FEATURE ARTICLE

COACTION PUBLISHING

An analysis of clinical reasoning through a recent and comprehensive approach: the dual-process theory

Thierry Pelaccia, MD, PhD(c)[1,2]*, Jacques Tardif, PhD[3], Emmanuel Triby, PhD[2,4] and Bernard Charlin, MD, PhD[5]

[1]Prehospital Emergency Care Service (SAMU 67) – Centre for Emergency Care Teaching (CESU 67), Strasbourg University Hospital, Strasbourg, France; [2]Health Sciences Education Research Laboratory, Department of Medical Education, Faculty of Medicine, University of Strasbourg, Strasbourg, France; [3]Department of Pedagogy, Faculty of Education, University of Sherbrooke, Québec, Canada; [4]Faculty of Educational Sciences, University of Strasbourg, France; [5]Centre of Pedagogy applied to Health Sciences (CPASS), Faculty of Medicine, University of Montreal, Québec, Canada

Context: Clinical reasoning plays a major role in the ability of doctors to make diagnoses and decisions. It is considered as the physician's most critical competence, and has been widely studied by physicians, educationalists, psychologists and sociologists. Since the 1970s, many theories about clinical reasoning in medicine have been put forward.

Purpose: This paper aims at exploring a comprehensive approach: the "dual-process theory", a model developed by cognitive psychologists over the last few years.

Discussion: After 40 years of sometimes contradictory studies on clinical reasoning, the dual-process theory gives us many answers on how doctors think while making diagnoses and decisions. It highlights the importance of physicians' intuition and the high level of interaction between analytical and non-analytical processes. However, it has not received much attention in the medical education literature. The implications of dual-process models of reasoning in terms of medical education will be discussed.

Keywords: *Dual process*; *analytical reasoning*; *expertise*; *professional intuition*; *hypothetico-deduction*; *pattern recognition*; *diagnostic errors*

Received: 6 December 2010; Revised: 7 February 2011; Accepted: 7 February 2011; Published: 14 March 2011

Background

Clinical reasoning refers to 'the cognitive process that is necessary to evaluate and manage a patient's medical problem' (1). It allows physicians to make diagnoses and decisions (e.g. laboratory tests and drug prescriptions), and is considered as one of the major determining factors of clinical competence (2). Many researchers – including health professionals, education specialists, cognitive psychologists and sociologists – have therefore invested this field of medical practice and education for nearly 40 years. Their work has helped many to understand clinical reasoning as an idiosyncratic, multifaceted and highly complex skill, characterized by different processes that mobilize specific knowledge held in long-term memory (3, 4). However, many researchers still have diverging opinions on how doctors think while making diagnoses and decisions, particularly on the place of intuition in the reasoning process and its interactions with analytic thinking.

This article aims at casting a comprehensive view on clinical reasoning, through a model developed over the past 15 years: the *dual-process theory*. This model of reasoning has been previously described in the cognitive psychology literature, but remains uncommonly used in the medical education literature. Our aim is to provide a review of the major works done over recent years on the dual-process theory, in order to make this approach more available to clinical teachers and medical educators. First we take a look at a description of this contemporary theory, in the context of reasoning in general. We then describe how it relates to the models of reasoning that have been identified in the field of medicine. Finally, we discuss the implications of this approach for medical education and define new

Citation: Medical Education Online 2011, **16**: 5890 - DOI: 10.3402/meo.v16i0.5890

challenging research topics related to the dual-process models of clinical reasoning.

Discussion

Dual-process theory: an emerging model

Dual-process theory stemmed largely from work done in the mid-1990s in the field of cognitive psychology, particularly by Epstein and Hammond (5, 6).

Two separate systems

According to this approach, two cognitive systems are used to reason.

- The first, described as 'intuitive', 'tacit' and also 'experiential', is a reflex system whose trigger occurs in automated mode (5, 7). It produces an intuitive response, which means that it is generated without effort and is below the threshold of perceptible consciousness (8). The intuitive system is therefore particularly rapid (9). It uses information which is readily available, in particular visual, and operates on the principle of recognition of a typical configuration of signs, or of similarities with previously encountered similar situations. The approach of the clinician is at once partial (only part of the available information is processed), holistic (the individual will make an overall assessment of the situation) and approximate (7). The response that is generated intuitively is highly dependent on contextual cues, as we will see later (10). In addition, the affective state of the individual is an important determinant of intuitive reasoning (9–11). In the medical literature, intuition has been compared to 'gut feelings' by some authors (12, 13).
- The second system is described as 'analytical', 'deliberate' and 'rational' (5, 7). It comes from a rational and deliberate judgement based on additional information collected actively by the individual in his or her environment and the conscious application of rules that have been acquired through learning (9–11, 14). Kahneman (9) speaks of a 'rule-governed' system. It is therefore rather slow and very demanding for cognition (11).

The place of intuition in the reasoning process

Bargh and Chartrand (15) state that the majority of our decisions and actions are the result of automated reasoning. In the same vein, Kahneman (9) considers that in our daily life it is the most common path of decision-making.

According to other authors, such as Epstein (5), Hogarth (7, 8) and Hammond (6), the two systems are jointly involved in most of our cognitive activities. Depending on the situation, the individual would rather use the intuitive system or the analytical system. Situations in which the valence goes towards one system or another remain unclear. Preliminary conclusions from recent publications in the medical literature tend to show that the valence goes towards the analytical system in the following situations (14, 16):

- when time permits
- when there are high-stake outcomes
- when the situation is complex
- when the decision-maker is facing ambiguous, non-routine or ill-defined problems – Schön speaks of "unstructured and indeterminate zones of practice" (16)
- in the context of uncertainty.

In contrast, routine problems associated with a higher level of certainty would be more often dealt with by the intuitive system, especially when time is lacking.

From a functional point of view, in the hypothesis that both systems are jointly involved in most of our decisions, reasoning always starts intuitively, which means that environmental information is interpreted preconsciously at first (8). The intuitive system is activated unconsciously and automatically (7, 8). As a general rule, the result of this automated processing will give rise in the working memory to the genesis of one or more possible solutions. Prompting the analytical system will then allow confirmation or invalidation of the relevance of these (8). However, in some situations actions can be undertaken automatically and thus can come before the understanding the subject has of the situation, in order to allow a prompt intervention (8, 15).

The monitoring function of the analytical system over the intuitive system

Kahneman and Klein (17) reviewed some experiments showing that individuals often adopt the intuitive response without checking it. They give priority to rapidly generated solutions rather than deep analytic thinking. Yet, theoretically, the analytical system plays a monitoring role over the intuitive response. It can consciously overrule the intuitive process in situations where a conflict in believability or validity is detected (9, 16). So to speak, during the reasoning process the intuitive response could be associated in these situations with a kind of 'sense of alarm' – using an expression borrowed from Stolper et al. (12) – i.e., the decision-maker would consider that something is going wrong.

This controlling function may be ineffective in two situations.

- When the level of vigilance of the individual (through his or her analytical system) is lowered by contextual factors such as lack of time, concurrent involvement in

Citation: Medical Education Online 2011, **16**: 5890 - DOI: 10.3402/meo.v16i0.5890

several cognitive tasks, fatigue, sleep deprivation, inattentiveness or distraction (9–11, 18). Psycho-affective factors such as overconfidence, self-deception, disillusionment, complacency and lack of motivation can also lead to the diminution of the level of vigilance of the analytical system (14, 16, 19, 20).

– When the analytical system is purely inhibited by the intuitive system (10). This phenomenon was described for the first time by Stanovich in the 1990s (14). The author speaks of 'dysrationalia' when pointing out the inability of individuals to think and behave rationally in the absence of intellectual deficiency (14).

Clinical reasoning in the framework of the dual-process theory

In the framework of the dual-process theory, pattern recognition and hypothetico-deduction – which have been extensively described in the medical literature – are the basis of the intuitive system and the analytical system, respectively (3).

Pattern recognition and hypothetico-deduction

Pattern recognition is the most common form of non-analytical processes. It consists of unconsciously making a link between a given clinical situation and patterns stored in the long-term memory, through the automated identification and treatment of clinical and contextual information. It allows clinicians to formulate diagnostic hypotheses very fast when encountering a patient for the first time (21, 22). In Barrows and Tamblyn's (1) multiple-step model of clinical reasoning, this process corresponds to step 1 – where the physicians perceives 'instantly and almost unconsciously' contextual and clinical cues from his environment – and step 2, where hypotheses are generated on the basis of past experiences with patients, through an 'unconscious act of memory association'. It has been shown that pattern recognition is widely used by clinicians, regardless of their degree of expertise (23–25). In the framework of the dual-process theory, pattern recognition corresponds to prompting the intuitive system (3, 9, 13, 23).

Hypothetico-deduction is a process in which diagnostic hypotheses are tested analytically (by questioning the patient, making a clinical examination, etc.) in order to confirm or invalidate solutions that have been generated non-analytically (2). In Barrows and Tamblyn's (1) model it corresponds to step 3, which consists of strengthening or ruling out the initial hypotheses. The use of hypothetico-deduction by physicians was shown early by Elstein, Shulman and Sprafka (26). Later, it was extensively demonstrated that both experts and novices use this reasoning process, which is considered a very common and general form of clinical reasoning (3, 23, 27).

In the framework of the dual-process theory, hypothetico-deduction corresponds to prompting the analytical system (3). Other forms of analytical thinking have been described in the medical literature, in particular 'forward reasoning', i.e., starting the reasoning process from the data to generate subsequently diagnostic hypotheses through a rule-governed approach (28, 29). This process is probably used by physicians when the intuitive system is unable to generate early relevant solutions to complex or rare problems. In these situations, clinicians may also have conscious recourse to their pathophysiological knowledge (29).

Further investigations are needed to show if physicians actually work within the frame of dual-process models of reasoning. Recently published papers highlight the relevance of this theory in the fields of anesthesia, emergency medicine and general practice (14, 30, 31). Balla et al. (31) specifically looked at the congruence of general practitioners' (GPs) reasoning and the dual-process models. The authors showed that GPs first automatically make a rapid framing of the problem to generate early hypotheses, based on salient features of the clinical picture. These latter are recognized thanks to previous experience and theoretical knowledge. This corresponds to prompting the intuitive system. Afterwards, GPs will deliberately test these hypotheses, through active collection of further information, until a decision threshold is reached. This is consistent with the functioning of the analytical system.

The place of intuition and analytical thinking in the clinical reasoning process, and the interactions between the two systems

It has been widely accepted for over a decade that the analytical and non-analytical processes identified within the scope of clinical reasoning research are not mutually exclusive (32–34). Thus, according to Eva (35), 'It is highly probable that both forms of processing contribute to the final decisions reached in all cases (for both novices and experts)'. Indeed, experimental studies show in both novice and expert physicians that using purely analytical or purely non-analytical strategies leads to lower diagnostic performance than when subjects are asked to use a combination of both processes (36–38).

In most situations, pattern recognition allows clinicians to formulate diagnostic assumptions and management options intuitively and rapidly; these will be confirmed or ruled out analytically through a hypothetico-deductive process. Neufeld et al.'s (24) findings highlight the importance of intuition in the clinical reasoning process: when a correct hypothesis is considered in the first five minutes, there is a 95 per cent chance of reaching the correct diagnosis. Failing this, there is an identical probability of being mistaken. In the same vein, early

studies showed the major impact of initial impressions on the final diagnosis (26).

The benefits of considering clinical reasoning through the framework of the dual-process theory

Although many grey areas remain, the dual-process model of reasoning is a very relevant and promising approach, in the context of both education and research.

- One major interest is to highlight and strengthen the plurality of the processes involved in clinical reasoning. Indeed, much work in the field of medical education has led to the partitioning of analytical and non-analytical processes. Preliminary research done in the framework of the dual-process model allows a better understanding of the interactions between the intuitive and analytical systems.
- The dual-process theory also highlights the fact that, to varying degrees, intuition is constantly involved in reasoning. This is a very important feature, since for centuries professional intuition has been considered in medicine as a 'mysterious' skill that is not accessible to consciousness and should not prevail over rational and scientific judgement. Highlighting the importance of intuition in medical expertise is associated with many important educational issues, as we will see.
- This approach also stresses the importance of contextual factors in the clinical reasoning process. According to Gruppen and Frohna (22), 'a growing body of research outside of medicine demonstrates that problem solving in real-world settings typically places a heavy reliance on the environment, both to support problems solving activities and to modify the problem solving process to fit the demands and constraints of the situation'. Some researchers even consider that context is one of the main constraints on reasoning in the healthcare setting (10).
- Finally, the dual-process approach allows researchers and medical educators to cast a new light on diagnostic errors.

Is intuition reliable?

A sticking point in the research community

Researchers disagree about the reliability of intuition. Some consider that although the intuitive system is much of the time effective, it is more vulnerable to errors than the analytical system, because of the contextual and affective factors that could affect its functioning (10, 11, 14). In contrast, other published works in the psychology literature provide evidence that inducements to the analytical system can lead to a poorer level of performance, because of the considerable cognitive resources that are needed to perform analytically (37).

As to theorists of the dual-process models of reasoning, they consider that, contrary to a common premise, the responses generated by the analytical system are not better than those from the intuitive system (8, 23). A recent review by Norman and Eva (37) underpins the fact that both systems are equally prone to errors. In the same vein, research carried out in the field of medicine has shown that pattern recognition strategies often lead to decisions that are identical to those obtained analytically (39). A holistic assessment of the situation may sometimes be even more relevant (40) in areas where visual information is dominant (36) as well as in other areas of medicine (23).

In regard to the theoretical framework offered by dual-process models of reasoning, we believe that these diverging opinions and research results could be partly due to the fact that it seems difficult to incriminate solely the intuitive or the analytical system when errors are made, given the high level of complementarity and interaction between both systems during the reasoning process. We could indeed consider that erroneous intuitive responses are as much the result of faulty intuitive judgement as they are the consequence of a dysfunction of the analytical system through its controlling role. Errors made during the analytical process could as well be the result of the dysfunction of the analytical system as the consequence of the inability of the intuitive system to generate early and relevant diagnostic hypotheses.

In order to deepen the question of the reliability of intuition, we will consider further the factors behind its effectiveness and possible bias. The work carried out within the scope of the dual-process theory allows us to consider a number of assumptions on this topic. We now discuss the importance of the affective state of the individual on his or her intuitive response, and also consider the nature of the information used by the intuitive system. Finally, we focus on the working environment in which clinicians' intuition is developed, considering the feedback given to these professionals in their practice.

The affective valence of intuitive judgements

As highlighted at the beginning of this article, the intuitive system is particularly sensitive to the affective state of the individual (8). For this reason, it is unrealistic to consider that clinical reasoning can only rely on objective judgements that are devoid of emotions (41).

Little work has been carried out on the affective component of clinical reasoning (41). However, there are sufficient arguments to suggest that the reliability of intuitive responses is largely influenced by the feelings of physicians towards their patients. A negative feeling could, for example, occur when facing an individual with morbid obesity, a history of drug abuse or psychiatric behavioural disorders. Labelling patients as 'plaintive', 'difficult', 'manipulative' or 'borderline personality' is also likely to influence reasoning (41).

Citation: Medical Education Online 2011, **16**: 5890 - DOI: 10.3402/meo.v16i0.5890

Croskerry (11) considers positive or negative feelings of a physician towards his or her patients as 'preconscious affective dispositions'.

The discussion about the affective valence of reasoning brings us to the notion of emotional intelligence, which is defined as 'The ability to monitor one's own and others' feelings, to discriminate among them, and to use this information to guide one's thinking and action' (42). Much has been written about this topic. To gain emotional intelligence, Hogarth (43) considers that "people should be aware that the information transmitted by their emotions is just part of the data that should be considered".

According to Croskerry, Abbas and Albert (41), 'The idea of affective influence on decision making will be unfamiliar to many clinicians… There is a growing imperative for medical educators to understand and incorporate this knowledge into clinical training.' Although we fully agree with these authors about the need to consider the affective valence of clinical reasoning in the context of medical education, the 'teachability' of emotional intelligence remains uncertain. A recent review by Norman (44) highlights the 'loose definition of emotional intelligence'. The author considers that its value has not been demonstrated in the field of health sciences education. In this context, it seems difficult to introduce any reliable educational recommendations in relation to emotional intelligence.

The nature of the information used by the intuitive system

Experts process information differently from novices. In their field of expertise, they can intuitively use a larger quantity of information (8). Paradoxically, some authors consider that very often the number of cues used in cognitive tasks intended to judge similarity is limited (45). More than quantity, it seems that the relevance of the cues may be a significant determinant of the efficacy of the intuitive reasoning process. Indeed, irrelevant information – in particular contextual (e.g., being a banker) – is likely to be involved in pattern recognition and could lead to diagnostic errors (46). The same is true for the under- or over-appreciation of contextual cues (10). In relation to our previous discussion on the affective valence of reasoning, we must also highlight the fact that physicians sometimes use "distracting cues" (such as gender, age, race, obesity and psychiatric illness) that could be inappropriate to make diagnoses and decisions (10).

The feedback given to clinicians

It is particularly important to take account of the environment in which intuition is acquired, and more particularly the feedback provided by this environment. In this regard, Hogarth (7) distinguishes between 'kind' and 'wicked' environments. The first are determined by the fact that the individual gets immediate, appropriate and unambiguous feedback. These environments lead to the appropriate development of intuition. Wicked environments are places in which feedback is inconsistent, late and sometimes inadequate – for instance, it is not directly attributable to the individual's actions. Broadly speaking, the working environment of clinicians is rather wicked. Indeed, feedback – comparing patient outcomes with diagnoses and decisions made by the physician – is often late and sometimes lacking in clinical practice. Moreover, the outcomes are not always directly attributable to the clinicians' actions: chance, luck, misfortune, bad compliance with treatments and other factors may be implicated in the evolution of the patient's health status.

The fact that physicians work in environments that are not naturally conducive to the development of their intuition could explain what we call 'the paradox of experience'.

The paradox of experience

Although experience is often considered as a reliable indicator of physicians' expertise, many researchers state that experience is not necessarily synonymous with expertise (16, 20). Several studies underpin this assessment, in many fields of medicine (20, 47, 48). They show that the physicians' level of performance in daily clinical tasks is not constantly correlated with their level of experience.

In regard to our previous discussion, the dual-process theory provides a comprehensive framework to understand 'the paradox of experience': in some situations, experienced physicians show poorer performance than their less experienced peers. In other words, if we consider that experience – through the feedback offered by clinical practice – is the ground for development of the intuitive response, experience may sometimes lead to faulty intuitions.

Consequences of the dual-process models of reasoning for medical education

Although further studies are needed to understand clinical reasoning better through the framework of the dual-process theory, a number of educational recommendations based on this approach can already be formulated.

The teaching of clinical reasoning in the medical curriculum

We must recognize that the academic environment of medical students hardly promotes the active development of clinical reasoning (5). Indeed, although medical educators share the view of clinical reasoning as a major determinant of physicians' expertise, it is not often an explicit educational objective in medical universities (14). Thus the development of clinical reasoning abilities will most often remain secondary in comparison with knowl-

edge and practical skills acquisition (49). Many believe that this competence will be gained gradually and naturally over time, through clinical experience. Other teachers may believe that reasoning relies on personality traits that will hardly be gained during medical studies if they are not already present at entry to medical school (50).

Kassirer (51) severely criticizes the way clinical reasoning is taught in medical schools. He considers that 'despite substantial advances in our understanding of human cognition during the last few decades, our teaching methods are still based largely on expert opinion'. There is a consensus among experts that clinical reasoning *can* and *must* be taught during medical studies (52, 53).

Given that one of the main interests of the dual-process theory is to stress the importance of intuition in the reasoning process, we will discuss further the conditions for the active development of intuition through medical education. We mainly consider the context of bedside teaching during clinical clerkships, which remains one of the most relevant places to learn clinical reasoning (54).

Exposure to the targeted skills area

According to Hogarth (7), 'What we learn is a function of the opportunities offered by the environments in which we live and act' and 'we cannot learn from something that we cannot see'. It is therefore desirable to confront the individual at first with situations in which his or her intuition is likely to grow, given the area of skills targeted.

For medical students these are courses in healthcare settings, which in this context establish a major interest when introduced early in the curriculum. However, some authors consider that students should first acquire a basis of biomedical and clinical knowledge, in order to be more confident and efficient when meeting patients for the first time (55). This does not mean that learning clinical reasoning should start with clinical practice; indeed, like many researchers, Ryan and Higgs (56) argue that the medical curriculum should 'infuse clinical reasoning principles throughout the entire programme'.

In an academic setting, using problem-based learning is likely to encourage the development of intuition, since this learning is consistently held in a given field as the individual is exposed to this field (43). However, this is not always effective, since the feedback provided to students is determinant in these learning situations.

Exposure to multiple and varied clinical cases

Exposure to multiple and varied clinical cases will allow the development of medical students' intuition through the construction of patterns in their long-term memory. Patterns are built on the basis of the transformation and abstraction of real clinical situations that lead to the representation of a disease in its most typical form (57). In this regard, Sanson-Fisher, Rolfe and Williams (55) consider that 'it is not adequate to see just one patient with that condition, as there can be considerable variability in patient presentations. Instead, students need multiple experiences with the same type of patient before that clinical condition can be understood.' In order to organize long-term memory knowledge in an efficient way for reasoning, students should first be confronted with typical presentations of a given disease, before managing uncommon presentations (57, 58).

Looking for feedback

Medical students should be encouraged to look actively for immediate feedback from their tutors, based on a verbal appraisal of their work. The role of feedback is critical in the development of students' reasoning (51, 54, 55, 58, 59), in particular when it allows teachers to point out errors immediately and discuss them with the learner (51). Lajoie (60) considers that feedback is also an effective tool for the development of expertise, which she describes as 'dynamic assessment', as the feedback is delivered *during* the activity. This improves the development of intuition in the context of problem solving. In the same vein, Gruppen and Frohna (22) consider that third-party intervention is particularly useful in order to develop the ability to reason intuitively.

It is unusual for students to ask for feedback (when not spontaneously provided by the tutor). Fear of criticism, fear of being judged negatively, lack of motivation and lack of time are plausible explanations for this.

Students' intuition exploration

So that feedback provided by tutors can focus on students' intuitive reasoning, students should be encouraged to let the tutors know about their intuition *during* the management of a patient. On-the-ground training practice in courses often runs contrary to this, as the usual guidance given to students is to collect the entire history of the disease and carry out an exhaustive systematic clinical examination before formulating diagnostic assumptions and suggesting therapeutic solutions. This way of proceeding means that it is mainly the analytical part of the reasoning process that is explored during the debriefing. Although common, this approach was considered 'illogical' by some early researchers (1). Norman et al. (36) later experimentally confirmed that it is inappropriate. Moreover, it leads to a lower level of performance.

As a consequence, in order to explore and use intuitive reasoning in the perspective of its effective development, students should have the opportunity to formulate diagnostic hypotheses from the first seconds or minutes of encountering the patient. The traditional question, 'What do you think about this patient?', should be raised very early – all the more as many clinicians are unaware

Citation: Medical Education Online 2011, **16**: 5890 - DOI: 10.3402/meo.v16i0.5890

of the existence of these early hypotheses (1). This will not strictly speaking encourage intuitive thinking – as intuitive responses will in any case arise, according to the dual-process theory – but will allow students and tutors to discuss the origins of the hypotheses that arise from intuition.

In this context, direct supervision – where tutors directly observe students during the clinical task – is useful (54). It allows teachers to raise questions during the patient encounter, in order to explore the learner's intuition and observe whether or not he performs a targeted clinical examination in relation to the intuitive assumptions. Direct supervision allows clinical teachers to point out what the learner really *did* and not just what he *says* about his actions. Moreover, this pedagogical approach is particularly appreciated by medical students (61).

The characteristics of effective feedback

The quality of feedback offered in the context of clinical education is of major importance for the development of intuition. Tutors should encourage learners to identify the information used to reach the intuitive assumptions formulated from the first seconds or minutes of the patient encounter, using questions such as 'What makes you say that?' This will lead to awareness of a spontaneous automated reasoning (7) and identification of contextual and clinical cues that have been used during the clinical reasoning process. The assessment of their relevance will give useful information about errors due, for instance, to the inappropriate use or overemphasis of some cues. In the case of faulty assumptions, students should be encouraged to look for information that would refute the diagnosis proposed and discuss alternatives. This may be complex, since 'people resist changing the mental path in which they are already embarked'; they "like their ideas and are reluctant to change them" (7). The approach is not always natural. Third-party intervention is likely to encourage this practice, which, when repeated, will become less difficult for the students to implement and may be underpinned by intuitive processes (7). This will allow students to develop skills to observe and extract relevant information from their surroundings, in order to think intuitively in similar situations (7).

Summary

Dual-process theory is a model of reasoning that integrates the major processes that have been identified since the 1970s in the field of clinical reasoning research. It allows us to understand better how doctors think in their everyday practice. It highlights the considerable importance of intuition, which plays a determinant role in most decisions.

Although many grey areas remain, we believe that the dual-process theory provides a very comprehensive and useful view of clinical reasoning to medical educators. These latter should consider the importance of providing learning environments in which medical students can develop their abilities to reason intuitively, notably through giving appropriate feedback.

Dual-process theory gives voice to multiple research themes that are still largely unexplored. These relate in particular to the influence of intuition and emotions on clinical practice, the understanding of diagnostic errors in the framework of this theory, the integration – in the academic training of medical students – of settings and devices which are designed to teach them how to reason intuitively, the role of tutorial feedback in the development of intuition, and the importance of metacognitive control for reasoning and learning to reason. It also invites us to undertake further research to (re)consider the definition of 'expertise'. Are experts those physicians who think intuitively – and therefore very rapidly – much of the time, because they possess many patterns in their long-term memory, based on a long clinical experience? Are experts those who are able to monitor their intuition constantly and reduce errors thanks to their analytical system, whatever the context and their affective state? Are experts those who can transition appropriately between the two modes of thinking, and make a distinction between routine cases and novel, unusual or ambiguous situations? Dual-process theory undoubtedly provides a very challenging framework to understand expertise better.

Acknowledgements

The authors acknowledge the Faculty of Education, University of Sherbrooke (Québec, Canada) and the French Society of Emergency Medicine (SFMU) for financial support for the project.

References

1. Barrows HS, Tamblyn RM. Problem-based learning. An approach to medical education. New York: Springer; 1980.
2. Charlin B, Tardif J, Boshuizen HP. Scripts and medical diagnostic knowledge: theory and applications for clinical reasoning instruction and research. Acad Med 2000; 75: 182–90.
3. Schwartz A, Elstein AS. Clinical reasoning in medicine. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. 3rd ed. Edinburgh: Elsevier; 2008, pp. 223–34.
4. Schmidt HG, Norman GR, Boshuizen HP. A cognitive perspective on medical expertise: theory and implication. Acad Med 1990; 65: 611–21.
5. Epstein S. Integration of the cognitive and the psychodynamic unconscious. Am Psychol 1994; 49: 709–24.
6. Hammond KR. Human judgment and social policy: irreducible uncertainty, inevitable error, unavoidable injustice. New York: Oxford University Press; 1996.
7. Hogarth RM. Educating intuition. Chicago (IL): University of Chicago Press; 2001.

8. Hogarth RM. Deciding analytically or trusting your intuition? The advantages and disadvantages of analytic and intuitive thought. In: Betsch T, Haberstroh S, eds. Routines of decision making. Mahwah (NJ): Erlbaum; 2005. pp. 67–82.
9. Kahneman D. A perspective on judgment and choice. Am Psychol 2003; 58: 697–720.
10. Croskerry P. Context is everything or how could I have been that stupid? Healthcare Quarterly 2009; 12: 171–6.
11. Croskerry P. A universal model of diagnostic reasoning. Acad Med 2009; 84: 1022–8.
12. Stolper E, Van Royen P, Van de Wiel M, Van Bokhoven M, Houben P, Van der Weijden T, et al. Consensus on gut feelings in general practice. BMC Fam Pract 2009; 17: 10–66.
13. Stolper E, Van Bokhoven M, Houben P, Van Royen P, Van de Wiel M, Van der Weijden T, et al. The diagnostic role of gut feelings in general practice. A focus group study of the concept and its determinants. BMC Fam Pract 2009; 18: 10–7.
14. Croskerry P. Critical thinking and reasoning in emergency medicine. In: Croskerry P, Cosby KS, Schenkel SM, Wears RL, eds. Patient safety in emergency medicine. Philadelphia (PA): Lippincott Williams & Wilkins; 2008. pp. 213–8.
15. Bargh JA, Chartrand TL. The unbearable automaticity of being. Am Psychol 1999; 54: 462–79.
16. Moulton CA, Regehr G, Mylopoulos M, MacRae HM. Slowing down when you should: a new model of expert judgment. Acad Med 2007; 82: 109–16.
17. Kahneman D, Klein G. Conditions for intuitive expertise: a failure to disagree. Am Psychol 2009; 64: 515–26.
18. Croskerry P. Clinical cognition and diagnostic error: applications of a dual process model of reasoning. Adv Health Sci Educ 2009; 14: 27–35.
19. Croskerry P, Norman G. Overconfidence in clinical decision making. Am J Med 2008; 121: 24–9.
20. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. Acad Med 2004; 79: 70–81.
21. Elstein AS, Schwartz A. Clinical problem solving and diagnostic decision making: selective review of the cognitive literature. BMJ 2002; 324: 729–32.
22. Gruppen LD, Frohna AZ. Clinical reasoning. In: Norman GR, van der Vleuten CP, Newble DI, eds. International handbook of research in medical education. Boston (MA): Kluwer Academic; 2002. pp. 205–30.
23. Coderre S, Mandin H, Harasym PH, Fick GH. Diagnostic reasoning strategies and diagnostic success. Med Educ 2003; 37: 695–703.
24. Neufeld VR, Norman GR, Feightner JW, Barrows HS. Clinical problem solving by medical students: a cross-sectional and longitudinal analysis. Med Educ 1981; 15: 315–22.
25. Norman GR, Young M, Brooks L. Non-analytical models of clinical reasoning: the role of experience. Med Educ 2007; 41: 1140–5.
26. Elstein AS, Shulman LS, Sprafka SA. Medical problem solving: an analysis of clinical reasoning. Cambridge (MA): Harvard University Press; 1978.
27. Gail J, Resnik L, Haddad A. Expertise and clinical reasoning. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. 3rd ed. Edinburgh: Elsevier; 2008. pp. 123–36.
28. Norman GR, Trott A, Brooks L, Kinsey-Smith E. Cognitive differences in clinical reasoning related to postgraduate training. Teach Learn Med 1994; 6: 114–20.
29. Kaufman DR, Yoskowitz NA, Patel VL. Clinical reasoning and biomedical knowledge: implications for teaching. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. 3rd ed. Edinburgh: Elsevier; 2008. pp. 137–50.
30. Glatter RD, Martin RE, Lex J. How emergency physicians think. In: Proceedings of the Fourth Mediterranean Emergency Medicine Congress (MEMC IV), Sorrento, 17–18 September 2007.
31. Balla JI, Heneghan C, Glasziou P, Thompson M, Balla ME. A model for reflection for good clinical practice. J Eval Clin Pract 2009; 15: 964–9.
32. Eva KW. The ageing physician: changes in cognitive processing and their impact on medical practice. Acad Med 2002; 77: 1–6.
33. Ark TK, Brooks LR, Eva KW. Giving learners the best of both worlds: do clinical teachers need to guard against teaching pattern recognition to novices? Acad Med 2006; 81: 405–9.
34. Kulatunga-Moruzi C, Brooks LR, Norman GR. Coordination of analytic and similarity-based processing strategies and expertise in dermatological diagnosis. Teach Learn Med 2001; 13: 110–6.
35. Eva KW. What every teacher needs to know about clinical reasoning. Med Educ 2005; 39: 98–106.
36. Norman GR, Brooks LR, Colle CL, Hatala RM. The benefit of diagnostic hypotheses in clinical reasoning: experimental study of an instructional intervention for forward and backward reasoning. Cognit Instr 2000; 17: 433–48.
37. Norman GR, Eva KW. Diagnostic error and clinical reasoning. Med Educ 2010; 44: 94–100.
38. Ark TK, Brooks LR, Eva KW. The best of both worlds: adoption of a combined (analytic and non-analytic) reasoning strategy improves diagnostic accuracy relative to either strategy in isolation. Proceedings of the Annual Meeting of the Association of American Medical Colleges, Boston, 5–10 November 2004.
39. Eva KW, Hatala RM, Leblanc VR, Brooks LR. Teaching from the clinical reasoning literature: combined reasoning strategies help novice diagnosticians overcome misleading information. Med Educ 2007; 41: 1152–8.
40. Gladwell M. Blink: the power of thinking without thinking. New York: Little Brown & Co; 2005.
41. Croskerry P, Abbass AA, Albert WW. How doctors feel: affective issues in patients' safety. The Lancet 2008; 272: 1205–6.
42. Salovey P, Mayer JD. Emotional intelligence. Imag Cogn Pers 1990; 9: 185–211.
43. Hogarth RM. On the learning of intuition. In: Plessner H, Betsch C, Betsch T, eds. Intuition in judgment and decision making. NewYork: Lawrence Erlbaum Associates; 2008. pp. 91–105.
44. Norman G. Non-cognitive factors in health sciences education: from the clinic floor to the cutting room floor. Adv Health Sci Educ 2010; 15: 1–8.
45. Gigerenzer G, Todd PM. Fast and frugal heuristics: the adaptive toolbox. In: Gigerenzer G, Todd PM, ABC Research Group, eds. Simple heuristics that make us smart. New York: Oxford University Press; 1999. pp. 3–34.
46. Hatala RM, Norman GR, Brooks LR. Influence of a single example on subsequent electrocardiogram interpretation. Teach Learn Med 1999; 11: 110–7.
47. Choudhry NK, Fletcher RH, Soumerai SB. Systematic review: the relationship between clinical experience and quality of health care. Ann Int Med 2005; 142: 260–73.
48. Friedman Z, Siddiqui N, Katznelson R, Devito I, Davies S. Experience is not enough: repeated breaches in epidural anesthesia aseptic technique by novice operators despite improved skill. Anesthesiology 2008; 108: 914–20.
49. Mandin H, Jones A, Woloschuk W, Harasym P. Helping students learn to think like experts when solving clinical problems. Acad Med 1997; 72: 173–9.

Citation: Medical Education Online 2011, **16**: 5890 - DOI: 10.3402/meo.v16i0.5890

50. Hendricson WD, Andrieu SC, Chadwick DG, Chmar JE, Cole JR, George MC, et al. Educational strategies associated with development of problem-solving, critical thinking, and self-directed learning. J Dent Educ 2006; 70: 925–36.
51. Kassirer JP. Teaching clinical reasoning: case-based and coached. Acad Med 2010; 85: 1118–24.
52. Chamberland M. Using research findings to improve our teaching and learning activities on clinical reasoning. Ped Med. 2005;6:197–9 (in French).
53. Kassirer JP. Teaching problem-solving – how are we doing? NEJM 1995; 332: 1507–9.
54. Vanpee D, Frenay M, Godin V, Bedard D. What can bring the authentic situated learning and teaching theoretical framework to optimize the education quality of clinical clerkships? Ped Med. 2010;10:253–66 (in French).
55. Sanson-Fisher RW, Rolfe IE, Williams N. Competency based teaching: the need for a new approach to teaching clinical skills in the undergraduate medical education course. Med Teach 2005; 27: 29–36.
56. Ryan S, Higgs J. Teaching and learning clinical reasoning. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. 3rd ed. Edinburgh: Elsevier; 2008. pp. 379–88.
57. Nendaz MR, Charlin B, Leblanc V, Bordage G. Clinical reasoning: from research findings to applications for teaching. Ped Med 2005; 6: 235–54.
58. Bowen J. Medical education: educational strategies to promote clinical diagnostic reasoning. NEJM 2006; 355: 2217–25.
59. Sefton A, Gordon J, Field M. Teaching clinical reasoning to medical students. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. 3rd ed. Edinburgh: Elsevier; 2008. pp. 469–78.
60. Lajoie S. Transitions and trajectories for studies of expertise. Educ Res 2003; 32: 21–5.
61. Langevin S, Hivon R. Why clerkship does not adequately fulfil its educational mandate? A qualitative study based on a systematic analysis of the literature. Ped Med 2007; 8: 7–23.

***Thierry Pelaccia, MD, PhD(c)**
Prehospital Emergency Care Service (SAMU 67)
Centre for Emergency Care Teaching (CESU 67)
Strasbourg University Hospital
1 place de l'Hôpital, 67000 Strasbourg, France
Tel: +33 6 03 78 03 28
Email: thierry.pelaccia@wanadoo.fr