence or individualism vs. collectivism is a key dimension underlying the cultural variation (Markus & Kitayama 1991; Triandis 1989), researchers have also examined alternative dimensions including honor (Nisbett & Cohen 1996), tightness (Gelfand et al. 2007b), religiosity (Cohen & Rozin, 2001), and hierarchy (Shavitt et al., 2010) among others.

More recently, the field has become increasingly more diverse in empirical content and more mature in theoretical orientation. This change is evident in a greater focus on mechanisms of cultural influence (Lehman et al. 2004; Schaller & Crandall 2004). A number of researchers have focused on cognitive mechanisms that mediate cultural influences with ingenious use of priming techniques. A situated cognition approach of Oyserman and colleagues (e.g., Oyserman & Lee 2008) conceptualizes culture as a bundle of cues that effectively activate independent or interdependent social orientations; whereas a dynamic constructivist approach of Hong and colleagues (e.g., Hong et al. 2000) hypothesizes that cultural knowledge becomes highly accessible and, as such, most likely to be brought to bear on social judgment and behavior when people have higher needs for cognitive closure. Although different, these approaches share the assumption that culture influences social judgment and behavior by activating relevant cognitive representations, such as independence and interdependence.

Important as these new developments clearly are, however, cognition might not be the only place where underlying mechanisms can be fruitfully sought. Some other researchers have remained true to an earlier insight of culture as fundamentally collective (e.g., Cohen 1998; Kitayama et al. 1997; Markus & Kitayama 2004). As noted by some founding parents of the research on culture (Kroeber & Kluckhohn 1952; Shweder & Bourne 1984), culture may be defined best at macro, ecological, and societal levels in terms of values (general goal states) and practices (behavioral routines often designed to achieve the values) that are collectively distributed and, to some important extent, shared. These ideas and practices vary as a function

of ecology, economy, and other social structural factors. These researchers have sought to go beyond the East-West paradigm by looking at effects of some macro-level variables including regions (Varnum et al. 2010), subsistence systems (Uskul et al. 2008), social class (Snibbe & Markus 2005), residential mobility (Oishi 2010), and settlement (Kitayama et al. 2006). Major theoretical efforts have been devoted to the understanding of production and dissemination of cultural ideas and practices (e.g., Kitayama et al 2010; Richerson & Boyd 2005; Schaller & Crandall 2004; Sperber 1996). Much of this work can be united by its commitment to the hypothesis that it is behaviors and shared social representations in a collective, social context, *not* cognitive representations in the head *per se*, that ultimately matter most in understanding culture.

It might strike one as paradoxical to state that the commitment to the collective level reality of culture has recently begun highlighting the brain as a crucial site of cultural influence. After all, the brain is a biological entity that would seem much "deeper" than cognition and, in that sense, diametrically opposite to the collective culture as research foci. In fact, the focus on the brain might seem unforgivably reductionistic. However, there is an important logical linkage that deserves an emphasis. As noted, public behavioral patterns that are afforded by myriad macro-level factors are central in defining culture. At the same time, recent work on neuroplasticity has suggested that such public patterns of behavior, over a number of repeated occurrences, are likely to cause systematic changes in neural connectivity of the brain (Anderson 2009). It is thus reasonable to hypothesize that recurrent, active, and long-term engagement in scripted behavioral sequences (what we call cultural practices or tasks) can powerfully shape and modify brain pathways (Kitayama & Park 2009). The influence of cultural behaviors on the brain, then, is unmediated by any symbolic or cognitive representations. The culture-mind interface could be much more "hard" and behavioral (Zajonc & Markus 1984), rather than "soft" and cognitive, than one might imagine based on the cognitive theories. Admittedly, cognitions such as self-concepts, identities, and attitudes can powerfully influence

which values one may endorse or which practices one may engage in as his or her life tasks. Nevertheless, once individuals define their own cultural tasks and begin practicing them, the resulting cultural behaviors will directly influence the brain. This insight would lead the field naturally to explorations into the link between culture and the brain (e.g., Chiao & Ambady 2007; Fiske 2009; Han & Horthoff 2008; Kitayama & Park 2009).

In our assessment, then, after the early infatuation with a bold idea that the mind itself might vary across cultures and after the intervening years of the earnest effort to document, one by one, the East-West differences that are both sizable and deep (see e.g., Kitayama & Cohen 2007; Markus & Kitayama 2010, for reviews), cultural psychology has gradually come of age, aspiring to be a mature empirical discipline committed to the theoretical understanding and explication of the interrelations among culture, mind, and the brain. Human psychological processes and functions are linked, on the one hand, to various macro-level factors, which are involved in the production, dissipation, and adoption of a variety of cultural ideas such as values and beliefs, practices, and tasks. They are also tied, on the other hand, to brain processes that plastically change as a function of one's engagement in the ideas, practices, and tasks of the culture.

The goal of this Annual Review chapter is to take stock of the two recent developments in the study of culture in psychology, thereby to project this knowledge to the future of the discipline. We will first present an overarching theoretical framework that regards the brain as one crucial site that accumulates effects of cultural experience. This cultural experience is patterned and organized by cross-generationally transmitted values and associated practices that are formed as a function of a variety of collective-level factors including ecology, economy, and other social structural variables. In the second section, we examine some of these macro-level factors that foster these social orientations. The focus of the third section is cultural influences on the brain. Finally, we will conclude with a brief discussion of future directions of research on culture, mind and the brain.

A Model of Neuro-Culture Interaction

Our discussion so far implies that once individuals define for themselves a particular set of cultural practices as their tasks and repeatedly engage themselves with these tasks, the resulting cultural behaviors have systematic influences on the brain. This basic premise of our analysis, however, needs to be expanded in two ways. First, it is important to specify the processes by which a set of cultural practices are made available in a given cultural context and, further, by which individuals choose some of them as their cultural tasks. Second, it is also necessary to understand what consequences the cultural influences on the brain would have on each individual's ability to achieve cultural and, eventually, biological adaptation. Our model depicting the interaction between culture and the brain, called the neuro-culture interaction model, is designed to address these two issues. The model, shown in Figure 1, is based on several important assumptions.

Collective-level reality of culture. The model is grounded in a view, consensually accepted by both past (e.g., Kroeber & Kluckhohn 1952) and current researchers (e.g., Bruner 1990; Markus & Kitayama 2010; Shweder & Bourne 1984), that culture is best conceptualized as a collective-level phenomenon that is composed of both socially shared meanings such as ideas and beliefs and associated scripted behavioral patterns called practices, tasks, and conventions. These ideas and practices are quite variable both within and between cultures. Elaborating on this conception of culture, we suggest that culture can be conceptualized as an amalgam of both cross-generationally transmitted values and corresponding scripted behavioral patterns called practices (Kitayama et al. 2009; Kitayama & Park 2009). These two components of culture are anchored in icons, stories, and other ideational elements of culture to be situated in a given place and time.

One dimension that has proven useful in describing observed variations in culture is the dimension of independence versus interdependence (Markus & Kitayama 1991) or individualism versus collectivism (Triandis 1995). Both independence (e.g., self-promotion, self-expression, and self-sustenance) and interdependence (e.g., social harmony and coordination, relational attachment, and social duties) are necessary for all humans, and these two sets of goals and tasks are available in all cultures. At the same time, however, both independence and interdependence require psychological resources to carry out and, moreover, they are sometimes in conflict with one another. Thus, any given individuals and groups must often place different priorities. As a function of a variety of ecological and societal factors, Western societies have historically placed a greater emphasis on independence over interdependence (i.e., more individualistic), whereas Eastern societies have given priority to interdependence over independence (i.e., more collectivistic) (Kitayama et al. 1997; Markus & Kitayama 1991; 2010; Shweder & Bourne 1984; Triandis 1989; 1995). This assumption has been used to integrate a large and growing body of cross-cultural literature.

Factors inducing independence and interdependence. As collective-level realities of culture, constituted by values and practices, independence and interdependence are likely to be afforded by various collective-level factors (Box 1 in Figure 1). Further, cross-regional dissemination of values and practices and subsequent adoption of them by people in different regions or cultures has proved to be equally important. It is fair to summarize this literature by noting that, on the one hand, cold and dry environment, combined with high residential or geographical mobility and low population density, which are often linked with nomadic and herding life styles at least historically, lends itself to a greater emphasis on independence over interdependence. On the other hand, warm and humid environment, combined with low residential or geographic mobility and high population density, which are linked, at least traditionally, to farming life style, gives rise to a greater emphasis on interdependence over independence.

Cultural participation, identity formation, and brain change. Any given culture offers a number of practices. For example, contemporary American culture offers a number of practices designed to achieve the overarching cultural values of independence such as self-promotion, self-expression, strong leadership, and so on. We assume that as each individual gradually forms his or her own self-identity, the individual chooses from the pool of available practices the ones that suit his or her developing identity best and incorporate them as their cultural tasks – tasks they perform repeatedly and earnestly to become a respectable member of the culture (Boxes 2 and 3). Nancy may become a good cultural member by trying "to be unique" in most situations whereas David may do so by trying "to be argumentative." We assume that there are substantial individual differences in both the kind of practices that are chosen as one's own cultural tasks and the degree of commitment to the identity formation that goes along with the foundational values of one's cultural group. If, for example, Nancy believed herself to be a very independent person she would pursue the task of "being unique" quite consistently and willingly, whereas if David did not hold this belief as strongly, his engagement in his own cultural task of "being argumentative" would be less consistent and less earnest.

As a result of repeated, sustained engagement in cultural tasks, relevant brain pathways are likely to change (Box 4). As noted by a number of neuroscientists who study neuroplasticity, neurons that are fired together will get wired together. This Hebbian principle of long-term potentiation, if adequately expanded to include possible macro-level rewiring across subsystems of the brain (Anderson 2009), can provide a simple, yet believable mechanism by which behavioral patterns (as defined by cultural tasks) plastically shape the actor's brain. What results will be culturally induced activation patterns of the brain that support the person when he or she intends to perform his or her cultural tasks.

One clear indication that a cultural conditioning of the brain is in fact taking place comes from the last two decades of research in cultural psychology that compared people in Eastern cultures (mostly East Asians) and those in Western cultures (mostly North Americans). This

work shows, for example, that as compared to interdependent Easterners, independent Westerners are more likely 1) to define the self in terms of personal (vs. relational or collective) attributes in context-general fashion (Cousins 1989; Rhee et al. 1995; Triandis 1995), 2) to seek the self's uniqueness (vs. similarity with ingroup members) (Kim & Markus 1999), 3) to perceive another person's behaviors as internally motivated even in the presence of situational constraint (Choi et al. 1999; Kitayama et al. 2009), 4) to focus their attention on a focal object in lieu of its context, instead of holistically attending to the entire scene (Kitayama et al. 2003; Masuda & 2001), 5) to use verbal code in problem solving (Kim 2002) and more linear in reasoning (Nisbett et al 2001); 6) to experience personal (vs. social) happiness (Kitayama et al. 2006b), 7) to focus on positive (vs. negative) features of the self (Heine et al 1999), 8) to show a greater self-serving or self-enhancing bias (Heine et al 1999), 9) to seek to influence (rather than adjust to) the social surrounding (Morling et al 2002), and 10) to place significance to personal (vs. public) decisions and choices (Iyengar & Lepper 1999; Kitayama et al 2004). As we shall see later in this chapter, recent neuroscience work has begun to uncover neural underpinnings of many of these cultural differences.

Situational norm, socially situated behavior, and adaptation. The above discussion should not be taken to imply that individuals always act as dictated by their culture. To the contrary, behaviors are extremely flexible and can be finely regulated by situational norms and relevant concerns (e.g., Zou et al 2009). Culturally shaped activation patterns of the brain, however, would enable the person to perform culturally scripted behaviors (for example, "to be unique" or "to be argumentative") when these very behaviors are called for by the specific situation at issue so that the person can enact the required behaviors both automatically and seamlessly (Box 5). Because the behaviors are spontaneous, they will be perceived as internally motivated and, thus genuine by the self and others alike, which in turn will affirm their status as cultural members of good standing in the eyes of both the individuals themselves (i.e., cultural identities) and the community at large (i.e., reputations) (Box 6), which will in turn

increase the chance of eventual biological adaptation as assessed by reproductive success (Box 7). It may therefore be anticipated that culture can serve as a potentially potent selective force in biological evolution (e.g., Laland et al. 2010).

Two Important Questions

The model illustrated in Figure 1 places key roles in two important processes. The first process involves the way in which both values and practices of culture become constitutive elements of collective realities. It may be anticipated that various macro-level features of the world we live in are likely to influence this process. The second concerns the relatively long-term change in the brain that is expected to occur as a result of sustained engagement in the collective reality of culture. In particular, we hypothesized that such change happens as a result of sustained engagement in cultural practices each individual chooses and adopts as his or her own tasks to achieve the culture's foundational values and, thus, to be a respectable cultural member, thereby enhancing the chance of adaptation in the culture.

Now we turn to each of these two issues. First, we will discuss how the collective realities of culture may be constructed by focusing on both production and adoption of cultural values and practices. Second, we will review available cultural neuroscience studies to assess the currently available evidence on the hypothesized cultural shaping of the brain.

COLLECTIVE-LEVEL REALITY OF CULTURE

In this section of the chapter, we will review currently available evidence for factors that are implicated in the change of culture, with a focus on independence and interdependence. We will start by distinguishing between two processes involved in cultural change, namely, production and adoption of cultural values and practices. This brief discussion is followed by a review of factors linked to the production of independence or interdependence. We will then

consider factors involved in the adoption of existing values and practices. This section will conclude with a brief discussion on possible gene-culture interactions.

Production and Adoption Processes in Cultural Change

In theorizing the process of cultural change, both production of new practices and dissipation and eventual adoption of existing practices must be taken into account. One recent hypothesis is that novel values and practices may be produced when there is a dire need for them because of a threat to biological, economic, and political survival (Kitayama et al. 2010). For example, new practice of independence may have been produced in large quantity in the wild frontier of the American West during the 18th and 19th century. Independent practices that highlight, for example, self-promotion, self-protection, and hard work motivated by self-efficaciousness might be an adaptation to the harsh ecological environment with minimal social infrastructures during that period. Furthermore, once new values have been established, they are likely to be transmitted vertically because inculcation of values – especially those that are deep and strong, requires an assortment of supportive beliefs and emotional conditionings and, as such, may be best accomplished by parents and other long-term care takers such as neighbors and teachers (Schönpflug 2009).

Adoption of existing practices from other cultural regions or groups may be very different. One important factor that motivates people to adopt existing practices is a desire to win within-group social competition for status and prestige (Kitayama et al. 2010). Adoption is likely to be most effective for those aspects of culture that can be easily imitated. Cloths and other aspects of fashion are highly imitable. So are a number of overt behavioral characteristics. Practices may be more likely to be adopted if they confer high social prestige and status on the adoptees (Richerson & Boyd 2005). For example, Kitayama et al (2010) argue that the frontier practices of independence were likely propagated backwards to Eastern, non-frontier regions of the U.S. through this mechanism. Because adoption occurs through imitation, it can happen quite rapidly through space and time. Geographic spread of, for example, fashion can be quite

rapid. Likewise, as scripted behavioral routines, cultural practices can also travel through space with relative ease.

Production of Independent and Interdependent Values and Practices

Ecology. Defined in terms of climate and various geographic features (Berry 1976; Diamond 1997; Georgas & Berry 1995), ecology has direct impacts on flora and fauna and thus availability of food, thereby shaping settlement patterns (e.g., nomadic or sedentary), demographic distributions (dispersed in small groups or densely concentrated in large units), economic, political and educational systems (Georgas & Berry 1995), and the emergence of symbolically marked groups (Boyd & Richerson 1985; McElreath, et al. 2003). As such, ecology can have substantial impacts on psychological processes by affording different socio-cultural systems – particularly, subsistence systems. One well-tested idea is that herding and nomadism require independent style social behaviors and associated psychological features such as assertiveness, competition, and individual decision-making (but see also Paciotti et al. 2005), whereas farming and, to some extent, family-based fishing encourage interdependent style social behaviors and associated psychological features such as collaboration and sedentary lifestyle. For example East African farmers were found to consult each other more frequently and act less individually than East African herders (Edgerton 1965). A large crossnational comparison showed that socialization practices of agricultural societies tend to foster compliance, conscientiousness, and conservatism, whereas those in hunting and gathering societies encourage independent decision making, individualism, assertiveness, and risk-taking (Barry et al. 1959).

Independent social orientation is often associated with a decontextualized, analytic mode of thought, whereas interdependent social orientation is associated with a contextualized, holistic mode of thought (Varnum et al 2010). Consistent with this, Berry (1966) found that in comparison to Eskimo hunters and gatherers of the Baffin Island in Canada, Temne farmers of Sierra Leone had a greater difficulty in disentangling objects from their surrounding field. Berry

and colleagues (1986) made a similar point in a comparison between agriculturalist Bagandu villagers with hunter-gatherer Biaka pygmies of the Central African Republic. A strong demonstration of the same point was also obtained by Uskul and colleagues (2008), who focused on neighboring villages in the eastern Black Sea region of Turkey that share nationality, language, and numerous aspects of culture except for the mode of production. Relative to the members of sedentary farming communities and cooperative small-scale fishing communities, those in herding communities were more analytic in cognitive style in that their decisions were rule-based (rather than similarity-based), their classification was category-based (rather than thematically based) and their attention was more focused (rather than holistic).

Economic development and industrialization. Commercialization and industrialization may foster independence because they require independent decisions and judgments as well as interaction with people outside of one's immediate community. Evidence has been obtained in a study on Mayan communities that vary in the degree of commercialization (vs. agriculture) (Loucky 1976). An extensive cross-cultural experiment with an economic game has suggested that industrialization is linked to the emergence of the sense of fairness (Heinrich et al. 2009).

A recent longitudinal study in Zinantec Mayan communities in Chiapas, Mexico find that, over a period of 30 years, a shift from agricultural subsistence to entrepreneurial commerce was associated with a change from a conservative weaving apprenticeship (emphasizing compliance to the master) to an innovative apprenticeship (featured by learner independence and experimentation) (Greenfield et al. 2003). Moreover, this change in social organization was associated with a shift from concrete to abstract representation of weaving patterns. An extensive, 30 year-long study in Turkey (Kağıtçıbaşı & Ataca 2005) observed that children were increasingly more likely to be appreciated for their psychological values rather than their utilitarian, material values (e.g., as labor force) from the 1980s onwards. Increasing wealth is a likely reason for this change. Using the World Value Survey, Inglehart & Baker (2000) find that over the span of 10-20 years since the 1980s, most countries of the world shifted their values in

the direction of self expression (as opposed to survival). The only exception to this general trend is a cluster formed by ex-communist countries in Eastern Europe, where economy (as well as political systems) collapsed during the period.

Socio-economic status. Distribution of resources -- including economic, educational, and symbolic ones, within a given society is discussed under the rubric of socio-economic status (SES) (e.g., Hauser & Warren 1997). The foregoing discussion suggested that amount of resources (as assessed by industrialization and urbanization) is associated with independent practices. Extrapolating from this literature, it would seem reasonable to expect that SES within a given society is also associated with independence. Consistent with this reasoning, higher SES is positively associated with a number of psychological features related to independence including personal mastery (Lachman & Weaver 1998) and self-directedness (Kohn & Schooler 1983). More recently, Markus and colleagues (Snibbe & Markus 2005; Stephens et al. 2007) have employed a series of experimental tasks involving choice to show that middleclass (i.e., college-educated) individuals are more likely than working class (i.e., high-school-educated) individuals to express uniqueness and seek control. For example, middle class (but not working class) participants like their choices less when they are constrained. In fact, middle class participants justify their freely made choice more (Snibbe & Markus 2005). Moreover, unlike working class participants, who seek their likeness to their fellow workers through their choice, middle class participants seek personal distinctiveness through their choice (Stephens et al. 2007).

If independent social orientation promotes more analytic (vs. holistic) mode of thought, middleclass individuals may prove to be more analytic than working class individuals. In a large-scale community-based study, middle class individuals (defined by both educational attainment and occupational prestige) were found to be more analytic than their working class counterparts in terms of attention to an object (vis-à-vis its visual context), greater use of semantic categories (rather than thematic associations) in classification, and a more linear (vs. dialectic) view of

change (Na et al. 2010). A similar pattern has been obtained by Kraus et al. (2009), who used a subjective indicator of social class and found that analytic mode of thought becomes more prominent as a function of perceived social class. An analogous social class difference has been observed not only in the US but also in Russia (Grossmann & Varnum 2010).

Residential mobility. As compared to individuals living in a relatively small and stable community for an extended period of time, individuals who are more mobile, changing their residence often are more likely to ground their selves and identities on relatively stable internal attributes such as personality traits, abilities, and skills of the self rather than on social roles and positions within a community. As may be predicted, as compared to non-movers, frequent movers are more likely to rate personality traits as more central and group affiliations as less central in their identity and have an extensive friendship network (Oishi 2010). Intriguingly, baseball fans in residentially stable cities tend to support their local professional baseball teams even when the teams are struggling (showing a strong sense of one's identity to their own local teams), but those in residentially mobile cities tend to support their teams only when the teams play well and, thus, they are instrumental in boosting their individual self-esteem (Oishi et al. 2007).

Residential mobility may account, at least in part, for the cross-cultural differences between more mobile Americans and more sedentary Asians (Sato et al. 2008). In all likelihood, however, the causal relationship between residential mobility and independence is bi-directional: residential mobility can enhance the independence of the self while at the same time an independent construal of the self motivates individuals to move from one place to the next depending on their own personal goals and desires (see Chen et al. 2009, for a similar point made in respect to occupational mobility). This issue deserves more careful attention in future work.

Pathogen susceptibility. One novel idea purported to account for cultural collectivism (vs. individualism) comes from evolutionary psychology. Thornhill and colleagues (e.g., Fincher et al.

2008) have argued that in addition to a sophisticated biological immune system designed to detect and kill or neutralize various pathogens, humans have evolved a "behavioral immune system," which seeks to prevent the pathogens from coming into contact with the body in the first place. Individuals are therefore predisposed to avoid groups or individuals that are likely to pose an increased threat of contagion especially when they are vulnerable (see also McElreath et al. 2003).

In support of this idea, xenophobic responses are stronger among people whose biological immune systems are temporarily compromised (Navarrete et al. 2007) and are amplified by disease cues (Faulkner et al. 2004). Moreover people with greater chronic worries about disease demonstrate stronger negative responses to foreign ethnic groups (e.g., Faulkner et al. 2004). These individual-level correlations are mirrored at the cultural level. Using an index of historical prevalence of infectious diseases in dozens of countries worldwide, Schaller & Murray (2010) showed that ecological variability in disease prevalence predicts cross-cultural variability in xenophobia.

Because exclusion of outgroup members, of which xenophobia is an extreme example, is more common in collectivistic cultures (Triandis 1995), collectivism in general might also be associated with pathogen susceptibility. It might be the case that tight social control associated with collectivism is a defensive response to a chronic pathogen threat the society faces over time. Consistent with this reasoning, Fincher et al. (2008) have shown that disease prevalence – especially the historical (rather than contemporary) prevalence, correlates positively with collectivism and negatively with individualism even after controlling for a number of potentially confounding country-level variables such as GDP per capita, inequity in the distribution of wealth, population density, and life expectancy.

Voluntary frontier settlement. In their voluntary settlement hypothesis, Kitayama and colleagues have proposed that voluntary settlement in sparsely populated, novel environments that impose significant survival threats, such as the Western frontier in the U.S. during the 18-

19th century, breed strong values and associated practices and mentalities of independence (Kitayama et al 2010). This hypothesis integrates some of the considerations noted above: Low population density and high residential or geographic mobility, in combination, would make it very hard to form stable, reciprocal social relations. Further, given these ecological conditions, herding provides a viable economic means. In addition, low population density, combined with cold and dry climate especially in winter times, may substantially reduce the susceptibility to pathogens. The frontier conditions multiply defined by the factors noted above may then be expected to foster a strong cultural ethos of independence. Equally important, such regions may well attract people who are independently minded.

The voluntary settlement hypothesis provides a sensible interpretation for the finding that North Americans are quite independent (as assessed by several implicit indicators such as dispositional attribution, personal [vs. social] happiness, and self-enhancement), even in comparison to Western Europeans such as the English and Northern Germans (Kitayama et al. 2009). Further evidence indicates that similar frontier conditions breed independence even outside of the West. In particular, residents of a northern island of Japan (Hokkaido), the island that has a recent, 100 years history of massive settlement by ethnic Japanese, have been shown to be more independent than a comparable group of mainland Japanese (Kitayama et al. 2006).

Turning to within U.S. regional differences, Vandello & Cohen (1999) used census data to examine several face-valid behavioral indicators of individualism, such as percent of people living alone, divorce to marriage ratio, and percent of people voting libertarian in past presidential elections. As expected, the Mountain West, western states in the Great Plain, and the Pacific Northwest were the most individualistic in this criterion. Further, Plaut and colleagues (Plaut et al. 2002) have observed similar differences in well-being and self. In a more recent study, Park and colleagues (2010) had college students in four flagship state universities report their value priorities and found that values of both individualism (defined positively by e.g., self-

direction and negatively by e.g., conformity) and anti-power (defined positive by e.g., benevolence and negatively by e.g., power) are systematically higher in a Western region (Montana) than in Eastern regions (Massachusetts and Georgia). Curiously, in this study the pattern in Michigan was closer to the pattern in Montana due, perhaps, to a sustained period of frontier historically. The regional variation was evident only for those students all of whose ancestors were born in the U.S. over three successive generations, suggesting the significance of family lineage in transmission of cultural values. Future work should explore other frontier regions of the world to refine the original hypothesis.

Adoption Process

So far, our discussion has focused on the production of new values and practices of independence or interdependence. To complete our discussion, it is important to note that cultural change can also occur as a result of adoption of existing values, practices, and associated ideas from other cultures and regions (Box 1 of Figure 1). Whereas the production of values and practices are likely to be motivated by need to achieve biological, economic, and political survival, the adoption of existing values and practices is likely to be motivated by very different concerns. Following an earlier analysis by Richerson and Boyd (2005), Kitayama et al. (2010) have argued that when people experience no major threat to their survival, culture is used as a means for social competition for status and prestige within one's own community and, as a consequence, practices and other aspects of higher-status groups are likely to be imitated and adopted by lower-status groups (Henrich & Gil-White 2001). In understanding the adoption process, several considerations are important.

*In*adoptability of values. Cultural values – at least the values that are long-lasting and that provide foundations of a given cultural group such as Confucianism in East China or Protestantism in Western Europe and North America – are quite deep and strongly held in that they are embedded in a rich array of associated beliefs and a cascade of emotional conditionings. The cognitive and emotional structure that anchors the foundational cultural

values is not easy to adopt. For one thing, it is not easily observable. But more importantly, this underlying psychological structure will have to be inculcated through long-term socialization process by care takers such as parents and teachers with the aid of various cultural artifacts such as moral stories and proverbs that are designed to highlight and bolster the values at hand (see e.g., Keller 2007, for a review). In other words, foundational values of a society are likely to be transmitted vertically through family lines. They may also be transmitted horizontally across regions or countries. But when this happens, this process may be rather slow and ineffective.

One implication of this analysis is that traditional values can be surprisingly stable. Indeed, when values of different countries are followed over 20 years, they are, in fact, highly stable (Inglehart & Baker 2000). Moreover, evidence shows that values are transmitted vertically. Several researchers have found positive cross-generational correlations in value endorsement (see Schönpflug 2009, for a review). A further demonstration of the same point comes from a study by Rice & Steele (2004). It is known that European nations vary systematically in life satisfaction ratings. Intriguingly, the ranking is preserved almost perfectly when the same set of ethnic groups are tested within the U.S. It would appear that relevant values have been transmitted along family lines. We also noted above that regional variations within the U.S. are largely preserved. It is important to keep in mind that the measures used in these studies tap on explicit values of independence (vs. interdependence) (e.g., Park et al. 2010; Plaut et al. 2002) or deliberate behaviors directly linked to such values (e.g., Vandello & Cohen 1999). The well-preserved regional variation is not only consistent with the hypothesis that values are transmitted vertically, but also suggest that cross-regional or cross-cultural dissemination of explicit cultural values should be very ineffective and slow if it does happen at all (Hout et al 2001).

Behavioral imitation. Cultural practices may be very different in this respect. They may be transmitted horizontally, across geographical space. Because they are represented as behavioral scripts, they can be easily imitated even when the behavior is not directly observable

as long as it is cognitively represented in the form of stories (Bruner 1990). Studies in several fields of psychology, including evolutionary psychology (Richerson & Boyd 2005), developmental psychology (Tomasello 1999), personality psychology (Bandura 1973), and social cognition (Chartrand & Bargh 1999) have converged to suggest that behavioral routines can be imitated, often quite automatically and spontaneously, as long as the adopters hold positive attitudes to and, thus identify with the model (Lakin et al. 2008). The discovery of mirror neuron systems in humans (Iacoboni 2009) supplies a plausible neural mechanism by which the imitation takes place. The hypothesis that people imitate behaviors of higher-status, likable others, is consistent with research in both evolutionary psychology (Henrich & Gil-White 2001) and social psychology (Cialdini 2001). It is also well known that behavioral imitation or conformity needs not be accompanied by corresponding change in underlying beliefs or values (Asch 1951).

The consideration of adoption process is important to understand one curious dissociation that can happen between explicitly held values and practices. We noted above that a regional variation is well-preserved in contemporary U.S., with independent values more strongly endorsed in Western (or non-Eastern) regions than in Eastern regions. Curiously, however, there is every reason to believe that cultural practices that encourage independence such as “show-and-tell” or “publish-or-perish” are quite widely shared, without any obvious regional variation. Kitayama et al. (2010) argued that these practices were originally produced by believers of the corresponding values of independence, namely, frontier settlers during the West-bound settlement period. However, the American Western frontier experienced massive economic success and, moreover, it was officially endorsed by the federal government and, as a consequence, these practices were subsequently adopted (i.e., “imitated”) by residents of the Eastern regions of the country. If, as hypothesized in the neuro-culture interaction model (Boxes 3-5 of Figure 1), repeated participation in cultural practices gives rise to automatic cultural biases in cognition and emotion, the regional variation should be much weaker when implicit

psychological tendencies of independence (vs. interdependence) such as dispositional bias in attribution, self-serving bias, and personal (vs. social) happiness are tested. This prediction has received empirical support (Park et al. 2010).

Gene x Culture Interaction?

Will any of the cultural or even regional differences we have reviewed so far involve any genetic components? For a long time it was a taboo in social sciences to talk about ethnic or cultural differences in mental processes in terms of genetic differences. This, however, is likely to change with a more sophisticated understanding on gene-environment interaction. One clue to possible involvement of genetic process is already noted in the discussion of the neuro-culture interaction model. We hypothesized that spontaneous and seamless performance of cultural tasks when it is called for by a given situation is likely to help individuals to succeed in the culture at issue and eventually to find desirable mates, thereby achieving biological adaptation as assessed by their reproductive success (Box 7 of Figure 1). It is possible then, that genes that help individuals perform available cultural tasks may be positively selected in the long run. Not much is known. Yet, given its significance, it is worthwhile to briefly discuss a current perspective on the issue.

Accelerated pace of human evolution in the last 10,000 years. It has been known for some time that frequencies of very simple genetic mutations (called single nucleotide polymorphisms [SNPs]) are vastly influenced by local conditions of ecology and culture. Although tiny and by no means influencing the basic design of the body or mind itself, some of these polymorphisms can have important consequences on specific aspects of mentality and behavior (as well as morphology and physiological processes) under appropriate environmental conditions. Furthermore, it has been recently uncovered that evolution did not stop when humans diverged from their evolutionary cousins. Instead, if anything, the speed of human evolution (as assessed by the rate of SNPs that are preserved in the human genomes) has increased dramatically in the last 10,000 years ever since the invention of agriculture (Cochran

& Harpending, 2009). This exponential increase of the speed in evolutionary change is caused by both increased population size and increased complexity of ecological, social, and cultural environments in respect to which biological adaptation is achieved. As may be expected, the vast majority of the SNPs are selected for their adaptive values relative to highly local ecological and cultural environments. For example, lactose tolerance is contingent on pastoral nomadic modes of living (for reviews see Boyd & Richerson 1985; Laland et al 2010).

One consequence of the recent expansion of the human genetic variability is that a number of culturally relevant SNPs are also local and cross-culturally variable in frequencies. For example, long (e.g., 7-repeat) allelic versions of DRD4 (a dopamine receptor gene) have been linked to ADHD and novelty seeking. Importantly, however, these versions of the gene are quite common among Caucasian Americans, but they are virtually absent among Asians. Chen et al. (1999) hypothesize that long allelic versions of DRD4 provide selective advantage in new, challenging environments because they are increasingly more predominant as a function of distance by which different ethnic groups immigrated in historic and evolutionary times (see also Cochran & Harpending 2009 for alternative possibilities). Findings such as these strongly suggest that to complete a full understanding of the origins of cultural differences in psychological processes, genetic processes must be taken into account.

Gene-environment interaction and culture. It bears an emphasis that it is not genes alone, but it is the intricate interactions between genetic potentials and environments that ultimately give concrete shapes to behavior. For example, Sheese and colleagues (2007) report that DRD4 functions very differently depending on quality of parenting. Long-allelic versions of the gene were associated with sensation seeking, high-intensity pleasure, and impulsivity only for the children who receive poor quality parenting. A similar effect has been observed for a serotonin transporter gene, 5-HTTLPR (Caspi et al 2003; but also see Risch et al 2009).

One important shortcoming of the literature at this point is that it is premised on the assumption that any given behavior, say, depression or schizophrenia is *always* regulated by a

single genetic locus. In fact, even in schizophrenia -- a mental disorder that has an arguably large genetic component, large scale genome association studies have failed to identify any single genes that control this disease. The alternative hypothesis that has been recently advanced is that the phenotype is dynamically controlled by multiple different genetic loci or "rare mutations" (Dickson et al 2010; Robinson 2010).

Furthermore, at present, most studies on gene x environment interaction in the development of mental disorders have been conducted in Western cultures. It is assumed that these interactions take the same functional form across different societies and cultural groups, but there is some reason to cast doubt on this assumption. For example, cultures are different in terms of normatively sanctioned levels of arousal, with Western cultures placing greater values on high (as opposed to low) arousal than Eastern cultures do (Tsai et al 2006). It is not too far-fetched to hypothesize that certain genetic “risk factors” might be “risky” in some cultures, but not in some others. For example, the double short allelic combination of the serotonin transporter gene is considered a “risk” factor because of its effect to inhibit extraversion and sensation seeking. It might seem possible, however, that a subdued behavioral style fostered by the double short allelic combination is valued more under conditions produced by cultural collectivism. Consistent with this reasoning, Chiao & Blinzinsky (2009) report that population-level prevalence of this particular allelic combination is associated with cultural collectivism, which in turn is linked to lower population-level prevalence of depression.

In short, it is fair to summarize the current literature on culture and genes by noting, first, that gene expressions are contingent on environments including cultural environments. Second, genes themselves (particularly, frequencies of SNPs) are contingent on relatively long-lasting environmental conditions including cultural conditions and, third, cultural environments themselves are the creation of humans who show various culture-contingent behavioral tendencies. By considering these three points together, one would begin to see that behavior (and the brain), culture, and genes are *mutually* related to one another to a far greater extent

than has ever before been imagined. Explicating this dynamic is an important future agenda for the field.

Cultural Shaping of the Brain

The neuro-culture interaction model (Figure 1) suggests that repeated participation in a set of independent or interdependent cultural tasks results in the corresponding patterns of brain activations and the corresponding psychological tendencies. Note, however, behaviors are influenced by myriad situational factors in addition to the over-learned cultural information in the brain. This means that expected cultural variations should be demonstrated just as clearly or even more so with neural measures as compared to more traditional behavioral or self-report measures.

Furthermore, relevant neural activities should become culturally patterned increasingly more as a function of the person's active engagement in pertinent cultural tasks over a relatively long span of time. It would follow, then, that cultural influences on neural processes should become clearer for those who have high commitments to the values and the corresponding worldviews that are sanctioned by their culture. Last but not least, one potentially important prediction of this analysis would be that one's commitment to the values and worldviews (as reflected in one's own self-beliefs and identities) might not predict overt behaviors as clearly as it predicts the underlying neural activity patterns. The reason is that behaviors are influenced not just by the underlying neural activation patterns, but also by pertinent situational norms and concerns. Research in this area is still very new. Thus, evidence is incomplete at best. Nevertheless, each of these predictions has received some preliminary support in several domains.

Aside from the fact that neuroscience measures are necessary to test any theoretical ideas on the culture-brain interface, these measures have potential of moving the field forward above and beyond the level that can be achieved with behavioral measures alone (Kitayama &

Tompson 2010; Zou & Cacioppo 2010). Already it is clear that 1) cross-cultural brain differences can exist even in the absence of any behavioral differences (e.g., Hedden et al 2008) and, moreover, that 2) the same behaviors can be mediated by different brain pathways across cultures (e.g., Tang et al 2006). Further, 3) neuroscience measures enable researchers to more directly test prior theories and assumptions embedded in them (e.g., Zhu et al 2007). Altogether, it is fair to say that neuroscience measures carry information that is related, but substantially non-redundant from information obtained with behavioral measures.

Available Evidence on Culture and Brain

Neural representations of the self. A fair number of cross-cultural studies have investigated cognitive representation of the self with a 20-statement test. Participants are asked to list 20 aspects or features of themselves. As expected, these studies have shown that whereas abstract traits are frequently generated by North Americans, relational or collective features of the self are relatively more frequent in East Asians' self-descriptions (e.g., Cousins 1989). The same prediction was recently tested with an fMRI method. Zhu et al. (2007) had Chinese and Westerners in Beijing go through a series of self-reference judgment. Relative to a control condition where judgment was requested in reference to a public figure (e.g., the prime minister or president of the respective countries at the time of the study), self-reference judgment resulted in substantially increased activations in the medial prefrontal cortex (mPFC), consistent with previous work in this area. Further, this was the case for both Chinese and Western participants. An interesting cross-cultural difference appeared, however, when the participants were asked to make comparable judgments in reference to their mother. Relative to the public figure control, Chinese showed a substantial increase in the mPFC in the mother judgment, indicating that the area of the brain used in the self-judgment was also recruited in the mother judgment. In contrast, Westerners showed no such increased activation at all in the mother-reference condition. This evidence is consistent with the notion that the self and the mother are mutually interdependent among Chinese, but not among Westerners. That is, they

are closely related to the point where much is shared between the self-representation and the representation of the mother.

Another interesting prediction that would follow from the present analysis is that whereas independent cultural tasks foster de-contextualized, abstract self-representations, interdependent cultural tasks give rise to more contextualized self-representations. Initial evidence for this prediction came from a study by Cousins (1989), wherein both Japanese and American high-school students were asked to produce features of the self. In line with the pattern of the results reviewed above, Americans were far more likely to generate abstract traits than Japanese did in this condition, suggesting that American selves are more context-independent. However, consistent with the hypothesis that Japanese selves are more contextual, the likelihood of abstract traits to be generated was much higher for Japanese than for Americans once a specific social context was specified (e.g., in school, at home).

The hypothesis that independent people hold clear self-representations (as reflected in the production of unqualified general traits) when no context is specified, but interdependent people hold clear self-representations when a specific context is specified has further been investigated with the fMRI method by Chiao et al. (2009a). Japanese in Japan and European Americans in the US performed a series of self-reference judgments with a context either unspecified or specified. The researchers measured each participant's independent versus interdependent self-construals with the Singelis (1994) self-construal scale. Across the two cultures, independent people tend to show greater mPFC activations in the context-general condition than in the contextualized condition, but interdependent people showed the opposite pattern, showing greater activations in the contextualized condition than in the context-general condition. The study is notable because of its demonstration of a strong effect of a self-belief measure of independence and interdependence moderating the brain response. One caveat, however, is that the study did not replicate the cross-cultural evidence by Cousins (1989) due,

possibly, to a selection bias in subject recruitment especially in Japan where imaging research was still new and likely perceived as a high-risk, high-return means to earn a participation fee.

Another recent study by Chiao et al.(2009b) primed either independence or interdependence by having participants read a short story involving the selection of a general on the basis of either individual merit (the independent prime) or connection by kinship (the interdependent prime) and show that these primes caused differential brain activations such that the independent prime leads to a greater mPFC activation in the context-general (rather than contextualized) condition, but the interdependent prime results in a greater mPFC activation in the contextualized (rather than context-general) condition.

Person perception and underlying neural pathways. Whereas independent tasks would require the assumption that others are also independent, motivated primarily by their internal attributes, interdependent tasks would foster the contrasting assumption that others are interdependent, attuned to social expectations and normative demands. The social psychology literature on correspondence bias or dispositional attribution has provided abundant evidence that when asked to explain another person's behavior the social perceiver do so by focusing on dispositional characteristics of the person such as his or her attitudes and personality traits while ignoring situational constraints even when these constraints are blatantly clear (Jones 1979; Gilbert & Malone 1995). This bias is quite pervasive and, in some cases at least, clearly erroneous (as when participants who merely see someone reading an attitudinal statement allegedly composed by someone else still infer and attribute an attitude corresponding to the statement to the person). The bias has thus been called fundamental attribution error (Ross 1977).

One consensually accepted theory of the bias (Gilbert & Malone 1995) states that from an observed behavior the social perceiver automatically and spontaneously infer the corresponding trait or attitude. This spontaneous inference of dispositions is then to be followed by an optional process of situational adjustment, wherein any effects of available situational

constraints are taken into account. However, because the situational adjustment is optional and resource-dependent, it will not be complete, resulting in a relatively greater weight assigned to disposition rather than situation in accounting for the cause of the behavior.

Within this theoretical framework, it might be predicted that interdependent people would show a lesser degree of dispositional bias because they are relatively more attuned to situational constraints. Since an original demonstration of this point by Joan Miller (1984), there is now a quite solid body of evidence for this point (see Choi et al. 1999 for a review). It has been shown, for example, that when asked to explain another person's behavior, which is described in a short vignette, European Americans are more likely than Asians to assign greater importance to dispositional factors (e.g., the person's personality and attitude) rather than to situational factors (e.g., social norms and atmosphere of the situation) (Kitayama et al. 2006). Moreover, when asked to infer another person's "real" attitude while observing the person stating his opinion on the issue at hand, European Americans ignore obvious situational constraints and conclude that the person's "real" attitude would correspond to the stated opinion. Unlike European Americans, however, Asians show little or no such tendency especially when the situational constraint is made salient (Masuda & Kitayama 2004).

From the above evidence alone, however, it is not clear whether Asians show less or even no dispositional bias because of their sensitivity or attentional attunement to situational constraint alone. It is also possible that Asians do not draw any dispositional inferences to begin with when observing another person's behavior. In a recent study Na and Kitayama (2010a) presented European Americans and Asian Americans with a number of pairs of a facial photo and a behavioral description. Subsequently, participants were given a lexical judgment task. On each trial they were shown the facial photo first as a fixation point, which was immediately followed by a trait word that was either consistent or inconsistent with the trait implied by the pertinent behavior. An ERP component that is known to be sensitive to the detection of semantic incongruity (the negative polarity that occurs approximately 400 ms post-stimulus) was

assessed. As predicted, this ERP component was significantly greater in response to incongruous traits than to congruous traits for European Americans, indicating that the corresponding trait was abstracted and linked to the facial photo when the behavior was presented in the first phase of the study. Importantly, in support for the supposition that Asians and Asian Americans do not engage in spontaneous trait inference, this effect was completely vanished for Asian Americans. This study assessed each participant's beliefs of the self as independent or interdependence with the Singelis (1994) scale. The relative magnitude of the negativity to inconsistent traits was associated positively with independence (vs. interdependence). Indeed, the cultural difference was partially mediated by independence (vs. interdependence).

In a recent fMRI study, Kobayashi et al. (2007) presented European American and Japanese participants with either stories that would require mind reading of a protagonist or control stories that would not require mind reading. Relative to the control stories, the mind reading stories tended to activate areas of the brain that are typically linked to inference of traits and other internal states such as intentions and desires, including the temporal pole, the temporo-paraetal junction, and the mPFC. Although this effect was commonly observed for both European American and Japanese participants, it was significantly more pronounced for the former than for the latter, thereby providing initial brain evidence for the cultural difference abundantly documented in the last two decades of research on dispositional inference. Interestingly, this cultural difference was observed even when Japanese participants were tested in English. Because these Japanese lived in Japan for most of their lives, this might imply the relative significance of early socialization (rather than language per se) in establishing one's style of social perception and social inference (see also Ishii et al. 2003, for a similar point).

Neural pathways of holistic attention. Evidence indicates that the tendency to focus attention on the "inside" of a target person in lieu of his or her surrounding context (the dispositional bias), which is quite common among European Americans but not among Asians

or Asian Americans, is generalizable to non-social domains. Masuda & Nisbett (2001) find that when asked to explain an underwater scene, Americans start their story with a description of focal fish whereas Asians start theirs with a description of contextual scene and elaborate on the scene before moving on to describe the focal fish. In an even more non-social rendition of the same idea, Kitayama et al. (2003) show that Americans are quite accurate in drawing a line that is identical to the standard in absolute length while ignoring square frames of varying size. However, they are less accurate in drawing a line that is identical in proportion to the height of a square frame as the standard is to the height of to its own square frame that varies in size. Thus, Americans are better at ignoring context than at attending to it. In contrast, Japanese show a greater accuracy in the drawing of the relative line than in the drawing of the absolute line, demonstrating their relative ease with which to attend to context than to ignore it.

With fMRI, Hedden et al. (2008) show that Americans in fact engage more deliberate and intentional attention (as signified by the fronto-parietal attention network) when performing the relative task, but Asians engage the same brain network when performing the absolute task. Importantly, the American effect increased systematically as a function of their independent construal of the self. In contrast, the Asian effect decreased systematically as a function of their reported acculturation in the American culture. In this study there was no cultural difference in a performance measure that was tested due supposedly to the attentional compensation that occurred at the brain level. Recent work by D. Park and colleagues (Goh et al. 2007; Jenkins et al. 2009) have amassed evidence from their imaging work that goes beyond the Hedden et al. (2008) finding by providing initial evidence for the specific neural pathways of holistic perception.

Lewis et al. (2008) used an ERP oddball paradigm and investigated the idea that relative to European Americans, Asian Americans pay more attention to contextual stimuli and, as a consequence, they should be more “surprised” when presented with a novel stimulus. Participants were exposed to a number of stimuli one at a time in a random order. 76% of them

were standard (the number “8”), 12% of them were target (the number “6”), and the remaining 12% were oddballs (English words, consonants, and numbers such as “DOG,” “TCQ,” and “305”). Their task was to press a key when the target was presented. Previous work with this oddball paradigm finds two different positive polarities of electrical signal that occur around 300 ms after stimulus presentation (thus referred to as P3). A target P3 occurs when the target stimulus is presented. This ERP response is most prominent in the posterior area and considered to indicate attention focused on the target. A novelty P3 occurs in response to an oddball and is most prominent in more anterior regions of the brain. As predicted, as compared to European Americans, Asian Americans showed a greater intensity in the novelty P3 and, moreover, this response was predicted by their construal of the self as interdependent as assessed by a scale by Triandis (1995). As also predicted, European Americans showed a marginally greater intensity in the target P3 than did Asian Americans.

Another ERP component that is potentially quite useful in investigating holistic attention is N400, which is often associated with the detection of semantic incongruity. One might expect that when a focal object (e.g., a car) is placed in a context that does not go together (e.g., an oceanic scene), Asian Americans might be more prone to detecting the incongruity than European Americans due to their relative sensitivity to context. This in fact was the case in a recent study by Goto et al. (2009) and, moreover, as may be predicted, the N400 was reliably associated with interdependent self-construal as assessed by the Triandis scale. In yet another related study, Ishii et al. (2009) used N400 as an indicator of the detection of incongruous vocal context in understanding the meaning of emotionally valenced words. The researchers validated the measure and, further, found that N400 was reliably predicted by one’s interdependence (vis-à-vis independence) as assessed by the reported intensity of experiencing interdependent emotions such as friendly feelings and guilt relative to independent emotions such as pride in the self and anger.

Choice, motivation, and the brain. One classic effect in social psychology involves choice. Early on, Lewin (1952) investigated effects of choices (or "decisions" in Lewin's terminology) on behavioral change and behavioral persistence. Later, choice was at the center of cognitive dissonance research (Festinger 1957). Choice has recently become one central topic in cultural psychology (Iyengar & Lepper 1999; Savani et al. 2010).

Behavioral research has shown that North Americans often interpret their behaviors in terms of personal choices they made (Savani et al. 2010) and, moreover, once they have made a choice in private, they invest themselves on it. As a consequence, they work harder on a task they choose (Patall et al 2008) and, further, they justify their choice by engaging in dissonance-reduction maneuvers (Steele 1988). This effect, however, may not be as pronounced for people engaging in interdependent cultures because for them internal attributes that are highlighted in the private choice might not be as important as they are to those in independent cultures. Iyengar & Lepper (1999) provided initial evidence for this possibility by showing that as compared to European American children, Asian American children show a lesser intrinsic motivation on a task they have chosen by themselves. More recent data by Bao & Lam (2008) challenged the Iyengar & Lepper (1999) finding, showing that Hong Kong Chinese children are strongly motivated by their personal choice. Caution is in order because Bao & Lam's experimental instructions strongly implied that personal choice was something of a "special privilege" that only some small group of participants could have (not other children who had earlier participated in the study). It is possible that the Hong Kong children in the Bao & Lam study were motivated because of this superfluous element in the procedure. Without this procedural element, Asians are in fact much less motivated by personal choice than European Americans (Na & Kitayama 2010a).

Would interdependent people invest themselves on choices that are witnessed by others and thus public? Theoretically, public choices would implicate social aspects of the self such as reputation, face, and status, which are arguably more important than personal attributes in

defining the identity of interdependent selves. In their original work, Iyengar & Lepper (1999) showed that Asian American children are more motivated to work on a task shown by their ingroup members such as their mother and classroom teacher. This effect likely happened because of emotional identification the children had with the ingroup members (Bao & Lam 2008). Thus, the mother/teacher choice was likely perceived by the Asian American children as no different from the choice they would make. Further, the knowledge about the choice is obviously shared with the significant other (because this person actually did make it); so it was public. Thus, the finding is consistent with the hypothesis that interdependent selves invest themselves on their own public choices.

Also consistent is a finding that Asians (but not European Americans or Canadians) justify their choice when the choice is for their friend (Hoshino-Browne et al. 2005). This effect occurs because the friend would come to know the choice they make. Under such conditions, European Americans show little justification effect supposedly because the choice does not implicate their ever-important personal self. Further, Asians justify their choice when significant others are merely primed as long as they care about the others who are primed (Kitayama et al 2004). This is the case even when the priming is very subtle, no more than an exposure to a set of schematic faces that appear "watching" them from the participants' perspectives. The last finding has been replicated with performance in a cognitive task as a measure of motivation (Na & Kitayama 2010a). European Americans appear to show a weaker motivation effect under such public choice conditions supposedly because eyes of others are experienced as unnecessary impositions on their freedom (Imada & Kitayama 2010b).

Brain mechanisms underlying the self-investment on personal vs. public choice have also been investigated. Park et al (2009) tested a negative neural electric peak that occurs when an error is committed in a cognitive task (called error-related negativity or ERN). Evidence indicates that ERN increases as a function of motivational significance of the errors (Hajcak et al 2005). In the Park et al. experiment, immediately before each trial participants were briefly

exposed to a cue indicating witnessing eyes of someone else (the face priming trials) or a control stimulus (the control trials). As would be predicted, Asians showed a greater ERN in the face priming trials than in the control trials, but European Americans showed a reversed pattern, with a weaker ERN in the face priming trials than in the control trials. Of importance, the ERN magnitude in the witnessing eyes priming condition was significantly correlated with self-reported levels of interdependence (vs. independence) as assessed by the Singelis (1994) self-construal scale and, in fact, the cultural difference in ERN in this condition was completely mediated by interdependent (vs. independent) self-construal.

Because the ERN has been localized to the anterior cingulated cortex (ACC, Dehaene et al 1994), we may suggest that when a motivationally significant choice is made, the ACC is recruited to detect any errors or conflicts, which in turn informs associated brain areas serving motivational functions, including reward processing (e.g., nucleus accumbens, Knutson et al 2001), negative somatic arousal called cognitive dissonance (e.g., anterior insula, Van Veen et al 2009), and the midline default network recruited for episodic reconstruction of the self (e.g., mPFC, D'Argembeau et al 2007). These neural circuitries might be responsible for the behavioral effects of choice.

Individual Differences in Neural versus Behavioral Responses

In the previous section we presented a selective review of recent evidence indicating that repeated participation in cultural practices of independence and interdependence do result in cross-culturally divergent brain pathways. Building on previous behavioral studies that demonstrate consistent cross-cultural differences in a given domain, this new neuroscience research examines whether the corresponding differences could be observed in relevant brain responses. Although still small in volume, the initial evidence is highly encouraging.

Notably, several studies have demonstrated that culturally contingent brain responses are predicted by self-reported levels of independence or interdependence. The pertinent studies (some of which are already discussed) are summarized in Table 1. This evidence is quite

impressive because relevant behavioral studies have consistently failed to observe similar correlations. For example, given the correlation observed by Chiao et al between independence (vs. interdependence) and the mPFC activation in the context-general condition, one might expect to find an equally strong correlation between the frequency of abstract traits in a 20 statement test and a measure of independence (vs. interdependence). Such a correlation is directly tested by Na and colleagues (Na et al 2010). The observed correlation was negligible. Likewise, given the reliable correlation between novelty P3 and interdependence observed by Lewis and colleagues, one might expect a positive correlation between a behavioral measure of holistic attention and interdependence. Such a correlation, directly tested by Kitayama et al. (2009), was negligible in all the four countries tested.

Informally, we contacted 8 active psychologists on the field of culture, who have examined various behavioral measures and asked them if they have observed any systematic correlations between the behavioral measures they used and any self-belief measures of independence, interdependence, and related constructs. Judging from the responses we received from the researchers, when examined, these correlations are almost always negligible, which is rather consistent with the present authors' own experience over the years. This does not mean that no such correlations ever happen. In particular, in numerous studies that use scale measures as dependent variables (e.g., Singelis & Brown 1995), these measures do correlate with self-belief measures of independence or interdependence. Note, however, that these correlations can be accounted for by semantic overlap, shared method, or both.

How can it be that self-belief measures of independence/interdependence rarely predict behavioral responses (in e.g., self, cognition, and attention) and, yet, they do predict corresponding brain responses? It might seem possible that the magnitude of the correlations between self-belief measures and brain responses is vastly inflated. Vul et al. (2009) argue that because brain responses are so numerous, they lend themselves to false positives. Even if this argument is true for some fMRI studies, it is unlikely to apply to studies with ERPs because

possible data points are much smaller in number in the case of ERPs. For example, researchers investigating novelty P3 (Lewis et al 2008) typically focus on an anterior, midline electrode during a specific time window (e.g., 300-400 ms after the stimulus onset). It might also seem possible that behavioral responses are not as reliable as brain responses. However, a few studies are now available, showing that the test-retest reliability of many of the behavioral measures currently used in the literature is quite high (e.g., Na et al. 2010).

It is worthy of note that the stronger correlations observed for brain measures than for behavioral measures is in fact highly consistent with the neuro-culture interaction model. Remember this model proposes that through repeated engagement in cultural tasks, brain pathways change gradually. Because self-belief measures of independence/interdependence are likely to influence the degree to which individuals willfully engage in pertinent cultural tasks, they should predict the degree to which the pertinent culturally patterned brain pathways are formed.

In contrast, behavioral responses are influenced not only by the culturally patterned brain pathway, but also by myriad other situational factors. In fact, Zou et al. (2009) show that behavioral measures are predicted more by perceived situational norms than by self-beliefs about the self. When the situational constraints or prescriptive rules of the situation force the person to act in a way that is consistent with certain cultural practices, these constrained behaviors might be far less likely to cause any permanent changes in the brain that are caused by spontaneous, voluntary behaviors. At least in rats, increased levels of spontaneous activities in an “enriched environment” produce a substantial amount of new neurons in the cortex; but the same behaviors when produced with experimental manipulations rarely do so (van Praag et al. 1999).

All in all, then, the predictive power of the self-belief measures of independence/interdependence may be expected to be greater for brain responses than for comparable behavioral responses. Future work should examine whether brain responses would

always be predicted more by self-beliefs, but behavioral responses are predicted more by perceived norms instead. This double dissociation, if proven reliable, would offer an important empirical anchor for further theorizing.

CONCLUSIONS AND FUTURE DIRECTIONS

Drawing on a neuro-culture interaction model (Figure 1), we reviewed two emerging lines of work in cultural psychology. In the first line of work reviewed here, researchers have tested specific macro-level factors that are linked to independence and interdependence. This literature helps us go beyond the East-West paradigm by identifying specific collective-level processes underlying the observed differences between East and West. Moreover, it also allows us to systematically explore within-culture variations and subgroup differences. In the second line of work we examined, neuroscience methods such as fMRI and ERP are used to investigate neural underpinnings of known cultural differences in self, cognition, attention, and motivation. Given the rapid pace with which this area of research has unfolded, we will be seeing many more demonstrations of cultural effects on the brain in many other domains in the very near future.

While there is no question that the two recent developments summarized herein are important, and even impressive in both the width of coverage and the increasing level of theoretical and empirical sophistication, it is also quite clear that the findings have raised just as many or even more questions while solving some existing ones. This state of affairs is a clear indication of the vitality of the field. There is every reason to believe that the field will continue to grow in the years to come. To conclude this chapter we will suggest several important directions for future work.

First, the East-West paradigm will continue to be important in cultural psychology. It is likely to provide a model case for cultural psychologists as much as rodents have served as a

model animal for animal psychologists. There is nothing wrong with this as long as due cautions are made and new cultures are brought in to the literature whenever possible. In all likelihood, a substantial progress can be anticipated with concerted research effort to document one by one brain mechanisms underlying the known East-West differences in cognition, emotion, and motivation. As noted, this work has just begun with considerable promise and, yet, much has yet to be done.

Useful as it will surely prove to be, the focus on the East-West paradigm, if not duly accompanied by other approaches and paradigms, would surely be limiting and even debilitating to the development of the field. Thus, the second important direction of research involves effortful expansion of samples and populations. This effort might allow us to identify cultural dimensions other than independence and interdependence that are just as important and powerful. Religiosity, cultural tightness, and culture of honor are only three of possible dimensions or cultural complexes that deserve far more research. Moreover, the deliberate expansion of samples and populations would also provide an excellent opportunity for theory building (Henrich et al. 2009). For example, recent work on the production and adoption process in cultural change was motivated by questions regarding regional variations both within the U.S. and between the U.S. and its Western European cousins (Kitayama et al 2010).

Third, both cognitive and socio-cultural mediating processes will receive intense research attention in the near future. The present review focused on the “hard (i.e., non-cognitive)” interface between collective-level culture and the embrained mind. This, of course, by no means precludes cognition as a major theoretical element. In particular, cognitive processes are crucial in guiding one’s deliberate actions, constructing the meanings for one’s actions and immediate situations, and further developing self-identities. Thus, there is no question that cultural priming can play an important role in moderating cultural differences. Clearly, both cognitive and non-cognitive processes are involved in the full understanding of the

interaction among culture, mind, and the brain. We are hopeful that the neuro-culture interaction model is an important component of this comprehensive understanding.

Fourth, although much has been learned about cultural differences in behavior and brain responses in the recent years, much less is known about how such different responses are learned and acquired. For example, we know very little about when cultural differences begin to emerge. While developmental evidence is strong that certain cultural differences are quite evident very early on in life, it is often not certain whether and to what degree the differences are due to environmental affordances provided, for example, by caretakers (e.g., Rothbaum et al. 2010). Further, many sojourners seem to know, first hand, that once one misses a certain "critical period" or "sensitive period" one can never get "it" in full no matter how long and how hard the person tries to be a member of a new culture. As argued by Kitayama & Park (2009), if culture is a means for biological adaptation, it is to be anticipated that puberty defines a sensitive period where cultural learning is to be maximized because the learning of the most up-to-date culture would prepare the person very well for the "reproductive market" – a point that is supported by the fact that neurogenesis is quite active, next to the first 18 months of life, about early adolescence (Giedd et al. 2006; Minoura 1002 for initial behavioral evidence). Yet, much has yet to be learned.

The fifth direction we foresee pertains to genetic and epigenetic processes that are linked closely to both brain and culture. The active selections humans have undergone in the last 10,000 years, discussed earlier in this paper, are likely to be very miniscule in quantity, confined largely to single nuclide polymorphisms (SNPs). Yet, the small change can cause large effects given appropriate external conditions. Thus, consequences of the miniscule genetic change on body morphologies and psychological functions can sometimes be quite sizable and crucially important in understanding local forms of adaptation. For example, effects of double-short allelic combination of the serotonin transporter gene are likely to be dramatically different depending on specific conditions of early socialization (Caspi et al 2003; Suomi 2009).

The active genetic selections over the last 10,000 years are made possible by both increasing population size and high population density that accompany the invention of agriculture. The SNPs may thus be expected to be responsive to specific socio-cultural modes of adaptation. It no longer is possible to separate culture and biology, as matters of learning and organismic design, respectively. To the contrary, culture serves as a context for genetic selection, while at the same time particular genetic characteristics of local groups are constantly motivating certain forms of culture in lieu of others. Explicating this dynamic is going to be a massive endeavor that can only be achieved through extensive interdisciplinary collaboration.

We started this chapter by noting that the modern research on culture in psychology was initiated, in the early 1990s, with an arresting idea that culture might in fact influence basic psychological processes. The idea had an intoxicating quality at the time when the computer metaphor was still alive and well, rigidly believed and practiced, with cognitive psychology (which did and still does espouse the most universalistic view in psychology) enshrined as the model case of all human psychologies including an elder sister of the current cultural psychology, i.e., cross-cultural psychology (e.g., Berry et al 1996).

The time has changed, however. With increasing knowledge on brain plasticity, it is no longer possible to ignore the potent influences socio-cultural environments can have on human brain development and the psychological processes that ensue. Furthermore, with increasing availability of international or cross-cultural data and ideas, the news of enormous diversity in the human mode of existence has finally arrived in psychology at long last. The sibling rivalry between cultural psychology and cross-cultural psychology has naturally subsided without any scars left on either side. The time is quite ripe, then, for the field, now united, to renew its commitment to the study of the human mind as both enabled by the brain and underlying biology and evolution and, yet, at the same time, profoundly shaped and enabled by socio-cultural environment.

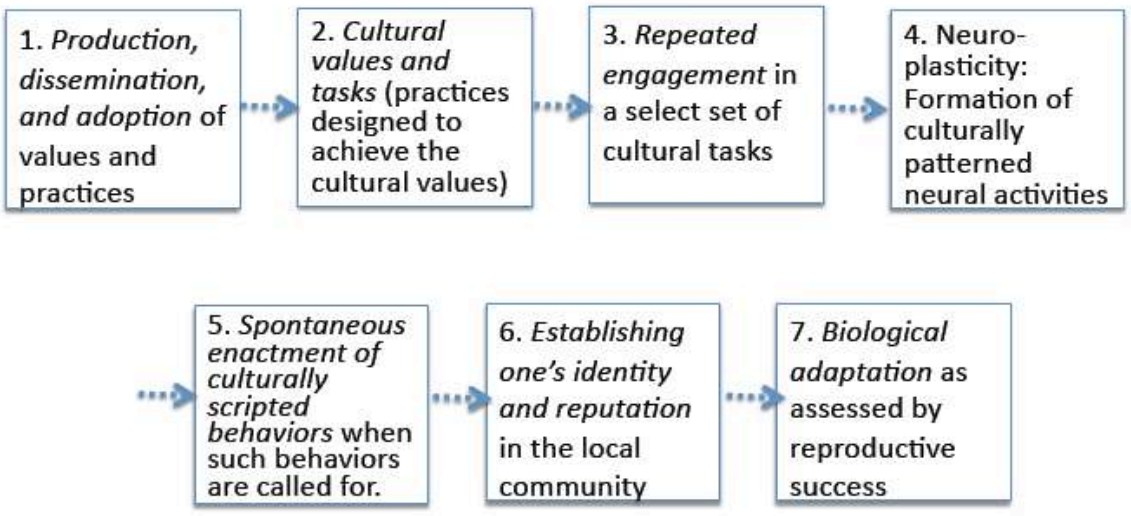

FIGURE LEGEND

Figure 1. A neuro-culture interaction model. Values and practices of culture are produced, disseminated, and adopted as a function of a variety of collective-level factors. Individuals select some select set of available cultural practices as their own cultural tasks. They then actively engage in them so as to realize their culture's primary values such as independence and interdependence in their own idiosyncratic ways. Repeated engagement in the cultural tasks results in culturally patterned brain activities, which in turn enable the individuals to spontaneously and seamlessly enact the culturally scripted behaviors when such behaviors are called for by situational norms. The ability of the individuals to perform the culturally scripted behaviors when normatively required to do so enhances their own identity and reputation as a decent member of the cultural tradition and, eventually, their ability to achieve biological adaptation as assessed by reproductive fitness.

Table 1. Studies that show significant correlations between self-belief measures of independence and interdependence and brain responses.

Studies	***Indices tested***	***Results***
Chiao et al. (2009)	MPFC activation in the context-general self-judgment condition – mPFC activation in the context-specific self-judgment condition	The index was positively correlated with independence (vs. interdependence) as assessed by Triandis scale of individualism and collectivism in a sample composed of both European Americans and Japanese.
Goto et al. (2009)	N400 response in a semantic incongruity ERP paradigm	The incongruity-induced N400 was larger as a function of increased independence as assessed by Singelis scale in a sample of European and Asian Americans.
Goto et al. (2010)	N400 response in a semantic incongruity ERP paradigm with face stimuli that display consistent vs. inconsistent emotional expressions	The incongruity-induced N400 was larger as a function of increased interdependence as assessed by the Singelis scale in a sample of European and Asian Americans.
Hedden et al. (2008)	Activation of fronto-pareital attention network either in a cognitive task that requires focused attention (FLT absolute task) or in a cognitive task that requires holistic attention (FLT relative task)	The activation of the attention network in the relative task was positively correlated with independence as assessed by Triandis scale for European Americans. (The activation of the attention network in the absolute task was negatively correlated with acculturation for Asian sojourners in the US.)
Ishii et al. (2009)	N400 response associated with detection of incongruity of semantic meaning of a spoken word with an attendant vocal tone	Only Japanese were tested. The magnitude of N400 was positively associated with interdependence as assessed by a Kitayama-Park (2007) emotion-based measure (i.e., relative intensity of experiencing socially engaged emotions such as friendly feelings and guilt [vs. socially disengaged emotions such as pride in self and anger]). This index is correlated with interdependence as assessed by Singelis scale.
Na & Kitayama (2010b)	After having memorized pairs of a facial photo and a behavior, participants were shown the facial photo, which was followed by a trait that was either consistent or inconsistent with the trait implied by the behavior. The relative magnitude of negative ERP response	The relative magnitude of the negativity to inconsistent traits was greater for European Americans than for Asian Americans. Moreover, it increased as a function of independence (vs. interdependence) as assessed the Singelis scale. The cultural difference was partially mediated by independence (vs. interdependence).

	(approximately 300-400 ms post stimulus) to the inconsistent (vs. consistent) traits was assessed	
Lewis et al. (2008)	Novelty P3 response in an oddball ERP paradigm	The index was positively correlated with interdependence as assessed by Triandis scale of collectivism. This effect fully mediated a cultural difference observed between European Americans and Asian Americans
J. Park et al. (2009)	ERN magnitude (the more negative, the greater) in the face prime condition minus ERN in the control prime condition	The index was positively correlated with interdependence (vs. independence) as assessed by Singelis scale. This effect completely mediated a difference observed between European Americans and Asians.
Ray et al. (in press)	Activation in the MPFC and the PCC in self-reference judgment minus the corresponding activation in mother-reference judgment	Only European Americans were tested. The index was positively correlated with interdependence as assessed by Singelis scale

KEY WORDS
neuro-culture interaction, cultural values and practices, Independence/interdependence, individualism/collectivism, neuro-plasticity, gene-culture interaction

ABSTRACT
Current research on culture focuses on independence and interdependence and documents numerous East-West psychological differences with an increasing emphasis placed on cognitive mediating mechanisms. Lost in this literature is a time-honored idea of culture as a collective process comprised of cross-generationally transmitted values and associated behavioral patterns (i.e., practices). A new model of neuro-culture interaction proposed here addresses this conceptual gap by hypothesizing that the brain serves as a crucial site that accumulates effects of cultural experience, insofar as neural connectivity is likely modified through sustained engagement in cultural practices. Thus, culture is “embrained” and, moreover, this process requires no cognitive mediation. The model is supported in a review of empirical evidence regarding 1) collective-level factors involved in both production and adoption of cultural values and practices and 2) neural changes that result from engagement in cultural practices. Future directions of research on culture, mind, and the brain are discussed.
(150 words)

SUMMARY POINTS LIST

1. Culture is a collective-level phenomenon that is composed of both socially shared meanings such as ideas and beliefs and associated scripted behavioral patterns called practices, tasks, and conventions.

2. Values and practices of independence and interdependence are encouraged by various collective-level factors, including ecology, economic development and industrialization, socio-economic status, residential mobility, pathogen susceptibility, and voluntary frontier settlement. Whereas cultural values are likely to be transmitted vertically through family lines, cultural practices are likely to be disseminated horizontally, across space, via behavioral imitation.

3. As each individual gradually forms his or her own self-identity, the individual chooses from the pool of available practices the ones that suit his or her developing identity best and incorporate them as their cultural tasks – tasks they perform repeatedly and earnestly to become a respectable member of the culture.

4. As a result of repeated, sustained engagement in cultural tasks, relevant brain pathways will undergo substantial rewiring, thus revealing a hitherto unexpected degree of neuroplasticity. Evidence is growing that cultures vary substantially in certain brain processes as assessed by fMRI and ERP. Moreover, these cultural signatures of the brain are systematically linked to self-beliefs on the pertinent cultural dimensions.

5. Culturally shaped activation patterns of the brain foster culturally scripted behaviors when these very behaviors are called for by the specific situation at issue. They therefore enable the person to enact the required behaviors both automatically and seamlessly. This, in turn, can help individuals achieve biological adaptation as assessed by their reproductive success. Culture then can serve as a context for biological selection.

6. Behavior (and the brain), culture, and genes are *mutually* related to one another. First, gene expressions are contingent on environments including cultural environments. Second, genes themselves are contingent on relatively long-lasting environmental conditions including cultural conditions. Third, cultural environments themselves are the creation of humans who show various culture-contingent behavioral tendencies.

FUTURE ISSUES LIST

1. The East-West paradigm will continue to be an important model case for cultural psychologists. A substantial progress will be achieved with concerted research efforts to document brain mechanisms underlying the known East-West differences in cognition, emotion, and motivation.

2. Future research should go beyond the East-West paradigm by expanding research populations. This effort will enable us to identify cultural dimensions that have so far been largely ignored, such as religiosity, tightness, honor, and hierarchy, thereby affording excellent opportunities for further theory building.

3. Both cognitive and socio-cultural mediating processes must be investigated. In particular, cognitive processes are crucial in understanding how people guide their actions, constructing the meanings for their actions, and thus developing their self-identities. The self-identities, in turn, serve as an indispensable element in regulating one's engagement in culture, which defines a necessary condition for cultural shaping of brain processing pathways. A the same time, an in-depth analysis of socio-cultural processes is also indispensable in explicating the available set of cultural practices that are brought to bear on the construction of self-identities and the subsequent engagement in culture.

4. Although much has been learned about cultural differences in behavior and brain responses in the recent years, much less is known about how such different responses are learned and acquired. Developmental processes involved in the acquisition of culture must be investigated, with a focus on neuro-biological mechanisms involved in putative sensitive periods in cultural acquisition.

5. It no longer is possible to separate culture and biology, as matters of learning and organismic design, respectively. To the contrary, culture serves as a context for genetic selection, while at the same time particular genetic characteristics of local groups are constantly motivating certain forms of culture in lieu of others. Explicating this dynamic is going to be a massive research endeavor that can only be achieved through extensive interdisciplinary collaboration.

KEY TERMS/DEFINITIONS LIST

1. independence versus interdependence: social orientations that emphasize each individual's distinctness, uniqueness, and separation from others (e.g., self-promotion, self-expression, and self-sustenance) versus each individual's embeddedness and connectedness with others (e.g., social harmony and coordination, relational attachment, and social duties), respectively
2. individualism versus collectivism: cultural syndromes that emphasize independence versus interdependence, respectively
3. cultural tasks: culturally prescribed means to achieve cultural mandates such as independence (e.g., expressing unique self) and interdependence (e.g., being sensitive to others' feelings)
4. voluntary frontier settlement: voluntary settlement in a frontier motivated by desires for personal wealth and freedom requiring major investment and personal sacrifice
5. single nucleotide polymorphism (SNP): a single nucleotide variation in a genetic sequence that occurs at appreciable frequency in the population
6. DRD4 (dopamine receptor gene 4): A gene that codes for a receptor for dopamine, one of the chemical messengers used in the brain. This gene is thought to interact with early experience to influence certain affective traits.
7. 5-HTTLPR: A gene that codes for the serotonin transporter. This gene is thought to interact with early experience to influence certain affective traits.
8. Medial Prefrontal Cortex (mPFC): The center part of the prefrontal cortex. MPFC is thought to serve a variety of functions including retrieving, manipulating, and integrating self-relevant information.
9. P3: An event-related brain potential, indicated by a positive deflection in voltage with a latency of roughly 300 to 600 ms after stimulus presentation. It is thought to index attention.
10. N400: An event-related brain potential, indicated by a negative deflection peaking approximately 400ms after stimulus presentation. It is thought to index the detection of semantic incongruity.

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