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Meta-Intelligence: Understanding, Control, and Coordination of Higher Cognitive Processes

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Abstract

Higher cognitive processes are often characterized as fitting into categories that, while treated as natural kinds, actually are human-made inventions, such as intelligence, creativity, and wisdom. Other germane categories include reasoning, problem solving, and concept formation. The different categories generate their own journals, their own tests, their own training programs, and, of course, their own cadres of researchers who specialize in one (or, more rarely, more than one) of the categories. I suggest in this article that the mental structures and processes underlying these various categories are largely the same. For example, all of them require metacomponents, or executive processes, such as recognizing the existence of problems, defining the nature of problems, formulating strategies to solve problems, and so forth. Their utilization also requires certain attitudes. What differs is the purpose to which processes and attitudes are utilized. In intelligence, the processes and attitudes are used primarily for knowledge acquisition, utilization, and analysis. In creativity, the processes and attitudes are used to generate new, useful ideas. In wisdom, the processes and attitudes are used to seek a common good. The arbitrariness of these separate categories serves artificially to isolate related theoretical and empirical work that should integrate intelligence, creativity, and wisdom. In this article, I discuss how the

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construct of meta-intelligence helps bring unity to theory and research endeavors that are now viewed as being largely independent of each other.

1 Introduction

Theory and research on higher cognitive processes is divided into a number of largely discrete categories. In approaches that had their origins in differential psychology, major categories have been intelligence, creativity, and wisdom. In approaches that had their origins in cognitive-experimental psychology, categories have been ones such as problem solving, reasoning, concept formation, and the like. These different categories have been perceived as different, although partially overlapping domains of psychological inquiry. They have given rise to different fields of endeavor, with largely different researchers, journals, professional societies, and graduate programs to prepare the next generation of researchers.

Worth considering is that these categories are human constructions or stipulated concepts. They are artificially constructed because they are convenient. For example, a textbook on The Psychology of Human Thought (Sternberg & Funke, 2019), has separate chapters for intelligence (Wilhelm & Schroeders, 2019), creativity (Lubart & Thornhill-Miller, 2019), wisdom (Glück, 2019), problem solving (Funke, 2019), reasoning (Davidson, 2019; St. B. T. Evans, 2019), decision-making (Nolte, Garavito, & Reyna, 2019), and concepts (Levering & Kurtz, 2019), as have other similar books in the past (Sternberg & Ben-Zeev, 2001; Sternberg & Smith, 1988). Other books have related topics (e.g., Minda, 2020).

2 Relations among Intelligence, Creativity, Wisdom, and Related Constructs

Clearly, the categories are highly overlapping. For example, in the differential-psychological domain, a typical divergent-thinking task used to measure creativity ("What are unusual uses of a paperclip?") requires divergent thinking, but also requires analytically intelligent thinking to determine whether a given answer produced by divergent thinking is appropriate. As an example, the paperclip might be used to tie up a plastic garbage bag; but if one generates the answer that it can be used as a substitute for toilet paper, that's harder to imagine! One needs an analytical filtering mechanism to screen out bad creative ideas. Similarly, wise

decisions, such as how to contain a burgeoning pandemic, require both creative thinking—something that has been somewhat hard to find during the COVID-19 pandemic—and analytical thinking to ensure that novel ideas—such as drinking bleach to purify one's insides—are removed if they are not useful or even are harmful.

In the cognitive-experimental domain, "reasoning" requires solving inductive- or deductive-reasoning problems, so clearly, people who reason are solving problems. They also have to decide what answer is correct, so the problems involve decision making. In a typical inductive-reasoning problem, reasoners have to learn one or more concepts, such as that a number series has the pattern "+2, -3," as in "8, 10, 7, 9, 6, ….?" so concept-learning is involved as well.

The different domains are clearly related, and yet insularity can make it difficult to conduct and publish research that cross-cuts categories. For example, if one develops a theory that cross-cuts intelligence, creativity, and wisdom, one may be at a loss as to where to submit an article based on the theory, at least if one wishes to submit it to a somewhat specialized journal. The problem is that intelligence and creativity journals are distinct and there currently are no wisdom journals at all.

The disadvantage to this modular approach is that the modules are not really modules. Claiming to have modules when one does not have modules is probably a bad idea because it creates illusory separations. The concepts of intelligence, creativity, and wisdom all overlap. For example, we know that explicit psychometric measures of intelligence, creativity, and wisdom are all intercorrelated (Lynch & Kaufman, 2019; Staudinger, Lopez, & Baltes, 1997), as are implicit-theory based measures (Sternberg, 1985b). Conceptually, the three are difficult cleanly to distinguish (Sternberg, 2003b); one theory, a balance theory of wisdom, views wisdom as inevitably involving creativity and intelligence (Sternberg, 2019b). Creativity and intelligence always have been very closely related conceptually (Sternberg & O'Hara, 2000). Guilford (1967) viewed creativity as largely a subset of intelligence, with divergent thinking one of the operations in his theory that could be applied to various contents and products. Gardner (2011a) has analyzed the creativity of famous creators in terms of his theory of multiple intelligences (Gardner, 2011b). A recent theory views successful intelligence, a broad construct, as drawing on analytical intelligence, creative intelligence, and wisdom (Sternberg, 2020a). CHC (Cattell-Horn-Carroll) theory places creativity in long-term storage

and retrieval (Glr), and fluid intelligence is also related to creativity (Carroll, 1993; Cattell, 1971; McGrew, 2005).

The differentiation in the cognitive literature among reasoning, problem solving, decision making, and concept formation are even harder to make. Reasoning problems are, well, problems. There is a problem to be solved. Decisions need to be made about the correct answer. Decision making usually requires solving some kind of problem, such as whether to do one thing or another. And concept formation is required for solving any kind of problem for one to learn enough information to be able to solve the kind of problem (see Sternberg & Funke, 2019).

In the augmented theory of successful intelligence (Sternberg, 2020a), creative intelligence—which is the ability part of creativity—is used to generate new ideas; analytical intelligence is used to ascertain the quality of those ideas; practical intelligence is used to put the ideas into practice and convince others of the value of the ideas; and wisdom is used to ensure that the ideas are used to help promote a common good. According to this theory, the cognitive processes used for the different aspects of intelligence are all largely the same, namely, a set of metacomponents, or executive processes—processes that were introduced in a much earlier version of the theory (Sternberg, 1980, 1983).

The metacomponential processes apply to all problem solving of any kind, including (a) recognition of the existence of a problem; (b) definition of the problem; (c) mental representation of the problem; (d) allocation of resources to the problem; (e) formation of a strategy for solving the problem; (f) monitoring of problem solving as it is ongoing; (g) evaluation of the solution to the problem after it is solved (see Funke, 2019, for a more comprehensive overview of processes of problem solving). On this view, all problems—whether seemingly based on intelligence, creativity, wisdom, or some combination; or whether requiring problem solving, reasoning, decision making, concept formation, or some combination—require execution of some and probably all of these metacomponents.

This enumeration comprises a fairly standard list of executive processes (see also, e.g., Bransford & Stein, 1993; Brown, 1978; Feuerstein, 1979, 1980). To my knowledge, the executive metacomponential processes, unlike performance components that execute the instructions of metacomponents, have not been experimentally separately (see Sternberg, 1983, 1985a).

For example, suppose the problem is a fluid-intelligence problem, such as an analogy. There are some necessary steps, which may or may not be conscious. One

has to recognize that there is a problem. Then one has to define it as an analogy. Next one has to decide how to represent the information in the problem—in terms of features, a spatial representation, or whatever. Then one needs to decide how to allocate mental resources, as well as time, to solve the problem, and to set up a strategy to solve the problem. One then has to monitor one's problem solving and evaluate it after one is done.

Test-like analogy problems are, arguably, somewhat trivial, although Spearman (1923, 1927) saw analogies as a primary basis for intelligent thinking. Consider now more complex problem.

For intelligence, consider comparing and contrasting two vaccines for their efficacy, safety, cost, portability, storage requirements, and the like. The executive processes would be the same as for the analogy. One would have to recognize there is a problem—a disease in need of a vaccine. One would have to define the problem—choosing which of two vaccines is a better choice. One would have to allocate resources to making a decision. One would have to represent the problem, set up a strategy to solve the problem, and then monitor and evaluate one's solution.

Consider now a creativity problem. Suppose one is designing the next year's model of a car. This year the car has not sold well. You want to design a new model that will sell better than the old model. You have to be creative, because what the car company is doing now is not working. So, you need to recognize there is a problem—the car is not selling well. You have to define the problem—why is the car not selling well? Is it the engineering, the design, the marketing, the sales force, the repair record, or what? If it is the design, what is wrong with the design? You then need to represent the problem—what does the current car look like and what does it need to look like? Maybe you will draw schematics of old and new versions. You need to decide how much time to allocate to the project and how you can stay within the budget allocated for the project. You need to create a strategy for designing and engineering the product—how are you actually going to make it happen? As you put the new car into production, you have to monitor whether the new version actually does fix what was wrong with the old version without introducing new problems. Finally, when a prototype is produced, you have to evaluate whether it actually works.

Finally, consider a wisdom-based problem. Two countries, X and Y, are drawing on a common water source. Country X accuses the other country, Y, of taking

more than its allotted share of the water. (This is actually happening today with the United States and Mexico.) Relations are deteriorating quickly over the conflict regarding the water source. And water is getting scarcer all around. How do the two countries resolve their dispute? They recognize there is a problem. They are seriously at odds with each other. They define the problem as either X's stealing more than its allotted share of water, or of Y's believing that X is stealing more than its fair share of water, even though it's not, or of X and Y disagreeing as to what fair shares of water are. They need to represent the problem, so perhaps they create a schematic of the shared water source, and the water flow to each of the countries. They need to decide how much time, money, and person-power to devote to solving the problem. They need to set up a strategy to solve the problem, perhaps appointing some kind of joint commission. They need to monitor the progress of the commission and then evaluate, at the end, whether the commission did indeed reach a solution acceptable to both countries.

The same metacomponents can be applied to all three types of problems. How, then, do the problems differ? They differ in what they are trying to accomplish—in their desired end-state. The intelligence problem with the vaccines is largely analytical and convergent—compare two vaccines on the basis of available information and decide which is a better choice. The creativity problem is largely one of discovery and invention. It is divergent—create a new model for a car that has not been selling. The wisdom-based problem is one of finding a common good.

On this view, what differs among intelligence, creativity, and wisdom is not the underlying mental processes, mental representations, or even need to formulate strategies and strategic goals. Rather the difference is one of purpose in problem solving. What is the problem solver trying to accomplish?

In point of fact, the three problems, like all problems, are not pure. There are few if any "pure" intelligence, creativity, or wisdom problems. The creativity problem, for example, requires at least some consideration of a common good. One wants purchasers to be happy with their purchase, stockholders to be happy with their profits, management to be happy with the enhancement of their product line, workers to be happy with their chance to develop something new, etc. The intelligence problem requires one to choose a vaccine that will help to achieve a common good for vaccine users, and it does require creativity in deciding the bases one should use for comparing the vaccines.

On the current view, use of intelligence, creativity, and wisdom involves not only mental processes, but also attitudes. One has to want to use the processes, or they never will get used. The biggest stumbling block to the use of creativity, for example, is not lack of creative skills, but rather attitudinal—the fear of using creativity because its use will engender opposition (Sternberg, 2018; Sternberg & Lubart, 1995). Wisdom also can and often does engender opposition, as Socrates learned in ancient times, paying for his wisdom with his execution. But the same problem exists today: as Malala Yousafzai discovered when she was shot for advocating the rights of young women to an education in Pakistan. Sometimes, even the use of intelligence can engender opposition, as leaders discover who are smarter than their followers and therefore are mocked for being too bookish (Sternberg, 2003a). To some extent, this happened in the United States to Harvard-educated Barack Obama, who spoke and wrote at a level higher than that of many of his constituents.

3 The Nature of Meta-Intelligence

Put another way, many serious life problems require some of intelligence, creativity, and wisdom jointly. The greatest problem is where, when, and how to allocate them—and this is the problem that the higher order construct of meta-intelligence is intended to solve. *Meta-intelligence* is understanding, control, and coordination of higher cognitive processes, such as the processes of intelligence, creativity, and wisdom, or problem solving, reasoning, decision making, and concept formation. Just as there are three levels of abilities in Carroll's (1993) three-tier model of human intelligence, here there are four levels of functioning, as shown in Figure 1.

In particular, meta-intelligence is at the top level of the hierarchy. It provides understanding, control, and coordination of the various aspects of intellectual functioning. When taken from a differential-psychological standpoint, these aspects include intelligence, creativity, and wisdom. When taken from a cognitive-experimental standpoint, these aspects include problem solving, reasoning, decision making, and concept formation. These aspects of functioning are highly overlapping, both between methodological categories (differential and cognitive-experimental) and within methodological categories (intelligence, creativity, wisdom; or reasoning, problem solving, decision making, concept formation).

These aspects of functioning are, in turn, a result of metacomponential thinking, otherwise known an executive processing. The metacomponents, in turn, control the utilization of performance components, which solve problems, and of knowledge-acquisition components, which learn how to solve the problems in the first place (Sternberg, 1984).

One might argue, of course, that meta-intelligence is just another manifestation of g. But the correlational patterns across intelligence, creativity, and wisdom simply do not support such an interpretation. Although there are correlations, they are modest. And at the level of construct-validation, it is quite clear that intelligence tests, from which the g factor is extracted, do not well measure either creativity or wisdom. On the contrary, there are many intelligent people who are not particularly creative or wise.

Rather, meta-intelligence serves a coordinating and control function over the different processes of higher of higher order cognition as they serve different purposes, either to analyze and solve, or learn how to solve problems in the first place (intelligence); to create new problems or solutions (creativity); or to solve

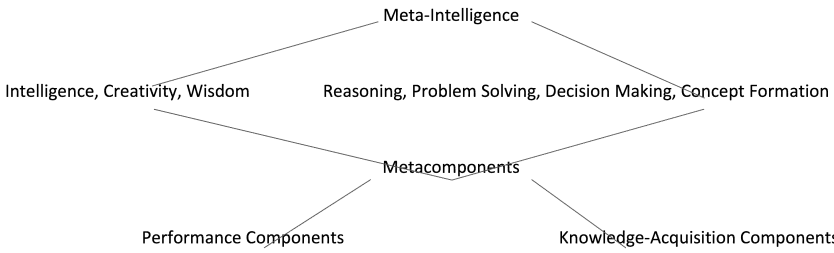

Figure 1: Levels of higher cognitive processes. Meta-intelligence, at the top level, provides understanding, control, and coordination of aspects of intellectual functioning. From a differential-psychological standpoint, these aspects are intelligence, creativity, and wisdom. From a cognitive-experimental standpoint, these aspects are reasoning, problem solving, decision making, and concept formation. These aspects are highly overlapping, both between categories (differential and cognitive-experimental) and within categories (intelligence, creativity, wisdom; or reasoning, problem solving, decision making, concept formation). These aspects are in turn a function of metacomponential thinking, otherwise known an executive processing. The metacomponents in turn control performance components, which solve problems, and knowledge-acquisition components, which learn how to solve the problems in the first place. Source: own illustration.

problems in a way that promotes a common good rather than just one's own (wisdom). What differs is not the set of processes, but rather the purposes to which they are put.

Does the construct of meta-intelligence exist? Well, in the sense that there must be coordination among the functions of intellectual functioning as they serve different purposes, it must exist at some level. Is it a single entity? We do not know. But we do not know whether g is a single entity either. Rather, g is a statistical regularity derived from scores on intelligence tests. One could conceive of a meta-intelligence test, which would present problems and require one to decide when and how to use the different cognitive functions, whether intelligence, creativity, or wisdom in the differential-psychological tradition, or problem solving, reasoning, decision making, or concept formation in the cognitive-experimental tradition.

Does a construct of meta-intelligence serve a useful purpose? The construct is new, so only time will tell. It will need to be construct-validated. But I believe it serves at least three important purposes.

First, meta-intelligence is the means by which we understand our own range of higher mental abilities. What are the various things we can do with our minds? The various "things" are not abilities, like verbal, quantitative, and spatial, for example, but rather, organized collections of these abilities that can serve different purposes—intelligence, creativity, and wisdom, for instance. We understand that we can recognize, define, and solve convergent problems (intelligence), divergent problems (creativity), and problems with solutions seeking a common good (wisdom).

Second, meta-intelligence is the means by which we control which set of collections of abilities we use when and how. Creativity is useful in many instances, but likely not when solving a multiple-choice standardized test problem. Intelligence is useful, but sometimes, maximizing one's own individual outcomes, as in optimizing one's career success, can come at the expense of the greater common good, as, for example, when one's career success results in making other people's lives worse (such as those careers that contribute ultimately to harming people, such as through air or water pollution).

Third and finally, meta-intelligence coordinates the use of the different collections of abilities. A given problem may require intelligence, creativity, and wisdom, such as a problem of how to allocate scarce resources, such as of a new vaccine

against an illness that has become a pandemic. Meta-intelligence enables us to know what to do when.

Some researchers might, understandably, be reluctant to introduce yet another construct to those already in the list of psychological constructs currently being used. But I would suggest that we have always utilized a construct functionally equivalent to meta-intelligence, without giving it a name. We've always known that people need to decide what kinds of higher order mental resources they need to allocate to a given problem. Meta-intelligence simply names this construct.

A similar construct, of course, is metacognition (see, e.g., Fiedler et al., 2019). Metacognition involves understanding, control, and coordination of cognitive processes. Meta-intelligence is different, however, because it involves attitudes, as described above, not just cognitive processes. Utilization of intelligence, creativity, and wisdom, as well as of various functions of problem solving, reasoning, and decision making, can involve attitudes as much as it involves cognitive processes. As noted above, failures of utilization are at least as likely to be attitude-based as process-based. A person decides not to be creative not because they can't be, but because they fear the consequences, and often, rightfully so (Sternberg, 2020b).

Another similar construct is self-regulation (Vohs & Baumeister, 2017). Whereas metacognition is narrower than meta-intelligence, self-regulation is much broader, applying as it does to all aspects of a person, whether related to intellectual, emotional, or motivational functions. Self-regulation falls much more broadly into the domains of personality, social, and clinical psychology as well as of cognitive psychology.

A reviewer of this essay wonder whether the appropriate construct would be some kind of "meta-cognition" rather than "meta-intelligence," that is, the combination, of intelligence, creativity, and wisdom. There might be some value in such a construct, but that construct, if it exists, is not what this essay is about. Rather, this essay is about knowing what skills and attitudes to utilize where and when—under what circumstances. It is not some unified power, but rather, a power to understand, control, and coordinate different functions of the mind.

Other researchers might want to know where in the brain meta-intelligence is located. I doubt it is located in any one place, any more than intelligence is (Haier, 2020; Haier & Jung, 2007; Jung & Haier, 2007). Gardner (2011b) might disagree, but the current evidence is for broad distribution of intellectual skills in the brain. Almost certainly, meta-intelligence is distributed across parts of the brain. But the

exact parts remain to be determined. It further remains to be determined whether meta-intelligence can be extracted as a (probably higher order) psychometric factor. This is a first paper on the construct, and so many questions remain to be answered[1].

Is there any urgency to introducing such a construct? I believe there is. What has become clear, perhaps depressingly clear, is that the serious problems facing the world today cannot, or at best, have not been successfully solved by general intelligence alone (Sternberg, 2019a, 2019b, 2021). They take some kind of coordination of analytical-intelligence skills with creative and wisdom-based ones as well. That coordination so far has been lacking. Global climate change, air pollution, water pollution, weapons of mass destruction, pandemics, require creative and wise solutions that general intelligence alone does not provide. Meta-intelligence provides the key to coordinating these mental resources. We just have to find it within ourselves, utilize it, and develop it within our young people in order to reach better solutions to world problems than we so far have generated.

There is a tendency in intelligence research, and in some creativity and wisdom research, to turn inward—to seeking more and more refined understanding of cognitive and biological processes involved in intellectual functioning. Broader problems may be seen as beyond our range—as philosophical or political. But the construct we are studying, at least of intelligence, is too narrow. The world cannot afford a lot more high-g (general-intelligence) people that allow the conditions under which we live to keep becoming more and more degraded. Eventually, we may find IQs have gone higher and higher (Flynn, 2012), while adaptivity to the world has been left to viruses, bacteria, and cockroaches. That is not the future we want to look forward to. Meta-intelligence may provide one start toward understanding intelligence, creativity, and wisdom in their broader and interactive contexts within the world.

[1] 1. Although written subsequent to the writing of this paper, a follow-up paper was actually published first (i.e., earlier during calendar year 2021): Sternberg, R. J., Glaveanu, V., Karami, S., Kaufman, J. C., Phillipson, S. N., & Preiss, D. D. (2021). Meta-intelligence: Understanding, control, and interactivity between creative, analytical, practical, and wisdom-based approaches in problem solving. *Journal of Intelligence, 9*, 19, https://doi.org/10.3390/jintelligence9020019

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Robert J. Sternberg is Professor of Human Development at Cornell University and Honorary Professor of Psychology at Heidelberg University. Previously, he was IBM Professor of Psychology and Education at Yale University. His PhD is from Stanford and he holds 13 honorary doctorates. Sternberg has won the Grawemeyer Award in Psychology and the James and Cattell Awards from the Association for Psychological Science. He is past-president of the American Psychological Association and the Federation of Associations in Brain and Behavioral Sciences. Sternberg's most recent books are *The Nature of Intelligence and Its Development in Childhood* (Cambridge University Press, 2020) and *Adaptive Intelligence: Surviving and Thriving in a World of Uncertainty* (Cambridge University Press, February 2021). According to Google Scholar, he has been cited roughly 192,000 times and has an h index of 211. His wife, Karin, received her undergraduate and graduate degrees in psychology from Heidelberg University and the family hopes that their triplets, Samuel, Brittany, and Melody, age 9, also will receive their degrees from Heidelberg.

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