The Arrival of Neuroscience to Diagnostic Reasoning: Four Issues to Keep in Mind

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The Arrival of Neuroscience to Diagnostic Reasoning: Four Issues to Keep in Mind

With the rapidly increasing access to brain imaging facilities, we are potentially at the dawn of a new era for understanding diagnostic reasoning. Although, this may sound bold, and appears to echo the many claims made in other disciplines, we will highlight in this paper why neuroscience can be a useful tool for advancing diagnostic reasoning research. But first some cautionary notes. Fact is that all too often the high expectations of neuroscience are not met, such as the expectation in “educational neuroscience” that the insights of the brain will transform classroom teaching and learning.1 There is currently no compelling evidence that this has happened on any scale.2 Therefore, a healthy dose of scepticism is required when considering the potential role neuroscience can play in the understanding of diagnostic reasoning. With that in mind, we do however believe that the role neuroscience can play in advancing our understanding of diagnostic reasoning is quite different compared with education. Here, the primary objective is not to pursue a wholesale change of educational practice, but to test a fundamental assumption of a cognitive theory that claims to help our understanding of what diagnostic reasoning is about; Dual-Process Theory.3 Dual-Process Theory claims that there are two systems in the brain. System 1 is considered intuitive, fast and reliant on automatic activation of “illness scripts” stored in memory and leading to effortless pattern recognition. System 2 on the other hand is considered analytic, slow, deliberate, and systematic. The clinical reasoning literature is divided; one group of researchers defending System 1 reasoning as the hallmark of expert decision-making, whereas the other camp of researchers considering System 2 reasoning as superior and more likely to achieve diagnostic accuracy.4,5 Neuroscience can make a significant contribution to help scrutinise the validity of Dual-Process Theory by examining if these two systems exist in different anatomical regions in the brain.

Currently the evidence for the existence of these two systems is derived mainly from two behavioural variables: (1) response time and (2) diagnostic accuracy scores.6 Neuroscience could help connect these two key variables with distinct brain regions. This means neuroscience is not to replace behavioural data by looking at the brain alone, but to combine behavioural measures with brain imaging data to get a more comprehensive picture of what is going on when a physician is making a diagnosis.

To further exemplify this point, consider the following example. AlQatani and colleagues investigated whether subjecting residents to time pressure results in more diagnostic errors.7 The results of their study suggest that this was indeed the case: 37% more errors occurred in the group that was subjected to time-pressure. This was particularly prevalent for residents with less experience. The researchers proposed that this is the case because less experienced residents did not have time to switch to the more analytical and slower System 2. They were forced to rely on System 1, which was less developed considering their lack of experience and knowledge. If neuro-imaging would have been used in this study, the researchers would have been in a better position to directly test this assumption by comparing brain activation in the prefrontal cortex between both conditions. (The assumption being that the activation of intuitive System 1 leads to less activation in that region). Thus, combining neuroimaging with behavioural research currently employed can throw a new light on the underlying brain and reasoning mechanisms as they occur in real time.
Take for instance a recently conducted study by Hruska and colleagues. In their study, sixteen written medical cases were devised: eight easy and eight hard clinical cases. Difficult cases were made deliberately difficult by providing the patient's initial contextual data that were not concordant with the lab data presented, whereas for easy cases the patient's contextual data were concordant with the lab data. To examine Dual-Process Theory they asked novices (10 second-year medical students) and experts (10 practicing gastroenterologists) to diagnose the easy and hard cases. It was assumed that experts would rely more on System 1 thinking and novices would rely more on System 2 thinking. They then examined, by means of fMRI, if the different level of expertise was reflected in different neural areas of activation in the brain.

Introducing neuroimaging to diagnostic reasoning is however not an easy feat and as straightforward as one may expect. Even at this early stage, with only a handful of neuroimaging studies in existence, methodological issues and design limitations have started to emerge, which may result in problems down the road. The objective of this editorial is to highlight four of the pertinent issues and to propose avenues for resolving them. The four issues are: (1) The external validity issue; (2) The ecological validity issue; (3) The quasi-experimental issue; and (4) The block-design issue. We will deal with each in the following sections.

**The external validity issue**

The external validity issue refers to mindlessly generalising findings from a psychological domain to the medical domain. For instance, the findings from Tsujii and Watanabe are frequently cited in the medical literature as examples and evidence for the existence of System 1 and System 2 in diagnostic reasoning. However, Tsujii and Watanabe did not study clinical reasoning. They did research on the belief-bias effect in syllogistic reasoning tasks. Belief bias refers to "the tendency of people to be more likely to accept the conclusion of a syllogism if they find it believable than if they disbelieve it, irrespective of its actual logical validity (p.119)." For instance, a believable syllogism is "no mammals are birds and all dogs are mammals, therefore no dogs are birds." An example of an unbelievable conclusion of a syllogism is "no mammals are birds and all pigeons are mammals, therefore no pigeons are birds." There is some evidence that suggests that this bias results from the competition between System 1 and 2 reasoning when evaluating such arguments. Tsujii and colleagues found that in the cases of unbelievable syllogisms, the inferior frontal cortex (IFC) was activated, which suggest that analytical reasoning was involved associated with System 2.

These findings are promising and provide preliminary support for the notion that different anatomical regions in the brain are responsible for the two distinct reasoning systems. However, one has to bear in mind that the experimental materials used do not resemble the complex context in which medical diagnostic reasoning occurs; medical diagnoses involve more variables and a vast array of signs and symptoms. Furthermore, clinicians often face dynamic situations with evolving information. It is therefore questionable whether findings from studies with syllogisms are directly transferable to the field of diagnostic reasoning. If one intends to study the relevance of Dual-Process Theory for clinical reasoning, one has to conduct the study in the clinical context as well.

**The ecological validity issue**

The ecological validity issue refers to the question whether findings derived from using written cases can be generalised to real clinical settings. Most studies use cases consisting of clinical vignettes. There are at least two complications with that. First, these written cases always take time to process since there is quite some information to be read before one is able to consider a diagnosis. We believe that they are therefore not necessarily suited to study a cognitive process like System 1, which is supposed to be fast and automatic. To address this issue, it is therefore important to consider using cases that allow for more immediate diagnosis. For instance, using X-ray images of various pulmonary problems would allow for instant pattern recognition.

Second, it is known that the act of reading results in all sorts of brain activity that is difficult to separate from the actual reasoning process the researcher intends to study. For instance, Hruska and colleagues use written medical cases. In their study, they had difficulties distinguishing between reading and diagnostic reasoning (i.e., to establish a baseline contrast). They proposed using simple opposing tasks as baseline rather than using the reading state as a baseline. Using images, as proposed above, would resolve the issue.

**The quasi-experimental issue**

The quasi-experimental issue presents perhaps the most significant difficulty in the study of Dual-Process
The block-design issue

Finally, the block-design issue refers to a technical issue of how stimulus materials are typically presented in neuroimaging studies. A block design entails that variations in treatment are presented in sequential blocks. For instance, in the Tsuiji et al. syllogistic reasoning task studies mentioned earlier, four trials of believable conclusions were presented in a block followed by four trials of unbelievable conclusions. This is done to first allow the signal to reach optimal strength and second to amplify the observed effect. In fNIRS and fMRI studies the lag time is several seconds. Having the stimuli arranged in a block allows sufficient time for the concentration changes in the blood oxygenation to occur. Although the block design is commonly applied in these kind of studies, it is at the cost of authenticity.

To address this issue, we propose presenting the stimuli in random order is more authentic because participants are unable to anticipate what to expect next. This can, however, only work if the researcher allows for sufficient lag time between stimulus presentation for the signal to come down to baseline levels.

One-sentence bios

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References


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