Chapter 1
Individual Differences in Cognition: in Search of a General Model of Behaviour Control

Philip J. Corr

Introduction

Individual differences in cognition are important for both theories of cognition and for theories of differential psychology. Furthermore, this topic is important for the unification and future development of psychology that runs the risk of fragmenting into a disparate number of loosely connected disciplines with no central theoretical core. The aim of this chapter is to provide an overview of some fundamental, but thorny, issues that need to be acknowledged and addressed before we can start to lay the firm foundations upon which to build the integration of the two great traditions of experimental/cognitive and differential psychology. Specifically, this chapter focuses on how to build a general model of behaviour control, which would provide the theoretical hub around which the particular issues revolve.

This chapter is in the form of a theoretical itch, which the presented material and discussion are intended to scratch. I have one overriding aim: to stimulate thinking about the relationship between systematic individual differences and cognition; however, I cannot claim a priori completeness or, even, correctness, so I will have to be content with receiving succour from Dennett's (1991, p. xi) dictum,

> …we often learn more from bold mistakes than from cautious equivocation.

Unification of Psychology

Before embarking on our journey, which will take many winding roads towards our final destination, we should first survey what is at stake, in terms of scientific theories as well as the future development of psychology as a coherent discipline. Forging closer links between cognitive processes and individual differences (principally, but not exclusively, personality and intelligence/abilities) would serve to achieve one of the major goals in psychology, *viz.* the unification of the differential and experimental/cognitive traditions (Corr, 2007). This problem is not new – indeed, it is now rather hackneyed – but it still remains important. It was famously articulated by Cronbach (1957, p. 671) in his APA Presidential Address,

This chapter is dedicated to the memory of Błażej Szymura

P.J. Corr (✉)
School of Social Work and Psychology, University of East Anglia, Norwich, NR4 7TJ, UK
e-mail: p.corr@uea.ac.uk

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> Psychology continues to this day to be limited by the dedication of its investigators to one or the other method of inquiry rather than to scientific psychology as a whole

Cronbach's call was echoed by Hans Eysenck (1965, p. 8) who wrote,

> Individuals do differ….and it seems to me that psychology will never advance very far without a recognition of the complexities which are produced by this fact of personality

Later Eysenck (1997, p. 1224) was to reiterate his call in his final published paper,

> It is suggested that the scientific status of psychology is put in danger by the lack of paradigms in many of its fields, and by the failure to achieve unification, psychology is breaking up into many different disciplines. One important cause was suggested by Lee Cronbach…: the continuing failure of the two scientific disciplines of psychology – the experimental and the correlational – to come together and mutually support each other

As discussed by Corr (2007), the work of Hans Eysenck provided a new way of thinking about individual differences. Rather than viewing them as yet more separate faculties of mind (located in a trait box, and rarely brought out in experimental/cognitive research), he conceived of them as reflecting fundamental brain–behavioural systems that have the following characteristics:

1. They show (systematic) variation in the population.
2. They have pervasive effects on cognition, emotion and behaviour.
3. They show stability over time.

Which brain–behavioural systems are implicated in important individual differences? Well, according to this formulation, *any* and *all* that show the above characteristics. Taking this line of argument, we can see that individual differences and behavioural/cognitive processes are reflections of the same thing – opposite sides of the same coin. Therefore, to understand fully the functioning of cognitive and behavioural processes, it is necessary to consider individual differences; and vice versa.

For those of us with interests in differential psychology, it would be tempting to blame this lack of progress on the failure of cognitive psychology to recognise the importance of differential variables and processes. However, this would be a mistake, for as noted by Revelle and Oehlberg (2008, p. 1390) in their review of personality research,

> The unfortunate conclusion from this brief review of publication practices is that the use of experimental techniques is uncommon in current research. This suggests that the desired unification of the correlational/observational with the experimental disciplines called for by Cronbach and Eysenck has not yet occurred

It is timely that the current volume does a volte-face in tackling this issue.

Defining Cognition

Attempts to integrate individual differences and cognition are fraught with problems (e.g. see McNaughton & Corr, 2008a; Matthews, 2008). For this reason, it may be useful to define what I mean, and do not mean, by "cognition" – this will also serve the purpose of avoiding "straw-man" arguments that generate more emotional heat than intellectual light.

Throughout this chapter, I assume that what is generally meant by "cognition" is the capacity to know and to have knowledge, and this rubric encompasses the structures and processes that support knowing/knowledge. Cognition entails many processes: sensory registration, perception, appraisal, decision making, memory, learning, concept formation, perceptual organisations, language, and many more. This knowledge and the process of "knowing" are embedded in structures, beliefs and operations (e.g. decision making) that, in a fundamental conceptual sense, exist independently of nervous activity (although, of course, they are instantiated in this activity). In principle, knowledge can change as a result of "information" and is not determined, or constrained, by the activity of cell assemblies. However, before we run away with the idea of "pure" knowledge, we should recognise two things: (a) specific neural systems in the brain are dedicated to organising and processing specific forms of information (e.g. visual and linguistic); and (b) evolutionary pressures may have shaped neural structures to bias the selection of information and the formation of knowledge (e.g. social knowledge in the form of cheating strategies, see Corr, 2006). Here, emotion seems particularly pertinent, biasing cognitive processing in specific ways that are consistent with the prevailing reinforcement properties of the source of information (see McNaughton & Corr, 2009).

With these caveats in mind, the theoretical arguments proposed in this chapter are framed within the standard definitions of cognition, some of which are given below.

According to Harnish (2002, p. 4),

> Construed narrowly, cognitive science is not an area but a *doctrine*, and the doctrine is basically that of the computational theory of mind (CTM) – the mind/brain is a type of computer

According to Matthews (2008):

> The key issue is the role of symbolic information-processing in human behavior. From the cognitive science standpoint (e.g., Pylyshyn, 1999) processing requires computations performed on discrete symbolic representations, so that, just as in a digital computer, we can distinguish the mental software from the (neural) hardware that supports it (p. 485)
>
> A particular challenge in this respect is the cognitive-psychological view that much of behavior is controlled by symbolic information-processing, rather than being direct by contingent upon activation level of neural systems (p. 484)
>
> Within cognitive science, symbolic, "cognitive" processes are very much different in principle from neural processes that use no symbolic representation. Cognitive science models, in addition to "hardware" and "software" levels, also differentiate a third type of explanation, referred to as the "knowledge" (Newall, 1982) or "semantic" level (Pylyshyn, 1999) (p. 486)
>
> Behavior may be explained by reference to the meanings that the person attributes to stimuli, in relation to personal goals (p. 486)
>
> Lack of conscious awareness does not imply subcortical and/or non-symbolic processing, and symbolic cognition is not obliged to be slow and deliberative (p. 489)

These beliefs are not endorsed by all cognitive scientists though. Jackendorff (1987, p. 35) states,

> In the brain, by contrast, there is far less clear-cut division between "software" and "hardware" change. If the reactivity of a synapse changes, is this a change in the "program" or "wiring"? If a neuron grows new connections, as happens at least during growth, is this a change in "program" as well as in "wiring"? And so forth. In addition, computational functions in the brain are affected by blood flow, hormonal action, and the like, which have no counterpart in computer function. Thus the brain undergoes a great deal of "hardware" change with corresponding effects on the mind. This means that ultimately it is less feasible to separate computational considerations entirely from their physical instantiation in the brain and might be expected from the computer analogy

The theoretical arguments presented below do not depend on any special form of knowledge structures/processes: I am content to proceed as if knowledge is hardware free and represented symbolically (elsewhere, I have argued that this assumption is open to challenge (McNaughton & Corr, 2008a), but for present purposes it shall suffice). To anticipant any subsequent confusion, I am explicitly *not* saying "cognition" is synonymous with conscious awareness, and nor am I assuming that cognition is always slow in operation.

Now, in terms of cybernetic control systems, these knowledge structures/processes must interface with behavioural control systems in some form in order to set the weights at critical points in the self-regulatory feedback system that choreographs behaviour. Somehow, and in some form, this is how symbolic-laden knowledge structure/processes *must* work; otherwise, they could never gain control of behavioural reactions, which we shall see below are orchestrated at a pre-conscious level.

Thus one major problem that *any* theory of cognition and behaviour must address is how knowledge level structures/processes (likened to computer "software") interface with biological structures/processes (likened to computer "hardware") of the neuroendocrine system.

Dual Process Models

The problem of how knowledge structures/processes ("software") interface (or fail to) with behaviour control systems ("hardware") is a real one, as evidenced by the plethora of dual-process models in the literature (for a review, see Carver, 2005). As noted by Toates (1998, 2006), standard psychology textbooks continue to contrast "learning theories" and "cognitive theories"; and this approach follows the long-fought territorial battles between stimulus-response (S-R) theorists (e.g. Skinner), who argued for automatic bonds between eliciting stimuli and responses, and cognitive theorists (e.g. Tolman), who argued for intervening variables between stimuli and responses entailing some form of knowledge structure/process.

The necessity of assuming (at least) two relatively autonomous systems further suggests that evolution had to negotiate conflicting demands; that is, how to achieve adaptive "fast and dirty" behavioural responses, especially in defensive reactions that require reflex-like reactions, as well as "slow and clean" behavioural responses that require deliberate and controlled cognitive processes (for example, as seen in reflective cognition).

Most dual-process models contain some combination of the following features.

1. *Reflexive*: fast, coarse-grained, automatic, ballistic (implicit/procedural learning), and pre/non-conscious.
2. *Reflective*: slow, fine-grained, deliberative, controlled (explicit/declarative learning), and often open to conscious awareness.

The variety of applications of dual process models is shown in the (non-exhaustive) list below.

1. Automatic vs. controlled processing: distinction between automatic processing (unconscious, fast inflexible, parallel, effortless) and controlled processing (conscious, slow, flexible, serial, effortful).
2. Implicit and explicit memory.
3. Procedural and declarative learning.
4. Top-down (concept) processing vs. bottom-up (data) processing.
5. Fast-dirty (subcortical) and slow-refined (cortical) fear processing.
6. "Action system" (dorsal stream) and "perception system" (ventral stream).
7. Neuropsychology (e.g. "blindsight" and "touchsight").
8. Emotion literature: Zajonc–Lazarus debate (emotion triggered by stimulus features of appraisal).
9. Personality: impulsivity vs. constraint.

In terms of specific theories, the following (again non-exhaustive) list illustrates their wide application. (It is perhaps too simplistic to present reflexive and reflective as separate processes, but they do seem to be sufficiently distinct, although maybe overlapping or on a continuum, for us to enquire as to how they interface.)

1. Epstein's (1973, 1994). Rational–experiential model posits that the rational system is mostly conscious, uses logical rules, is verbal and deliberative, and slow; in contrast, the experiential system is intuitive, associative, and uses "quick and dirty" automatic processes.
2. Hirsh (1974). S-R and cognitive systems (hippocampal lesions convert animal to S-R automaton; see below Gray's, 2004, BIS-hippocampal link with consciousness).
3. Toates (1998). "On-line" (fast S-R automatic responses) and "off-line" (slow reflective deliberate responses); extended by Toates (2006) to include emotion changing the weights of "on-line processes" (e.g. background valence on the on-line startle reflex).
4. Rothbart (from the 1980s onwards; see Rothbart & Bates, 2006). Positive and negative affective systems, and "*effortful control*", which is similar to *Constraint* in Tellegen's model. *Effortful control* is concerned with attentional management and inhibitory control – this is superordinate to the affective systems in that he can exercise executive control.

5. Carver (2005). Level of control in impulsivity and constraint.
6. Metcalfe and Mischel (1999). Model comes out of the "delay of gratification" literature, relating to impulsivity vs. restraint. The "hot" system is emotional, impulsive and reflexive; the "cool" system is strategic, flexible, slower and unemotional.
7. Eisenberg (2002). Extended Rothbart's model to the regulation of emotion.
8. Rolls (1999). The first system is based on implicit stimulus-reinforcement learning that accommodates reinforcement history, current motivational state and other factors influencing the reward value of the outcome. The second, explicit route to action is explicitly language based, supported by cortical language, motor and planning areas.
9. Lieberman, Gaunt, Gilbert, and Trope (2002). Attribution model has *reflexive* and *reflective* modes of working.
10. Evans (2003). Thinking and reasoning, referring to a range of biases in logical inferences.
11. Ortony, Norman, and Revelle (2005). Model of three levels of control: reactive, routine, reflective, each with affect (feelings), motivation (needs/wants), cognition (knowledge, thought and beliefs), and behaviour (action). The reactive and routine levels are comparable to on-line and fast, reflexive system, while the reflective level is comparable to slower and more deliberate forms of cognitive control.

Velmans (1991) reviewed a large experimental literature from which he concluded that all of the following processes are capable of being, and normally are, completed pre-consciously – that is before there is any conscious awareness of what has been carried out: (a) analysis of sensory input; (b) analysis of emotion content and input; (c) phonological and semantic analysis of heard speech; (d) phonological and semantic analysis of one's own spoken words and sentences; (e) learning; (f) formation of memories; (g) choice and preparation of voluntary acts. (For a detailed discussion of the implications of these findings for consciousness studies, see Velmans, 2000.) At the point of response *preparation and execution*, Velmans is surely correct in stating that processes are pre-conscious – this is now widely accepted amongst consciousness researchers, as shown by the consensus amongst discussants (which included Velmans) at a meeting of the *British Psychological Society* Consciousness and Experiential Psychology Section (London, 22nd November, 2008).

The Lateness of Conscious Experience

The conclusions reached by Velmans' analysis of pre-conscious processing is strengthened by work on the timing of conscious experience. The importance of this work is to show that conscious awareness comes too late causally speaking to influence the process it *re*presents – this is of importance because many of the variables of interest to the differential psychologist are represented in consciousness, but we still believe that they have, in some way, causal influence on behaviour.

Since the 1950s, Benjamin Libet (1985; for a summary, see Libet, 2004) has conducted a series of experiments, which show that it takes some 200–500 ms of brain activity for consciousness to be generated: this is the "lateness" of conscious experience. Libet has conducted a variety of experiments. In some experiments, the sensory cortex of awake patients was directly stimulated (Libet, 1982) – these patients were undergoing neurosurgery during which the surgeon stimulates parts of the cortex to localise functions. In one series of studies, the somatosensory cortex was stimulated with trains of pulses – such stimulation leads to the sensory perception (e.g. being touched). What was intriguing about these studies was the finding that there appeared to be a necessary period of "neuronal adequacy", that is, some 300–500 ms of stimulation is required before consciousness is experienced – any less stimulation than this figure does not lead to conscious awareness. This period of time would suggest that complex processes are engaged in the generation of consciousness; it may also indicate that a lesser length of time does not lead to conscious awareness because the eliciting stimulus was not sufficiently important.

A number of different types of experiments were conducted to test whether, indeed, conscious awareness lags 300–500 ms behind the initial sensory stimulation. In one such experiment, Libet stimulated the skin and, then, between 200 and 500 ms later stimulated the somatosensory cortex. If skin stimulation takes 500 ms to generate consciousness, then stimulating the cortex after 200 ms should abolish the conscious experience of the touch. This is what was found.

Such findings pose a problem for any adaptive theory of consciousness because long before 300–500 ms, motor actions have already been initiated (e.g. the removal of the hand from a hot stove occurs before awareness of the hand touching the stove). In this specific case, removal of the hand is involuntary and not controlled by conscious processes. However, a further twist of these findings is that events are not experienced as if they happened 300–500 ms ago: consciousness appears to refer to what is happening *now*. Libet suggests that the conscious experience of a stimulus is "referred back in time" once neuronal adequacy has been achieved to make it *seem* as if there was no delay – however, this intriguing finding is not central to the theoretical position advanced in this chapter.

Concerning the volition of will, in later experiments, Libet explored absolute timing using conscious intentions. Briefly, the typical experiment required participants to note the instant they experienced the wish to perform a "voluntary" action (e.g. simple flexion of finger) – that is, the instant they were consciously aware of this wish to act. To record this time, participants remembered the position of a revolving spot on a cathode ray oscilloscope, which swept the periphery of a face like the second hand of a clock (one sweep took 3 s). During this time, the "readiness potential" from the motor cortex was recorded by EEG. This procedure allowed Libet to calculate the precise moment at which the participant "decided" to make the movement. Libet then compared this moment with the timing of events in their brains. He found evidence that these "conscious decisions" lagged between 350 and 400 ms behind the onset of "readiness potentials" recorded from scalp electrodes – once again, the conscious wish comes a long time *after* the brain started to initiate the action, but subjectively it does not feel this way. There are criticisms of Libet's experiments as well as his interpretation of his data (e.g. Libet, 2003; Zhu, 2003; for an overview of this, and related consciousness, literature, see Blackmore, 2003), but the basic finding of the lateness of conscious awareness has withstood attempts at refutation.

What is important for us is the puzzling finding that conscious experience comes so late after the initial stimulation, and often long after brain–behavioural actions have been initiated. Thus, any theory of consciousness needs to take account of these findings. As noted by Gray (2004, p.23),

> The scandal of Libet's findings is that they show *the conscious awareness of volition to be illusory*

It would be a mistake to believe that these effects have only limited generalisability, or are oddities of the specific experimental methods employed by Libet's and others. As noted by Gray (2004), we can reduce these experimental effects to something simpler: it *must* be the case that brain events precede conscious events, including the conscious state of free-will. Such effects relate to *all* cognitions and behaviours that have a representation in conscious awareness. Now, for computational models of cognition that do not include an off-line conscious component, these findings are irrelevant; however, this possible theoretical salvage is accompanied by its own problem: such pre-conscious cognitive processes can be no different to brain–behavioural on-line processes.

In everyday life, we routinely experience these illusions of *conscious awareness of volition*. For example, braking hard to avoid hitting another car which we do (thankfully!) automatically; only hundreds of milliseconds later do we (re)experience the event in conscious awareness (we might be fooled sometimes into thinking we consciously "willed" the breaking action). A different example makes the same point more persuasively. When international tennis players are on the Centre Court at Wimbledon, they prepare their return of the ball in a completely non-conscious (i.e. on-line) fashion: the speed of the ball is simply too fast for their brains to have enough time to use conscious processing to prepare their return – certainly, their prior conscious experience of the subtle cues of their opponent's body position, etc., is important, but this conscious awareness is not directly involved in the fast, on-line behaviour needed in returning the ball. As we build the general model of behavioural control below, we might want to keep in mind this tennis player example.

The Direction of Causation

The work of Velmans, Libet and others point to a fundamental issue: we are consciously aware only *after* the brain–behavioural event – that is, on a millisecond-by-millisecond basis, the *re*presentation in conscious awareness of the behaviour to which it relates *must* lag behind the brain execution of the behaviour itself. In addition, only the *results* of the process are accessible to conscious awareness, not of how the behaviour was executed (the production of language is perhaps the most obvious example of this distinction). It is important to note that this realisation is not limited to only some mental events, but to all, even including conscious awareness, which must itself be preceded by necessary brain activation in consciousness-generating circuits.

Now, it is easy to confuse the causal processes – of which we have no direct access – with the *display* in conscious mind of their outputs. As discussed in detail below, this *re*presentation comes after the brain–behavioural processes that cause the behaviours and cognitions displayed. Yet, it is the contents of the *re*presented display that dominates our thinking – indeed, this statement runs the risk of being tautological because so much of our "thinking" is conscious. This begs the question of what are the causal cognitive processes, and how do these cognitive processes differ from more reflexive processes involved in behaviour.

A further moment's thought reveals that, at the point of preparation and excitation of a response, processing is not, and indeed cannot, be accessible to consciousness: that is, *at the very moment* of brain–behaviour execution, behaviour *must* be reflexive – and *not* influenced by simultaneous (conscious) cognitive activity, which itself only becomes accessible to consciousness hundreds of milliseconds after the brain–behavioural causal processes have happened. To deny this flow of causation requires slippage into a scientifically futile Cartesian position (see McNaughton and Corr, 2008a). We will see below that off-line conscious awareness can, and indeed does, exert an important regulatory control function on behaviour, *but not* on the behaviour it immediately *re*presents in the consciously experienced display medium.

I have already conceded that cognition can be automatic, fast, and fine; yet, much of what concerns personality psychology contains constructs that are amenable to conscious awareness; indeed, most cognitive tasks involve, at least some, conscious awareness of the task. Clearly, self-belief, metacognition, etc., are largely conscious. So the problem is: how do we relate reflexive and reflective processes? But note that this problem does not dissolve when we consider pre/non-conscious cognitive processes; here too, at the moment of the execution of cognitive routines, etc., everything is reflexive *even* highly sophisticated "cognitive" ones that have been previously "compiled" into brain-executable behavioural control routines.

Martians, Phantoms and Zombies

In this section, we see evidence of the fundamental construction of cognition of the external world and of our concept and experience of the "self", and the implications of this construction for individual differences and cognitive research. This material is presented in order to build the argument that there is a problem to be solved, namely, how reflexive (on-line) processes and reflective (off-line) processes interface in the control of behaviour.

Martians

If Martians were to land on Earth, fairly soon after they turned their attention to understanding human psychology, what would they have to say about the phenomenon of conscious awareness? I doubt that they would dismiss it as of no scientific importance – the behaviourist's stance – or of no causal significance – the epiphenomenalist's stance. They would surely be intrigued by it and would probably hold off final judgement until it was investigated fully. They should surely be interested in the following observations:

1. Human beings report *having* qualia (e.g. "redness" of the rose)[1];
2. Human beings report *being* conscious of outputs of cognition processes but not of the processes themselves;
3. Human beings behave *as if* conscious awareness is important to them, emphasising such constructs as:
   (a) Values
   (b) Beliefs
   (c) Meta-cognitions
   (d) "Self"
   (e) Volition

They may also consult personality psychology books and learn that many of the concepts that dominate the thinking of psychologists involve a high degree of conscious awareness. They would also be aware of Libet's work and may, quite naturally, wonder how cognitive consciousness relates to automatic (on-line) behavioural routines, which they know precedes conscious awareness.

Martians would, in all probability, conclude that there is a problem to be solved. A great help in the Martian's scientific quest would be the lack of philosophical baggage concerning venerable debates over the mind–body problem, which has been taken place historically within a religious or quasi-religious context. Being good scientists, they might look for a biological solution to the "problem of consciousness" – and that is where we too might look.

In the case of phantoms, we are here less concerned with ghostly apparitions than with the neurological variety. We often learn much from clinical neuropsychology, where we find bizarre cognitions and behaviours associated with specific neurological damage. Such conditions include: cortical colour blindness, unilateral neglect, alien hand, prosopagnosia ("face blindness"), blindsight, Capgras ("imposter") delusion, synesthesia (e.g. numbers elicit the experience of colours – it is perhaps no coincidence that the number and colour representations in the brain are next to one another, causing "cross-sparking"), and phantom limb pain. What many of these conditions show is that there are multiple levels of control, and that our representation and experience of the body and external world are not always veridical – indeed, sometimes, they may not even approximate the true reality.

Phantom Limb Sensations/Pain

Phantom limb pain is of special significance. It provides us with one of the best pieces of evidence for the hypothesis that our perception of the external world is, really, constructed between our ears, and is not "out there" in the naïve sense suggested by our perceptions. Even the intact body is a

[1]Qualia (singular is "quale") is a term used in philosophy to denote the subjective quality of mind, referring to the way things seem to us (from the Latin "what sort" or "what kind") in the form of properties of sensory experience such as sensations (e.g., pain) and percepts (e.g., colour).

phantom – it is still real, but our subjective representation of it is not determined by its physical properties.

V. Ramachandran (2003, p. 2) notes,

> Your conscious life, in short, is nothing but an elaborate post-hoc rationalisation of things you really do for other reasons

He goes on to say (Ramachandran, 2005, p. 58),

> *Your own body* is a phantom, one that your brain has temporarily constructed purely for convenience

Although the essential construction of conscious experience is not new, its implications are widely ignored in empirical research; for this reason, it may be useful to consider another example in the form of visual illusions.

Illusory Visual Illusions

We shall see soon how such phantoms of the mind are not found only in the neurological clinic but are part-and-parcel of the normal brain–mind. In particular, we shall see that much of our conscious experience is *illusory* – by which I mean is it not what it seems. If you look at Fig. 1.1, you will probably be able to discern the edges of an *apparent* triangle; but no edges exist in terms of differences in the electromagnetic energy reflected off the page. A perhaps more remarkable demonstration of the construction of perception can be seen in Fig. 1.2. Most people (although not all) report some of wheels moving in their peripheral vision, which on a piece of paper they clearly cannot – as this example demonstrates, "seeing may be believing", but it is a false belief!

What is interesting about visual illusions is not that they show how our visual system (there are also similar auditory, olfactory and haptic examples) can be "tricked" by ambiguous stimuli, or how our system has design flaws. Instead, illusions give us some of the most obvious and direct evidence of something much more theoretically compelling: *all* of our experience is *constructed* in the brain. The crucial point here is not so much that experience is constructed in the brain – after all, this "constructivist" position is neither new nor widely challenged – but the implications of this view for understanding how different levels of behavioural control interact. In the arena of personality psychology, this point is nowhere more important than in the construction of the "self".

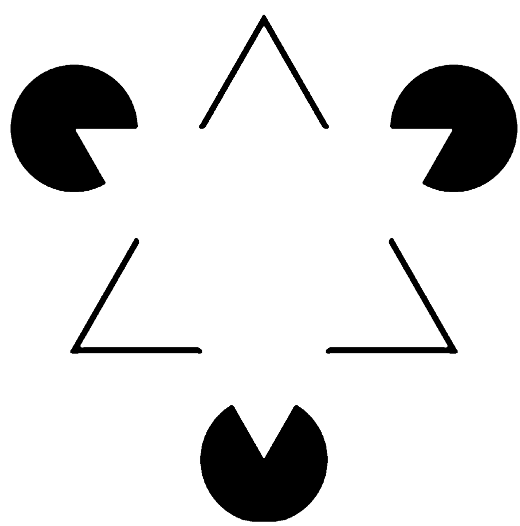

Fig. 1.1 The Kanizsa triangle showing illusory contours where contours are perceived without a luminance or colour change across the contour

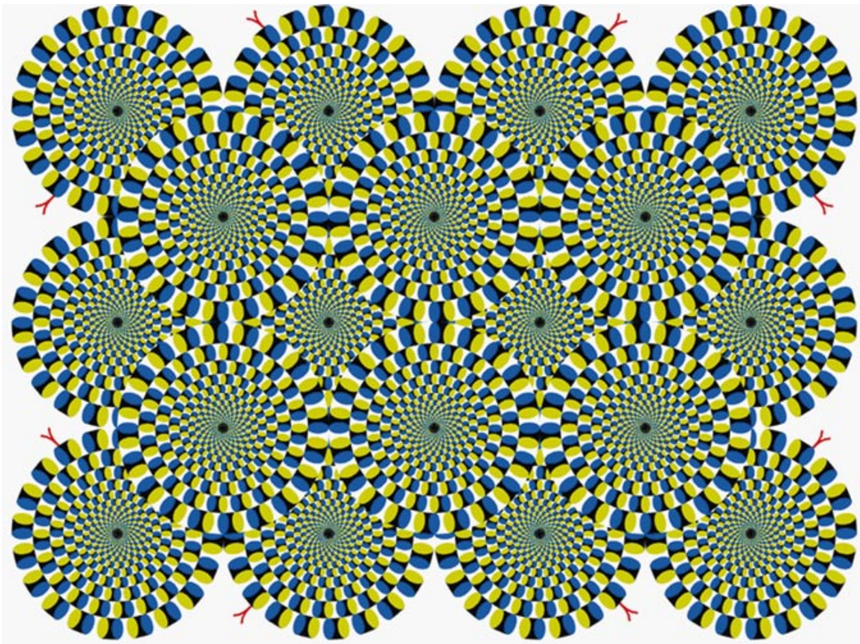

Fig. 1.2 The peripheral drift illusion. Movement is experienced on the periphery, although the *circles* are not moving at all (and they cannot on a magic-free plain sheet of paper). Focusing on one particular part of the display shows that it is stationary; yet, the parts in peripheral vision seem to be moving, until focus is shifted to them. This phenomenon was discovered by Akiyoshi Kitaoka and Hiroshi Ashida, of Department of Psychology, Ritsumeikan University, Kyoto, Japan

The perception of apparent colour in the world is perhaps the best example of this fact: objects in the external world are not coloured, but they do reflect "light" energy from a very narrow part of the electromagnetic spectrum, which gets transduced into electrochemical nerve impulses, which then, somehow, lead to the subjective experience of the qualia of colour. Neurological damage shows that these qualia can be selectively lesioned by, for example, accidental poisoning – then the world may be black and white. It is also possible that other animals may "hear" the energy that we "see" as colours – Richard Dawkins hypothesises that this might be how bats "see" in the dark. Certainly, other animals are sensitive to a far wider range of the electromagnetic spectrum than us, and thereby experience a much richer perceptual world. The problem of constructing conscious awareness (e.g. "redness") from raw physical data (e.g. the patterns of electromagnetic energy reflected off an apple) is a major one for evolution to solve; however, as argued by Gray (2004), the close alignment of the *physical* world and our *psychological* construction of it ("physical–psychological correspondence"; Corr, 2006) provides perhaps the best argument for a natural selection pressure on the evolution of consciousness – if this were not the case, then indifferent "genetic drift" would lead to each of us having our own unique idiosyncratic perceptual experiences, including distance and speed perception, which would have immediate consequences for our survival (whether on the African Savannah or the busy highway).

Zombies

The concept of the zombie is a thought-device used by philosophers to allow for the possibility that there may exist people who look, sound and behave like you and I, but who are completely unconscious – that is, they have no subjective experience of the external world and nor of themselves within that world (they would resemble, in psychological terms, current-day "mindless" robots).[2] Our ignorance of consciousness is so great we do not even know whether zombies could, or indeed do, exist.

But hold on for one moment. As a matter of empirical fact, we know that they do exist, at least to some extent: all of us are part-zombie. Much of our behaviour is controlled by nonconscious processes of which we remain blissfully unaware (e.g. speech production, and the "action" visual system that is intact in consciously blind "blindsight" patients; see Weiskrantz, 1986). I am part-zombie in writing these words, and you are part-zombie in reading them: I know what I want to say to you in this chapter (I have rehearsed this in my conscious mind), but I do not have the faintest idea as to how this writing is being generated as I tap the letters on the keyboard (syntax of sentences, semantics, etc.), and even if I engaged in conscious processing, I would probably not be too much the wiser; and you do not have much idea of the brain–cognitive processes required to read and understand these words, and nor do you have to have much, or any, idea because your reflexive system is in control of the cognition/behaviour needed to read understand what I have written (they are then *re*presented in your conscious mind for reflection, analysis, criticism and judgement).

Neurological and normal zombie examples provide clear evidence of the multiple levels of behavioural control that exist, as well as showing that much of our behaviour does not even involve consciousness ("zombie processing"); but, importantly, of those behaviours that do find representation in conscious awareness, their *preparation* and *execution* is no less zombie-like.

The Problem to Be Solved

We are now in a position to state the problem to be addressed in the remainder of this chapter. If we are conscious only of the *products* of cognitive processes, and these are *re*presented *after* their causal influence, then how do off-line *reflective* processes exert any influence (if they do) on on-line *reflexive* processes? This question is central to the understanding of individual differences in cognition.

For example, we may assume that individual differences exist in the extent to which information is taken off-line for further (reflective) processing. As discussed below, individual differences in a behavioural inhibition system (BIS), which detects conflict between stimuli or between responses, should be expected to be closely coupled with the content of conscious awareness (e.g. threat-dominated rumination of anxious patients). Furthermore, the BIS-related contents of consciousness should be expected to influence the amount and quality of cognitive processing, for example, cognitive efficiency and semantic priming. As much of individual differences concepts are found at the off-line level (e.g. verbally expressed self-concepts), the generation of conscious awareness, from individual differences in on-line systems (e.g. the BIS), is clearly important. Later in this chapter, we will see further examples of the importance of this problem for understanding individual differences in on-line and off-line processes.

Once again, for the purpose of this argument, it does not matter whether cognition is fully conscious or not: either it is completely an on-line reflexive process – comprising "pre-compiled" automated brain–behavioural routines – or it has off-line reflective (although not necessarily conscious) qualities. The problem resides in the latter case.

[2]However, the zombie may think and feel that they *are* conscious: this raises the interesting possibility of what *we* non-zombies think and feel as consciousness is nothing really of the sort, but a grand illusion of the brain (for further discussion, see Corr, 2006). This possibility need not detract us from the use of the term zombie here: clearly, some of our behaviours can be shown experimentally to be zombie-like, and these stand apart from those behaviours to which we assign conscious awareness.

Recall the important conclusion reached above. At the point of execution, *all* brain–behavioural processes are controlled by the reflexive system. We can *never* be aware of the process of execution (including, of course, the execution of processes that lead to conscious awareness). Brain (reflexive) events *must* precede mind (reflective) events, *always*.

Is There Really a Problem to Be Addressed?

You may well be starting to wonder whether there is a problem at all and that, to the extent that there is one, it is more apparent than real. Presenting the contents of this chapter at various gatherings of academic psychologists has convinced me that the issues raised are not easily appreciated – indeed, they are typically not even acknowledged. Among many psychologists – and certainly amongst the vast majority of the general population who hold explicitly Cartesian views of the mind–body relationship – there is still the sense that consciousness, especially free-will expressed in consciousness, is in charge of the behaviour to which it immediately relates. Naively, we think: "I'm thirsty, so I shall go to get water". The causal chain runs in order of: recognition of some bodily state ("thirsty"), free-will to address state ("I"), and behaviour to achieve this end-goal ("get water"). This is how the causal chain of events *appears* to us. To argue against this perceived chain of events is deeply upsetting to the naïve observer, and equally discommoding to the many psychologists who still, albeit tacitly, adopt a Cartesian view of the mind–body, or at least believe that such argument is simply irrelevant to the day-to-day business of differential or cognitive psychology.

Other researchers have noted a similar reluctance to accept the causal priority of pre-conscious events. For example, in relation to action (dorsal stream) and perception (ventral stream) visual systems, Goodale and Milner (2006, p. 663) note,

> The most difficult aspect of our ideas for many people to accept has been the notion that what we are consciously seeing is not what is in direct control of our visually guided actions. The idea seems to fly in the face of common sense. After all our actions are themselves (usually) voluntary, apparently under the direct control of the will; and the will seems intuitively to be governed by what we consciously experience. So when we claimed that a visual illusion of object size (the Ebbinghaus illusion) did not deceive the hand when people reached out to pick up objects that appeared to be larger or smaller that they really were, vision scientists around the world embarked on a series of experiments to prove that this could not possibly be true

This is not surprising at all. We all find it difficult to abandon beliefs about the world when our beliefs seem to be based on "fact" – "I look at the world and I see that it is coloured!" We also have to contend with the realisation that our beliefs, etc., are, themselves, the product of off-line processes and, as such, do not provide a veridical reflection of the external (or internal) world. Although not of central concern to this chapter, the finding of Libet that conscious experience is back-dated to the brain initiation of cognition/behaviour further strengthens the illusion that our experience is very real in a naïve causal sense.

The Function of Consciousness and Its Role in Cognition

In this section, I sketch a model of the functions of conscious awareness, and then in later sections show how this model can be put to use in explaining the role of individual differences in behaviour and cognition.

To start with, it is somewhat surprising that the nature of consciousness is all too rarely discussed alongside individual differences research. However, this is not unique to the field of individual differences as the problems of consciousness, especially those that seem so scientifically intractable, have, at least until the recent past, been largely ignored by psychology in general – until not too recently, even considering this subject was seen as sign of some kind of (never stated) epistemological flaw in one's thought processes. We are, therefore, fortunate that Jeffrey Gray's (2004) last book, *Consciousness: Creeping up on the Hard Problem*, addressed the problems of consciousness. His work is important for psychology in general – especially the problem of the relationship between systems controlling behaviour and conscious awareness – as well as for understanding individual differences in cognition.

First, Gray does not offer an account of the "Hard Problem" (Chalmers, 1995), which is, the *why* and *how* of conscious experience, especially how the brain *generates* conscious awareness. He instead addresses the *function* of consciousness: what is it *for* and *how* it is implemented?

The data of Libet, summarised above, shows that conscious awareness of emotion, volition, behaviour, etc., does not play any direct (i.e. immediately proximal) role in the brain–behavioural routines *to which they refer* – but we shall shortly see it does exert causal (distal) effects on *subsequent* behaviour.

Gray's (2004) model of consciousness posits three linked functions.

1. It contains a model of the relatively enduring features of the external world; and the model is experienced as though it *is* the external world;
2. Within the framework afforded by this model, features that are particularly relevant to ongoing motor programmes or which depart from expectation are monitored and emphasised;
3. Within the framework of the model, the controlled variables and set-points of the brain's unconscious servomechanisms can be juxtaposed, combined and modified; in this way, error can be corrected.

To understand these functions, imagine you are confronted by a dangerous snake and your fear system fires-off an automated (on-line) brain–behavioural routine (e.g. simple fleeing reaction): all this happens long (i.e. hundreds of milliseconds) before you are consciously aware of (i.e. "see" and "feel") the snake. (Charles Darwin made the point that he could not stop himself flinching from an attacking snake even though it was safely behind glass in a zoo.) It would now be highly adaptive to "replay" the immediate past in order to analyse its contents, especially at those times when the on-line fear behaviour did not achieve its goal (e.g. avoiding the snake in the first place).

Central to Gray's model of conscious awareness is a "comparator", which serves to compare actual stimuli with expected stimuli – these latter stimuli are based on "plans", and related expectations, of the future state of the world (Gray, 1982). When there is no discrepancy, and "all is going to plan", the comparator is said to be in "just checking mode"; however, when there is a mismatch between the expected and actual states of the world, then the comparator goes into "control mode". According to Gray, in this control mode, the *contents* of consciousness are generated.

This general approach is compatible with other models of consciousness, for example, Baars' (1997) theory of global workspace. Within the terms of off-line simulation of the world, working memory is important as it has the putative function of disseminating information to various modules throughout the brain – indeed, the latter is necessary in order for off-line processing to affect on-line reactions. Upon the workspace "backboard" of Baars' model, error-prone information, which has been taken off-line, is written and subjected to further processing. According to Baars, consciousness is similar to a bright spot on the theatre stage of Working Memory (WM), directed by a spotlight of attention under executive guidance (Baddeley, 1986). Continuing with this metaphor, the rest of the theatre is dark and unconscious. Gray's theory proposes *why* information is subjected to the spot-light of working memory and cognitive processing that often leads to conscious experience.

It is interesting to note that Jackendorff (1987, p. 327), when discussing language, noted,

> One possible answer to these questions [i.e., the apparent pointlessness of consciousness] is that the Privileged Representations serve as a kind of "early warning system" for comprehension: it might be crucial to have introspection processors in order to compare what is detected with what is understood, so that attention can be directed to the problematic portions of the field

Jackendorff (1987) provides an elegant explanation for the existence of conscious awareness, at least the qualia aspect of it. His "intermediate level theory" argues that the brain–mind has a fundamental problem to solve: how to organise incoming raw, physical information into cognitively meaningful categories. He contends that it is at the juncture of this data-concept boundary that qualia are generated. In this sense, there is a continuous "error" signal being generated at this boundary. One, possibly counter-intuitive, corollary of this argument is that with closer matches between data and concepts, the less conscious awareness would be generated. Although, this prediction may seem a tad fanciful, it corresponds with much of every-day life, as well as the training/learning literature: early stages of skill acquisition require slow, controlled and deliberate processes that are prone to many errors, but with practise comes fast, automated and attentionally effortless processes that are, largely, error-free (remind yourself of the cognitive effort required to learn to drive a car and how once easier it become with extended practise, which no longer involved the necessity of conscious awareness to change gears, steer, etc).

Reinforcement Sensitivity Theory

Before developing the argument for how off-line reflective processes interface with on-line reflexive processes, it would first be useful to define the two defensive systems and the one approach system that defines reinforcement sensitivity theory (RST) (Gray & McNaughton, 2000; McNaughton & Corr, 2004, 2008b), which, in the rest of this chapter, will be used to illustrate the role played by on-line processes.[3]

1. The *Fight–Flight–Freeze System* (FFFS) mediates reactions to aversive stimuli of all kinds, conditioned *and* unconditioned. It is insubstantiated by a hierarchical array of neural modules, responsible for avoidance and escape behaviours. The FFFS is associated with the emotion of fear and the associated personality trait factor of fear-proneness and avoidance, which is clinically mapped onto such disorders as phobia and panic.
2. The *Behavioural Inhibition System* (BIS) mediates the resolution of *goal conflict* in general (e.g. between BAS-approach and FFFS-avoidance), and is insubstantiated by a hierarchical array of neural modules, responsible for the inhibition of pre-potent conflicting behaviours, the engagement of risk assessment processes, and the scanning of memory and the environment to help resolve concurrent goal conflict. The BIS is associated with the emotion of anxiety and the associated personality trait factor of anxiety proneness, which maps clinically onto the classic anxiety disorders.
3. The *Behavioural Approach System* (BAS) mediates reactions to *all* appetitive stimuli, conditioned and unconditioned. This is the system that generates the emotion of "anticipatory pleasure", and hope. The associated personality comprises optimism, reward-orientation and impulsiveness, which clinically maps onto various varieties of high-risk, impulsive behaviour.

"Late Error Detector" and the Inhibition of Pre-potent Behaviour

The BIS detection of error in the cognitive/motor program, and the generation of an error-signal, leads to the interruption of automatic brain–behaviour routines ("reflexes"). The salient features of this error-triggering environment are then *re*presented (in fact, constructed in a display medium that we

[3] The systems of RST are not exclusively "on-line" (reflexive) as they have representations at all levels of the behavioural hierarchy. However, they embody many on-line features, especially at the lower and more primitive levels of defensive reactions.

experience in the form of conscious awareness) and subjected to careful analysis. This mechanism solves one major evolutionary problem: how to ensure that on-line automatic responses are appropriately activated – recall above, that all behaviours, *at the point of neural execution*, are on-line and reflexive. Off-line control is invoked only at critical junctures, when a definite choice has to be made, and where the continuation of automatic, on-line behavioural routines would be inappropriate (e.g. continuing to forage in a field populated by predators). (This process is similar to Libet's idea of "free won't"; that is, the interruption of already-initiated on-line program.) In terms of Gray's notion of the BIS (Gray & McNaughton, 2000; for a summary, see Corr, 2008), this off-line display medium is highly adaptive – but, as seen in clinical conditions, it can also be maladaptive. At these critical junctures, and after analysis of the display medium, cybernetic adjustments can then be made to the on-line system, such that when the same (or similar) stimulus (e.g. snake) is encountered in the future the reflexive behaviour would be more appropriate. By this mechanism, conscious awareness exerts a causal influence, but on *future* on-line behaviours ("future" in this context can be within seconds). By this mechanism, the fine bodily adjustments required by high-ranking professional tennis players are achieved (see above).

The BIS achieves this function by recursively increasing the negative valence of the goals – held in memory stores and cortical processing centres – creating the conflict, via activation of the FFFS, until resolution is achieved either in favour of FFFS avoidance/escape of, or BAS approach to, the stimuli. For this reason, BIS activation is associated with worry, rumination and the engagement of working memory resources, the contents of which are accessible to, and often come to dominate, conscious awareness.

Defensive Systems of Behaviour

We can further illustrate the problem faced by evolution in relation to defensive systems of behaviour. According to Gray and McNaughton (2000; McNaughton & Corr, 2008b), avoidance and escape behaviours are arranged according to a hierarchical system of defence, distributed across brain systems that mediate specific defensive behaviours associated with level of threat experienced, ranging from the pre-frontal cortex, at the highest level, to the periaqueductal grey, at the lowest level (see Fig. 1.3). It is a reasonable guess that the evolution of these separate systems, which in combination comprise the whole defensive system, evolved by a "rules of thumb" (ROT) approach (McNaughton & Corr, 2009), according to which separate emotions (e.g. fear, panic, etc.) may be seen as reflecting the evolution of specific neural modules to deal with specific environmental demands (e.g. flee in the face of a predator) and, as these separate systems evolved and started to work together, some form of regulatory process (e.g. when one module is active, others are inactivated) evolved. The resulting hierarchical nature of the defence system reflects the fact that simpler systems must have evolved before more complex ones, which provides a solution to the problem of conflicting action systems: the later systems evolved to have inhibitory control on lower-level systems. The inhibitory functions of consciousness seem well placed to serve this purpose.

Now, one important consequence of modifying behavioural weights attached to on-line processes is to inhibit inappropriate pre-potent responses. Automatic routines are well suited to predictable stimuli, but they are not so good for tasks requiring a departure from fixed routines (e.g. a novel task) or when automatic performance is not going to plan, which would be the case in most complex environments. The higher level (off-line) systems in the hierarchical arrangement are charged with controlling behaviours appropriate to these complex and unpredictable environments; while behaviours in more simpler and predictable environments are controlled by lower level (on-line) systems that fire-off species-specific reactions. For this reason, the higher level systems entail complex cognition, entailing modelling, planning, etc. We see this operation in Obsessional-Compulsive

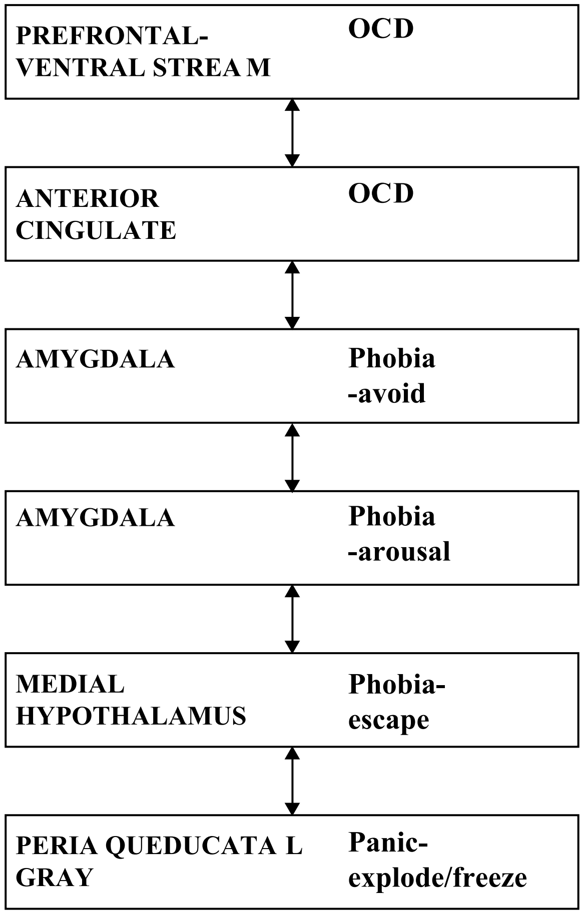

Fig. 1.3 The Fight–Flight–Freeze System (FFFS) comprises a hierarchical array of neural models, each relating to specific cytoarchitectonic complexity, functional level, and emotion. Complexity and sophistication increases up the hierarchy, and each module has the capacity to inhibit the action of modules below it (Modified from McNaughton and Corr, 2008b)

Disorder (OCD) where pathological worry consumes working memory and attentional resources and pervade conscious awareness. As the case of defensive systems show, much of cognitive processing must involve inhibitory functions, and the "late error detection mechanism", activated when things are not going to plan, serves this function.

Jacoby Exclusion Task

An experimental demonstration of the power of conscious awareness to inhibit pre-potent (automatic) responses is seen in the "Jacoby exclusion task" (Debner & Jacoby, 1994). In this task, words are presented either too fast for conscious recognition (i.e. 50 ms) or slow enough for recognition (i.e. 150 ms); backward masking is used to ensure these precise presentation times. In this experimental paradigm, participants are presented with the prime-word, for example:

H O U S E

They are given a stem-completion task, for example:

H O U _ _

A possible stem completion is to add S and E to form "HOUSE".

Now, the crucial manipulation in this task is the instruction to participants *not* to complete the word-stem with a prime-word. In the above example, you might complete it with the N and D to form "HOUND".

This task is trivially easy for most people, but *only* when the word is presented above the threshold of awareness (at 150 ms). What happens when the prime-word is presented *below* the threshold of consciousness? In this case, there is an inability to follow the instruction not to complete the word-stem with the presented prime-word. In fact, what happens is that the word-stem is completed *more often* with the covertly presented prime-word, HOUSE rather HOUND (or some other word completion). It, thus, seems that the default reaction to a word-prime presented covertly is to prime the word-stem, and that the generation of conscious awareness is needed to prevent this automatic priming effect – the fact that the conscious mind can prevent this priming effect demonstrates its power to inhibit pre-potent automatic reactions (in this example, a priming effect; other empirical data on this effect are discussed below).

This result points to something important about conscious awareness: *somehow*, the generation of conscious processing (in this example, by supra-threshold prime-word presentation) enables the inhibition of pre-potent (automatic) responses. This is a fundamental role for consciousness: in unfamiliar or unpredictable environments, being *unable* to stop the running of automatic (on-line) routines would be a severe disadvantage – instead of being the successful predator with a hearty meal as a result, one might be the meal of a predator.

A Model of Behavioural Control

We have now reached the stage of sketching a general model of behavioural control, sufficient to explicate the role of individual differences in cognition. As we saw above, defensive systems of FFFS and BIS may be differentiated, to some extent, in terms of on-line and off-line processes, respectively – although, as noted, there are gradations of off-line processing at higher levels of the FFFS defensive hierarchy (see Fig. 1.3) – this distinction accords with Rothbart's negative affective system (~FFFS) and effortful control (~BIS) (see above).

In a review of the literature, Toates (1998) draws attention to the fact that both on-line (S-R) and off-line (cognitive) processes are observed in human and non-human animals, and that consideration of these reflexive and reflective systems, respectively, help us to better understand normal and abnormal behaviour in general, and consciousness in particular. To these two applications, we can now add individual differences in cognition.

Toates' (1998) model comprises the following elements. A stimulus has a given strength of tendency to produce a response; that is, a stimulus has a response-eliciting potential, which varies from zero to some maximum value (this strength depends upon innate factors and learning). "Cognition" in this context refers to those processes that encode knowledge about the world in a form not tied to particular behaviours (but, as shown below, they influence such behaviours). Where there is uncertainty, novelty or a mismatch of actual against expected outcomes, behavioural control shifts from the on-line processing to off-line processing.

This model contends that some actions that can be organised at the reflexive on-line level (e.g. fleeing from a predator) can nonetheless be affected by reflective off-line processes. For example, a fear state that is experienced consciously has the capacity to sensitise the whole defensive system and, thereby, affect *subsequent* fast, automatic responses. Thus, Toates' model emphasises the cybernetic weights attached to motor programs, off-line processes modify the weights of on-line responses.

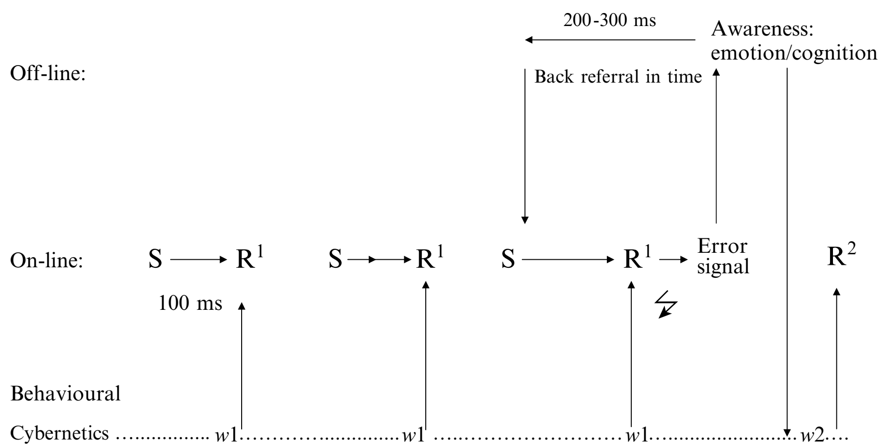

Fig. 1.4 Late error detection model of the function of consciousness. Off-line (reflective) processes monitor the success of on-line (reflexive) processes, and when "everything is going to plan", on-line processes are not interrupted. When an error signal (⚡) is detected (i.e. mismatch between *expected* and *actual* state of the world), the salient stimuli features of internal (e.g. memory) and external (both perceptual in terms of imagery, etc.; and affective, in terms of emotion) worlds are taken off-line, represented and displayed in a medium that is experienced as conscious awareness, where they are subject to fine-grained analysis – all of this can happen within hundreds of milliseconds. Although off-line conscious experience lags behind on-line processes, crucially, off-line processing can alter the cybernetic weights (e.g. *w*2) of on-line processes and, thereby exert a causal influence on *subsequent* on-line processes (R^2) when the same (or similar) stimuli/worlds are encountered. Subjectively, this process is seamless, and importantly, the lag in causal effect is obscured by "back referral in time", which provides the illusion that the experience is occurring at the same moment as the stimuli that it represents

The relevance of on-line and off-line systems can now be seen. According to this model, on-line (nonconscious) processes are modified by off-line (conscious) processes; in Toates' terminology, the weights attached to response propensities in on-line processes are adjusted on the basis of the fine-grained off-line processes. Gray (2004) also uses the terminology of cybernetics with behavioural weights attached to specific stimuli (see Corr, 2006).

Off-line processes have a causal effect on *subsequent* on-line processes; in other words, our behaviour is modified by experience: we *learn*. (Before our discussion slides blindly into a dualistic mode of thinking, it needs to be emphasised that both on-line and off-line processes are products of the brain, and that off-line processes are also prepared and executed non-consciously; however, the two levels of processing have different functions) Specifically, they differ: (a) in their temporal characteristics; (b) their level of analysis; and (c) their representation in conscious awareness (see Fig. 1.4). Thus, on-line behaviour, which *always* comes before the generation of conscious awareness, can be modified by off-line processing that brings to the fore salient features (e.g. novelty and mismatch) that attracts attention and is subject to further analysis, the outcome of which is changed cybernetic weights of the on-line system.

What-If Simulations

Consistent with the general form of Gray's (2004) model is the additional idea that consciousness allows "what-if" simulations of future behaviour, produced off-line in a virtual reality environment (e.g. imagination) that represents the important features of the real physical environment. Indeed, this function seems highly important to human beings: much of our time is spent *imagining* the likely consequences of our behaviour and making plans for the future. Such behaviours require complex computational processes, specifically involving inferences concerning the likely behaviour of other people, based on a "theory of mind". It is obvious that personality in particular relates to such simulations, and, it may be speculated that much of the "energy" for neurotic disorders comes from these off-line cognitive processes. In this regard, it is probable that variance in neuroticism will require an explanation to incorporate longer-term, off-line cognitive processes that decouple these processes from actual stimuli: thus, we can have "free-floating" anxiety and "worry about worry" – but once again, they can exert their effects only by influencing on-line processing routines.

Emotions present a special problem, because they are generated after the behaviour that is designed to deal with the emotion-provoking stimulus has been initiated – they come too late to affect the *immediate* on-line processes to which they refer (e.g. subjective sensation of pain after you have withdrawn your hand from the hot stove). This very fact might give a clue to their function, namely, hedonically to bathe off-line *re*presentations so as to simulate their significance in terms of their real world importance (e.g. the fear of a snake, the worry of the job interview, the jealousy of a sexual partner) – the distinction between motivation and emotion, which is relevant to this debate is discussed in detail elsewhere (McNaughton & Corr, 2009). According to this theoretical position, the experience of what we term "emotion" does not affect immediate on-line brain–behavioural processes to which it refers, but it can alter the cybernetic weights of on-line processes and, thereby, affect subsequent behaviour. In passing, it may be noted that this general theoretical position goes a long way to dissolving the differences between the James–Lange (behaviour → emotion) and cognitive appraisal (cognition → emotion → behaviour) positions concerning the causal role of emotion: both positions may be seen to be correct, but they operate differentially at on-line (reflexive) and off-line (reflective) processes.

Implications of Reflexive and Reflective Processes for Individual Differences in Cognition

We are now in a position to summarise the main points of the discussion.

1. Many of the variables falling under the rubric of "cognition" (especially those available to conscious awareness and involving concepts of the self) come too late in the causal chain of events to affect the behaviour they *re*present.
2. Cognition need not involve conscious awareness, but then this form of "cognition" (e.g. priming) does not differ in fundamental respects from "on-line" reflexive behaviour (it may still be relatively complex, e.g. language comprehension) – in this way, pre/non-conscious cognition does not pose a problem for the model presented here of individual differences in cognition (but it must be stripped of any "late" concepts involving consciousness).
3. In relation to point 2, we may ask:
   (a) To what extent are beliefs, values, intentions, etc. on-line and to the extent that they are off-line.
   (b) If such beliefs, values and intentions are, indeed, on-line and reflexive, then how can they differ, in fundamental terms, from on-line reflexive "biological" processes (e.g. basic defensive reactions, as discussed above?). At this point of synthesis, "biological" and "cognitive" levels collapse to a single on-line process; and as such, our only problem remains to show how *conscious* cognition (off-line) relates to on-line processes.
4. *All* behaviour, at the moment of preparation and execution, is the result of on-line reflexive processes, but *future instances* of these behaviours may be modified by off-line reflective (cognitive conscious) processes by changes in on-line cybernetic weights.
5. According to this model, reflexive and reflective processes serve very different functions, are compatible, and need to be integrated into a unified general theory of behavioural control.

Some Implications

Some interesting conclusions, with practical applications, flow from a serious consideration of the separate and joint roles of reflexive and reflective processes.

First, we could have all the "will" (i.e. conscious desire) in the world to behave in a certain way (e.g. dieting), but this "will" can only translate into actual behaviour if it interfaces with on-line systems that are responsible for priming effects of by hunger, desire, etc.

Secondly, in the case of emotional engagement and expression, we may see a dysfunction of regulation in mood disorders, where on-line defensive reactions are difficult to stop or inhibit (e.g. violent rage) – drugs may directly inhibit these on-line processes, but off-line talk therapy (e.g. cognitive–behavioural therapy, which usually has an on-line behaviour component) would have the power to modify the cybernetic weights of the on-line system. This process distinction is consistent with the commonly found gap between counter-productive behaviour and the conscious desire not to engage in such behaviour.

Thirdly, there may be an insufficient lack of representation in off-line processes, leading to hard-to-stop counter-productive behaviour. For example, smoking may be difficult to stop because there is more representation in on-line processes than off-line ones; and the same would be true for most forms of drug dependence.

Fourthly, in psychiatry, we often witness the breakdown in the normal regulation of on-line and off-line systems, with material prematurely entering off-line consciousness where it may be experienced (i.e. qualia are produced) as delusions and hallucinations, as seen in the case of schizophrenia. This example points to the aberrations seen when on-line material, inappropriately, is taken off line for conscious processing. We also see this aberrant process in the many varieties of neurotic disorder.

Empirical Evidence

There has been a paucity of evidence directly addressing individual differences in how on-line and off-line processes interface. One intriguing finding, from the clinical literature, was reported by Jermann, Van der Linden, Adam, Ceschi, and Perroud (2005). These authors noted that memory deficits linked to depression are well-established, including impairments in situations that require conscious recollection of an (explicit) episode, whereas implicit memory task performance is, relatively, spared. This distinction suggests that depressed patients are impaired in their ability to use effortful (conscious) processing (both encoding and retrieval) – their automatic processes are intact. Using the Process Dissociation Procedure (PDP; Jacoby, Toth, & Yonelinas, 1993) – which enables a distinction to be made between automatic (via familiarity judgments) and controlled (via recollection data) processing (all stimuli presented above perceptual threshold) – this study employed inclusion instructions (i.e. complete the word-stem with the prime-word) and exclusion instructions (i.e. do not complete the word-stem with the prime-word). In the exclusion condition, controlled and automatic processes work in opposite directions, creating interference. Jermann et al. (2005) reported that clinically depressed patients, compared with normal controls, had lower estimates of controlled processing, but their automatic processes were intact. This automatic-controlled distinction may account for the impaired ability of depressed patients to inhibit, by off-line system activation, their pre-potent ruminative thoughts that, themselves, are mediated by the on-line and automatic defensive system, as discussed above in terms of RST. In passing, it is interesting to note that one of the most effective psychological treatments for depression, namely Cognitive Behavioural Therapy (CBT), is aimed at addressing the controlled level of cognitions (albeit, with an on-line, practical, components as well).

In relation to individual differences measures, several studies have addressed the automatic-controlled processing distinction. Corr (2003) reported that both the traits of psychoticism and neuroticism impaired automatic processing (i.e. the procedural learning of the sequence of stimuli) in the presence of controlled (attentional) dual-task processing, but only when the controlled task was difficult (i.e. mental arithmetic). When the controlled dual task was relatively easy (i.e. counting of nonsense syllables), only (high) psychoticism was related to impaired procedural learning. These results suggest that psychoticism, and to a lesser extent neuroticism, impairs procedural learning in the context of conscious processing, a finding which may point to why this dysfunctional automatic-controlled interface leads to the cognitive dysfunctions seen in psychoticism (e.g. impaired learning of stimulus irrelevance, as shown by latent inhibition) and neuroticism (e.g. impaired processing of stimulus regularities, which may underlie the inability to resolve cognitive conflicts, hence producing the rumination, threat-perception, and worry that accompanies high neuroticism). These data seem to show that major factors of personality are related to individual differences in the interplay of automatic and controlled processes.

A similar study by Szymura, Śmigasiewicz and Corr (2007) lends support to the above findings. Using a divided attention task, they reported that psychoticism was related to the degree of attentional flexibility, specifically, low psychoticism individuals performed best with a regular selection rule that was predictable, whereas high psychoticism individuals performed best with a random selection rule where the presentation of stimuli was irregular. The interpretation of these data is that, with the change in the random selection rule, individuals had to detect signals that previously served as distractors and that poor cognitive inhibition provided high psychoticism individuals with a relative performance advantage (a similar performance advantage is seen in latent inhibition, where a failure to inhibit the irrelevant stimulus in phase one of the task leads to faster associative learning of the pre-exposed, irrelevant stimulus, now serving as the CS in phase two, and the US). These data show that the personality trait of psychoticism does not necessarily impair attentional performance; indeed, in this study, high psychoticism individuals performed well especially in attentional efficiency tasks that required small demands of attentional control, in dual-task conditions (at least, with slow stimulus presentation times), and where inhibition of previously presented material is a disadvantage to subsequent performance. These results are intriguing when psychoticism is seen in the light of schizophrenia research, where attentional dysfunctions loom large and where is a profound disruption of the smooth interplay of controlled and automatic processes.

The involvement of psychoticism in controlled processing is also demonstrated by Smillie, Cooper, Tharp, and Pelling (2009), who showed that psychoticism, but not extraversion or neuroticism, had involvement in the switching of an explicit rule (i.e. extra-dimensional rule shifting), as measured using an analogue of the Wisconsin Card Sorting Task (WCST), as well as in reversal of a reinforcement-contingency (i.e. reversal learning), as measured by a modified version of the Iowa Gambling Task (IGT). Specifically, high psychoticism is related to poorer rule updating in response to unannounced extra-dimensional shifts on the WCST; and, unlike low psychoticism individuals, those scoring high on this personality measure failed to show performance improvement on reversal learning on the IGT. Although, in this study, no attempt was made to contrast automatic and controlled processes, in such tasks as the WCST and IGT, automatic processes would be involved – a similar point is made by Jacoby et al. (1993) in relation to explicit and implicit memory tasks.

Clearly, further research is needed to clarify the precise role played by psychoticism in the automatic and controlled distinction, and this may prove especially informative in relation to how psychoticism relates to the schizophrenia spectrum (e.g. the impaired inhibitory processes seen in both high psychoticism subjects and patients diagnosed as having schizophrenia; see Corr, 2003). Adding a measure of cognitive consciousness to such studies, along with explicit error signals, would enable the test of the model proposed here in more rigorous terms.

Conclusions

I have highlighted what I perceive to be some fundamental problems raised by a consideration of individual differences in cognition, and proposed a, albeit tentative, solution. It was first noted that unification of psychology still has not been achieved. It is concluded that this unsatisfactory state of affairs is partly the result of these fundamental problems not being acknowledged and appreciated. Next, I defined cognition, and then related it to the plethora of dual-process models that populate the psychological literature. Discussion of these matters was in the form of scene setting. The lateness of conscious awareness was then described, and its implications outlined. Then, the implications of seeing this topic from the Martian point of view was noted; and, perhaps more convincingly, theoretical insights from clinical neuropsychology of phantoms of the mind, discussed in relation to zombie processes, pointed to two fundamental levels of processing. Jeffrey Gray's model of the functions of conscious awareness was next delineated. This model emphasised the inhibition of on-line (reflexive) pre-potent behaviours, which was illustrated in relation to basic defensive systems of personality. Lastly, a model of behavioural control was sketched, and implications of the model proffered.

The focus of this chapter has been on conscious awareness and basic defensive systems. However, it is evident that there are many individual difference variables that play important roles in the control and regulation of behaviour (e.g. intelligence), and that there are many cognitive mechanisms that play similarly important roles (e.g. working memory). In the attempt to provide a tentative solution to the major problem of how reflective (off-line consciousness) and reflexive (on-line automatic routines) interface together – or, as stated above, at least, an indication of the general form such a solution may take – I have chosen to focus on only a small number of major processes for two main reasons: the first was to show how the problem of the reflexive–reflective interface may be addressed; and the second was to take, as examples, pervasive processes of wide-ranging influence. In further development of the model here presented, it will be necessary to include additional individual differences and cognitive factors.

I started this chapter with the aim of scratching a theoretical itch, which has now been satisfied. I doubt that the many assumptions and inferences drawn in this chapter will find universal consent; however, I do hope that they provoke critical thinking, of both theoretical and empirical issues, of the complexity of relating individual differences in cognition, especially those that are represented in conscious awareness. Whether these ideas are themselves examples of off-line aberrations of thought must await further scrutiny and research.

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