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Current Opinion in Psychology

Dopamine-system genes and cultural acquisition: the norm sensitivity hypothesis☆

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Previous research in cultural psychology shows that cultures vary in the social orientations of independence and interdependence. To date, however, little is known about how people may acquire such global patterns of cultural behavior or cultural norms. Nor is it clear what genetic mechanisms may underlie the acquisition of cultural norms. Here, we draw on recent evidence for certain genetic variability in the susceptibility to environmental influences and propose the norm sensitivity hypothesis, which holds that people acquire culture, and rules of cultural behaviors, through reinforcement-mediated social learning processes. One corollary of the hypothesis is that the degree of cultural acquisition should be influenced by polymorphic variants of genes involved in dopaminergic neural pathways, which have been widely implicated in reinforcement learning. We review initial evidence for these predictions and discuss challenges and directions for future research.

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Current Opinion in Psychology 2016, **8**:167–174

This review comes from a themed issue on **Culture**

Edited by **Michele J Gelfand** and **Yoshihisa Kashima**

For a complete overview see the Issue and the Editorial

Available online 24th December 2015

http://dx.doi.org/10.1016/j.copsyc.2015.11.006

Introduction

The last two decades of research in cultural psychology shows that cultures vary in social orientations of the self as independent or interdependent [1–3]. Western cultures (e.g. European American cultures) value the independence of the self from others. In contrast, Eastern cultures (e.g. Asian cultures) value the interdependence of the self with others. The social orientation dimension of independence versus interdependence has systematic influences on cognition [4,2,5], emotion [6–8], and motivation [9••,10,11]. So far, however, it remains unclear what mechanisms might underlie the acquisition of the culturally sanctioned social orientations of independence and interdependence — in particular, the learning of explicit and implicit rules governing these orientations [12•], notwithstanding some initial evidence suggesting that culture-typical behavioral characteristics emerge after six or seven years of age and become more pronounced over the course of adolescence [13–15].

Here, we explore a novel perspective on the acquisition of explicit and implicit rules of social behavior, or cultural norms, by drawing on recent advancements in social genomics — a new field of research that investigates ways in which genetic and epigenetic processes are dynamically linked to socio-cultural processes to constitute various phenotypes including health and other psycho-social outcomes [3,16••,17,18]. Evidence suggests that individuals are genetically variable in terms of their sensitivity to environmental influences [16,17,19•]. Extending this work, we propose the norm sensitivity hypothesis [20••], which holds that people are genetically variable in their sensitivity to global patterns of cultural behaviors or social norms.

Mutual influences between culture and genes

Recent research in population genetics suggests that over the past 10 000 years of human history, numerous polymorphic genetic changes have been positively selected. Moreover, the rate of positive selection appears to have accelerated [21–23]. This exponential increase of genetic change seems likely to be related to the massive increase in human population and exposure to new environments (including domesticated animals and plants) and the resulting diversity in both infectious diseases and available nutrition. This is consistent with ideas in evolutionary biology and biological anthropology that genetic evolution and cultural evolution have proceeded in tandem as suggested by theories of dual inheritance [24] or gene–culture co-evolution [24–27]. Initial evidence for the gene–culture co-evolution came from effects of herding and milk production on emergence of genetic mutations that support the digestion of lactose — the milk sugar [28], leading to rapid

☆ Writing of this paper was supported by a National Science Foundation grant (SES 1325881) and an Air Force grant (FA955-01-41-0020) to SK and a National Institute of Health grant (RO1 MH098023) to MH.

incorporation of these mutations and supporting the growth of dairying culture.

One intriguing recent proposal is that some genetic variants may lend themselves to plasticity of behavior [17]; that is, carriers of certain alleles could be differentially susceptible to environmental influences [17,29,30]. Such individuals might be more susceptible to early childhood adversity or maltreatment. Indeed, early life traumas increase the risk of depression and posttraumatic stress disorder later in life, but particularly in carriers of specific alleles in the serotonin transporter gene (5-HTTLPR) [29], glucocorticocoid receptor chaperone gene (*FKBP5*) [31], and beta-2 adrenergic receptor gene (*ADRB2*) [32].

Extending this literature, Kim and colleagues argued that culture is but one element of one's eco-social environment that encourages certain behaviors and inhibits others. It would then seem to follow that genetic alleles that increase behavioral plasticity might also amplify cultural differences in behavior [16]. For example, it is normative to seek emotional or social support at times of distress in European American cultural contexts, but not in Korean cultural contexts; Kim and colleagues found cultural differences tended to be larger for carriers of the G allele of the oxytocin receptor gene (*OXTR*) polymorphism rs53576, previously linked to increased socioemotional sensitivity [33].

So far, work has focused on isolated behavioral traits such as social support [33] and emotion suppression [34], leaving open the question of whether genetic polymorphisms might modulate each individual's readiness to acquire global phenotypic traits such as norms and behavioral patterns of independence and interdependence. Although social learning has long been argued to be central in maintaining long-lasting cultural traditions [35,36,37•] (see also the Tomasello article in this Special Issue), rarely has this line of reasoning considered genetic factors that foster social learning.

The norm sensitivity hypothesis

Reinforcement-mediated social learning and dopaminergic system genes

The norm sensitivity hypothesis suggests that acquisition of global behavioral patterns and norms of culture, such as independence and interdependence, is influenced by reinforcement-mediated social learning. This type of learning is based on a set of mechanisms that enable the organism to select behavioral options that maximize anticipated rewards [38]. These mechanisms include discerning of behavioral patterns, selection of one's behaviors, and tracking of the reinforcements given to these behaviors [39,40]. Major components of reinforcement-mediated social learning (e.g. social rule learning and reinforcement tracking) involve dopamine-mediated brain substrates (e.g. frontal cortex and striatal reward processing area) [41,42]. By highlighting the role of rewards in social learning, we hypothesize that cultural and social learning is not merely cognitive, but also inherently motivational. We may therefore anticipate that cultural acquisition would be facilitated by gene variants that increase the efficiency of central dopaminergic pathways.

To illustrate, children in any society must infer the rules governing their 'street' by trial and error. The emerging cognitive representation of others' response patterns constitutes the perceived norm for the community. Individuals respond to such norms by formulating their own responses, which may in turn be reinforced either positively (i.e. complimented and praised) or negatively (i.e. punished and ignored). This social mechanism is universal, although cultures vary in terms of how tight or loose in application of social norms [43]. The individuals must track reinforcement history to assess validity of inferred social norms. Resulting behaviors tend to be consistent with group norms, some aspects of which are culture-specific (e.g. independence versus interdependence) and others are more universal (e.g. within-group cooperation and altruistic behavior); although culture-unique socio-ecological conditions such as mobility and strength of within-group ties are likely to influence the extent of such behaviors [44].

Our theoretical framework, illustrated in Figure 1, explains contemporary cultural variations in terms of large-scale ecological considerations. Anatomically modern humans evolved in Africa approximately 200 000 years ago [45], spread out of Africa approximately 50 000 years ago, and started farming and herding approximately 10 000 years ago. One factor that initially differentiated Eastern versus Western regions of the Eurasian continent is the type of crops available and successfully domesticated (e.g. wheat versus rice) [46••]. This differentiation might have imposed a strong constraint on divergent paths of cultural evolution in the two broadly demarcated regions of the continent.

As a result of sedentary forms of living afforded by newly-emerged subsistence systems, human groups became increasingly large and started to incorporate non-kin members. We may assume social norms were utilized to breed much-needed within-group cooperation and coordination [47,48]. Dopaminergic system genes may therefore have played an instrumental role in facilitating the norm-based system of cooperation and coordination — the system we call culture. Given that human groups expanded in size over the last 10 000 years since the inception of sedentary living, the evolution of norm sensitivity must have been critical over this recent evolutionary past [49,50]. As argued by recent theorists [51], complex traits influencing social learning are likely to be