Patients with borderline personality disorder have unstable emotions, difficulty maintaining relationships and a high probability of self-inflicted damage. A recent experiment of Posner et al. that measured reaction-time differences derived from a simple task, revealed that alerting and orienting is normal in these patients. By contrast, and perhaps at the root of this personality disorder, the module responsible for cognitive conflict resolution is defective.

In the middle of the 19th century an interest in the mind, which had been developing within philosophy for centuries, began to take root among scientists, who, with the knowledge that the brain and its electrical and chemical mechanisms could be directly observed and quantified, wondered whether there was any hope of objectively exploring the workings of the mind. One of these pioneers, the Dutch physiologist F.C. Donders, wrote: ‘...will all quantitative treatment of mental processes be out of the question then? By no means! An important factor seemed to be susceptible to measurement: I refer to the time required for simple mental processes.’ [1]. Encouraged by Helmholtz's measurement of the speed of neural conduction, Donders applied the same subtractive logic to measure the speed of mental processes (see Box 1).

Mental chronometry and the measurement of reaction time
A century later, Donders' optimism was realized as a wide range of cognitive processes including the components of attention [2], language comprehension [3], memory scanning [4], mental rotation [5], visual search [6] and so on, yielded to scientific investigation, primarily through the use of reaction time as the dependent variable. In his book, Chronometric Explorations of Mind [7], Michael Posner captured the excitement of these advances by describing how a range of chronometric methods (of which the measurement of reaction time was but one) could be used to answer fundamental questions about the mind, particularly those bound up in the concepts that can be grouped under ‘attention’. Subsequently, three isolable subsystems of attention (alerting, orienting and control) have been proposed, identified and measured [8] and technological advances and interdisciplinary research [9] have begun to reveal how their functions are implemented in the brain [10,11].

Converging evidence for this division of attentional labor would be provided by demonstrating that different disturbances of behavior and thought result when different subsystems fail to operate normally. Conversely, our understanding of disturbances of behavior and thought might benefit from considering how they may be rooted in a dysfunctional attentional subsystem. Reflecting such a strategy, Posner and his colleagues recently explored the attentional mechanisms of borderline personality disorder [12].

Measuring attention in borderline personality disorder
The essential feature of the inaptly named borderline personality disorder (BPD) is instability: of affect (emotion), of self-image and of interpersonal relationships. It is the most frequently diagnosed of the personality disorders, affecting an estimated 2% of the population (mostly women) and is often accompanied by marked

Box 1. Origins of mental chronometry

Helmholtz measures neural conduction time
In 1850, Helmholtz stimulated a frog’s leg at two different distances from the peripheral muscle (Fig. I). The latency between the delivery of the electrical stimulus to the nerve and the resulting twitch of the foot (arrow at right of figure) was timed for each position of the stimulating electrode (vertical arrows). The velocity of neural conduction was determined by dividing the distance (d) between the two electrodes by the time difference between the two latencies.
impulsivity and self-destructive behaviors. Because uncontrollability of affect is a core characteristic, Posner et al. hypothesized that individuals with BPD might suffer from a deficit in the attentional subsystem related to control but not in those related to alertness or orienting.

A simple task, the Attention Network Test (ANT) [8], was administered in which the participants had to determine whether a central arrow, accompanied by congruent or incongruent distractors and preceded by different warning cues, pointed to the right or the left (Fig. 1). Reminiscent of Donders’ method, a set of orthogonal subtractions of reaction times (RT) was used to assess the efficacy of the three components of attention: alerting was assessed by the degree to which the RT was slower in the ‘No cue’ than in the ‘Double cue’ condition; orienting by the degree to which the RT was reduced by foreknowledge of the target’s location; and conflict resolution by the degree to which the RT was affected by the congruency of the irrelevant flanking arrows.

As Posner and colleagues had hypothesized [12], patients with borderline personality disorder were worse than controls at ignoring the irrelevant distractors yet their alertness and orienting scores were in the normal range. An interesting secondary finding was provided by a group of non-clinical controls who were matched with the BPD patients for temperament. In their conflict resolution scores, this group was intermediate between the normal controls and the BPD patients. This might mean that negative affect with low levels of effortful control is a risk factor for developing BPD with, perhaps, a critical ingredient being experiential factors (or triggering events, such as abuse).

Posner has argued that orienting can be broken down into disengaging, moving, and engaging, and that each of these mental operations can be linked to different brain structures [9]. Hence, the network mediating orienting is more complex than that which is measured by the single ‘orienting’ subtraction score generated by the ANT, a score that probably places greater emphasis upon the ‘engage’ operation than upon ‘disengaging’ and ‘moving’. Similarly, there is evidence that separate areas of the anterior cingulate cortex are involved in processing emotionally-laden and emotionally-neutral inputs [13]. Together with the particular difficulty BPD patients have controlling their internal emotional states, it seems likely that the deficits they manifest when trying to filter out emotionally-neutral arrows would be magnified if they were required to filter out stimuli with emotional valence.

If we consider the ANT as a ‘recipe’ for interdisciplinary study of the components of attention, then the adage that the ‘proof is in the pudding’ suggests that it is a pretty good recipe [8]. However, even though there is a certain appeal to the simplicity of the ANT, the complexity of the neuropsychological machinery that mediates the components of attention, of which the ANT provides a mere glimpse, suggests that we must treat the results provided by the ANT as preliminary and exploratory.

**A strategy for research linking mind and brain**

A strategy, like the one described by Posner and colleagues aimed at linking basic cognitive processing differences to a...
mental disorder, requires a firm foundation of cognitive and clinical assessments. Posner and colleagues note that their clinical ‘...diagnosis involved 11 hours of objective measures and interviews...’ By contrast, assessment of the components of attention through administration of the ANT requires only 20 minutes or so [8]. Imagine how much more we will learn when exploratory measures like the ANT are followed up by a more thorough cognitive assessment as might be provided if 11 hours were spent on the cognitive side of the equation.

As illustrated in Fig. 2, a fruitful cognitive neuroscientific strategy [14] seeks to link mind and brain through computational models that explicitly reveal how cognitive processes are implemented in neural structures. A noteworthy feature of Posner’s research strategy is the diversity of sources of evidence that he and his colleagues have used to explore the mind–brain interface: neuroimaging, development, genetics, brain damage, psychiatric disorders and individual differences [8,9,11–13,15]. Through such converging evidence and with the development of computationally explicit theories (for example [16–18]) exploration will eventually give way to understanding.

References


How are qualia coupled to functions?

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What determines the nature of subjective experience: associated behavioural functions or mediating neural activity? A recent analysis by Hurley and Noë of a variety of cases of behavioural and neural plasticity shows that, under different conditions, either can predominate. This adds to other efforts to transfer the doctrine of functionalism from philosophical debate to empirical scrutiny, where it is hoped that it may eventually be resolved.

No-one doubts that behavioural function is tightly linked to neural activity, nor is there any mystery in principle about how the linkage is accomplished (despite many details that remain to be established). But sometimes – although by no means always [1] – this cosy marriage turns into a troubling menage-a-trois, joined by a mysterious intruder: conscious experience. Such experience, at least most of the time, if not invariably [2], takes a perceptual form. But there are also powerful modes of unconscious sensory processing [3], so the vocabulary of perceptual science is often ambiguous as to whether it addresses conscious or unconscious perceiving. For this reason, to refer to specifically conscious perceptual experiences, I shall borrow from philosophy (but without intending adherence to any particular philosophical position) the term quale (plural, qualia).

So, in this menage-a-trois, do qualia couple principally with behavioural function or neural activity? The answer to this question given by the dominant view in contemporary science and philosophy – functionalism [4] – is behaviour. In its extreme form, this doctrine goes so far as to claim that the use of brain tissue to control behavioural function is incidental: if identical functions were accomplished by computers, robots or an array of tin cans, then they would give rise to identical states of consciousness. The contrary answer – that qualia are coupled to the