Dual System Theories of Cognition: Some Issues

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Abstract

Theories positing dual cognitive systems have become popular in cognitive and social psychology. Although these theories have a lot of common features, close inspection of the literature reveals a number of difficult and unresolved theoretical issues. Issues discussed in this paper relate to the age of evolution of the systems, consciousness and control, domain specificity, individual differences methods and the question of how many distinct systems there might be in the mind.

Dual processing accounts of cognition have been developed in a range of areas including learning (e.g. Reber, 1993), attention (Schneider & Shiffrin, 1977), reasoning (Evans, 2003), decision making (Kahneman & Frederick, 2002) and social cognition (Chaiken & Trope, 1999). In spite of a considerable degree of independence in the formulation of these accounts, they include a number of striking similarities. Processes that are rapid, automatic and effortless on the one hand are contrasted with those that are slow, sequential and controlled on the other. These theories typically characterize the two processes as independent sources of control for behavior that may come into conflict and competition.

A number of theorists have mapped these dual processes on to two distinct cognitive systems. These systems have been given various names including experiential-rational (Epstein, 1994), heuristic-analytic (Evans, 1989; in press), heuristic-systematic (Chen & Chaiken, 1999), implicit-explicit (Evans & Over, 1996; Reber, 1993), associative and rule-based (Sloman, 1996) and the neutral System 1 and System 2 (Stanovich, 1999). Again the characteristics attributed to these underlying systems show quite a large degree of consensus across theories and domains of application. For example, System 1 (using this as a generic label for the fast, automatic system) is often described as evolutionarily old, shared with other animals and independent of individual differences in general intelligence, whereas System 2 is by contrast evolutionarily recent, uniquely human and related to heritable differences in intelligence and working memory capacity.

Given this degree of consensus in dual system theories developed across different cognitive domains, it is tempting to conclude that the brain must indeed contain two systems broadly as described. However, closer inspection of these theories and the relevant literature reveals more questions than answers. There are a number of significant issues that need to be addressed if a fully coherent dual system theory of cognition is to be developed that is consistent with the available evidence. The purpose of this paper is to highlight these issues.

Issue 1: Old system/new system

The idea that System 1 cognition is ancient and System 2 cognition is modern, in evolutionary terms, is a recurring theme in dual-process theories. This is often linked to the assertion that while System 1 cognition is shared with other animals, System 2 cognition is uniquely human. The last idea arises from its association with uniquely human processes such as language and reflective consciousness and the apparent ability to perform cognitive acts (such as hypothetical simulation of future and counterfactual possibilities) that are assumed to be beyond animals. However, little if any direct reference is generally made to literature on animal cognition.

In fact, there is evidence also for distinct cognitive systems in animals. For example, in a recent survey of cognition in a wide range of animal species, the biologist Toates (in press) has claimed that there is a widespread division between cognition that is stimulus-bound on the one hand and involving higher order control on the other. Stimulus-bound cognition includes conditioning and the application of instinctively programmed behavior of a fixed nature. However, he shows that higher-order cognition is also present in many species and suggests that this developed into consciousness in humans. If he is right, then the assumption that the dual system distinction is unique to humans may be wrong. At best we could say that System 2 was better developed in humans.

The description of System 1 as ancient may be oversimplified also, as it is likely that System 1 really includes a number of different forms of implicit cognitive processing that evolved at different times (see also Issue 5). What does appear to be ancient is associative learning, at least in its most basic forms, since humans share this facility with most other animals, including birds, reptiles and fish. However, if our implicit system also includes *cognitive modules*, predisposing us to develop cognitive abilities that are encapsulated in specific domains, there is good reason to believe that these evolved much later. The cognitive archaeologist Mithen (1996) has argued from data in the archaeological and anthropological record that ancient hominids (in common with apes) relied heavily on general learning, whereas early humans (such as Neanderthals and archaic Homo Sapiens) developed specialized intelligences in social, technical, natural history and (eventually) linguistic domains. Mithen's arguments do, however, support the view that System 2 evolved recently and uniquely in modern humans. He describes the emergence of a fluid intelligence, allowing cross-linkage between specialized intelligences that facilitated the 'big bang' of human culture c. 60,000 years ago, with the emergence of art, religion and the ability rapidly to adapt the design of artifacts to changing environmental demands (see also Mithen, 2002).

Some dual-process accounts, particularly in the philosophy of mind, talk as though the contrast to conscious analytic thinking was primarily with modular cognition. Fodor (1983) contrasted input modules, such as those involved in vision and language with a general purpose reasoning system in a form of dual process theory. The processes of such modules were said to be encapsulated within dedicated mechanisms and only the outputs of the modules (for example, the represented meaning of a sentence or some perceptual input) would be available to general thinking and reasoning. Fodor laid out strict criteria for modules including domain specificity, association with specific brain areas, specific course of development, specific patterns of impairment and so on. However, evolutionary psychologists (Cosmides & Tooby, 1994; Tooby & Cosmides, 1992; Pinker, 1997) later applied the concept of domain-specific, information-encapsulated modules to higher order cognitive processes in reasoning and decision making, ignoring a number of these criteria in the process (see Fodor, 2001 for a strong riposte).

The evolutionary psychology debate is relevant to dual-process theorists as evolutionary psychologists initially sought strongly to downplay the role of general purpose cognition in favor of domain-specific modules as well as that of heritable individual differences in general intelligence (Tooby & Cosmides, 1992) thus apparently allowing little if any role for System 2. Dual process theorists have responding with strong criticisms of this programme of work (Stanovich, 2004; Stanovich & West, 2003; Over, 2003). More recently, evolutionary psychologists seem to have conceded that humans have unique abilities to apply their reasoning across a broad range of domains, albeit described in terms of 'modules' for meta-representation or mental logic (Cosmides & Tooby, 2000; Sperber, 2000).

The mapping of the old-new distinction on to the two systems seems to work better in terms of knowledge representation than in terms cognitive processing. It is often claimed that there are two forms of knowledge, an old form captured implicitly in neural networks and a modern human form represented explicitly in a propositional belief system (for example, Epstein & Pacini, 1999; Reber, 1993; Sun et al. 2005). However, the application of the old-new distinction to implicit and explicit *reasoning* systems (Evans & Over, 1996; Stanovich, 1999) has a led to something of a muddle. The problem is that one kind of implicit processing that has greatly interested reasoning theorists are the pragmatic processes which automatically contextualize problems with prior belief and knowledge (Evans, in press; Stanovich, 1999). Hence, the function of such processes relates to what other theorists are describing as knowledge stored in the *modern* human system.

The paradigm case for dual-process theories of reasoning is that of belief bias. In this method (Evans et al., 1983; Klauer et al., 2000) participants are given logical arguments to evaluate whose conclusions either follow or do not follow logically, and are either consistent or inconsistent with belief. The research repeatedly shows that both logic and belief significantly affect decisions made but that the two appear to be in conflict within individuals. Consistent with dual-process theory, the ability to resolve belief-logic conflict problems in favor of logic is known to be related to individual differences in cognitive ability (Newstead et al., 2004), to decline in old age (Gilinsky & Judd, 1994) and to be impaired by instructions to respond rapidly (Evans & Curtis-Holmes, 2005).

In a neuropsychological study of the belief-bias effect, Goel and Dolan (2003) have shown that when belief-logic conflict is resolved in favor of logic, brain areas associated with executive control are recruited. However, the same research also shows (unsurprisingly) that belief bias arises in modern frontal brain areas associated with semantic memory. Thus while these pragmatic processes have the typical System 1 characteristics (rapid, parallel, automatic etc), they are certainly not 'ancient' in origin. Nor are they likely to be shared with non-human animals that lack an explicit belief system. Thus while some cognitive biases may be attributed to a mismatch between the function of evolutionarily old cognitive systems and the much changed environment of the current world (Stanovich, 2004) we clearly need a different account for others, including belief biases. As Evans (in press) demonstrates, cognitive biases may also arise during analytic processing in System 2.

Issue 2: Consciousness and control

Dual system theories clearly associate the unconscious-conscious distinction with the division by System 1 and 2. System 1 represents the 'cognitive unconscious' (Reber, 1993) or 'adaptive unconscious' (Wilson, 2002) with associated characteristics often described as rapid, automatic, parallel etc. System 2 thinking is usually described as slow and sequential and 'controlled', all features of conscious thinking. Hence, research on dual processes would appear to speak to the issue of what are the cognitive correlates of consciousness. For example, Evans and Over (1996) argue that all forms of hypothetical thinking of necessity require *explicit* representation of suppositions and are hence associated with System 2.

The difficult issue that is concerned here is that of the notion of cognitive control. Some philosophers of mind believe that folk psychology, or belief-desire psychology can provide a convincing level of explanation of the human mind (Haselager, 1997), although the need for this to be incorporated within a dual-process framework has recently been recognized (Frankish, 2004). Intentional level accounts of the mind in terms of conscious expressed beliefs and goals do seem to give an account of aspects of human behavior that would be intractable in terms of implicit learning or modular processes as has been recognized by a number of dual process theorists.

Dual process studies of reasoning and decision making have drawn quite heavily upon individual differences methods (see Issue 4). While individual differences in cognitive ability (IQ, working memory capacity) have been shown to be good predictors of analytic reasoning ability, such research has also shown that residual variance can be accounted for in terms of cognitive styles (Kokis et al., 2002; Klaczynski, 2000; Stanovich, 1999). The importance of a disposition to reason critically or analytically supports the volitional nature of System 2. Such dispositions can be induced by personality, instructional set or cultural context (Nisbett et al., 2001). The notion that what is not implicit and automatic is conscious and controlled also has foundations in studies of attention and motor control (Schneider & Shiffrin, 1977) which have been a major influence on dual process theories of social cognition (Chaiken & Trope, 1999).

The problem, however, is that it is far from clear the extent to which conscious thinking really is 'in control' of behavior. First, it seems that heuristic processes in System 1 will control our behavior by default unless a conscious effort is made to override these by explicit effortful reasoning (Evans, 2006; Kahneman & Frederick, 2002, Stanovich, 1999, 2004). Such effort may, however, be unsuccessful: for example, no amount of exhortation to reason logically and ignore prior beliefs has yet been able to remove (as opposed to simply weaken) belief biases in reasoning (Evans et al., 1994). Just as our conscious level cognition can lack control, so also – according to some social psychologists – can unconscious level cognition sometimes be intentional (see Hassin et al., 2005) suggesting that the automatic-controlled distinction between the Systems 1and 2 is far from clear cut.

The other problem, recognized by some dual process theorists (Evans & Over, 1996; Stanovich, 2004) is that analytic reasoning in System 2 can often be applied to the rationalization of unconsciously controlled behavior and to the confabulation of explanations. It seems we apply folk psychology to explain our own behavior as well as that of others. This problem has long been recognized as a source of difficulty in the interpretation of introspective reports (Nisbett & Wilson, 1977; see also Wilson & Dunn, 2004). Thus our consciously experienced and expressed beliefs, desires and intentions may sometimes provide an intentional level account of behaviors controlled in System 2, but may also provides mere rationalization of behaviors controlled in System 1. To my knowledge, no methodological device exists for reliably telling one from the other.

Issue 3: Domain specificity

The notion that System 1 cognition is domain-specific while System 2 is domain-general is yet another recurring theme. For example, Stanovich (1999) regards System 1 thinking as heavily contextualized in line with what he calls the 'fundamental computational bias' whereas System 2 thinking (which he strongly associates with heritable individual differences in general intelligence) is capable of abstract reasoning which can lead to normatively correct solutions to problems in logical reasoning, statistical judgment and decision making. Implicit cognition is generally regarded as domain-specific whether acquired through implicit learning (Berry & Dienes, 1993) or from innate cognitive modules (Tooby & Cosmides, 1992).

A popular theory of reasoning holds that the mind includes a mental logic comprised of abstract inferential rules (Braine & O'Brien, 1998; Rips, 1994). The description of deductive competence in terms of semantic processing of mental models (Johnson-Laird & Byrne, 1991) can also be regarded as a form of mental logic. If System 2 is abstract, decontextualized and normative then it might be tempting to equate it with some from of mental logic. However, the notion of a mental logic seems too narrow to capture the range of features attributed to System 2 cognition. Nor is it even clear that logical ability should be a necessary part of the definition of analytic reasoning. There is, in fact, nothing in the concept of a process that is slow, conscious, explicit and demanding of central working memory resources that necessarily makes it abstract and decontextualized, let alone logically competent. Nor do all reasoning theorists accept that there is anything special about logic (Evans, 2002). It can be argued that solving logical reasoning problems is just one kind of strategic thinking that can be undertaken successfully by System 2 by those of sufficient cognitive ability who are appropriately instructed (Evans, 2000).

It does, however, appear that knowledge acquired experientially tends to remain captured in the domain of experience while that acquired through explicit study and instruction can be generalized to range of domains. An example is the law of large numbers that can be acquired in an implicit and domain-specific way (Nisbett et al., 1983) or an explicit and domain-general way (Fong et al., 1986). There is also extensive evidence that performance on abstract reasoning problems is much more strongly related to cognitive ability than is contextualized reasoning (Stanovich, 1999). It may well be the case that abstract, decontexualized reasoning cannot be achieved *without* use of System 2, although I am not sure it is wise to describe System 2 as 'rule-based' (Sloman, 1996) if only because it implies that System 1 cognition does not involve rules. Rules can be concrete as well as abstract and any automatic cognitive system that can be modeled computationally can in some sense be described as following rules.

I believe that thinking of System 2 as an abstract or logical system is a mistake to be avoided. Recently, researchers studying deductive reasoning have provided dual processing accounts of kinds of reasoning that are highly contextualized. In the case of conditional reasoning, for example, belief could influence us in a System 1 manner when we have an intuition of a degree of connection between antecedent and consequent based on our beliefs. However, it could also influence us in System 2 manner when we consciously decide that a counterexample retrieved from memory should block an inference that we would normally make. Evidence that two such processes may compete to control conditional reasoning in context has recently been produced (De Neys et al., 2005) supporting a dual process account that is independent of the concrete-abstract distinction.

Issue 4: Individual differences

As mentioned earlier, there has been an explosion of interest in the study of individual difference in cognitive ability as a technique for investigating hypotheses about dual processes, initiated by a series of studies by Stanovich and West (2000; Stanovich, 1999). The logic of the method is that problems requiring analytic reasoning should be better solved by those high in cognitive ability, whereas those that can be solved by application of belief based processes in System 1 should be independent of such measures. A classic example is provided by the study of Stanovich and West (1998) who showed that cognitive ability is much more strongly related to performance on the abstract Wason selection task than to that on concrete and deontic versions.

Some recent studies (e.g. Capon et al., 2003) have used measures of working memory capacity that are known to be closely related to general intelligence scores (Colom et al., 2004). However, there is problem here in that the concept of capacity and of executive control, or inhibition may be confused. While dual process theorists (e.g. Evans, 2003; Stanovich, 1999) have claimed that people of higher abilty are better able to inhibit belief biases (implying executive control) it is not clear that the data support this. While it is true that people of higher ability can more successfully resolve belief-logic problems in favor of logic, this method is confounded. It is possible that logical performance improves but that belief bias is no less marked in higher ability participants as indeed recent studies suggest (Newstead et al., 2004; Torrens et al., 1999).

The issue which needs to be resolved in this area is whether higher ability participants are more likely to reason analytically (as the inhibition hypotheses implies) or whether they simply are more effective and normatively correct when they do engage in such reasoning. It could be that the tendency to apply analytic reasoning is entirely a function of dispositional variables and independent of cognitive ability.

Issue 5: Two systems or many?

The final issue that I will raise in this paper concerns the number of cognitive systems in the mind and in particular the coherence of the concept of System 1. System 2 which is by definition a singular, sequential system requiring conscious attention and access to a single central system of working memory seems reasonably coherent. The problem, however, arises in labeling all forms of cognitive processes that are in not in System 2 (that is unconscious, automatic, rapid, parallel etc) as belong to a single alternative system (System 1, heuristic system, implicit system etc). I have already shown earlier how this way of thinking has led to a muddle in which automatic processes associated with the modern human belief system have somehow been labeled as ancient.

It seems clear to me that there are quite a number of different kinds of implicit cognitive processes in the mind. Experiential learning of various kinds, including low level associative and conditioning processes is (at least) one kind. There is at least some cognition that is modular in Fodor's sense, at the level of perceptual systems and quite probably underlying language and our theory of mind. These processes may be ancient and intermediate in evolutionary terms respectively if Mithen's (1996) arguments are accepted. I have also referred here to pragmatic processes, important in dual process theories of reasoning that retrieve and apply relevant knowledge from explicit memory and belief systems which are of recent evolution and associated with the modern human mind. To these three types of implicit processes, I can add a fourth: *automated* cognition. In fact, the term 'automatic' process has a narrower sense than that in which I have been using it, when applied to processes that start off explicit under conscious control and later become automated, an important concept in studies of attention and motor control (Monsell & Driver, 2000). Stanovich (2004) recognizes a similarly diverse range of implicit cognitive systems and for this reason has preferred to use the term TASS – the set of autonomous subsystems – to the previous catch-all 'System 1'. Unconscious processing is also associated with multiple systems by Wilson (2002).

It seems that there are implicit processes that were once conscious, others that were never conscious but deliver a product to consciousness, and still others that influence our behavior without ever being conscious in any sense at all. Does it make sense to classify all these together in 'System 1'? Almost certainly not. All that really links dual process theories together is the nature of System 2 and the way in which implicit and automatic processes (of whatever kind) appear to compete with it for control of our behavior. Our knowledge of the underlying architecture of all this is next to non-existent. It may be that the mapping of cognitive functions on to neurological regions will help with this enterprise, but that is far from clear at present (Goel, 2005). For example, there is no *a priori* way to know whether cognitive systems would be mapped on to brain systems in a localized or distributed manner.

Conclusions

Dual process theories are widespread in psychology and seem necessary to account for many cognitive tasks. The difficulties identified in this paper arise from attempts to map dual processes on to underlying cognitive systems. Although it is striking that theorists in different areas have proposed dual systems with broadly similar characteristics, it is far from evident at present that a coherent theory based on two *systems* is possible. For example, the equation of automatic and controlled with unconscious and conscious processing is fraught with difficulties. It also appears that there are a number of different kinds of implicit cognition and the underlying subsystems probably have quite distinct evolutionary and neurological bases. We have little or no understanding of the cognitive architecture that underlies this.

The most perplexing issue in all this is how generally well controlled, predictable and effective most of our behavior actually is. Sane people, by and large, execute successfully many parallel life plans of differing durations. Most people manage to get up in the morning, go to work, manage their domestic affairs, maintain relationships and utilize their leisure time broadly in accordance with their goals. Although system conflicts occasionally become manifest (as when a person finds it difficult to lose weight, quit smoking or give up gambling in accordance with a consciously expressed intention) we generally breeze through life with little awareness of the cognitive turmoil that is apparently afflicting our minds. If the conscious, analytic system is at best only partially in control and in competition with not one but several implicit systems, how come everything works so well? Understanding how generally adaptive behavior can result from such an apparently chaotic cognitive architecture is one of the great challenges for cognitive science.

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