What a tale of two minds can be

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The dual process theory is a view that there are two information-processing systems in our mind and that we often employ either or both of them in a wide variety of problem-solving tasks. This theory has attracted considerable attention in cognitive and social psychology for the last decade, but this does not mean that there have been no challenges to the theory. In particular, a concern about underlying mechanisms for each system is one of the most serious objections. In this paper I shall explore how we can interpret the theory so that it can meet this challenge. I will argue that the dual process theorists may be overly optimistic for the prospect of finding underlying causal basis for each system in neural regions, because according to recent findings, almost any single brain region is involved in a wide variety of tasks and it is hard to find *the* region primarily responsible for each system. Instead, I will argue, the dual process theorists should seek for the causal basis in evolutionary history.

Overview of the dual process theory

Dual process accounts have been explored in various fields of psychology, such as cognitive and social psychology, to explain conflicting responses subjects give in an experiment. Although the details differ from one account to another, the basic tenet is similar: the subjects have two distinct information-processing systems, each of which has a cluster of distinctive characteristics, and those systems are responsible for the conflicting responses.

Take deductive inference to illustrate how a dual process account is called for (Evans 2003). Psychologists found that when we are asked to check the validity of a syllogistic inference, many of us take one of the two strategies: first, we may simply look at the believability of the conclusion and infer the inference is valid when the conclusion

seems true (this is often called *the belief bias*). At other times, however, we may draw an Euler diagram and confirm that the conclusion must be true when all the premises are true. Jonathan Evans, a leading supporter of the dual process theory, observes that 90% of subjects see valid arguments with a believable conclusion as valid, while less than 60% think valid arguments with an *un*believable conclusion are invalid. The dual process theorists propose that this is because we have two kinds of mental processes. Each kind of processes are characterized by a cluster of properties------when we "intuitively" judge the validity with the help of a cue, our response is automatic, quick, and taking less mental effort, but prone to error; in contrast, thinking "deliberatively" by drawing a diagram takes much more mental effort and time but leads us to the correct judgment in many cases.

This is how a dual process account is called for in deductive inference. But what is striking is that dual process accounts have been proposed in various areas of psychology, including reasoning (Wason selection task, hypothetical thinking, etc.), judgment and decision making (judgment of probability, decision making under risk, social judgment theory), and social cognition (processing of social information: person perception, stereotyping, and attitude change). And there is significant overlap in what the authors list as properties of each kind of process. (Evans (2008) summarizes the properties in a table; see Table 1). The dual process theorists argue that this overlap is no mere coincidence. Rather it is evidence for the existence of two processes, or systems in our mind. There are two distinct systems with a cluster of properties working across these phenomena.

It is worth noting that those properties associated with either system in the list are correlated with each other. If a subject's response in one experiment exhibits a property of System 1 (say quickness), then it is likely to have other properties in the list, such as implicitness, automaticity, domain-specificity, and mental effortlessness. The same is true of System 2: if one's response is slow, then it is likely to have other properties of System 2: being explicit and controlled, generality, and taking high mental effort. Some of the correlations are found by changing experimental conditions [1] .

Lack of causal basis

One of the criticisms frequently levelled at the dual process theory is that it is nothing but a list of property-pairs as in Table 1 (Keren & Schul, 2009; Sahlin et al., 2010). One way to reply to this objection is to find causal basis for each process. Properties listed above are largely phenomenological and do not refer to underlying causal basis: type-1 processes largely work automatically, but it is not clear what is behind this automaticity. The theory would be better supported if each kind of process has material or neurological foundation, one might argue.

The "intuitive" process (System 1)	The "deliberative" process (System 2)
Evolutionarily old	Evolutionarily recent
Shared with animals	Unique to humans
Unconscious, preconscious	Conscious
High capacity	Low capacity
Fast	Slow
Automatic	Controlled or volitional
Low effort	High effort
Parallel	Sequential
Implicit knowledge	Explicit knowledge
Contextualist, belief based	Abstract, decontextualized
Linked with emotion	No direct link with emotion
Independent of individual differences in general intelligence and working memory capacity	Correlated with individual differences in intelligence and working memory capacity
Ecological or evolutionary rationality	Normative rationality

Table 1. Characteristics typically associated to the two kinds of processes. From Evans (2008).

This is why the dual process theorists have attempted to find deeper causal mechanisms for phenomenological properties. For example, Evans (2010) cites the neurological studies by Matthew Lieberman (2007). In these studies, Lieberman attempts to find neural regions corresponding to Systems 1 and 2 by using brain-imaging technologies such as functional magnetic resonance imaging (fMRI). As a result of these experiments, he assigns brain regions such as basal ganglia, amygdala, and lateral temporal cortex to System 1 and regions such as medial temporal lobe, posterior parietal cortex, and rostral ACC to System 2.

Yet it is not clear how far Evans can get by appealing to the studies like those, because some researchers, such as Michael Anderson (2010), doubt that there is a strong one-to-one correspondence between cognitive tasks and brain regions; most brain regions are involved in a much wider range of tasks than those authors might expect. Anderson proposes the *neural reuse hypothesis*, according to which "neural circuits established for one purpose are commonly exapted ... during evolution or normal development, and put to different uses, often without losing their original functions" (p. 246). For instance, he observes that out of 968 anatomical brain regions reported to be active at least in one task domain ------including execution, vision, attention, and language------ over 90% of them are active in more than one domain. If his hypothesis is on the right track, then one should not be overly optimistic about the prospects for finding *the* brain regions responsible for either kind of process.

Reflective and intuitive minds as evolutionary functional kinds

In this section I shall argue that if we interpret the dual process theory in terms of their evolutionary functions, it could solve the problem of causal basis for the two minds. The two minds are evolutionary functional kinds: Each mind is to solve different evolutionary problems.

Functional kind

A functional kind is characterized by its (causal) role its members play and has an explanatory force in a scientific theory due to those roles. Take money as an example of a functional kind. Money is a functional kind because of its roles in generalization and explanation in economics. There are regularities or laws in economics concerning the relationships money takes to other objects: if more money is supplied to the economy of a country by central bank, then there is likely to be inflation. Money illustrates *multiple realizability* of a functional kind. Money can take different physical forms: it can take the form of a bill or coins or tobacco.

An evolutionary functional kind is a group of evolutionary traits which evolved and is designed to resolve the same or similar adaptive tasks. In other words, such a kind

is *analogical* traits as opposed to *homological* traits which share evolutionary origin with each other. Wings in birds and insects are a familiar example of analogical traits-----both are solutions to the same or similar adaptive task (flying in the sky) but were invented independently in the evolutionary history. The reason why they have similar functions is that they are solutions to the same adaptive problems, not because the similarity at hand was inherited to them from their common ancestor.

Biological analogues have key features in common with money. The concept of analogy has explanatory force. Birds' and insects' wings share some properties, such as relative weight to body mass and aerodynamic structure. One can explain why they share those properties but not others because of the selection pressure shared by birds and flying insects. Analogues are multiply realizable, too. Birds' and insects' wings are wings, even though their physical composition is very different. Thus an analogue constitutes a functional kind (Brigandt, 2010).

Two minds as evolutionary functional kinds

So much for the description of a functional kind. My proposal is that the dual process theory can meet the challenge if the two systems are evolutionary functional kinds: they are designed to solve different (adaptive) tasks, as wings and heart are designed to solve different adaptive problems. Put simply, the two systems are evolutionary analogues. Then the question is what problem each mind is designed to solve. A brief sketch of the problems will be the following:

- The intuitive mind: designed to solve swiftly and automatically typically simple cognitive-adaptive problems which we routinely encounter in our life or our evolutionary history, by giving a specific output to a specific environmental cue.
- The reflective mind: designed to solve complex problems in novel and unforeseeable environments even with taking considerable time and cognitive resources.

We have seen that the properties in a cluster characterizing each system are *correlated* with each other (p. 70). Now if we reflect upon the correlations from natural selection and problem-solving, they seem to point to two different cognitive *strategies* we

adopt, and it is thus *explained* why those properties are in fact correlated. Let us look at the familiar trade-offs between the reliability of a solution and its costs. Checking the validity of a deductive inference illustrates this (p. 69). To evaluate the validity of a syllogism with drawing an Euler diagram is to increase the reliability of our judgment, but it comes at the expense of additional time and mental effort. To look only at the truth value of its conclusion will certainly save time and mental effort, but our judgment will be less reliable. That is, there is a trade-off relationship between the accuracy or reliability of a judgment and costs in time and mental effort.

Trade-offs like this point to two broad cognitive-adaptive strategies in our mind. The first, "cost-sensitive" strategy is to put more stringent time and energy constraints in problem-solving at the expense of the accuracy or reliability of a solution. The reliability still matters for this strategy, but it does so as long as it doesn't cost too much time and mental effort. Looking only at the truth value of a conclusion is an instance of this strategy. The other, "reliability-raising" strategy is to put more stringent constraints on the reliability and justification of a solution. If reliability really counts, one could take time to make sure that she really reaches the right conclusion. Drawing an Euler diagram to check the validity of an inference is an instance of this strategy. Then one can make sense of the observed property correlations of either type of process: they can be seen as supporting the case for the two cognitive-adaptive strategies. Correlations among the properties of type 1 processes, such as quickness, automaticity, and mental effortlessness, can be viewed as a result of taking the cost-sensitive strategy; while correlations among explicitness, reflectiveness, abstractness, and so on can be tied to the reliability-raising strategy.

Although we could in principle take either strategy regardless of the problem we face, one strategy could still be more effective in resolving a particular kind of cognitive-adaptive problems than the other. This suggests the possibility that the two minds are adaptations to different types of cognitive-adaptive problems. As several authors suggest (Smith & DeCoster, 2000; Stanovich, 2004; Evans, 2010), the cost-sensitive strategy typically taken by System 1 is good at solving a problem we routinely encounter in our environment. Take the in-group/out-group distinction as an example. There is a psychological tendency in us to classify anyone we encounter into in-group

("*us*") or out-group ("*them*") in a relatively short time. Our hominid ancestors frequently met this problem of identification in their environment. If we encounter it time and again, and if giving a relatively simple response to a behavioral or physical cue in the environment suffices to solve the problem, then it is not adaptive to spend much time and mental energy to solve it. It is because we could otherwise assign those resources to deal with other, more complex problems, which may be more important in survival and reproduction. A familiar instance of such complex problems is the problem of dealing with one's peers in changing social environment (see, for example, Byrne & Whiten, 1988; Sterelny, 2003). Cognitive-adaptive problems in social environment is generally complex because of the possibility of exploitation. If a male individual is in an alliance with another male to seek for dominance in his group (de Waal, 1982), he should always be aware of the possibility that his ally may betray him. To decide what to do depending on a simple cue is not a good strategy in a changing and complex environment.

Conclusions

The dual process theory has been popular in cognitive and cultural psychology in the last decade, but there are objections to it as well. One of the most serious objections concerns the apparent lack of causal basis of the two Systems. We suggested that the attempt by some dual process theorists to find causal basis for the two minds in neural circuits might be misplaced given that any brain regions are capable of playing a wide variety of functions. Instead, it was suggested that we should seek for the causal underpinnings in evolutionary history: the two Systems are adaptations to different cognitive-adaptive tasks. This view explains why the properties associated to each kind of a process are mutually correlated as they are.

Notes

1. Here I assume that each "system" is a homeostatic property cluster kind the members of which share the clusters of characters. See the discussion in Samuels (2008).

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