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DUAL-PROCESSING ACCOUNTS OF REASONING,
JUDGMENT AND SOCIAL COGNITION

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ABSTRACT

This chapter reviews a diverse set of proposals for dual-processing in higher cognition within largely disconnected literatures in cognitive and social psychology. All these theories have in common the distinction between cognitive processes that are fast, automatic and unconscious and those that are slow, deliberative and conscious. A number of recent authors have suggested that there may be two architecturally (and evolutionarily) distinct cognitive systems underlying these dual-process accounts. However, it emerges that (a) there are multiple kinds of implicit processes described by different theorists and (b) that not all of the proposed attributes of the two kinds of processing can be sensibly mapped into two systems as current conceived. It is suggested that while some dual-process theories are concerned with parallel competing processes involving explicit and implicit knowledge systems, others are concerned with the influence of preconscious processes which contextualize and shape deliberative reasoning and decision making.

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INTRODUCTION

Dual-processing accounts of human behavior abound in cognitive and social psychology. So many authors have appealed to dual processes in so many different ways that it has proved a complex and challenging task to draw together any coherent overview of this topic. The review is restricted to ‘higher’ cognitive processes typically described as thinking, reasoning, decision making and social judgment, although selected work from outside of these domains is also included where directly relevant. For example, there is some reference to work in the psychology of learning and memory, the philosophy of mind and evolutionary psychology.

What dual-process theories have in common is the idea that there are two different modes of processing, for which I will use the most neutral terms available in the literature, System 1 and System 2 processes (Stanovich 1999, 1999, Kahneman & Frederick 2002). Almost all authors agree on a distinction between processes that are unconscious, rapid, automatic and high capacity, and those that are conscious, slow and deliberative. Different authors have proposed a number of names for the two kinds of thinking they contrast, some of which are shown in Table 1. The labels are aligned in a manner consistent with generic dual-system theory (see below) under the headings System 1 and System 2. Despite the tidy way in which all these labels line up, readers should beware of inferring that there are necessarily just two systems or just two kinds of dual-processing theory for reasons that will become clear later. Some authors propose only dual-process distinctions without assumptions about underlying cognitive systems; some propose parallel and some sequential relationships between the two processes and so on.

(Insert Table 1 about here)

Attempts have been made to map various dual-process accounts into a generic dual-system theory (Evans 2003, Evans & Over 1996, Stanovich 1999, 2004). A major issue for this review will be to consider whether such a grand theory is sustainable, or whether, in spite of first appearances, we will need to classify dual-process theories as being of different and distinct kinds. I shall approach this question in part by considering the clusters of attributes supposedly belonging to System 1 and 2, which have been extracted from the numerous dual-process theories to be found in the literature. Of course, not all authors have made explicit statements about all of these attributes, but when they do so, they tend to make comments that are remarkably consistent from theory to theory. These putative features of Systems 1 and 2 are somewhat arbitrarily grouped here into four categories (see Table 2) and each will be discussed in turn prior to the review of specific dual-process theories of higher cognition.

(Insert Table 2 about here)

It should be noted that the attributes listed in Table 2 do not include emotion, the discussion of which is generally beyond the scope of this review. While many authors ignore emotion altogether in the fields reviewed here, it is clear that emotional processing would be placed in the System 1 rather than System 2 list. Emotion is explicitly linked to the first system in some dual-process accounts (Epstein 1994), implied by the neurological regions identified in others (Lieberman 2003) and specifically attributed to automatic processes in some recent accounts of social cognition (Hassin et al 2005). Moreover, the idea that emotions play a key role in decision making is being developed in some contemporary work on decision making that contrasts a fast emotional basis for

decision making with a slower and more deliberative cognitive basis (Haidt 2001, Wang 2006, Hanoch & Vitouch 2004).

FEATURES ATTRIBUTED TO DUAL PROCESSES AND SYSTEMS

Consciousness

A central concern for philosophers of mind, the problem of consciousness is one that has engendered a resurgence of interest in recent years in psychology and neuroscience (Velmans 2000). However, the concept of consciousness has had a somewhat checkered history in psychology. Mentalism and introspectionism dominated philosophy of mind and early laboratory studies of the 19th Century when psychology first emerged as a distinct discipline. Thereafter, a series of movements led instead to an emphasis on what is automatic and unconscious in the control of human behavior. These are sometimes described as the psychoanalytic, behavioral and cognitive unconscious (Uleman 2005). Each refers to a movement which undermined the concept of consciousness and the explanation (in scientific psychology) of behavior in terms of conscious beliefs and desires. Freud and other psychoanalysts introduced the world to the notion of an unconscious mind motivating our behavior with a combination of innate drives and repressed emotions as well as a conscious mind prone to rationalization and self-deception. Behaviorists such as Watson, Hull and Skinner demonstrated associative and instrumental learning processes in both humans and animals in theories that apparently allowed no place for consciousness and mentalistic accounts of behavior. However, the emergence of cognitive science and the widespread acceptance of a computational theory

of mind led in the later part of the 20th century to the idea of a *cognitive* unconscious (Kihlstrom 1987, Reber 1993) in the form of complex information processing in the brain that is conducted without conscious awareness. Some authors are now advocating a ‘new unconscious’ that incorporates also motivation and emotion (Hassin et al 2005).

While the problem of what consciousness *is* may seem intractable, the study of its function and evolution seems more promising. Dual-process theories of cognition effectively address the important question of the cognitive correlates of consciousness. The attributes listed for Systems 1 and 2 listed under Cluster 1 (Table 2) all reflect the proposed differences between the cognitive unconscious and the cognitive conscious. Authors talk of processes that are explicit and controlled (rather than implicit and automatic) reflecting two key concepts of consciousness: awareness and volition. Consciousness is also inherently slow, sequential and capacity limited. This might be taken to mean that folk psychological accounts of mind are adequate at the System 2 level provided the System 1 level of mind is also recognized (Frankish 2004). In other words, System 2 is a form of thinking under intentional level control, supported by unconscious processes in System 1 that deliver percepts, memories and so on. However, this happy state of affairs, which leaves ‘us’ in control of our behavior, is contradicted by much psychological research. Many researchers have emphasized the fact that unconscious processes may control our behavior without us being aware them doing so, and that conscious reasoning in System 2 is often used for the confabulation of explanations for these behaviors (Nisbett & Wilson 1977, Wason & Evans 1975, Evans & Over 1996, Stanovich 2004, Wilson 2002, Wilson & Dunn 2004). It appears that we use the concepts of belief-desire psychology to theorize about our behavior as well as that

of others. To muddy the waters further, some social psychologists are claiming evidence of intentionality in unconscious processing (Bargh et al 2001, Bargh & Ferguson 2000).

The distinction between automatic and controlled cognition has been extensively researched in the study of lower order cognition such as that involved in perception, attention and the acquisition of motor skills, in a tradition dating from Schneider and Shiffrin (1977) and more recently linked with neuroscience (Monsell & Driver 2000). In this tradition, automatic processes are typically viewed as having been *automated* from those which were once controlled and conscious, an approach which seems to have had a strong influence on the development of dual-process accounts of social cognition (Chaiken & Trope 1999). However, as Sloman (2002) points out, this conception is too limited for the purposes of dual-process accounts of higher cognition, in which we may feel an experience of conflict between an intuition acquired from experience and a conscious piece of reasoning. Moreover, there is a contrasting literature on implicit learning (Berry & Dienes 1993, Reber 1993, Sun et al 2005) which provides much evidence that people can acquire implicit knowledge, for example to predict or control a complex system, without ever knowing an explicit rule that they could state. Hence, the term 'automatic' is used here simply as a contrastive with 'controlled' implying no assumption about how such processes were acquired.

An operational definition of consciousness that seems to have appeared (often implicitly) in dual-process theories is that System 2 thinking requires access to a central working memory system of limited capacity, whereas System 1 does not. What we are aware of at a given time is represented in this working memory, through which conscious thinking flows in a sequential manner. This would seem to be a working memory of the

kind originally described by Baddeley and Hitch (1974) which has not only short-term memory capacity but also executive and inhibitory functions, a theory which has engendered a huge research literature in its own right (see Gathercole 2003).

(Consciousness is also closely associated with working memory in 'global workspace theory' - see Baars & Franklin 2003). The association of conscious thought with such a working memory explains the slow, sequential and low capacity nature of System 2 as well as its relation to individual differences in cognitive ability (see below). However, skeptics may see this as the only firm foundation on which the various dual-process theories stand: there is one conscious working memory system and everything else.

Age of evolution

The idea that System 1 cognition evolved earlier than System 2 is a recurring theme in dual-process theories (Reber 1993, Epstein & Pacini 1999, Evans & Over 1996, Stanovich 1999). System 2 is thought to be associated with language, reflective consciousness and higher order control and with the capacity to think hypothetically about future and counterfactual possibilities. Authors have often asserted that such characteristics of thought are distinctively or uniquely human, while at the same time arguing that System 1 cognition, shared with other animals, continues to control much of our behavior. However, there is considerable evidence of a distinction between stimulus-bound and higher-order control process in many higher animals (Toates 2006), including rodents, which could be seen as the biological foundations for the System 1 and 2 cognition in humans. There is also evidence that primates, especially chimpanzees, have the capacity for higher-order mental representations, manifest as rudimentary theory of

mind (Mithen 1996, Whiten 2000), albeit very limited in comparison with the ability of the human mind for metarepresentation and higher order intentionality.

The proposal that System 1 cognition is evolutionarily old and shared with other animals is also problematic because it is almost certainly not one system with a single evolutionary history. There are a number of distinct possible types of implicit cognitive processes including forms of learning, automaticity, modular cognition and the pragmatic processes that have been particularly studied in dual-process theories of deductive reasoning (see below). The concept of cognitive modules was introduced by Fodor (1983) in a dual-process theory that distinguished between input modules (such as those involved in vision and language) and general purpose, central cognition. Fodor proposed a number of strict criteria for modules including the requirements that they are innate, domain-specific, have specialized and isolated databases (knowledge encapsulation), are neurologically localized and associated with specific disorders. Some schools of evolutionary psychology later argued that the mind should consist mostly or entirely of domain-specific cognitive modules, even when engaged in higher order reasoning (Cosmides & Tooby 1992, 1996, Tooby & Cosmides 1992, Pinker 1997, Samuels 1998, Sperber 1994). This view included strong claims that domain-general processes would have little part to play in human cognition, such as that of Tooby and Cosmides (1992, p.112): ‘... there is a host of ... reasons why content-free, general-purpose systems could not evolve, could not manage their own reproduction, and would be grossly inefficient and easily outcompeted if they did.’ Not surprisingly, this ‘massive modularity hypothesis’ has been strongly attacked by dual-process theorists (Fodor 2001, Over 2003, Stanovich 2004, Stanovich & West 2003). More recent writings of evolutionary

psychologists appear to have more compatibility with dual-processing frameworks, however, as they acknowledge the extraordinary and distinctive features of human higher cognition (Cosmides & Tooby 2000, Sperber 2000). There has also been a recent trend to weaken the criteria for modules so as to make massive modularity a more credible hypothesis (Carruthers 2006, Barrett & Kurzban 2006).

It seems unsustainable to argue that there is just one form of implicit processing, in System 1, all of which is evolutionarily old and shared with other animals. For example, it seems that we may have forms of modular cognition that are relatively old (e.g. vision, attention) and others that are much more recent and distinctively human (e.g. language, theory of mind). Conditioning and other forms of associative learning appear to be ancient and shared with other animals, but forms of explicit memory and in particular the human belief system would seem to much more recent. However, while the notion that there are distinct implicit and explicit memory systems is central to a number of the dual-process theories to be considered in this chapter, it could well be an error to think of the latter as uniquely human in origin. There are powerful evolutionary arguments (as well as neurological evidence) for multiple systems of learning and memory in both humans *and* other animals (Carruthers 2006, Sherry & Schacter 1987). For example, Sherry and Schacter (1987), who interestingly referred to System 1 and 2 memory, noted that ‘... a strong case can be made for a distinction between a memory system that supports gradual or incremental learning and is involved in the acquisition of habits and skills and a system that support rapid one-trial learning and is necessary for forming memories that represent specific situations and episodes.’ (p.446). Taken in conjunction with the evidence of higher-order control systems in animals (Toates 2006), these

arguments suggest that dual-system theorists would be better off claiming that System 2 cognition is uniquely *developed*, rather than uniquely present in modern humans. Such an argument also has much greater evolutionary plausibility.

If Systems 1 and 2 incorporate different memory as well as reasoning systems, then it may be a mistake to assume that any influence of prior knowledge on reasoning necessarily arises in System 1. For example, Goel (2005) has questioned the idea that the ‘belief bias’ in reasoning which theorists have associated with System 1 processing (Evans & Over 1996, Stanovich 1999) could be ancient in origin or shared with animals that lack an explicit belief system. In support of this he has evidence from neural imaging studies that belief bias arises in the pre-frontal cortex, an area most strongly developed in the modern human brain (Goel et al 2000, Goel & Dolan 2003). However, a dual-system theorist can reply that while System 1 has much in common with animal cognition, it looks very different in a brain that has System 2. Thus Stanovich (2004, Chapter 2), for example, suggests that goals which are acquired reflectively through System 2 can through repeated activation be installed into rigid implicit processing mechanisms – a kind of automation of thought. This may be why Stanovich (2004) now prefers to talk about TASS – the set of autonomous subsystems – rather than ‘System 1’. Certainly, there seems to be little foundation in arguments based on age of evolution for the claim that all implicit processes belong – in any useful sense – to a single system.

Functional characteristics

Along with already discussed attributes of System 1 as rapid and automatic and System 2 as slow and controlled go a number of functional differences attributed to the two kinds

of cognition, as shown in Table 2 under Cluster 3. It appears that conscious thought is inherently sequential whereas many theorists suppose the rapid processing and high capacity of System 1 reflects use of parallel processes. System 1 has been characterized as *associative* by Sloman (1996, 2002, see also Smith & DeCoster 2000) as contrasted with *rule-based* cognition in System 2. Those authors who are not focused on the idea of innate modules, certainly emphasize the experiential nature of System 1 (for example, Epstein & Pacini 1999, Evans & Over 1996, Reber 1993) which could reflect implicit learning stored in functionally parallel neural networks (Smith & DeCoster 1999, 2000, Dijksterhuis & Smith 2005). However, while the notion that System 2 is in some sense ‘rule-based’ is compatible with the proposals of most dual-process theorists, the characterization of System 1 as associative is not. The problem, as already identified, is that there are multiple systems of implicit processes and it is far from clear that the different theories can be mapped on to each at the System 1 end. In particular, theories which contrast heuristic with analytic or systematic processing (Evans 2006, Chen & Chaiken 1999) seem to be talking about something different from associative processing.

Other recurring themes in the writing of dual-process theorists are that System 1 processes are concrete, contextualized or domain-specific whereas System 2 processes are abstract, decontextualised or domain-general. The notion that System 1 processes rapidly contextualize problems with prior knowledge and belief has been particularly emphasized in dual-process accounts of human reasoning (Stanovich 1999, Evans 2006, Klaczynski & Lavalley 2005). Such authors assume that belief based reasoning is the default to which conscious effortful analytic reasoning in System 2 may be applied to overcome. However, it may be unwise to define System 2 as being abstract and

decontextualised if we want also to retain its description as slow, sequential, explicit and rule-based as none of these characteristics may be limited to abstract forms of reasoning (Sloman 2002, Verschueren et al 2005). It would probably be more accurate to say that while abstract reasoning requires the use of System 2, concrete contexts do not preclude its application.

The consideration that System 2 thinking is not necessarily abstract and decontextualised is one reason also why it should not be equated with a *mental logic*. The idea that higher forms of thinking require a logic in the mind was popularized by Piaget (see Inhelder & Piaget 1958) and is particularly associated with the idea that people have natural logics in their minds comprised of inference rules (Braine & O'Brien 1998a, Rips 1994). However, the popular mental models theory of deductive reasoning (Johnson-Laird 1983, Johnson-Laird & Byrne 1991) can also be regarded as a form of mental logic, accounting for deductive competence by semantic rather than syntactic principles (Evans & Over 1996, Oaksford & Chater 1995). Whichever account of deduction is preferred, it is clear that the System 2 concept is much broader than that of logical reasoning, including such ideas as an inhibitory role (suppressing pragmatic influences of System 1) and the ability to engage in hypothetical thought via supposition and mental simulations. This is probably why most dual-process theorists prefer broader terms such as 'analytic' or 'systematic' to describe the second system.

Individual differences

A link between System 2 processing and general intelligence has been claimed by some dual-process theorists (Reber 1993, Stanovich 1999) with the corollary that System 1

processes are independent of general intelligence. This proposal has led to an increasing use of individual differences methodology in dual-process research as the following review sections will reveal. In addition to linking the effectiveness of analytic reasoning and decision making with general intelligence measures, researchers have also investigated two close correlates: working memory and age of development. It is now well established that individual differences in working memory capacity and general intelligence measures are very highly correlated (Colom et al 2004). Working memory capacity is known to predict performance levels in a very wide range of cognitive tasks and has been directly linked with dual-process accounts of cognitive functions, albeit primarily at a lower level than those that form the focus of the current chapter (Barrett et al 2004). Developmental studies are also relevant, as the analytic thinking skills that contribute to performance on general intelligence tests develop with age. However, it has recently been claimed that it is ability and not age that is the important predictor of analytic reasoning, which may explain some inconsistencies in developmental research (Kokis et al 2002). A further complication is that, as some researchers claim, that System 1 may develop in parallel with the System 2 (Klaczynski 2000, 2001).

Evolutionary psychologists such as Tooby and Cosmides (1992) have emphasised that their main interest lies in explaining intelligence that is universal and optimized across the human species. However, they have been strongly criticized (Stanovich 1999, Stanovich & West 2003) for down-playing the importance of heritable characteristics, particularly that of general intelligence, in their discussion of higher order cognitive processes such as reasoning and decision making. In general, the evidence that ‘controlled’ cognitive processing correlates with individual differences in general

intelligence and working memory capacity while ‘automatic’ processing does not, is one of the stronger bases for dual-systems theory. It seems at least to indicate that behavior may be controlled both with and without the use of executive working memory resources.

An important distinction in the individual differences approach is that between measures of cognitive capacity and dispositional thinking styles. The difference is between what people are able to do and what they are *inclined* to do. Stanovich (1999), for example, shows that residual variance in solution rates of reasoning and judgment task, when the effects of cognitive ability has been taken out, can be accounted for in terms of dispositions for critical thinking. Evidence for cross-cultural differences in thinking styles (Nisbett et al 2001) are also dispositional as they can alter when people move to another culture. In the social cognition literature there has been much attention to individual differences in thinking style as measured by such scales as ‘need for cognition’ (Cacioppo & Petty 1982) or the rational-experiential inventory (Epstein et al 1996). It is important to note that the observation of two thinking styles does not, in itself, constitute evidence for dual processes arising from two distinct cognitive systems.

APPLICATIONS OF DUAL-PROCESS THEORIES IN DIFFERENT DOMAINS

It is evident from the preceding discussion that System 2 appears a more coherent and consistent concept in the generic dual-system theory than does System 1 as there are multiple systems of implicit cognitive processes (Wilson 2002, Stanovich 2004). It is also likely that different dual-process theorists have different implicit systems in mind and that these systems do not have a single evolutionary history. I will return to the issue of whether generic dual-system theory is sustainable at the end of the chapter. At this

point, it would be helpful to look more closely at how dual-process theories are applied to the explanation of particular phenomena in higher cognition.

Dual-process theories of reasoning

The psychology of deductive reasoning was largely established by the work of Peter Wason in the 1960's and 70's (see Wason & Johnson-Laird 1972) who invented several famous tasks including the four card selection task that are still used in current research. The field has expanded rapidly over the past 40 years and also changed its character, as authors have become progressively less attached to the normative standard of formal logic and more interested in the influence of contextual factors invoking prior belief and knowledge (Evans 2002). Dual-process ideas developed quite early on, with the first use of the term appearing in the title of a paper published by Wason and Evans (1975). This paper was focused on the finding that while card choices on the selection task were strongly influenced by a seemingly primitive *matching bias* (selecting cards explicitly mentioned in the conditional statement.) Participants showed no awareness of this in their verbal reports, instead justifying their choices with regard to the experimental instructions to prove the rule true or false. Wason and Evans concluded that participants were *rationalizing* with their conscious reasoning causes of behavior that were in fact unconscious. Their arguments were very much in accord with the famous critique of introspective reports presented by Nisbett and Wilson (1977).

The heuristic-analytic theory of reasoning (Evans 1989) shifted the emphasis of the heuristic processes responsible for biases to a pragmatic and preconscious level that *preceded* any attempt at analytic processing. This theory is narrower in scope than typical

dual-process theories and strongly focused on the explanation of biases in reasoning and judgment tasks. The idea was that heuristic processes selectively focused attention on to task features that appeared relevant, introducing relevant prior knowledge in the process. Since analytic processing could only be applied to these selective representations, biases would be observed when either (a) logically relevant information was excluded or (b) logically irrelevant information was included by heuristic processing.

The sequential nature of the heuristic-analytic theory contrasts with parallel and interactive forms of dual-process theory, although many of the proposed features of the two processes correspond to those of the generic System 1 and 2: heuristic processes are fast, automatic and belief based while analytic reasoning is slow, sequential and can make an effort at deduction. In a recent reformulation of the theory, Evans (2006) has sought to reconcile it with conflict models by the proposal that heuristic responses can control behavior directly unless analytic reasoning intervenes. In other words, heuristics provide default responses that may or may not be inhibited and altered by analytic reasoning. Analytic system intervention may be cued by strong deductive reasoning instructions and may be more likely to occur when individuals have high cognitive ability or a disposition to think reflectively or critically (Stanovich, 1999).

For much of its recent history, the psychology of deductive reasoning has been dominated by a debate between proponents of mental logic theorists who attribute deductive competence to sets of abstract inference rules (Braine & O'Brien 1998a, Rips 1994) and mental model theorists (Johnson-Laird 1983, Johnson-Laird & Byrne 1991) who explain it in terms of a fundamental semantic principle: an argument is valid if there are no counterexamples to it. Although the writings of mental logic and mental model

theorists include little explicit discussion of dual-process theory, the distinction is implicitly present in the theories. Mental logic theorists (for example Braine & O'Brien 1998b) make great play of the distinction between 'direct' rules of inference which are applied effortlessly and accurately on the one hand and indirect rules which require conscious effort and are much more error prone on the other. They also explain errors in reasoning by reference to pragmatic implicatures and other contextual effects. Similarly, the mental model theory describes the formation of initial mental models as relatively automatic and effortless process. The process of searching for counterexamples (Johnson-Laird & Bara 1984) or the fleshing-out of initially implicit mental models (Johnson-Laird & Byrne 2002) is, however, effortful and error-prone and constrained by working memory capacity. Both theories include proposals that could account for pragmatic influences on reasoning and for the relation of reasoning accuracy to individual differences in cognitive capacity.

The paradigm case for dual processes in reasoning is belief bias. In the standard paradigm people are given syllogisms and asked to evaluate their logical validity. Syllogisms vary in both their validity (whether the conclusion follows from premises) and their believability (whether the conclusion conforms or conflicts with prior belief). Thus some syllogisms are belief-logic compatible but some provide conflict – valid arguments with unbelievable conclusions and invalid arguments with believable conclusions. The basic phenomena of this paradigm were established by Evans, Barston and Pollard (1983) whose findings have been replicated many times since (see Klauer et al 2000 for a recent extensive study). There is (a) a main effect of logic, in that valid conclusions are more often accepted than invalid conclusions, (b) a main effect of belief

(belief bias) in that believable conclusions are much more often accepted and (c) a belief by logic interaction, in that belief bias is much more marked on invalid syllogisms.

In the original study, Evans et al. (1983) argued, on the basis of protocol analyses and the examination of individual response patterns, that there was a *within-person* conflict between a logical and belief based reasoning process. They offered two explanations of the belief by logic interaction which were later augmented by one derived from mental model theory (Oakhill et al 1989). More recently, accounts of the phenomena have been developed which are strongly compatible with dual-process theory (e.g. Klauer et al 2000). These accounts are supported by evidence of a shift from logical to belief based reasoning under severe time pressure (Evans & Curtis-Holmes 2005) and under concurrent working memory load (De Neys 2006).

There has been considerable interest in how people reason on belief-logic conflict problems: that is the valid-unbelievable and invalid-believable syllogisms. Logical performance on such cases is known to decline with age (Gilinsky & Judd 1994) and to be related to individual differences in cognitive ability (Kokis et al 2002, Newstead et al 2004, Stanovich & West 1997). It has been argued on this basis by Stanovich (1999) that participants of higher cognitive ability are more able to inhibit belief based reasoning. However, available data are more consistent with the view that while high ability people reason more logically with belief laden (as well as abstract) syllogisms, the belief bias effect is no less marked for them than for lower ability people (Newstead et al 2004, Torrens et al 1999, Klaczynski 2000). Thus it may be that higher ability people do not engage in *more* System 2 reasoning but are simply more successful when they do so.

There is a large literature on how people reason with the Wason four-card selection task (see Evans & Over 2004, Chapter 5, for a recent review). The task requires people to decide which of four cards to turn over to decide the truth of a conditional statement. For example, if the statement says ‘If a card has an A on one side then it has a 3 on the other’ and the visible sides display A, D, 3 and 7, then the logically correct choice is the A and the 7. This is because only a card which has an A and *not* a 3 could disprove the statement. Few people give this answer and will be more likely to choose A and 3, or just A. While this abstract, indicative form of this task is very difficult, concrete and deontic forms (concerning rules and regulations) are much easier. For example, given the statement ‘If a person is drinking beer in a bar that person must be over 19 years of age’, most participants readily see that they must check beer (rather than coke) drinkers and those that are *under* 19 years of age.

The heuristic-analytic theory explains the difficulty of the abstract task on the grounds of heuristics that focus attention on selected cards, a claim supported by the time that people spend observing individual cards (Evans 1996, but see Roberts 1998, Ball et al 2003) and the accentuation of matching bias by a requirement to respond rapidly (Roberts & Newton 2001). Stanovich and West (1998) have produced strong evidence that analytic reasoning is involved in solving the abstract selection task, since the minority of solvers have much higher SAT scores than non-solvers. The relation to cognitive ability is, however, much weaker for concrete and deontic forms of the task suggesting that it can be solved by pragmatic belief based reasoning in System 1 (see also Newstead et al 2004).

Recently, dual-process theory has been applied by various authors to the inferences people draw from conditional statements. There is considerable evidence that reasoning with realistic conditionals is strongly influenced by pragmatic factors including the availability of counterexamples to inferences from semantic memory (Cummins et al 1991, Thompson 1994, 2000) and the strength of association of counterexamples as measured across both materials and individual participants (De Neys et al 2005, Markovits et al 1998, 2002). Participants are also more likely to draw inferences from conditionals that they believe rather than disbelieve (George 1997, Liu et al 1996, Newstead et al 1997, Stevenson & Over 1995, 2001). However, there is evidence that analytic, System 2 reasoning processes, as well as heuristic System 1 processes may be influenced by prior belief about the problem context (Verschueren et al 2005).

In conclusion to this section, dual-process theory has been widely applied to the study of syllogistic reasoning, the Wason selection task and conditional inference. Experimental evidence has consistently shown that responses are partially consistent with logic but also influenced by systematic biases such as matching bias and belief bias. Cognitive models have generally depicted these as competing influences in a within-participant conflict. In support of dual-process accounts are several different forms of evidence including (a) the observation of more logical and less belief based reasoning under strong deductive reasoning instructions, (b) the association (in general) of better logical accuracy with higher ability participants when problems cannot also be solved by a pragmatic route and (c) the finding that working memory load or instructions to respond rapidly increase levels of typical biases as well as reducing logical accuracy.

Dual-process theories of judgment and decision making

The psychology of judgment and decision making has been dominated by three main research paradigms: (a) the ‘heuristics and biases’ research program that is focused particularly on judgments of probability (Gilovich et al 2002, Kahneman et al 1982), (b) the study of decision making under risk (Wu et al 2005) and (c) social judgment theory and the lens model (Doherty 1996). The last of these paradigms, which may be less familiar to readers, is focused on judgments made where multiple cues are available in the environment. An example might be medical diagnosis in light a number of demographic factors, patient history, symptoms, diagnostic tests and so on. Using multiple regression analysis, it is possible to ‘capture’ the implicit policy of judges by showing which of the various cues predict their overall judgment.

Until recently, dual-process theory played a much smaller part in these fields than in the study of reasoning and social cognition. An exception is the cognitive continuum theory of Hammond (e.g. 1996), working in social judgment theory, which contrasts intuitive and analytic thinking. However, as the name suggests, this theory proposes two ends of a continuum rather than discrete processes or systems, and is hence is not the main type of theory with which this review is concerned.

Recently, Kahneman and Frederick (2002, 2005) have developed a dual-process theory of probability judgment which they link to the generic dual-system theory. Heuristic judgments, which lead to biases are associated with System 1 and analytic reasoning which may intervene with these judgments and improve them, are linked to System 2. This helps explain general findings that while biases in probability judgment can be linked to heuristics such as *representativeness* (Kahneman & Tversky 1972,

Teigen 2004) and *availability* (Reber 2004, Tversky & Kahneman 1973) these biases are not universally observed but appear to compete with a tendency to give normatively correct answers. Such conflicts stand in parallel with the findings in the deductive reasoning literature, reviewed above, in which matching and beliefs biases compete with logically correct answers. In general, normatively correct solutions to problems from both literatures tend to be found more often by those of higher cognitive capacity (Stanovich 1999) who may be assumed to make more effective interventions with analytic or System 2 reasoning processes.

The processing assumptions of Kahneman and Frederick's theory are similar to those of the heuristic-analytic theory of reasoning (Evans 2006). It is assumed that fast System 1 (heuristic) processes cue default intuitive judgments that must nevertheless be endorsed by the (analytic) System 2, which often does so casually. This may involve attribute-substitution, in which people actually answer a different (and easier) question than the one set. However, high-effort deliberative reasoning may be applied which can inhibit the biased response and replace it with one based on reflective reasoning. I call this kind of dual-process theory *default-interventionist* as compared with theories (e.g. that of Sloman, 1996) that are *parallel-competitive* in nature. Kahneman and Frederick suggest that even heuristics that are apparently conscious in application, such as the 'recognition heuristic' (Gigerenzer et al 1999) have an automatic component. In this case, feelings of familiarity are automatically recruited and then consciously interpreted as a basis for making a judgment, such as the relative size of foreign cities.

A major recent debate in the probability judgment literature has concerned the claim that probability problems are much easier if framed in terms of frequencies than

probabilities (Gigerenzer & Hoffrage 1995, Cosmides & Tooby 1996, Barbey & Sloman In press) thus reducing biases such as base rate neglect in Bayesian reasoning (Kahneman & Tversky 1973, Koehler 1996). It was argued from an evolutionary perspective that we would have evolved a cognitive module for processing frequency information in the environment (Cosmides & Tooby 1996) that could not be applied to one-case probabilities. However, from a dual-process viewpoint, it appears that such a module would affect learning behavior in System 1 rather than explicit System 2 reasoning about the quantitative word problems that are actually presented (Evans et al 2000). Consistent with this, there is now much evidence that what facilitates Bayesian reasoning is a problem structure that cues explicit mental models of nested-set relationships (Evans et al 2000, Sloman et al 2003, Girotto & Gonzalez 2001) as originally proposed by Tversky and Kahneman (1983). However, Hoffrage et al. (2002) have responded by arguing that such nested-sets are intrinsic to ‘natural sampling’, a process which leads to the observation of ‘natural frequencies’ which encode base rate information implicitly. Hence, they claim that Bayesian posterior probabilities can be derived from direct comparison of such frequencies with no difficult calculation involved. However, Barbey and Sloman (In press) have recently argued that this kind of evolutionary account, when examined in detail, is a good deal less parsimonious than an explanation in terms of dual-processing.

Discussion of work on reasoning and judgment to this point may have suggested that System 2 processing is in some sense *superior* to that of System 1, in that the former is often associated with normatively correct responding and the latter with cognitive biases. However, those authors who have looked at expert judgment and decision making

provide a somewhat different perspective. For example, Klein (1999) in his naturalistic studies of decision making in groups such as fire officers and paramedics, argues that very little rational decision making goes on, in the sense of deliberation between alternatives. What typically happens is that an expert recognizes a situation as of a kind encountered previously and rapidly retrieves a schema that provides a solution, a process he terms *recognition-primed* decision making. The application will involve some explicit reasoning (sometimes mental simulations to check feasibility of solutions) but the key to intelligent action is the automatic retrieval process.

The value of System 1 processing has also been emphasized by other dual-process theorists in application to decision making. For example, Reyna (2004) argues that experts acquire gist knowledge that allows them to make intuitive responses that are automatic, rapid and effective whereas novices need to rely on explicit analytic reasoning. However, she notes also that the former kind of process can lead to bias and error when novel problems are presented, as is typically the case in laboratory studies of probability judgment. Perhaps more controversial is the recent claim of Dijksterhuis et al. (2006) that there are processes of conscious and unconscious reasoning, both of a deliberative nature, and that the unconscious reasoning leads to superior decision making. This is a very different kind of claim from those of the theories we have been considering that envisage fast heuristic processes delivering contextualized content for application by a conscious, analytic process.

The evidence for superiority of unconscious decision making is that people may make better decisions as measured by normative analysis, or by correspondence with expert judgments (Wilson & Schooler 1991) when conscious deliberation is prevented by

shortage of time or by competing tasks. This applies to fairly complex, multi-attributed decision problems. However, it is unclear why any unconscious process of *deliberative* reasoning need be postulated. The evidence is consistent with the claim that where participants have a history of relevant experiential learning, fast recognition processes may provide accurate intuitive responses. What is interesting, however, is that conscious deliberative reasoning may then interfere with good decision making. It may be that this reflects its sequential and low-capacity nature. An analogous finding in the learning literature, is that complex rule learning may sometimes be inhibited by an instructional set for explicit learning (Reber 1993).

Dual processes would seem to be implicated when we contrast intuitive judgment against reflective decision making. Many everyday decisions seem to involve rapid intuitive judgments in which courses of action spring to mind with little or no effort of conscious thinking. Much expert decision making seems to have this character (Klein 1999). On the other hand, we can and do make some decisions in a manner much more akin to that prescribed by decision theory, exploring alternative actions and their consequences with extended mental simulations (Kahneman & Tversky 1982). Intuitive judgments seem to have the System 1 characteristics while reflective decision making seems much more like a System 2 process (see also Kahneman & Frederick 2002). Other examples familiar to us all concern phobias and compulsive behaviors like gambling, overeating or smoking where we may become aware of a System 1 and 2 conflict. We may judge our own behavior or that of others to be 'irrational' because we compulsively behave in ways that are at odds with our explicitly stated (System 2) goals. Some authors

have described these kinds of phenomena as implying two minds in one brain (Evans 2003) or a brain at war with itself (Stanovich 2004).

Dual-process theories of social cognition

Dual-process theories of social cognition emerged in the 1980's (Petty & Cacioppo 1981, Chaiken 1980) and developed in popularity to form the dominant paradigm for the past 20 years or more. Contemporary work particularly concerns the automatic and unconscious processing of social information in such domains as person perception, stereotyping and attitude change (Chaiken & Trope 1999, Hassin et al 2005, Forgas et al 2003, Wilson 2002, Bargh 2006, Smith & DeCoster 2000) and its apparent dissociation from explicit beliefs and conscious processing. The proposal of new accounts or at least new *labels* for dual-processes in social cognition has reached near epidemic proportions causing some reaction in terms of a 'unimodel' which instead emphasizes multiple parameters known to influence social judgments (Kruglanski et al 2003). Another interesting recent development is the 'quad-model' of Conrey et al. (2005) which proposes four kinds of process that should be distinguished in order to interpret research on automatic and controlled cognition.

Dual-processing accounts of social cognition have their roots in cognitive psychology, especially the study of automaticity and implicit memory, but have made curiously little connection with the dual-process theories of reasoning and decision making discussed above. While there is currently very little cross-referencing between these literatures, dual-process accounts in social psychology nevertheless share many common features with those in the cognitive psychology of reasoning and judgment.

However, there are differences of emphasis. In general, the social cognition literature is less concerned with issues about cognitive architecture and evolution but more focused on issues concerning consciousness, free will and the implications for moral and legal responsibilities of individuals.

A long-established dual-process theory is the heuristic-systematic model of Chaiken . According to Chen and Chaiken (1999, p.74, Petty & Cacioppo 1981) ‘*Systematic processing* entails a relatively analytic and comprehensive treatment of judgment relevant information ... Given its nature, systematic processing requires both cognitive ability and capacity’ whereas ‘*Heuristic processing* entails the activation and application of judgmental rules and “heuristics” that .. are presumed to be learned and stored in memory ... Relative to systematic processing, heuristic processing make minimal cognitive demands on the perceiver.’ Systematic processing seems a similar concept here to that of analytic or System 2 reasoning in theories encountered above. However, heuristic processing in this theory sounds more like the recognition primed decision making of Klein (1999) than the contextualization process postulated by reasoning theorists (Evans 2006, Stanovich 1999). In fact, heuristic processing so defined could be taken to be a form of System 2 or rule-based reasoning, albeit one less effortful than that what is called systematic processing (see Strack & Deutsch 2004).

The Cognitive Experimental Self Theory or CEST (Epstein 1994, Epstein & Pacini 1999) proposes two cognitive systems, labeled as experiential and rational that share many common features with the generic two system theory of reasoning. Like System 1, the experiential system is described as having a long evolutionary history with clear links to animal cognition, while the rational system, like System 2, is recent and

distinctively human. Many other features of the generic theory shown in Table 1 are included: fast-slow, unconscious-conscious, associative-rule based and so on while emotion is explicitly linked to the experiential system. However, the theory has a parallel-competitive, rather than default-interventionist structure, and includes the proposal that each system has access to distinct forms of knowledge. What is particularly distinctive about Epstein's approach is the linkage of the two systems to two competitive processing styles. In contrast with reasoning theorists like Stanovich, who keep a clear separation between cognitive systems and dispositional thinking styles, Epstein has developed a psychometric tool, the rational experiential inventory or REI (Epstein et al 1996) for measurement of the two styles based on self-report. Epstein and Pacini (1999) review a number of experimental studies which appear to support the existence of these two processing styles. However, neither people classified as 'rational' thinkers nor those scoring highly on the related 'need for cognition' scale, appear to have any advantage on abstract tests of logical reasoning (Bors et al 2006, Newstead et al 2004).

Social psychologists have been particularly interested in links between unconscious processing and implicit forms of knowledge representation. For example, it has been proposed that people may have both implicit and explicit attitudes (Wilson et al 2000), something which may help to explain the traditional dissociation between verbal and behavioral measure of attitude changes. It may be possible to change someone's explicit attitude, while an implicit attitude continues to control their social behavior. Similarly, it has been argued that we may have both implicit and explicit stereotypes that are dissociated from one another (Devine 1989, Bargh 1999, Bargh & Williams 2006). Many studies have used the methodology of semantic priming, borrowed from the

literature on implicit memory (Lucas 2000). For example, Macrae et al. (1997) showed that when people are shown photographs of males or females and required to process them in a semantic manner, their subsequent threshold for word recognition is primed for stereotype consistent words. Although, some authors have proposed an optimistic view that conscious processing can inhibit implicit stereotypes, the evidence suggests the contrary. Even people who have explicitly stated beliefs that are non-stereotypical and are aware of the problem of stereotypical behavior, can nevertheless be shown experimentally to have much of their social behavior unconsciously controlled (Bargh 1999).

A recent attempt to link dual-process accounts in social cognition with those in cognitive psychology was made by Smith and DeCoster (2000) who build on the distinction of two kinds of memory, one based on slow acquisition through associative learning and one linked to explicit memory (McClelland et al 1995). These leads them to a parallel system account with associative and rule-based processing (cf Sloman 1996) linked to the two forms of knowledge. This proposal is essential similar to dual-process accounts that have been developed to distinguish implicit and explicit forms of learning (Reber 1993, Berry & Dienes 1993, French & Cleeremans 2002, Sun et al 2005). Smith and DeCoster argue that the major dual-process theories in social psychology can be accommodated within this general framework. However, as noted earlier, this is doubtful in the case of the heuristic-systematic theory which looks more like two forms of rule-based processing (Strack & Deutsch 2004).

An important development for dual-process and dual-system theory generally is the emergence of social cognitive neuroscience. Particularly interesting is the

identification of reflexive (System 1) and reflective (System 2) cognitive processing with two neurological systems described as the X- and C-systems respectively (Lieberman 2003, Lieberman et al 2004). The X-system is comprised of the amygdala, basal ganglia and lateral temporal cortex, brain areas known to be involved in conditioning and associative learning and now being linked by Lieberman and colleagues with social cognitive processes traditionally described as automatic or implicit. The C-system involves the anterior cingulate cortex, prefrontal cortex and the medial-temporal lobe (including hippocampus), brain areas known to be involved with (among other things) explicit learning and inhibitory, executive control. This account is supported by recent findings concerning the neurological systems that underlie response to immediate and deferred rewards in decision making (McClure et al 2004), which correspond to X and C system regions of the brain. Although in its early stages, this research program provides perhaps the strongest basis in the literature for maintaining some form of dual system distinction.

A final issue to mention in this section is that of self-knowledge. Although the notion that System 2 reasoning may engage in rationalization or confabulation is mentioned in the cognitive literature (Evans & Over 1996, Stanovich 2004) this idea has been more thoroughly investigated in the social psychology literature, especially by Wilson and his colleagues (Nisbett & Wilson 1977, Wilson & Dunn 2004, Wilson 2002). The basic idea here is that while much of our behavior is unconsciously controlled, 'we' (conscious beings) are not aware of this fact and may live with an illusion that we are much more in control of our behavior than we actually are. On this view, we observe and

theorize about our own social behavior in much the same way as we attempt to perceive and understand the behavior of others.

CONCLUSIONS

Although dual-process theories have been around in cognitive and social psychology for 30 years and more, it is only within the past 10 years or so that the terms System 1 and 2 have come into common use. So popular are these terms now that it may be somewhat difficult to discourage their use and the implication of two underlying generic systems that they convey. However, close inspection of the evidence suggests that generic dual-system theory is currently oversimplified and misleading. In particular (a) it is not possible coherently to link together all the attributes associated with Systems 1 and 2 respectively in Table 2, certainly when moving between clusters and (b) there are at least two quite distinct forms of dual-process theory to be found in these various literatures that cannot readily be mapped on to each other.

We might be better off talking about type 1 and type 2 processes since all theories seem to contrast fast, automatic or unconscious processes with those that are slow, effortful and conscious (Samuels 2006). Such terminology does not commit use to a two system view. However, it would then be helpful to have some clear basis for this distinction. If we cannot associate all the System 1 (or type 1) features shown in Table 2 together, for example, then which are the key ones that should distinguish them from System (or type 2) processes? My suggestion is that type 2 processes are those that require access to a single, capacity limited central working memory resource, while type 1 processes do not. This implies that the core features of type 2 processes are that they are

slow, sequential and capacity limited. The last feature implies also that their functioning will correlate with individual differences in cognitive capacity and be disrupted by concurrent working memory load. Depending upon what else is assumed about working memory, there may be a rationale for describing such type 2 processes as registering in consciousness and having properties associated with executive processes and intentional, higher order control. Other proposed features of 'System 2' in the generic theory do not immediately follow from this definition of type 2 processes, however: for example, the proposal that such processes are uniquely human or associated with decontextualised thought or rule-based reasoning.

The problem with this distinction is that type 1 processes then simply refer to any processes in the mind that can operate automatically without occupying working memory space. As already indicated, there are a number of different kinds of such implicit processes. We may have innate cognitive modules with encapsulated processes for perception, attention, language processing and so on. We appear to have an associative learning system that implicitly acquires knowledge of the world in a form similar to weights in neural networks which cannot be called to mind as explicit knowledge but which can directly affect our behavior. We have habitual and automated behavior patterns that once required conscious type 2 effort but seem to have become type 1 with practice and experience. We also have powerful pragmatic processes that rapidly identify and retrieve *explicit* knowledge for conscious processing. Type 2 processing requires supporting type 1 processes to supply a continuous stream of relevant content into working memory.

If there are indeed multiple kinds of type 1 processes, then it is to be expected that psychologists will have developed different kinds of dual-process theories, which also seems to be the case. Parallel-competitive forms of dual-process theory seem to be rooted in the idea of two forms of learning, leading to two forms of knowledge (implicit and explicit) which can then lead to competing attempts to control behavior. Theories of this type include those of Sloman (1996), Reber (1993) and Smith and DeCoster (2000). As mentioned earlier, there is promising evidence that these theories can be mapped on to neurologically distinct X and C systems (Lieberman 2003). However, the category of theories which I call default-interventionist assume, in contrast, that rapid preconscious processes supply content for conscious processing, cueing default behaviors which the analytic reasoning may approve, or intervene on with more effortful reasoning. This approach is reflected in dual-process theories of reasoning (Evans 2006, Stanovich 1999) as well as the theory of intuitive and reflective judgment proposed by Kahneman and Frederick (2002). If there are indeed two parallel cognitive and neurological systems it is possible either that (a) the latter class of theories are mistaken in their architectural assumptions or (b) that they are dealing with interactions between preconscious and conscious elements of the second system.

In short, my conclusion is that while dual-process theories enjoy good empirical support in a number of fields of psychology, the superficially attractive notion that they are all related to the same underlying two systems of cognition is probably mistaken, at least in the way that Systems 1 and 2 are being defined in the current literatures. For example, it is almost certainly wrong to think of ‘System 1’ as one system, all of which is old and shared with other animals. Equally, it is probably a mistake to think of ‘System 2’

as the conscious mind, all of whose processes are slow and sequential. If there is a second system, distinctively human, involving working memory and neurologically distinct structures, it does not follow that all of its workings are conscious and controlled. It is perfectly possible that one system operates entirely with type 1 processes and that the other includes a mixture of type 1 and type 2 processes, the latter being linked to use of working memory, which this system uses *among other resources*. Such a proposal could resolve the evidence for dual systems on the one hand with the conflicting proposals of different dual-process theorists on the other.

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Table 1

Labels attached to dual-processes in the literature, aligned on the assumption of a generic dual system theory

	System 1	System 2
Fodor (1983, 1989, 2001)	Input modules	Higher cognition
Schneider and Schiffrin (1977)	Automatic	Controlled
Epstein (1994, 1999)	Experiential	Rational
Chaiken (Chaiken 1980, Chen & Chaiken 1999)	Heuristic	Systematic
Reber (1993); Evans & Over (1996)	Implicit / tacit	Explicit
Evans (1989, 2006)	Heuristic	Analytic
Sloman (1996); Smith and DeCoster (2000)	Associative	Rule based
Hammond (1996)	Intuitive	Analytic
Stanovich (1999, 2004)	System 1 (TASS)	System 2 (Analytic)
Nisbett et al. (2001)	Holistic	Analytic
Wilson (2002)	Adaptive unconscious	Conscious
Lieberman (2003)	Reflexive	Reflective
Toates (2006)	Stimulus-bound	Higher-order

Strack and Deustch (2004)



Impulsive

Reflective

Table 2

Clusters of attributes associated with dual systems of thinking

System 1	System 2
Cluster 1 (Consciousness)	
Unconscious (preconscious)	Conscious
Implicit	Explicit
Automatic	Controlled
Low effort	High effort
Rapid	Slow
High capacity	Low capacity
Default process	Inhibitory
Holistic, perceptual	Analytic, reflective
Cluster 2 (Evolution)	
Evolutionarily old	Evolutionarily recent
Evolutionary rationality	Individual rationality
Shared with animals	Uniquely human
Non-verbal	Linked to language
Modular cognition	Fluid intelligence
Cluster 3 (Functional characteristics)	
Associative	Rule-based
Domain-specific	Domain-general
Contextualised	Abstract
Pragmatic	Logical
Parallel	Sequential
Stereotypical	Egalitarian
Cluster 4 (Individual differences)	
Universal	Heritable
Independent of general intelligence	Linked to general intelligence
Independent of working memory	Limited by working memory capacity

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