Dual-Process and Dual-System Theories of Reasoning

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Abstract

Dual-process theories hold that there are two distinct processing modes available for many cognitive tasks: one (type 1) that is fast, automatic and non-conscious, and another (type 2) that is slow, controlled and conscious. Typically, cognitive biases are attributed to type 1 processes, which are held to be heuristic or associative, and logical responses to type 2 processes, which are characterised as rule-based or analytical. Dual-system theories go further and assign these two types of process to two separate reasoning systems, System 1 and System 2 – a view sometimes described as 'the two minds hypothesis'. It is often claimed that System 2 is uniquely human and the source of our capacity for abstract and hypothetical thinking. This study is an introduction to dual-process and dual-system theories. It looks at some precursors, surveys key work in the fields of learning, reasoning, social cognition and decision making, and identifies some recent trends and philosophical applications.

1. Introduction

Dual-process and dual-system theories are empirical theories of human psychology. A dual-process theorist holds that there are two distinct processing modes available for a cognitive task, which employ different procedures and may yield conflicting results. One process (type 1) is characterised as fast, automatic and non-conscious, the other (type 2) as slow, controlled and conscious. Type 1 processes are also described variously as associative, heuristic or intuitive, and type 2 processes as rule-based, analytical or reflective. Dual-process theories have been proposed by researchers on several aspects of human cognition, including deductive reasoning, decision making and social judgment. Researchers have also proposed dual-process theories of learning and memory, which posit dual attitudes, implicit and explicit, associated with distinct systems, one fast-access but slow-learning, the other slow-access but fast-learning. More recently, some theorists have proposed dual-*system* theories, according to which human cognition is composed of two multipurpose reasoning systems, widely known as System 1 and System 2, the former supporting type 1 processes, the latter supporting type 2 ones. In addition, it is often claimed that System 2 is an evolutionarily recent, uniquely human system, which is the source of our capacity for decontextualised, abstract thinking in accordance with logical norms.

This study is an introduction to dual-process and dual-system theories. There are now many such theories, developed across different disciplines, so the survey is necessarily selective, but key points are covered. (For other surveys, see Frankish and Evans; Evans, 'Dual-Processing Accounts of Reasoning, Judgment and Social Cognition'.)

2. Precursors

In their modern form, dual-process and dual-system theories are the product of the last 30 years or so, but ideas about mental duality and division have been around much

longer. The core of dual-process theory is present in the everyday distinction between intuition and reason – the former immediate, quasi-perceptual, sensitive to subconscious cues and sometimes biased; and the latter slow, effortful, explicit and more cautious. (In philosophical usage, however, 'intuition' has traditionally been used in a more restricted sense for a kind of pure intellectual apprehension, free from error (e.g. Locke, Vol. 2, 138). Here, everyday usage is closer to the modern psychological one.)

Within philosophy, a dual-process perspective can be found in some discussions of animal mentality. Several authors have proposed that humans exhibit a qualitatively different kind of mentality from other animals, anticipating the modern claim that there is a uniquely human reasoning system. To take two examples: Leibniz claimed that animals lack a capacity for demonstrative reasoning and are capable only of associative and inductive reasoning, and Descartes argued that animals do not think at all and that their behaviour is the product of mechanical processes (Leibniz 188–91; Descartes, Vol. 1, 140). However, these writers also allowed that humans sometimes operate in animal mode. Leibniz suggested that 'three fourths' of human behaviour is guided by associative and inductive reasoning, and Descartes held that much human behaviour is the product of animal-like mechanical processes, including such complex activities as walking and singing when they are done unreflectively (Leibniz 208; Descartes, Vol. 2, 161). Such claims reflect a tacit dual-process view.

Dual-process ideas are also latent in theorising about the unconscious. Although most pre-20th-century philosophers identified the mind with consciousness, there was a consistent undercurrent of speculation about non-conscious mentality (for reviews, see Ellenberger; Reeves; Whyte), and Schopenhauer and Nietzsche developed elaborate theories of the unconscious, which prefigured Freud. Some 19th-century philosophers and physicians also accumulated evidence for unconscious processing underlying conscious thought and action (see Wilson 10), and pioneering experimental work in this area was carried out by the Victorian scientist Francis Galton (Galton).

The most important pre-modern account of the unconscious (historically, at least) was, of course, Freud's. Freud held that the human mind is composed of two systems: one conscious, and the other unconscious. He held that these systems operate in different modes ('primary process' and 'secondary process'): the former associative, and the latter logical. He also held that the contents of the unconscious were inaccessible to the conscious mind, and that the unconscious system was a source of motivation and mental conflict. With all of this, most modern dual-process theorists agree. Nevertheless, there are huge differences between Freud's unconscious and contemporary psychologists' System 1 (i.e. the system supporting fast, automatic, non-conscious processes). The Freudian unconscious consists largely of repressed impulses or memories; it is not a reasoning system and seeks only to maximise pleasure and minimise pain; and it can influence action and conscious thought only indirectly, through dreams, neurotic symptoms and symbolic activities (Freud 69–70, 73–4). By contrast, System 1 (the 'cognitive unconscious', as it is sometimes called) has its own knowledge base and goal structure, which are not the product of repression; it is a set of inferential mechanisms adapted for the control of everyday behaviour; and it can directly influence action and conscious thought.

Despite these precursors, pre-20th-century thinking about the mind was largely concerned with the conscious mind, and early psychologists focused on the study of conscious mental processes, using introspective reporting. In dual-system terms, the focus was on System 2. With the behaviourist revolution of the early 20th century, the focus switched. Mainstream psychologists rejected introspective evidence and mentalistic theorising, and concentrated their experimental work on associative learning – in effect,

focusing on System 1. It was only after the cognitive revolution of the 1960s that the theoretical tools became available for more encompassing theories. The following sections introduce this modern work, beginning with local dual–process theories, then moving on to general dual–system ones.

3. Dual-Process Theories

Dual–process theories developed, largely independently, in four separate areas of psychol–ogy: learning, reasoning, social cognition and decision making. Related ideas also appeared in philosophy of mind. Each area will be reviewed in turn.

In the field of learning, pioneering work was carried out by Arthur Reber. Beginning in the 1960s, Reber devised techniques for investigating implicit learning, defined as the 'acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired' (Reber 5). One of these techniques involved artificial grammar learning. Participants were asked to memorise strings of letters that had, unknown to them, been generated by a set of complex rules (an 'artificial grammar'). Then in a second stage, participants were informed of the existence of the rules and asked to say whether new strings did or did not conform to them. Surprisingly, they were able to do this at levels well above chance, even though they could not say what the rules were. They had been extracting rule information implicitly, without conscious awareness or effort. The existence of implicit rule learning has been confirmed by researchers using other experimental techniques (for reviews, see Berry and Dienes; Reber; Sun), and neuropsychological studies indicate that implicit and explicit learning are associated with distinct brain systems (Eichenbaum and Cohen).

Dual–process theories of deductive reasoning were devised in the 1970s and 1980s, with Jonathan Evans being a central figure in the research. One motivation was to account for the discrepancy between participants' behaviour on reasoning tasks and their introspective reports. Wason and Evans studied this discrepancy in performance on the Wason selection task, which involves indicating which cards must be examined to verify or falsify a conditional (Wason and Evans). Participants' behaviour suggested that they were simply choosing cards with the symbols mentioned in the conditional (displaying a 'matching bias'), but when asked to explain their choices participants gave rational expla–nations in line with the instructions they had received. Wason and Evans concluded that participants' choices were determined by an unconscious matching bias and that their introspective reports were the product of *post hoc* rationalisation, and they coined the terms 'type 1' and 'type 2' processing to refer to the unconscious and conscious processes respectively. The idea that introspective explanations are often confabulatory harmonises with much experimental work in social psychology (e.g. Nisbett and Wilson; Wilson).

A second motivation was to account for an apparent conflict between logical processes and non–logical biases on deductive reasoning tasks, notably syllogistic reasoning, where participants have to evaluate the validity of an argument. Analysis of participants' responses suggested that two competing processes were at work: a logical process sensitive to deductive relations, and a 'belief bias' that leads participants to endorse arguments with believable conclusions (Evans, Barston and Pollard). This led to the development of Evans's *heuristic–analytic* theory of reasoning (*Bias in Human Reasoning*). On this view, ana–lytic (type 2) processes generate logical responses, rather than merely rationalising intuitive ones, as on Wason and Evans's account. However, these processes are strongly influenced by preconscious heuristic processes of a type 1 character, which direct attention and

activate prior knowledge before analytic processing occurs. Biases arise when the heuristic processes omit relevant information or include irrelevant information, and they may or may not be overridden by subsequent analytic processing. (Note, however, that later versions of Evans's theory ascribe biases to both types of processing; see Section 5.) Approaches of this type are supported by studies showing that belief bias is reduced in people of higher ability or motivation and that it can be increased by loading working memory or reducing response time.

Dual–process theories of social cognition originated in the 1980s and have come to dominate the field (see Smith and Collins, and the papers in Chaiken and Trope). Early models were devised by researchers studying persuasion and attitude change – how people react to persuasive messages such as arguments or adverts. It was proposed that two distinct processes are at work, corresponding to type 1 and type 2: a default process reliant on simple associations and contextual cues, such as the likability of the communicator, and a more cognitively demanding process involving assessment of the message's content. Experimental studies suggested that which process is dominant varies systematically depending on the participant's motivation and ability. Influential models of this kind were Chaiken's heuristic/systematic model and Petty and Cacioppo's elaboration likelihood model (Chaiken; Petty and Cacioppo; Chen and Chaiken).

Dual–process models were also devised to explain dissociations between actual social behaviour and reported attitudes, reflecting the parallel trend in reasoning research. There is strong evidence that people's social judgments and perceptions are unconsciously influenced by stereotypes and prejudices that are widespread in their culture, even if these conflict with their conscious attitudes, as revealed by their verbal reports. There are various techniques for tapping these unconscious attitudes, one of the most important being *priming*. Participants are given a task that is, unknown to them, designed to evoke a stereotype (it might, for example, involve looking at a photograph of a person of a particular ethnic group). They are then asked to perform a social judgment task, such as evaluating a person's character or actions. As numerous studies have shown, primed stereotypes affect performance on these tasks, even if they conflict with the participant's reported attitudes.

Such findings support a dual–process approach. Devine, for example, argues that stereotypes are activated automatically by appropriate stimuli, but that the ensuing responses may be inhibited by subsequent controlled, conscious processing, reflecting the subject's unbiased 'personal' beliefs (Devine).[1] Similarly, Wilson, Lindsey and Schooler advocate a dual-attitude model, contrasting implicit attitudes, which are automatic, and explicit attitudes, whose activation requires capacity and motivation. Implicit attitudes, they argue, are harder to change than explicit ones, but in the right circumstances their effects on behaviour can be suppressed (Wilson, Lindsey and Schooler). It should be noted, however, that not all dual–process theorists agree that social perception and judgment can be controlled. Bargh argues that the influence of automatic stereotypes cannot be effectively suppressed by conscious thought, and that the 'cognitive monster' of automatic stereotype application can be quelled only by eradicating the cultural stereotypes themselves (Bargh). Much of the work in this area has been influenced by cognitive psychological work on automaticity, in particular Schneider and Shriffin's distinction between automatic and controlled processing in attention and the acquisition of motor skills (Schneider and Shiffrin; Shiffrin and Schneider).

In the field of judgment and decision making, dual–process ideas took longer to make an impact, but they have become influential within the 'heuristics and biases' tradition. According to this tradition, founded by Kahneman and Tversky in the 1970s, our

judgments of probability are typically the product of rough–and–ready estimation proce-dures (heuristics), which deliver results that deviate from the rules of probability theory and produce systematic biases. (An example is the Linda problem, in which participants are given a description of Linda that stresses her independence and liberal views, and then asked whether it is more likely that she is (a) a bank teller or (b) a bank teller and active in the feminist movement. Participants tend to choose (b), since it fits the description of Linda (following the 'representativeness heuristic'), even though the co-occurrence of two events cannot be more likely than one of them alone.) A dual-process perspective, contrasting heuristic–based intuition with rule–based reasoning, was implicit in some of the early work in this tradition (see Kahneman and Tversky), and recently Kahneman and Frederick have developed an explicit dual-process model, drawing on the dual-system theories discussed below (Kahneman and Frederick). According to this model, which is similar to Evans's heuristic/analytic theory, heuristic-based System 1 processes generate default judgments, often involving attribute substitution (answering a simpler question than the one actually asked). This answer is then passed to System 2, which exercises a supervisory role. Often, System 2 will simply endorse the intuitive judgment, but given sufficient capacity and motivation, it may override it in favour of a judgment in line with normative theory. (Evans dubs architectures of this type 'default-interventionist', in contrast to parallel–com-petitive models, in which the processes work in parallel and compete for behavioural control ('Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition').)

Another dual-process approach to decision making is Valerie Reyna's fuzzy trace the-ory (Reyna). This distinguishes intuitive and analytic processing, the former involving gist memories, which are imprecise but capture the essential meaning of an experience, and the latter involving verbatim memories, which are precise but more superficial. Unlike some other dual-process theorists, Reyna holds that intuitive judgments are often superior to analytic ones, and that experts rely on gist rather than verbatim knowledge. In this, Reyna agrees with other recent authors who have stressed the value of unconscious deci-sion making (e.g. Myers; Gladwell; Dijksterhuis et al.; Gigerenzer).

Dual-process themes have also emerged independently in philosophy. A central topic in modern philosophy of mind is the analysis of everyday ('folk') psychological concepts – principally *belief* – and their role in the explanation of thought and action. A number of authors have argued for a dual-attitude approach, which posits different types of belief. Proposals of this kind have been made by Dennett, Cohen, and Frankish, among others. Dennett draws a distinction between belief and opinion (*Brainstorms* 300–9). Belief in Dennett's sense is a basic mental state, which is common to humans and animals, and for which the possession criteria are behavioural. Opinions, by contrast, are more sophisti-cated, 'linguistically infected' states, possessed only by humans. To have an opinion is to be committed to the truth of a sentence in a language one understands (to have 'bet on its truth'), often as a result of consciously making up or changing one's mind.

Cohen makes a related distinction between belief and acceptance (Cohen). To believe something is simply to be disposed to feel it true, whereas to accept it is to have a policy of taking it as a premise in one's conscious, rule-based reasoning. Belief is passive, graded, non-linguistic and exhibited by animals as well as humans, whereas acceptance is active, binary, linguistically formulated and not exhibited by animals. Cohen suggests that these dual attitudes are associated with dual processes, with belief processes being modelled by connectionist networks and acceptance-based ones by digital computer programs.

Frankish distinguishes basic belief and superbelief, the former non-conscious, implicit, passive, graded and non-linguistic, and the latter conscious, explicit, active, binary and language–involving (*Mind and Supermind*). Beliefs guide spontaneous, unreflective

behaviour, whereas superbeliefs influence action only if they are called to mind and used in conscious reasoning. Building on Cohen's account of acceptance, Frankish develops a model of conscious beliefs as premising policies, which are actively adopted and executed.

There is a common theme to these distinctions: there are two types of belief: one implicit, non-linguistic and associated with parallel, connectionist processing; the other explicit, language-involving and associated with serial, rule-governed processing. There is a clear correspondence here with dual-process theories in psychology – the implicit form of belief corresponding to type 1 processing and the explicit form to type 2. Folk psychology, it seems, may be tracking, obscurely, the same fundamental duality that scientific psychology has identified.

4. Dual-System Theories

The theories discussed in the previous section posited dual processes and attitudes. This section looks at dual-system theories, which attribute these processes and attitudes to two distinct cognitive systems, with different structures, functions and evolutionary histories. In their most ambitious form, dual-system theories claim that we have, in effect, two minds.

A two-systems framework was present in Reber's work on implicit learning, already mentioned, and Reber was one of the first to propose key elements of the two-systems approach. In particular, he argued for the 'primacy of the implicit' – the view that sophisticated non-conscious perceptual and cognitive systems were in place long before consciousness evolved. He also identified various features of implicit systems, including low individual variability, independence of general intelligence and commonality across species (Reber, Chapter 3).

In the 1990s, influential dual-system theories were proposed by Sloman, Evans and Over, Stanovich, and Epstein. Sloman's account, which is limited to reasoning and judgment, distinguishes a reflexive associative system, which draws inferences from statistical regularities in the environment, and a deliberate rule-based system, which operates on symbolic structures and aims to describe the underlying logical and causal structure (Sloman). The model is a parallel–competitive one, with the two systems vying to generate responses. (Sloman suggests that introspection will often reveal which is the winner: when a response is generated by the associative system alone, we are aware only of the result of the process; when the rule-based system is responsible, we are aware of the computational process as well.) Sloman presents a range of evidence for this model from studies of judgment, reasoning and categorisation, focusing in particular on cases of simultaneous contrary belief ('Criterion S'), where a person is drawn to two contradictory responses to a reasoning task, one reflecting an associative process and the other a rule-based one. Sloman's account has had wide influence and has inspired dual-system accounts of social judgment (e.g. Smith and DeCoster).

Evans and Over propose a dual-system model of reasoning and judgment, building on dual-process theories of reasoning and work on implicit learning (*Rationality and Reasoning*). Their model posits implicit and explicit cognitive systems. The implicit system is non-conscious or pre-conscious, rapid, parallel, low effort, high capacity and shaped by biologically constrained, domain-specific learning. The explicit system, by contrast, is conscious, slow, serial, high effort, limited capacity and responsive to verbal instruction. Inferences and decisions can reflect processes in either system, but there is also interaction between the systems, and conscious thinking is continuously 'shaped, directed and limited' by implicit, pre-attentive ones (*ibid*. 146). The model also links the systems with different

types of rationality, instrumental and normative. Instrumental rationality consists in achieving one's goals and is compatible with deviations from the rules of logic and decision theory, whereas normative rationality involves explicitly following the rules of a normative theory. Although Evans and Over do not equate the two forms of rationality with the two systems, they argue that our instrumental rationality, which is high, derives mainly from the implicit system, and that our capacity for normative rationality, which is limited, depends on the explicit one. Their model gives a relatively restricted role to the explicit system, which, they argue, often serves merely to rationalise intuitive choices, as Wason and Evans proposed. However, Evans and Over also claim that the explicit system is required for *hypothetical* thinking (thinking about possibilities and entertaining suppositions) and is thus an important source of foresight and flexibility (*Reasoning and Rationality*; *If*).

Stanovich uses a dual-system framework to interpret studies of individual differences in reasoning (*Who is Rational*; *The Robot's Rebellion*). The framework itself is a generic one, drawn from various sources, and Stanovich employs the terms 'System 1' and 'System 2', which he introduced. (He stresses, however, that System 1 is not a single system, but a suite of systems, many modular in nature, and he also refers to it as The Autonomous Set of Systems, or TASS.) Numerous studies of reasoning and judgment show that when a task requires abstract reasoning to determine the normatively correct response, performance correlates positively with intelligence, as measured by SAT scores. But when the correct response can be determined by contextualised processes, drawing on background knowledge, this effect largely disappears; participants of low and high intelligence do equally well (e.g. Stanovich and West). Confirming Reber's view, mentioned above, Stanovich concludes that differences in general intelligence are differences in the capacity of System 2, not System 1.

Stanovich also addresses questions of evolution and rationality. He argues that System 1 was designed for the promotion of narrowly genetic goals, such as reproductive success, whereas the more flexible System 2 serves the goals of the individual person and allows us to rebel against genetic imperatives (it is still an evolutionary product, of course, but is under 'long-leash' genetic control). In modern technological and bureaucratic societies, Stanovich argues, success often requires us to engage in abstract, decontextualised reasoning and to suppress System 1 processes, with their tendency to contextualise problems (the 'fundamental cognitive bias'). Stanovich is thus, in his own terms, a Meliorist, who thinks that human reasoning can be improved, as opposed to a Panglossian, who thinks that humans are optimally rational, or an Apologist, who thinks that humans perform as well as is cognitively possible for them.

Finally, Epstein's cognitive-experiential self-theory is a dual-system theory that integrates Freudian psychodynamics with modern theories of the cognitive unconscious (Epstein; Epstein and Pacini). Epstein distinguishes experiential and rational processing systems, which both compete and interact. The distinction has much in common with those already discussed (non-conscious/conscious, holistic/analytic, associative/logical, concrete/abstract, rapid/slow, etc.), but Epstein differs from other theorists in characterising the non-conscious, experiential system as emotionally driven. Epstein also suggests that relative preference for one or other of the two processing modes correlates with individual differences in thinking style, such as relish for intellectual challenge or belief in trusting one's hunches.

Some philosophers have also proposed dual-system frameworks, drawing on the idea that natural language serves as the medium of conscious, explicit thought. Carruthers and Frankish have both produced detailed accounts of this kind (see also Dennett, *Consciousness Explained*).

Carruthers's account is designed to explain how a massively modular mind, composed of numerous domain-specific reasoning systems, could support flexible, domain-general thinking. Such thinking, Carruthers claims, depends on our capacity for the mental rehearsal of schemata for the production of utterances. This, he argues, generates auditory feedback (inner speech) that is processed by the speech comprehension system and tends to produce effects at the modular level appropriate to the thoughts the utterances express. As utterances may combine outputs from different modules, the process implements a form of domain-general thinking, and cycles of mental rehearsal create a domain-general reasoning system (*The Architecture of the Mind*; 'An Architecture for Dual Reasoning'). Frankish also characterises the conscious mind as language-dependent. Conscious reasoning, he argues, is an intentional activity, which involves producing and manipulating sentences of inner speech and other forms of mental imagery to execute various problem-solving strategies. These actions, Frankish claims, are motivated and supported by non-conscious metacognitive attitudes (desires to solve problems, beliefs about the strategies that may work, and so on), and they influence action in virtue of a non-conscious desire to act on the results of one's conscious reasoning (*Mind and Supermind*; 'Systems and Levels'). Carruthers and Frankish both make explicit links with dual-system theories in psychology, and they suggest that their accounts explain how System 2 could evolve without major changes to neural hardware. In their models, this system is a 'virtual' one, which emerges from the interaction of components that originally evolved for other purposes.

Despite the differences between the dual-system accounts reviewed, especially concerning the relation between the two systems and their roles in action, there is much common ground, and a composite dual-system picture can be constructed, based on features commonly ascribed to each system. This is summarised in Table 1.

5. Recent Work

Finally, this section highlights some trends in recent work on dual processes and systems. First, researchers continue to revise the theories themselves. In particular, there has been a recognition of the diversity of the processes within each system. It is widely accepted that System 1 is a rag-bag of processes and subsystems of varying character and evolutionary history, including associative learning, domain-specific modules, heuristics and automatised versions of processes that were consciously learned. Likewise, many researchers now accept that it is wrong to characterise System 2 reasoning as uniformly abstract, rule-based and logical. Explicit reasoning, they argue, may involve a variety of other techniques, including the application of heuristics, explicit associative thinking, manipulation of mental imagery and selective direction of attention (Buchtel and Norenzayan; Evans, 'How Many Dual-Process Theories Do We Need?'; Frankish, 'Systems and Levels'; Stanovich, 'Distinguishing the Reflective, Algorithmic, and Autonomous Minds'). Likewise, many writers now accept that System 2 may fail to deliver normatively correct results. In the updated version of his heuristic–analytic theory, Evans assigns cognitive biases as much to analytic reasoning as to heuristic processes ('The Heuristic-Analytic Theory of Reasoning'; *Hypothetical Thinking*). In a similar vein, Stanovich proposes that many cognitive failures arise from omissions or errors in the rules, procedures and strategies ('mindware') used by the analytic mind (System 2) (Stanovich, *What Intelligence Tests Miss*).

Partly in response to such developments, some researchers have redefined the distinction between the two systems in terms of a single core feature, demoting the others to the status of typical but non-essential ones. Stanovich focuses on the role of System 2 in

Table 1: Features commonly ascribed to the two systems

	System 1	System 2
Processes	Fast	Slow
	Automatic	Controlled
	Nonconscious or preconscious	Conscious
	Low effort, high capacity	High effort, low capacity
	Heuristic	Analytic
	Associative	Rule-based
Attitudes	Implicit	Explicit
	Cultural stereotypes	Personal beliefs
	Slow acquisition and change	Fast acquisition and change
	Fast access	Slow access
Content	Actual	Hypothetical
	Concrete	Abstract
	Contextualised	Decontextualised
	Domain-specific	Domain-general
Architecture	A set of systems, modular	A single system
	Parallel	Serial
	Does not use working memory	Uses working memory
Evolution	Evolutionarily old	Evolutionarily recent
	Shared with animals	Unique to humans
	Nonverbal	Language involving
	Serves genetic goals ('short leash' control)	Serves individual goals ('long-leash' control)
Variation	Independent of general intelligence	Linked to general intelligence
	Little variation across cultures and individuals	Variable across cultures and individuals
	Relatively unresponsive to verbal instruction	Responsive to verbal instruction

supporting hypothetical thinking and exerting high-level control of behaviour, whereas Frankish defines System 2 processes in terms of personal-level control (Stanovich, *ibid*.; Frankish, *ibid*.). Evans, meanwhile, recommends reverting to talk of processes rather than systems. The core distinction underlying dual–system approaches, he argues, is between type 1 processes, which do not require working memory, and type 2 (or analytic) processes, which manipulate explicit representations in working memory (Evans, 'How Many Dual-Process Theories Do We Need?').

Another trend involves making further distinctions within the existing frameworks. Evans makes a distinction among type 1 processes, distinguishing autonomous processes, which control behaviour directly, and preattentive processes, which supply content to working memory (*ibid*.). Thus, he argues, there are two different dual-process distinctions to be made: between autonomous and analytic processes, which work competitively and in parallel, and between preattentive and analytic processes, which work co-operatively and in sequence. Evans also introduces a third category of processes, type 3, which are responsible for initiating type 2 processing and for resolving conflicts between autonomous and analytic processes, and which have ultimate control of behaviour.

Stanovich also makes a new distinction, this time within System 2. He distinguishes the reflective mind and the algorithmic mind, corresponding to two levels of organisation ('Distinguishing the Reflective, Algorithmic, and Autonomous Minds'; *What Intelligence Tests Miss*). The reflective mind is the top level and consists of higher-level goals and 'thinking dispositions' such as openmindedness and willingness to engage in effortful thought, which regulate and shape our conscious reasoning. The algorithmic mind consists of the processing machinery that supports these reflective-level states. Support for this

distinction comes from studies of individual differences in reasoning. As noted earlier, performance on reasoning tasks correlates with general intelligence, but there is further variation in performance once general intelligence has been controlled for, and measures of thinking dispositions predict this. Stanovich argues that tests of general intelligence measure the processing efficiency of the algorithmic mind, whereas measures of thinking dispositions reflect individual differences in the reflective control of reasoning. (Thus Stanovich, unlike Epstein, sees differences in thinking style as differences in the use of System 2, rather than in the differential use of Systems 1 and 2.)

A third trend in recent research is the integration of dual–process ideas from different domains and the development of dual-system perspectives on topics such as cognitive development, rationality and cross-cultural psychology (for a selection of recent work, see Evans and Frankish). In particular, important work on development has been carried out by Paul Klaczynski, who argues that the two systems have different developmental paths, a view that challenges unidirectional theories of cognitive development (Klaczynski).

Finally, philosophers are becoming increasingly interested in applying dual–process ideas to traditional philosophical problems. In the philosophy of mind, it has been argued that a two–systems perspective can resolve certain tensions in folk psychology and explain forms of irrationality involving mental conflict and division, such as akrasia, self-deception and belief–behaviour dissociations (Frankish, *Mind and Supermind*; Frankish, 'Delusions: A Two-level Framework'; see also Dennett, *Brainstorms*; Cohen). Philosophers have also begun to apply dual-system theory in the area of moral psychology. For example, Leland Saunders has argued that a two-systems framework is needed to understand the relation between moral intuition and moral theory and their influence upon each other (Saunders). These are likely to be fertile areas for future research. If our judgments and actions can be generated by either of two mental systems, then many traditional philosophical questions will need to be recast to allow for this duality, with implications for debates about agency, autonomy, responsibility, rationality and knowledge, among other topics.

Philosophers have also begun to use dual–process ideas at a meta level, to provide psychological explanations for certain philosophical problems and paradoxes. For example, Jennifer Nagel has drawn on dual-system theory to explain the conflicting judgments that generate a paradox about knowledge (Nagel). On the one hand, we want to say that people have knowledge of everyday matters, such as where their car is parked. Yet, we are also inclined to deny that they know various hard-to-know propositions that are entailed by this putative knowledge, such as that their car has not just been stolen. Nagel argues that this conflict reflects the fact that judgments about everyday matters and about their hard-to-know entailments are typically made in different modes, automatic and controlled. Because controlled cognition is more reflective and systematic, she argues, we are less inclined to judge that people know propositions that they consider in that mode. Fiala and colleagues have used a similar approach to explain our sense that there is an explanatory gap between physicalist theories of mind and the facts of consciousness (Fiala, Arico and Nichols). They argue that ascriptions of conscious states may be made either by an intuitive 'low-road' (System 1) process that is sensitive to superficial features characteristic of agency, or by a reflective 'high-road' (System 2) process involving deliberate reasoning and drawing on a wide range of information. Physicalist theories of consciousness may satisfy the high-road system, but they will not trigger the low-road process, and it is the resulting dissonance, the authors claim, that generates our sense that such theories leave something out. The general strategy employed by Nagel and Fiala and colleagues has application to problems across the philosophical spectrum, and it will doubtless be exploited further in the years to come.

Acknowledgements

Short Biography

Keith Frankish works in the field of philosophical psychology, with a particular focus on mental architecture and the nature of belief. He is the author of *Mind and Supermind* (Cambridge University Press, 2004) and *Consciousness* (The Open University, 2005). He has published numerous research papers and book chapters, including articles in *Analysis*, *Mind*, *Philosophical Psychology* and *Philosophical Quarterly*. With Jonathan Evans, he planned and organised the first major interdisciplinary conference on dual processes, held in Cambridge in 2006, and he and Jonathan subsequently co-edited a collection of research papers originating from the event (*In Two Minds: Dual Processes and Beyond*; Oxford University Press, 2009). He is also co-editor of *The Cambridge Handbook of Artificial Intelligence* and *The Cambridge Handbook of Cognitive Science* (both forthcoming with Cambridge University Press; co-editor William Ramsey), and of *New Waves in Philosophy of Action* (forthcoming with Palgrave-Macmillan; co-editors Jesús Aguilar and Andrei Buckareff). Keith is a Senior Lecturer in Philosophy at The Open University, where he has been the Director of the Mind, Meaning, and Rationality Research Group, and he is also an Adjunct Professor with the Brain and Mind Programme at the University of Crete.

Notes

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[1] Note that personal beliefs here contrast with culturally transmitted stereotypes. Frankish also uses the term 'personal belief' in a dual-process context, though in a different sense ('Systems and Levels').

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