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Adaptive Intelligence and Cultural Evolution

Chi-yue Chiu, Hiu-sze Chan, Sau-lai Lee, and Jennifer Yuk-Yue Tong

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> People shoot themselves, or take poison, or jump off a cliff. But suicide does not have to be individual and it does not have to be quick. If people, collectively, destroy the water they drink, the air they breathe, the climate in which they live, they are doing collectively and slowly what a person may do individually and quickly. The ultimate effect is the same … Humans seem to be much better at seeing short-term consequences for individuals than long-term consequences for either individuals or collectivities. They avoid thinking sufficiently about the long-term future. But that is a flaw in their intelligence: To be adaptively intelligent, one must look not only at the short-term, but also at the long-term, as illustrated by the tragedy of the commons.
>
> —Sternberg (2021, p. 6)

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C. Chiu (✉) • H. Chan • S. Lee • J. Y.-Y. Tong
The Chinese University of Hong Kong, Hong Kong, Hong Kong
e-mail: cychiu@cuhk.edu.hk

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As the volume of big data multiplies, data scientists start to rethink what artificial intelligence is. A machine can be trained to convert inputs into insights to enable action. However, does it always deliver the most context-relevant output whenever required? How can we render artificial intelligence actually intelligent? Can this be achieved without human involvement (Joshi, 2019)? Whereas most intellectual capacities captured by conventional IQ tests can be replaced by "intelligent" machines, adaptive intelligence—the ability to deliver contextually relevant outputs for the survival and sustainable development of humans and the world they inhabit—may be a uniquely human ability.

Detailed expositions of the nature, measurement and training of adaptive intelligence can be found in Sternberg (2021). In this chapter, we attempt to further enrich the theoretical construct of adaptive intelligence by connecting it to cultural evolution theories. We also consider some abilities and processes that may support the development of adaptive intelligence, and discuss issues related to the measurement of adaptive intelligence.

In the first part of the present chapter, we will link adaptive intelligence to cultural evolution theories (e.g., Creanza et al., 2017; Forgarty and Kandler, 2020). We propose that adaptive intelligence is supported by a concatenation of mutually reinforcing individual and interpersonal capacities. These capacities have evolved and are evolving to support adaptation of human populations to the environment and its changes. Furthermore, adaptive intelligence is solution-oriented; it enables human groups to identify/create and implement optimally adaptive strategies to meet challenges in concrete physical, socioeconomic and social ecologies. Based on these ideas, in the second part of the chapter, we propose a conceptual framework for understanding, measuring and developing a psychological system of adaptive intelligence.

Adaptive Intelligence: What Is It, and Why?

Intelligence has been defined narrowly as "what IQ test measures" (Boring, 1923). For over a century, the view that intelligence is a context-free positive manifold (i.e., an intrapersonal entity associated with many important achievement and life outcomes) has been a heavily promoted idea in intelligence research and popular culture. Many intelligence researchers still believe that individual differences in intelligence can be captured by the shared variance of a test battery that is statistically associated with cognitive performance (e.g., performance in memory, spatial-linguistic tasks) and life outcomes (e.g., school success; see Van de Mass et al., 2014).

Nonetheless, there are alternatives to this conventional view of intelligence. For example, instead of regarding intelligence as a context-free positive manifold, the functional view of human intelligence treats intelligence as a concatenation of mutually reinforcing context-responsive capacities that enable and support individuals' goal-directed behaviors (Sternberg and Salter, 1982). This perspective can be traced back to David Wechsler (1944), who defined intelligence as "the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his [*sic*] environment" (p. 3).

Adaptive intelligence (Sternberg, 2019) is a conceptual hybrid of the functional view of intelligence and a broad cultural evolutionary perspective (see Alvard, 2003). Adaptive intelligence extends the functional view of intelligence by featuring collective adaptation as a hallmark of human intelligence. According to this view, any thought and behavior labeled as adaptively intelligent must contribute to the perpetuation of human populations instead of being destructive to this perpetuation (Sternberg, 2019).

Cultural Evolution

Cultural evolution is the study of how culture drives human evolution. Like biological evolution, cultural evolution can drive human adaptation. Moreover, cultural evolution can override the adaptive effect of biological evolution. To understand the cultural evolutionary perspective, consider the example offered by Richerson and Boyd (2005). Many plants contain toxic substances. Through natural selection, the *TAS2R* gene family and the bitter taste receptors on the tongue that could bind to toxic chemicals were evolved. Animals developed taste aversions to bitter plants; they use the bitter taste of these plants as a signal that they are inedible. However, humans can override these taste aversions when they learn from others that certain plants (e.g., *Coptis chinensis* used in Chinese medicine) with an aversive bitter taste have medicinal value. Although our sensory physiology has not changed (eating these plants still leaves a bitter taste in the mouth), the cultural belief in these plants' medicinal value increases the likelihood of their consumption in the population.

Three important questions cultural evolution theories attempt to address are also at the heart of the theory of adaptive intelligence. First, why do human actions often seem to be mildly (or sometimes wildly) dysfunctional and sometimes lead to colossal catastrophes? According to Heylighen (1992), natural selection favors individuals who can produce many copies or replicas of themselves (survival of the fitness). That is, individuals are biologically prepared to use scarce resources to the limit to produce a maximum of copies. This explains the tragedy of the commons: Competition between self-interested individuals causes rapid depletion of shared resources (e.g., clean water and air) and ultimately threatens the survival of all species.

Second, how did cooperation evolve in human populations to regulate dysfunctional behaviors and prevent colossal catastrophes? To answer this question, Tomasello et al. (2012) have put forward *the interdependence hypothesis*. According to this hypothesis, there were two steps in the evolution of human cooperation. First, interdependence in collaborative foraging required individuals to have a direct interest of their partners. Individuals developed new motivations and skills that support cooperation. Next, these motivations and skills were scaled up to group life; cultural conventions, norms and institutions that supported cooperation were evolved.

Finally, what are the characteristics of a human psychology that is uniquely adapted to complex culture. Tomasello (2016) believes that in the first step of the evolution of cooperation, humans began to "form with one joint goal toward mutually beneficial ends, structured by joint attention." They also "recognized simultaneously different individual roles in the collaborative activity and different individual perspectives on their joint focus of attention" (p. 62). It is the evolution of these characteristics, collectively known as *joint intentionality*, that allowed humans to engage in cooperative collaboration.

Adaptive Intelligence and the Multilevel Selection Problem

Cultural evolution theories explain why we need adaptive intelligence to escape from the tragedy of the commons. Neoliberalism asserts that to optimize the collective interest of the society, all individuals in the society should always be able to freely and rationally choose any available options to maximize their self-interests. However, this neoliberal assumption does not always hold (see Bettache and Chiu, 2019). Consider a mixed motive social dilemma game in which a group of players make bids anonymously to decide how much timber to harvest from a self-replenishing forest. In this game, selfish choices would almost always benefit the individuals at the expense of the group's long-term interest (Sheldon and McGregor, 2000).

This example illustrates the problem of *multilevel selection*: Evolution takes place at multiple levels simultaneously. More importantly, selfish choices that almost always benefit the individuals can place the group's long-term interest at risk (Campbell, 1990; Chiu et al., 2010). Enron's failure, a prelude to the financial market meltdown in 2008, ensued from financial engineers' proneness to privately profit from competition at the expense of the economy's financial health. As Turchin (2016) puts it, "It is cooperation that underlies the ability of human groups and whole societies to achieve their shared goals… But what Skilling [Enron's CEO] did at Enron was to foster within-group competition, which bred mutual distrust and back-stabbing (if not throat-stomping). In other words, Skilling completely destroyed any willingness among his employees to cooperate—not with each other, not with their bosses, not with the company itself. And after that, collapse was inevitable" (p. 47).

Unlike a collection of competitive selfish maximizers, a group that possesses cooperative characteristics would flourish, although the advantage of cooperation may not be apparent at the individual level. A lesson we learn from the COVID-19 pandemic is that citizens in societies with strict cooperative norms are prepared to voluntarily adopt social distancing and contact tracing practices. These practices protect public health, although they entail self-imposed restrictions on personal freedom. As a consequence, these societies had lower infection and mortality rates (Gelfand et al., 2021).

Harmonization of personal and collective interests requires social processes that (a) incentivize cooperative behaviors, (b) enable early detection of free riders (people or organizations who privatize profits and externalize losses) and (c) support formation of coalitions to sanction selfish maximization (Sheldon et al., 2000). It also requires psychological processes and abilities that support *co-opetition*, the act of cooperating with competitors to achieve a common goal (Brandenburger and Nalebuff, 1996). We shall explore some of these processes and strategies later in the present chapter.

Context-Responsiveness in Behavioral Expressions of Adaptive Intelligence

Cultural evolution theories also help to illustrate several important aspects of adaptive intelligence. First, according to Tomasello (2016), the thinking processes that enable human adaptation to dynamic changes in the environment is a self-regulating thinking system that can process, store and evaluate environmental information and utilize it to realize individuals' goals by flexibly adjusting behavioral strategies to (sometimes novel) situations occurring in its dynamically changing habitat.

Second, adaptive intelligence underscores the interdependence of behaviors and their environments. Consistent with this emphasis, cultural evolution theories assert that, generally speaking, environmental affordances and constraints exert selection pressure on behavioral preferences, although the selection pressure does not rigidly determine behavioral choices (Alvard, 2003). For example, external threats and competition with out-groups increase the preferences for belonging to a large group and hierarchical social organizations (Turchin, 2016).

Furthermore, cultural evolution theories also highlight the cultural and temporal variations in humans' responses to different environments and environmental changes. For example, ancient droughts in Arabia during the Dark Millennium (from approximately 5900 to 5300 years ago) led to marked regional differences in technological, economic and cultural responses. In southeastern Arabia, where there were less extensive aquifers, the droughts led to widespread depopulation of the interior settlements and a shift to coastal occupations. In contrast, in northern Arabia, there were large and shallow aquifers. To survive the climate shifts, the inhabitants developed new technology to capture runoff through construction of landscape features and excavation of wells. These technological changes enabled the onset of oasis agriculture (Petraglia et al., 2020).

The extent to which a certain behavioral strategy is adaptively intelligent depends on the context; a type of behavior that is adaptive in one cultural context might not be adaptive in another (Sternberg, 2019). As an example, consider growth mindset, the belief that one can raise one's level of intelligence by mobilizing effective effort. This belief has been shown to enhance resilience in the face of achievement setbacks (Hong et al., 1999) and consequently increase academic performance (OECD, 2021). However, the beneficial effects of the growth mindset are significantly attenuated in societies with lower academic mobility, operationalized as the percentage of children from low-education households to graduate from tertiary education (Jia et al., 2021). Across 30 countries, depending on the academic subject (math, science and reading literacy), the gain in academic performance from exhibiting the growth mindset was reduced by 42% to 45% from a country with high academic mobility to one with low academic ability. Inducing the perception of low academic mobility in a controlled experiment also attenuated the positive effects of growth mindset interventions on learning motivation. In low mobility societies, students do not feel that improvement in academic performance will increase the likelihood of rising to a higher social and economic position. Even if they believe that they can raise their ability, they may not be motivated to invest in academic pursuits.

In a stable environment, there is no demand for adjusting the self or altering the environment. Status quo maintenance is the optimal adaptation strategy under these circumstances. However, when a massive change in the environment occurs, adaptation to the novel environment becomes necessary. The inhabitants of a society can adapt to the new environment in two ways: (a) *Self-adjustment*: the inhabitants adjust their behavioral preferences to the new exigencies of the environment; and (b) *Environment reshaping*: inhabitants take agentic, innovative actions to reshape the environment (Forgarty and Kandler, 2020). Table 3.1 shows the major

Table 3.1 Four patterns of adaptive responses to the environment

		Self-adjustment	
		Not preferred or permissible	Permissible and preferred
Environment reshaping	Not preferred or permissible	Migration or environment selection	Standing variations of existing preferences
	Permissible and preferred	Niche construction; De novo innovation	Person-environment co-evolution

patterns of responses to environmental changes, depending on whether self-adjustment and environment reshaping are permissible or preferred. *Migration (environment selection) is* likely to occur when both self-adjustment and environment reshaping are not preferred or permissible. For example, *the inhabitants in* southeastern Arabia migrated to the coastal areas in response to the droughts in the Dark Millennium (Petraglia et al., 2020. *Standing variations* are likely to occur when only self-adjustment is preferred or permissible. Self-adjustment is preferred and tends to spread in societies with immutable structures and norms. In these societies, individuals can achieve their personal goals only by navigating the fixed structures and norms (Su et al., 1999). People in these societies tend to imitate behaviors exhibited by the majority of the population (Leung et al., 2014). The *conformist bias* is likely to prevail in these societies; the probability of adopting a more common cultural variant in a population exceeds its frequency (Denton et al., 2020). *Niche construction* and *de novo innovation* are likely to occur when only environment reshaping is preferred or permissible. Environment reshaping is preferred and tends to spread in an environment with mutable structures and norms. In these societies, individuals prefer to change the environment instead of the self to achieve their personal goals (Su et al., 1999). The inhabitants are interested in the exploration of novel practices. They also tend to display the *anti-conformist bias*; the probability of adopting a more novel cultural variant in a population exceeds its frequency (Denton et al., 2020). Finally, *person-environment co-evolution* tends to occur when both self-adjustment and environment reshaping are preferred or permissible.

COVID-19 is a catastrophic environmental shift that requires a coping response. Survival of human groups depends on their ability to meet the new environmental challenges; status quo maintenance is no longer an option. Before effective pharmaceutical interventions (e.g., vaccination) were found, societies needed to rely on non-pharmaceutical preventive measures (e.g., lockdowns, social distancing and mask use) to contain spread of the virus. To some extent, effectiveness in implementing these non-pharmaceutical measures depended on government efficiency. However, to a critical extent, it also depended on citizens' willingness to comply with the government policies, and to give up some personal freedoms and regulate their own behaviors for a common good.

Voluntary adoption of non-pharmaceutical measures would more likely occur in societies that already have strict cooperative norms. In these societies, most citizens would adopt the measures willingly once they recognized that mask use, social distancing and other non-pharmaceutical practices were a part of the prevailing cooperative norms. In contrast, in neoliberal societies that prioritize unbridled expression of individual freedom, government-imposed non-pharmaceutical prevention policies might meet disapproval and even resistance from a sizeable proportion of the population (Mair, 2020). Consistent with these contentions, there is research evidence that before COVID-19 vaccines were available, the cumulative percentages of confirmed cases and deaths were lower in tight countries (countries with strict norms) than in loose countries (countries that tolerate rule-breaking; Gelfand et al., 2021), and in collectivist countries (countries that prioritize attainment of group goals) than in individualist countries (countries that prioritize attainment of personal goals; Lu et al., 2021). The same relationship was found when data from 3141 counties of 50 US states were analyzed and when controlling for a host of variables (including GDP per capita, stringency of the non-pharmaceutical preventive measures and government efficiency).

In a recent study, we analyzed the rates of vaccination (a pharmaceutical preventive measure) across 43 countries since COVID-19 vaccines were available in these countries. Latent profile analysis results show that these countries can be classified into loose-individualist or tight-collectivist countries based available measures of cultural tightness, individualism and power distance (see Chiu et al., 2015). These two types of societies show markedly different responses to the non-pharmaceutical and the pharmaceutical preventive measures. We will illustrate these differences with the data from Hong Kong (a tight-collectivist society) and Canada (a loose-individualist society), although the pattern holds generally for other tight-collectivist and loose-individualist societies. These results remain significant when controlling for GDP per capita, stringency of the non-pharmaceutical preventive measures and government efficiency.

Figure 3.1 shows the patterns of responses to the pandemic prevention measures in Hong Kong and Canada from March 2020 to July 2021. The black vertical line marks the date when vaccines started to be available in the society. The upper panel displays the daily rates of new confirmed cases and COVID-related deaths. The lower panel shows the stringency of government-imposed non-pharmaceutical preventive measures and

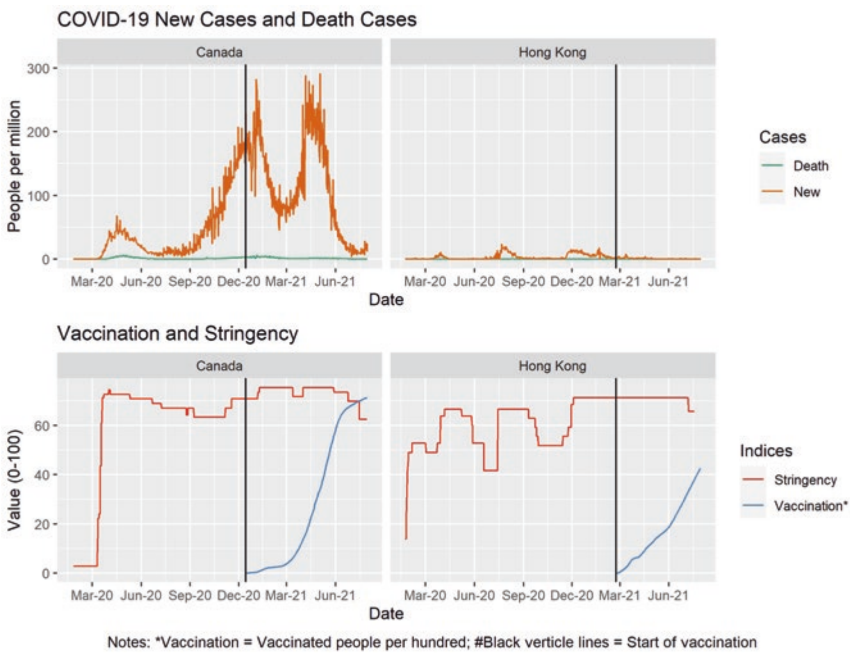

Fig. 3.1 The responses of Canada and Hong Kong to COVID-19 from March 2020 to July 2021

the rates of vaccination (percentage of vaccinated people in the population). Hong Kong, a tight-collectivist society, had lower rates of confirmed cases and deaths before vaccines were available in March 2021, compared with Canada, a loose-individualist society. These cultural differences were not attributable to differential strictness in government-imposed pandemic policies, because these policies were more stringent in Canada than in Hong Kong most of the time.

Innovations that directly address a massive environmental threat can reverse the relative fitness of different cultural preferences. Consider the example of cultural tightness and coping with COVID-19 again. In a tight society, people are expected to follow strict norms to avoid social sanction or reputation loss. In contrast, in a loose society, people are expected to pursue personal goals to maximize personal gains. Thus, whereas a tight culture prioritizes loss prevention, a loose culture promotes aspirations for gains (Li et al., 2017). In Hong Kong, given the low infection rate, there was not much to gain from vaccination. However, potential side effects of vaccination could fuel the chronic prevention anxiety in the city. Accordingly, in Hong Kong, the motivation to be vaccinated is relatively weak, as is evident in the slow increase of its vaccination rate. In contrast, in Canada, the high infection rate and the prospect of regaining personal freedoms through vaccination had accelerated the country's vaccination rate. Achievement of herd immunity had at least temporarily stopped the spread of the pandemic in July 2021.

The rapid spread of new variants of the COVID-19 virus in August 2021 represents another massive environmental shift, which may trigger another cycle of adaptive responses, and the relative fitness of tight versus loose cultures may change again. Person-environment co-evolution may become a long-term solution to win the war against COVID-19. Environmental threats posed by the pandemic may pressurize individuals to temper selfish maximization of personal freedoms with communal values, and at the same time incentivize innovations that will help create a new, nonthreatening environment for humankind. Adaptive intelligence will have a key role to play in this person-environment co-evolution.

Abilities and Processes that Support Adaptive Intelligence

Despite the presence of spatiotemporal variations in the behavioral expressions of adaptive intelligence, certain abilities and processes may foster cultural adaptation to the environment and its changes in all populations (Sternberg, 2019, 2021). These abilities and processes may strengthen people's adaptive intelligence.

As discussed in the previous sections, adaptive intelligence prioritizes agility in encoding nuanced meanings of situations and use them to navigate shifting environmental demands and the capacity for co-opetition. Table 3.2 presents some cognitive abilities and processes in four domains of intellectual performance that we propose to be relevant to these two proclivities. The four domains are attention, memory, problem-solving and innovation (or niche construction). For each domain, we sample one process/ability that fosters environmental information processing and one that promotes cooperation and collaboration.

Attention

In the Wechsler Intelligence Scale for Children (Wechsler, 2014), the Freedom from Distractibility Index is derived from the sum of the scores of the arithmetic and digit span tests. This index treats attention to

Table 3.2 Some abilities or processes that support the development of adaptive intelligence

Cognitive domain	Adaptively intelligent abilities or processes
Attention	Discriminative facility Shared and coordinated attention
Memory	Meta-memory of what is currently available in external memory devices; Efficiency in retrieving information from external memory stores; Transactive memory system
Problem-solving	Practical intelligence; Wisdom
Niche construction	Foresight Creativity

nuanced environmental information and its adaptive significance as distractors. In contrast, adaptive intelligence regards attention to nuanced situational information as a valuable cognitive facility. *Discriminative facility* refers to an individual's sensitivity to subtle cues about the psychological meanings of a situation. It is assessed by an individual's readiness to attend to nuanced psychological meanings of a situation and to discern situation-appropriate behavior across a variety of novel stressful situations (Chiu et al., 1995). This ability has been shown to predict adaptation to stressful life changes and better quality of interpersonal experiences (Cheng et al., 2001; Cheng et al., 2014).

S*hared and coordinated attention* is another attention process that supports adaptive intelligence. Tomasello et al. (2007) have proposed the *cooperative eye hypothesis*. According to this hypothesis, unlike other primates, human eyes have a distinct color contrast between the white sclera, the colored iris and the dark pupil. This distinctive and visible characteristic of the human eye was evolved to permit humans to follow the eye gaze of their collocutors or coworkers effortlessly in interpersonal interactions. A subset of neurons in the lateral intraparietal (LIP) area has been identified to mediate gaze following and shared attention (Shepherd et al., 2009). These neurons fire both when a macaque looks at a certain object and when the macaque notices that another macaque is looking at the same object. Gaze following, an evolved biological trait, fosters the development of shared and coordinated attention and cooperation, which in turn enable rapid cultural evolution.

Building on this idea, Shteynberg (2015) observes that the potential for attending to the environment with others has grown considerably with the emergence of mass media technologies, which allow for shared attention in the absence of physical copresence. There is also research evidence that sharing attention with others to a certain object *X* increases the amount of cognitive resources committed to processing *X*, improves individuals' memory of *X*, intensifies feelings about *X*, increases the motivation to interact with *X* and enhances behavioral learning from the interactions with *X*.

Memory

Environmental change has altered the relative adaptive value of different memory skills. For example, advances in information technology have created the *Google effect*; when people are expected to have future access to information, they tend to remember where to access it instead of recalling the information itself (Sparrow et al., 2011). Almost all information we need is stored externally, which is retrievable literally with a touch of a finger. As a consequence, meta-memory of what is available in external memory stores (e.g., iCloud) and efficiency in retrieving information from external memory devices have become more useful than retention and recall of the learned materials in the human brain.

Memory is externalized in interpersonal networks as well. *Transactive memory system* refers to a socially externalized memory system through which a collection of interconnected individuals collectively encodes, stores and retrieves knowledge (Wegner, 1987). A *transactive memory system* is a shared store of knowledge that consists of (a) the knowledge encoded into each individual's memory and (b) meta-memory containing information about the different networked individuals' domains of expertise (e.g., knowledge of what other people in my network know; Wegner, 1995). Like other externalized memory systems, the transactive memory system enables members of the social network to be aware of what information is available for use within the network. Research has shown that transactive memory systems can catalyze cooperative interdependence in teams and foster innovation (Zhang et al., 2007). Transactive memory systems also improve close relationships (Wegner et al., 1991).

Problem-Solving

Adaptive intelligence is solution-oriented. It was evolved to solve adaptation problems. The solution orientation of adaptive intelligence is also recognized in the concept of *practical intelligence*, one of the three components of human intelligence in Sternberg's triarchic theory of intelligence (Sternberg, 1985). Practical intelligence is the ability to apply one's intelligence to navigate the environment even in unfamiliar circumstances and solve problems in everyday situations. Practical intelligence requires adaptation to, shaping of and selection of new environments (Wagner and Sternberg, 1985).

Wisdom is a variant of practical intelligence (Sternberg, 2000); it involves the use of one's intellectual abilities under the guidance of positive ethical values toward the achievement of a common good. Grossmann et al. (2013) assessed wisdom by the degree to which people use various pragmatic schemas to deal with social conflicts and found significant associations between wise reasoning and greater life satisfaction, less negative affect, better social relationships, less depressive rumination, more positive versus negative words used in speech and greater longevity. These associations remained significant when controlling for socioeconomic factors, verbal abilities and several personality traits. In contrast, intelligence as measured by conventional intelligence tests was unrelated to these well-being outcomes.

Innovation or Niche Construction

Niche construction refers to the modification of the environment to enhance the selective advantages of a population (Laland et al., 2016). Thus far, we have focused largely on the intellectual abilities and processes that support cooperation and adjustment of the self to the environment. When faced with large environment shifts, adaptation may require renovation of the existing environment and creation of a new environment. Both renovation and innovation take time. Inevitably, there will be a time lag before renovations or innovations are available to address newly emerged environmental threats. For example, in the case of COVID-19, hundreds of millions were infected and millions of lives were lost before vaccines were available to contain the spread of the virus.

Foresight, defined as the ability to predict future situations, can help prepare human groups for the adverse effects of future environmental shifts, shorten the time lag of adaptive responses through innovations and hence provide a selective advantage (Suddendorf and Corballis, 2007). For example, sensitivity to the early signs of climate change and simulation of its consequences have informed scientists and policy makers of the technologies that need to be developed and new practices that need to be adopted in order to slow down global warming and mitigate its anticipated effects.

Suddendorf and Carballis (2007) conceptualize foresight as a process of "mental time travel" that allows people to foresee, plan and shape a specific future event. According to them, "to evolve a flexible anticipation system, many cognitive components may need to be in place to achieve a level of accuracy that provides a selective advantage sufficient to compensate for the enormous expense of cognitive resources" (p. 307). The cognitive components include prospective thinking, idea generation, autobiographical memory and processing of self-referential information and contextual and episodic imageries. Consistent with this idea, in a cognitive neuroscience study of foresight, Addis et al. (2007) found that imagining future events recruits the right frontopolar cortex, which is involved in prospective thinking, and the left ventrolateral prefrontal cortex, which is involved in idea generation. Future event construction also engages the right hippocampus, possibly as a response to the novelty of these events. When people elaborate a future event, the brain regions involved in autobiographical memory retrieval, self-referential processing, and contextual and episodic imagery are engaged.

Creativity drives cultural evolution and increases the complexity of cultural novelty over time (Gabora, 2018). In cultural evolution theories, creativity is a *social* process. It often starts with people receiving an inspiration from an external source, which could be an idea of other people or an idea embodied in the creative products of other people (Thrash and Elliot, 2003). The inspiration evokes the motivation to replicate the idea. Unlike other animals, humans are more oriented toward learning from others the *process* of producing inspiring products rather than merely reproducing the products. Process focus in imitation often leads to creation of low-fidelity reproductions or new variants of the original products. As creative ideas beget other creative ideas, accumulation of modifications increases the overall fitness as well as the level of diversity of the ideational outputs in the culture, a phenomenon known as the *ratchet effect* (Tenne et al., 2009).

Chaining and contextual focus are two mental facilities that have been hypothesized to invigorate the ratchet effect. *Chaining* refers to the capacity to modify thoughts and ideas by thinking about them in the context of other thoughts and ideas. As Gabora (2018) puts it, "For minds to evolve through communal exchange they must be organized such that, for any given concept or idea, there exists some pathway … by which it could potentially interact with and modify other concept or idea. The concepts and ideas must form an integrated whole, i.e., they must be able to interact with and modify others." Creative cognition researchers also recognize that when unrelated ideas are merged to form a new concept, novel ideas with appealing emerging properties often emerge (Finke, 1995). Frequent practices of solving novel conceptual combination problems (combination of concepts with no overlapping instances; e.g., what is a vehicle that is also a fish?) can improve creative performance (Wan and Chiu, 2002).

Contextual focus refers to the ability to switch between an implicit associative mode of thinking and an explicit analytic mode of thinking. Associative thinking is conducive to insight and novel idea generation, whereas analytic thinking supports logical problem-solving (Gabora, 2003). The creative process consists of a generative phase and an evaluative phase (Chiu and Kwan, 2010). Individuals are more fluent in novel idea generation when they engage in associative thinking, and are more able to select promising ideas for elaboration and further development when they think analytically (Lam and Chiu, 2002). Thus, creative performance will benefit from the ability to switch between the associative and analytic modes of thinking (Gabora, 2003, 2018) in response to the changing nature of the task.

Implications for Measuring Adaptive Intelligence

In the *APA Dictionary* (American Association of Psychology, 2021), intelligence is defined broadly as "the ability to derive information, learn from experience, adapt to the environment, understand, and correctly utilize thought and reason." However, a narrower definition of intelligence assessment is found in the same dictionary: assessment of intelligence refers to "the administration of standardized tests to determine an individual's ability to learn, reason, understand concepts, and acquire knowledge." In practice, conventional measures of intelligence have focused on assessing performance in verbal and nonverbal cognitive tasks. For example, the five primary abilities assessed in the Wechsler Intelligence Scale for Children (WISC, Wechsler, 2014) are verbal comprehension, visual-spatial processing, inductive and quantitative reasoning, working memory, and processing speed. These conventional intelligence measures portray an intelligent person as someone who is quick at acquiring verbal and visual-spatial knowledge and efficient in managing and manipulating information in their head.

Unlike these conventional measures of intelligence, assessment of adaptive intelligence aims at assessing the fitness-enhancing intellectual abilities that enable adaptation of human populations to the environment. As such, instead of measuring abilities that are decontextualized, disembodied and context-free or context-fair, adaptive intelligence tests should measure abilities that are as follows:

(a) Contextualized: the contents of assessment are relevant to the joint goals of individuals in social interactions, the collective goals of groups and collective goals worthy for humanity.
(b) Embodied: the assessment should capture individuals' abilities to access, generate and learn from information through action, and use the information to discover optimal solutions to adaptation problems (Cangelosi et al., 2015).
(c) Situated: the assessment needs to take discriminative situational variations in responses seriously (instead of treating them as noise or measurement errors). How people respond discriminatively and adaptively to varying expectations in different social, material and historical settings should constitute the substance of adaptive intelligence assessment (Roth, 1998).

Based on similar principles, Sternberg (2021) has designed solution-oriented measures of adaptive intelligence. In these tests, respondents are presented with cases related to grand challenges (e.g., climate change, racism and wealth inequality) and asked: (1) What can they do personally to meet the challenges, (2) what are the limitations of the current solutions, (3) what solutions would they recommend to the authority and (4) what are the obstacles that need to be overcome? The test requires the respondents to identify and define the problems, generate new solutions, evaluate the merits and limitations of promising solutions, and select and recommend the wisest course of action. As such, these measures assess the respondents' analytical skills, creativity, practical solving abilities and wisdom.

The theory of adaptive intelligence emphasizes co-development of the self and the collective: Individuals develop their adaptive intelligent skills to improve the environment for a common good. A valid adaptive intelligence test should be able to predict individuals' behavioral tendency to adapt their own behavior to increase mutual outcomes and avoid exploitation. Example measures of such cooperative behavioral tendency include the Social Value Orientation Scale (Van Lange and Liebrand, 1991) and the Social Mindfulness Scale (a measure that uses a social decision-making paradigm that measures the behavioral tendency to leave or limit choice options for others; Van Doesum et al., 2013). Modal performance on the adaptive intelligence test of a certain collective should also predict adaptation outcomes of the collective. Example outcome measures at the country level may include the extent to which the collective has successfully achieved the UN Sustainable Development Goals (the United Nations, 2021).

Summary and Future Directions

In this chapter, we have elucidated the cultural evolutionary foundation of the theory of adaptive intelligence (Sternberg, 2019, 2021). Many conventional conceptions of intelligence view intelligence as a concatenation of correlated *intrapersonal* abilities that predict individuals' efficiency in acquiring, manipulating and applying knowledge when performing *decontextualized* intellectual tasks. In contrast, adaptive intelligence considers adaptation a primary function of our intellectual faculties. As such, intelligence comprises a group of mutually reinforcing context-responsive abilities and processes that contribute to the perpetuation of human populations (Sternberg, 2019). By situating intelligence in the context of the multilevel selection problem and relating it to adaptive responding to environmental shifts, our analysis reveals the spatiotemporal variations in the behavioral expressions of adaptive intelligence. This analysis also helps to identify some intellectual processes and abilities that support the development of adaptive intelligence.

Table 3.3 depicts the nomological network of the constructs we discuss in the present chapter, which can be used to guide future research on adaptive intelligence. Future research is needed to test the associations of these proposed processes and abilities with the newly constructed measures of adaptive intelligence. Future research is also needed to establish the multilevel predictive relationships of adaptive intelligence with (a) behavioral expressions of it by individuals (e.g., the tendency to cooperate and make socially mindful choices) and (b) sustainable development of the collectives. Based on the theory of adaptive intelligence, we have designed an undergraduate general education course at the Chinese University of Hong Kong (*the Successful Self*) to nurture students' adaptive intelligence. Future research that attempts to identify the environmental affordances of adaptively intelligent behaviors will inspire new ideas and practices in the teaching of adaptive intelligence.

Table 3.3 Nomological network of adaptive intelligence

Supportive factors		Adaptive intelligence	Multilevel outcomes
Environmental affordances Supportive intrapersonal processes and abilities		Adaptive intelligence as measured by tests of adaptive intelligence	Sustainable development of collectives Example: The effectiveness of a society in attaining UN sustainable development goals
Environment Responsiveness	Cooperative Capacity		
Discriminative facility; Externalization of memory; Practical intelligence; Foresight	Shared attention; Transactive memory; Wisdom; Inspiration and creativity		Behavioral expressions of adaptive intelligence Examples: social mindfulness; social value orientation

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