Editorial

Why China is currently underperforming in medical innovation and what China can do about it?—Part III: social psychology and evolutionary psychology perspectives

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"It is fun to do things that people don't think are possible or likely. It's also exciting to achieve the unexpected."
—Michael Saul Dell (founder and CEO of Dell Inc.).

In our recent survey, we documented that China is currently underperforming in medical innovation (1-3). From social psychology and evolutionary psychology perspectives, in this editorial I put forward some plausible reasons to partially explain why current China is disadvantaged in science and technology innovation, and also why China produced few polymaths.

Aristotelian principle: the 'flow'

Intrinsic motivation is the drive to engage in a task because it is interesting, enjoyable, or positively challenging. In 1943 psychologist Abraham Maslow [1908-1970] introduced the concept that lowest level of human needs is primitive: food, water, shelter, sex (4). Once those needs are satisfied, the human try to satisfy a sequence of other inborn needs. The need for longer term safety follows the need for day-to-day survival, then comes a need for intimacy with other people, then the need for recognition and respect from others, and finally self-actualization (4). The Aristotelian principle as explained by philosopher John Rawls [1921-2002] is that other things equal, human beings enjoy the exercise of their realized capacities (their innate or trained abilities), and this enjoyment increases the more the capacity is realized, or the greater its complexity. In the early 1970s, psychologist Mihaly Csikszentmihalyi studied the nature of enjoyment by interviewing people who spent long hours and intense effort on activities that had little monetary reward, rock climbers, chess players, amateur modern dancers, and high school basketball players. Why did they invest so much of themselves in these activities? What did they get out of them? Csikszentmihalyi published a series of documents elaborating the data and the theory that now goes under the label of *flow* (5-7). *Flow* is human enjoyment in its most meaningful form. Human beings enjoy the exercise of their realized capacities. Harry Harlow [1905-1981] also showed that monkeys would repeatedly solve mechanical puzzles despite the absence of food or other extrinsic rewards (8). Humans persistently exhibited tendencies to enjoy the stimulation of new things, complexity, surprises, even in the absence of any perceptible external reinforcement.

The pursuit of excellence is as natural as the pursuit of happiness, as Murray noted: '*The genius…in the way they did their work, they more commonly resembled a craftsman at his bench, struggling to get it right, agonizing over mistakes, doing it over again, with a vision of perfection insistently pulling him onward*' [(9), page 458].

Abraham Flexner, the founding Director of the Institute for Advanced Study at Princeton, USA, wrote (10): '*While practical benefits often result from pure academic research at the most fundamental level, such benefits are not guaranteed and cannot be predicted; nor need they be seen as the ultimate goal. Ventures into unknown territory inevitably involve an element of risk, and scientists and scholars are rarely motivated*

by the thought of an end product. Rather, they are moved by a creative curiosity that is the hallmark of academic inquiry'. Also according to Schoenberg [1874-1951], an Austrian composer and painter, and the leader of the Second Viennese School (11): '*Those who compose because they want to please others, and have audiences in mind, are not real artists. They are not the kind of men who are driven to say something whether or not there exists one person who likes it, even if they themselves dislike it. They are more or less skillful entertainers who would renounce composing if they did not find listeners*'.

Following the economic successes of China of recent decades, there is a tendency that her citizens, including the potentially creative minority, are being more attracted to materialism, while there is less idealism and romanticism. This does not help China to produce high quality science.

Reward and motivation

The controversy over rewards has a long intellectual history (12-14). Jean-Jacques Rousseau [1712-1778] argued that if a person gets an external reward for doing something, like money, after a while this person comes to see the activity merely as a means to an end, rather than as an opportunity for enjoyment or exploration. Many studies find that those who are rewarded seem to work harder and produce more activity, but the product is of a lower quality, contains more errors and is less creative than the work of comparable non-rewarded subjects working on the same problem (12,15). To offer a material reward such as money, or try to link the task with something intrinsically more interesting typify the motivational strategies used by administrator, managers, teachers and parents worldwide. But psychological research now showed, if not used properly, these tactics might reduce motivation in the long term (16).

In the 1970s experiments first appeared in which people were presented with an interesting task like playing games, creating art or solving puzzles for which they received various rewards, ranging from money, sweets and gold stars to praise. The control group performed the activity without receiving any reward at all. Both groups were then observed during a non-reward period in which they were free to continue performing the task or to engage in some alternative activity. It was repeatedly found that rewarding people stopped them continuing to do a task when no reward was available. This experiment has since been replicated many times, with numerous variations in design and in types of subjects (17-23). It seemed the external reward changed their motivation from doing a task because they enjoyed it to doing it only for the reward. Being offered an extrinsic reward seems to 'crowd out' intrinsic motivations (12). Persons who are paid to solve problems typically choose easier ones than those who do not expect any payment (24). Particularly negative effects are found on high-interest tasks when the rewards are tangible, expected (offered beforehand), and loosely tied to level of performance (25). Similarly, Murray augured that rewards may lead to more quantity of the work, but not high quality work, and also monetary award does not lead to excellence [(9), page 105].

The '*show me the money*' theory is based on the negative view of human character that contends we only do things because of the monetary reward (12). Then inevitably people demand more and more cash, in order to do less and less. The other major problem with this approach is many members naturally become resentful of their lack of financial reward compared to those they see unfairly reaping the benefits of '*show me the money*' (12).

Intrinsic motivation is a precious thing to be nurtured and often might get snuffed out by external rewards (12). The reason why we pursue scientific truth is out of curiosity, and also sometime to gain respect from those around us. The materialism awards and promotions currently abundant in current Chinese academia, such as the monetary award with linkage to the number of publication or journal impact factor or other rankings, will likely discourage China to produce high quality science. The recent *Lancet* editorial (26) suggested that current huge investments in biomedical research will not translate into new discoveries or more reliable medical evidence without a sea change in China's current research culture.

Evolutionary psychology

Evolutionary psychology showed that many human drives can't really be understood as ways people maximize their well-being in their own lifetimes, but can only be interpreted as adaptations to survival and reproduction in an ancestral environment (27). Natural selection refers to differential survival or reproduction of one genotype *vs.* others in a population leading to changes in the gene frequencies of the population. Referred to as the 'Baldwin evolution', Baldwin [1861-1934] expressed the idea that, under some conditions, learned behaviors can affect the direction and rate of the evolutionary change by natural selection (28). If this selection pressure continues in successive generations, the originally learned innovation

or practice or culture can eventually come under genetic control and thus become a candidate for natural selection. Importantly, Theodosius Dobzhansky [1900-1975] discovered that mutations which could be harmless could create variability far greater than anyone had previously imagined. He showed that, due to random mutation, fruit flies of the same species became quite distinct (29). Dobzhansky's work was instrumental in spreading the idea that it is through mutations in genes that natural selection takes place. In addition, evolutionary biologist Richard Lewontin developed the 'niche construction theory'. It emphasizes an even closer and more imbedded relation between the environment and organisms. Lewontin argued that organisms are not passive receivers of environmental influences but are active constructers of its environment (30). Richard Dawkins further argue that culture and technology are simply extended phenotypes (31). Like beavers' dams or groundhogs' underground tunnels, the human culture is the result of genes changing the environments of their hosts, i.e., organisms who are genes' vehicles. Thus, the modified environments such as society, culture, and technology are extended phenotypes (31,32).

One typical case of strong and recent natural selection is the unique demography and sociology of Ashkenazi Jews in medieval Europe selected for high intelligence (33). Ashkenazi Jews have the highest average intelligence quotient (IQ) of any ethnic group. They are overrepresented in fields with the high cognitive demands. During the 20th century, they made up about 3% of the US population but won 27% of the US Nobel science prizes and 25% of the ACM Turing awards. They account for more than half of world chess champions (33). Another intriguing aspect is the story in Russia during 1870-1950. Russia drove out a large portion of its Jewish population, and persecuted the ones who remained. And despite all that, Jews are over-represented among Russian significant figures in sciences and humanity by a ratio of 4:1 during this period [(9), page 281]. However, in pre-Diaspora times, the Jews did not occupy an unusual ecological niche nor did they yet exhibit unusual cognitive traits. Most Jews then were then farmers, just as in nearly all settled populations, and they must have experienced evolutionary pressures similar to those experienced by other peoples of the region. There was also no elevation of intelligence observed among Sephardic and Oriental Jews today (34-37). Ashkenazim experienced unusual selective pressures in medieval Europe that favored increased intelligence. There was an increase in the frequency of particular genes that elevated intelligence as a by-product of this selective regime, which in the meantime led to an increased incidence of hereditary disorders (33). Another trade-off is that Ashkenazim has relatively low spatio-visual ability, and they would most likely suffer competitive disadvantage as hunter-gatherers, for example (33). A similar phenomenon can be found in India. The Parsi is an endogamous group with high levels of economic achievement, a history of long-distance trading, business and management. They descend from a group of Zoroastrians from Great Persia who migrated to India during the 8th or 10th century to avoid persecution by Muslim invaders. The Parsis have made considerable contributions to the history and development of India, all the more remarkable considering their small numbers (constituting only 0.006% of the total population of India). India's ruling Nehru-Gandhi dynasty, which has dominated the Congress Party since independence was created when Feroze Gandhi (a Parsi with ancestral roots in Bharuch) married the then Indira Nehru. Ratan Tata, India's most successful industrialist and owner of Jaguar Land Rover and Corus Steel, the late Field Marshal Sam Manekshaw, India's most celebrated soldier, and the acclaimed novelist Rohinton Mistry are all Parsis (38-40).

The value of creativity in the arts, sciences, technology, and political endeavors is immense. Some researchers argued that creativity constitute humankind's ultimate resource (41). Social and technical innovation relies heavily on creative people (42). While it is largely acknowledged that intelligence (primarily measured by IQ) and creativity [primarily measured divergent thinking (DT)] are related, the exact nature of their interplay is still under debate (41). Psychologist Joy Guilford [1897-1987] found a positive linear relationship in the lower to average IQ range while there was no correlation at above-average levels of intelligence (43). Above-average intelligence is thought to form a necessary but not a sufficient condition for high creativity. More specifically, it is assumed that there exists a threshold in intelligence which is usually set to an IQ of 120 (44,45).

The issue of East Asian 'creativity problem' has been highly debated (46-49). Some argue that the ideographic Asian languages curb abstract thinking and creativity among Asians (48). Others point out that Asian cultures devalue and discourage critical thinking (9). Chang *et al.* proposed that East-West cultural differences (e.g., independent *vs.* interdependent self-construal; autonomy *vs.* harmony in values; hierarchical *vs.* egalitarian relationships) could result from social learning and individual learning as primary means to adapt to the local environment (50). When

the environment is relatively stable either vertically or horizontally, copying is more effective and efficient than the individual learning of trial and error. If the environment changes rapidly, either vertically, from one generation or cohort to another, or horizontally, due to migration among habitats, copying of an existing adaptive behavior might not be adaptive to the changing environment. Individual learning is needed to match adaptive behaviors to the changing environment. Individual learning is less efficient than social learning, and trial and error takes up more time, energy, and brain power. Historical and contemporary evidence showed that indicates smaller extents of environmental variability in China than in Europe, favoring social learning in the East and individual learning in Europe (50). Corresponding to these different adaptive strategies, East-West differences stem from learning styles that differ between copying and rote memorization, on the one hand, and critical thinking and innovative problem solving, on the other hand. Eastern cultures also encourage conformity and compliance and social hierarchy all of which facilitate social learning and Western cultures encourage independence, self-assertion, and personal pursuit of interest which enable individual learning or innovation.

The differences between today's Asians and Westerners can be due to the different environments after humans left Africa. Climatic change in terms of glacial-interglacial variations, seasonal fluctuations, and changes due to natural disasters create pressure for phenotypic plasticity of cognitive systems (51). Social dynamics represents a source of environmental variability by generating unpredictable social situations which would favor the evolution of plasticity of the brain (52). Cooperation, competition, and coalition among humans exert the strongest pressure on brain development (53,54). Cultural adaptations and the gene-driven cognitive adaptations act together rather than separately (32). Some authors argue that 'an individual's position on this continuum (of social *vs.* asocial learning) is a genetically heritable trait' (55), or that 'Which (learning) strategy is used is genetically determined for each individual' (56). It is noted that Asian students grown up in the west retain some of the behavioral traits of the East culture (50). Chinese students grown up in the west tends to do well in primary and secondary schools which use more social learning style, but not necessarily in university which more requires individual learning (57,58). Chinese are known to hyper-susceptible to motion sickness (59,60); this could partially reflect our ancestors in China had a less adventurous history.

Arabic, Chinese, Japanese, and Indian cultures and those of the rest of Asia and elsewhere are familistic, hierarchical, and consensual, this would work against sustained exploration and innovation [(9), page 401]. The relative lower achievement of American students in primary and secondary schooling, as compared to some East Asian students, may reflect more distant forces due to cultural traditions that emphasize individual learning and social learning differently. However, Euro-American countries remain the world leader in scientific, technological, and business innovations. The evolutionary psychology may partially explain why it is difficult for recent China to produce polymaths such as Mikhail Lomonosov, Leonhard Euler, Henri Poincaré, Andrey Kolmogorov, John von Neumann, or Leonid Kantorovich.

Conclusions

With the understanding of these social psychology and evolutionary psychology perspectives as discussed above, we can see that current China is in some ways disadvantaged in science and technology innovation. However, the unprecedented cross-cultural exchange on a global level is likely to result in reduced East-West differences in evolutionary psychology (61). In the meantime, the current author calls for China to invest more on '*soft*' sciences such as psychology, and attract bright students to study social sciences, which will undoubtfully promote China's capability to do high quality '*hard*' sciences as well as technological innovation. In the meantime, the author calls for more idealism and romanticism.

Explanation note: evolutionary psychology of *Homo sapiens* left Africa

The Pleistocene epoch (about 1.6 million to 10,000 years ago), during which humans evolved, was a period of extraordinary constancy and continuity. The narrow habitat range of the East African Valley and the long span of time of Pleistocene and earlier led to the evolution of a genetic blueprint, including the domain general and domain-specific cognitive architectures, which differ across individuals but not across groups or regions (50,62). In Pleistocene epoch Africa there were very few evolutionarily novel problems for our ancestors to solve during most of human evolutionary history, general intelligence was never that important in the ancestral environment. Cultures and cultural differences emerged mainly after but not before humans left Africa.

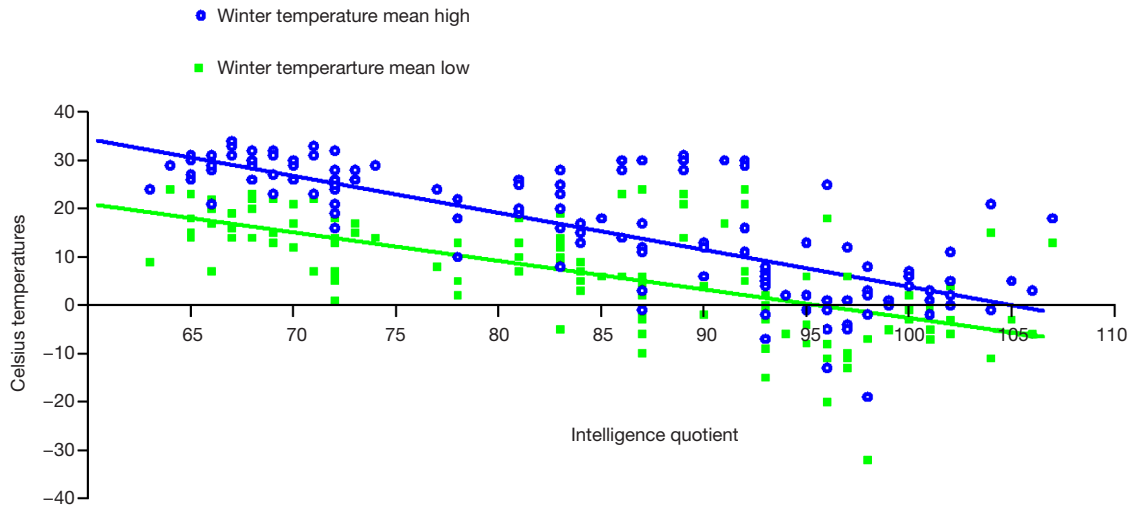

Figure 1 A negative correlation between intelligence quotient (IQ) *vs.* mean winter time Celsius temperatures for 129 nations (67).

Another factor contributing to fast growing cultures and cultural differences is human acquisition of language, which also seems to have occurred after, rather than before, humans left Africa (50).

After left Africa, our ancestors did not have prepared solutions in the form of evolved psychological mechanisms for novel, non-recurrent problems. Novel, non-recurrent problems require thinking and reasoning in order to solve them. Solutions to novel, non-recurrent problems require improvisational intelligence, the ability to reason deductively or inductively, think abstractly, use analogies, synthesize information, and apply it to new domains. As a result, many of our potential ancestors undoubtedly died because they could not solve these novel problems. Kanazawa (62) argues that general intelligence (*g*) evolved as a domain-specific adaptation against the background of the originally limited sphere of evolutionary novelty in the ancestral environment in Africa. Intelligent individuals are better able to solve problems than less intelligent individuals, only if the problems are evolutionarily novel. It has become universally important because we now live in an evolutionarily novel world. If novel, non-recurrent problems happened frequently enough in the environment of evolutionary adaptedness, then any genetic mutation that equips its carrier to think and reason would be selected for and could evolve as an adaptation in order to solve novel, non-recurrent problems.

Some intelligence researchers (63-66) point to the importance of climate and temperature in the evolution of general intelligence. Life in temperate and cold climate in Asia and Europe is harder to survive than that in tropical and subtropical climate in Africa where humans lived most of evolutionary history. Food is scarcer, and shelter and clothing more difficult to construct properly, in colder than in warmer climate. Cognitive demands placed by the need to survive harsh winters in cold climate select for higher intelligence, and thus general intelligence is expected to evolve and become higher in colder climates. A climate that is too cold to grow crops for part of the year demands foresight and self-control skills, which then serve as resources for other development. When migration to frontiers or rugged lands of cold winter and sparse population; settlement in the frontier encourages independent mentality and individualistic social institutions (66). Templer and Arikawa's analysis showed that (67), across 129 nations, winter temperature is negatively correlated with average intelligence (r=–0.76, P<0.01, with winter high temperature, and r=–0.66, P<0.01, with winter low temperature) (*Figure 1*). These findings could also be viewed as being congruent with the contention that higher intelligence evolves in colder climates. Pathogen, natural disasters, war, and migration all pose significant challenges to the maintenance and sustainability of human society. Other aspects of evolutionary novelty include new species of fauna and flora, geography, topography, and altitude.

Pathogenic diseases impose selection pressures on the social behavior of host populations. The existence of cross-cultural differences in human cognition and behavior is also contingent upon the relative presence of pathogens in the

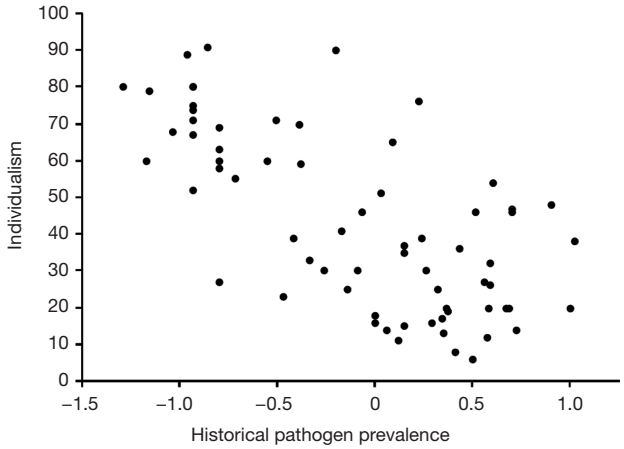

Figure 2 The correlation between historical pathogen prevalence and individualism [adapted from reference (69) Hofstede 2001; r=–0.69, P>0.001, n=68]. Hofstede [2001] assessed attitudes and values from over 100,000 IBM employees worldwide. He also consulted other published reports, observations and descriptive information. From these data Hofstede estimated individualism/collectivism scores for 68 specific geopolitical regions. Higher scores indicate greater individualism. IBM, International Business Machine.

local ecology. It has been shown collectivism (compared with individualism) will more often characterize cultures in regions that have historically had higher prevalence of pathogens (68). Drawing on epidemiological data and the findings of worldwide cross-national surveys of individualism/collectivism, Hofstede showed the regional prevalence of pathogens has a strong positive correlation with cultural indicators of collectivism and a strong negative correlation with individualism (69) (*Figure 2*). The correlations remain significant even when controlling for potential confounding variables.

Below are the accounts of historical and contemporary evidence of environmental variability of China and North/Western Europe (50).

Latitude and climate

The climate in Europe (36°N to 63°N in latitude) is more variable than that in China (18°N to 45°N). Firstly, rainfall and temperature are more variable over the course of a year and extreme cold is more severe toward the poles. There were more severe natural disasters in Europe than in China. For example, 19 of the worst famines and droughts in recorded history happened in Europe, whereas China has only experienced nine; more ice storms and snowstorms are recorded in Europe than in China; and there have been more earthquakes in Europe than in China (70). Because Earth is tilted at 23°, the duration of daylight at higher latitudes is also more variable throughout the year than it is at lower latitudes. The solar radiation energy received on a given surface area, varies throughout the year, and it variations increase with latitude. This means that on a long time scale, China, occupying lower latitudes, has a more stable solar radiation energy level than Europe, located at higher latitudes (71). Finally, because most hominid and human evolution took place in Africa close to 0° of latitude, high latitude by itself represents environmental novelty and variability deviating from the human evolutionary environment.

Pathogens

China has higher pathogen prevalence than Europe by both historical and contemporary measures of pathogen prevalence (50). Pathogen itself presents an independent drive for social learning because the cost of trial and error may be injury or death. Many studies have found that pathogen prevalence is negatively correlated with absolute latitude. Specifically, China (18°N to 45°N) has been found to have higher pathogen prevalence than Europe (36°N to 63°N) by both historical and contemporary measures of pathogen prevalence (71).

Warfare

Warfare adds to increased population movement. Environmental change was realized through the utilization of new military weapons and technologies and diffusion of the ideas and cultures of the victorious nations. Throughout history, more wars have been fought in Europe than in Asia. From 1816 to 1965, Europe saw 144 interstate and extra-systematic wars whereas 28 of these two types of wars have taken place in Asia (excluding the Middle East) (72). The number of war engaging months for this period was 2,514 for Europe and 737 for Asia (72). Another data source shows that, among a total of 177 major military conflicts that happened in the world between 1648 and 1989, Europe had 97 wars whereas Asia had only 26, most of which broke out after 1945, and many of which involved Western nations (73). According to Gochman and Maoz (74), as many as 261 armed confrontations occurred between 1816 and 1976 in Europe. During the same period, Asia had

140 military disputes, and 99 of them occurred after 1945. According to Neiberg (75), Chinese preferred defense to offense, whereas Western civilizations advance through exploratory and expansionary means.

Political unity-plurality

Since the establishment of the Qin Dynasty in 221 BC, the land comprising China has been ruled by a single centralized government. For most of its history and in most of its territories, China has maintained a single written language. In Europe, however, centralized governance has been much shorter-lived and has ruled smaller areas. Thus, by governance plurality and language diversity, Europe has had much more changing and variable environment than China in the past 2,000 years till the present day.

Migration

Migration provides another important source of environmental change and variability (76,77). From about the 8th century BC to the 16th century AD, the frontier zones separating China from its northern nomads remained virtually unchanged. During the same period in Europe, the frontier zones separating its high civilizations from underdeveloped civilizations have periodically expanded, with successive migration and population movement (78). Throughout Chinese history, different dynasties restricted population movement (79). In Europe, citizens, merchants, and craftsmen traveled much more freely.

Agriculture

China has been an agricultural or horticultural state throughout its history whereas Europe has practiced nomadic pastoralism and dairy farming alongside agriculture. Agricultural production in China has been family based throughout its history, which depends on land and family traditions rather than mobility, trade, and innovations. Ancient European agriculture production promoted divisions of labor, trade, and the eventual development of a commodity economy (80).

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Footnote

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