

## **Prepublication Manuscript:**

**May, S.A. (2013) Clinical reasoning and case-based decision-making: the fundamental challenge to veterinary educators. Journal of Veterinary Medical Education 40, 200-209.**

# **Clinical Reasoning and Case-Based Decision-Making: The Fundamental Challenge to Veterinary Educators**

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## **Key words**

Clinical reasoning, scientific reasoning, type 1 reasoning, type 2 reasoning, generic reasoning, clinical bias, case-based decision-making, clinical expertise, clinical education.

*Medicine is the “practice of an art which consists largely in balancing possibilities.... It is a science of uncertainty and an art of probability... Absolute diagnoses are unsafe and made at the expense of conscience”.*

*“To study the phenomenon of disease without books is to sail an uncharted sea, while to study books without patients is not to go to sea at all.”*

Sir William Osler

## **Abstract**

Confusion about the nature of human reasoning and its appropriate application to patients has hampered veterinary student development of these skills. Expertise is associated with greater ability to deploy pattern recognition (type 1 reasoning), and this is aided by progressive development of data-driven, forward reasoning (in contrast to scientific, backward reasoning), analytical approaches that lead to schema acquisition. The associative nature of type 1 reasoning makes it prone to bias, particularly in the face of “cognitive miserliness”, when clues that indicate the need for triangulation with an analytical approach are ignored. However, combined reasoning approaches, from the earliest stages, are more successful than one approach alone, so it is important that those involved in curricular design and delivery promote student understanding of reasoning generally and the situations in which reasoning goes awry, and develop student ability to reason safely and accurately whether presented with a familiar case or a case that they have never seen before.

## Introduction

In an ideal world, every patient would display unambiguous signs of disease conforming to classical text-book descriptions, and the clinician's pharmacy would be an assembly of rational and efficacious therapeutic agents which would collectively address all the diseases of the animal kingdom! Unfortunately, the ideal world is not the real world, and a series of limitations relating to all aspects of diagnosis and therapy make veterinary medicine (like medicine) "a science of uncertainty". Arriving at the most likely diagnosis, "best" treatment and most informed prognosis is a high order skill. It requires synthesis and interpretation of a variety of data and, in many cases, re-evaluation in response to therapy. It has been argued that "the killer application of the human brain" is judgement<sup>1</sup>; case-based decision-making at its best is one of the supreme examples of human judgement.

Achievement of diagnostic, therapeutic and prognostic expertise presents a formidable challenge to veterinary educators and their students. Experience over many generations (articulated eloquently by Sir William Osler) has taught that the skill of clinical reasoning is gained through ever broadening and deepening knowledge and understanding developed alongside exposure to patients<sup>2,3</sup>. However, the "ideal" blend of classroom and clinics, and the nature of the pedagogical bridges between classroom and clinical learning and practice are rarely discussed in the detail that they deserve. Veterinary educators often think that exposure of students to laboratories and clinics results in students developing the reasoning skills that their mentors possess. Yet feedback from graduates frequently reveals a very different story (Table 1). The educational environment is complicated by students receiving mixed messages when clinical reasoning is discussed. As modernising curricula introduce both formal learning and assessment of clinical reasoning, students in one school have complained that they are being told in the clinics that they should not engage in "pattern recognition" but that the assessment is pushing them to think in that way<sup>4</sup>.

The intention of this paper is to explore the elements involved in clinical reasoning and case-based decision-making, expose some of the myths that have arisen over what students should and should not do, and demonstrate how sound pedagogical principles can guide those involved in curriculum design and delivery in this fundamental area of student learning.

## The Scientific Basis of the Profession

Although the "Social Contract" that underpins the health professions, including veterinary medicine, is based on clinical practice rooted in science<sup>5,6</sup>, it is important to distinguish scientific reasoning from clinical reasoning, so that the strengths (and weaknesses) of each can be recognised. The scientific method is one of the most powerful ways of answering questions about the natural world, but it is restricted to areas where "scientific questions" can be clearly framed and technology exists for conducting tests. It conforms to modern "scientific method" and the philosophy of "falsificationism"<sup>7</sup>. This is very different from the context provided by much of clinical practice. Schön<sup>8</sup> has characterised "the varied topography of professional practice" as a terrain consisting of "high, hard ground overlooking a swamp", where problems can be addressed by scientific theories and techniques, and "swampy lowland", where problems are confusing and messy, and not amenable to scientific method. Scientists can choose the area in which to work according to their expertise and available methods, and do not need to announce any conclusions until content that all avenues have been explored. In

contrast, clinical practitioners must address the problems presented by their clients. They are unlikely to be experts on every case, yet conclusions are required on which to base action, and decisions on action may need to be taken in the face of incomplete data sets.

Thus science contributes the provisional knowledge base (constantly being updated) that informs evidence-based practice, and demonstrates the strength of disciplined study in arriving at defensible conclusions, but it does not provide the methods that contribute to clinical reasoning and case-based decision-making. Science starts with the hypothetical answer and works backwards, in a process of hypothetico-deductive logic, to check that all the elements present are as predicted. In contrast, much of clinical reasoning starts with the problem and works forwards, probabilistically, through a process of inductive logic, to the likely answer<sup>9</sup>.

Of course, the scientist and the practitioner are not necessarily separate as discussed here for contrast. Particularly for academic clinicians, these can be seen as the "two minds" of the practitioner<sup>10</sup>, depending on the context in which they are working and the nature of the problems being addressed (Table 2).

### **The Human Capacity for Reasoning**

Psychologists distinguish two domains of human reasoning, now simply referred to as type 1 and type 2<sup>11,12,13</sup>. The type 1 domain embraces categories of thinking that are non-analytical and involved in rapid decision-making, often based on associations with past events. It has been variously referred to as intuitive and "pattern recognition". In contrast, the type 2 domain, seen as distinctively human, embraces those categories of thinking that are reflective and analytical, permitting hypothesis formation and abstract reasoning. Use of methods of thinking that belong to this domain has been variously referred to as the "first principles", scientific and rational approach to reasoning. Type 2 reasoning uses short term working memory, is cognitively demanding and relevant to novel situations. No-one could get through their day if they had to engage in this form of reasoning for every decision. Therefore most daily decisions are based on type 1 thinking. Although type 1 reasoning is deployed to solve problems, it relies on solutions that have already been generated<sup>14</sup>.

Thus, for all, life represents a blend of type 1 and type 2 reasoning, with learning taking place as type 2 generated solutions are retained in long term memory to be deployed in type 1 processes. However, it is important to consider how individuals learn to tackle more and more complex problems as their knowledge and skills in a given area develop. Type 2 reasoning is limited by working memory capacity, and if problems are too complex this will be overloaded. One strategy is to engage individuals in simplified versions of a problem for which they can deploy the cognitive resources. This involves removing the extraneous load (the detail not related directly to the problem itself) so that the intrinsic load (that related to solving the problem) and the germane load (that related to the associated learning) is within an individual's cognitive capacity<sup>15,16</sup>. Once the method has been learned, this can be recalled for future related problems, so working memory can then cope with more complexity and novel features.

In relation to learning, it is relevant to consider the mental representation of what has been learnt. Concept learning seems to be based on mapping to prototypes<sup>17</sup>, that can be used as staging posts for more general abstraction or exploration of detail. As knowledge and skill in an area increases such

prototypes can act as the framework for organising this knowledge, so that, for clinicians, pathophysiological knowledge is “chunked” into higher concepts<sup>18,19</sup> in ways that mean that it can be applied to problems without conscious recall of all the elements separately<sup>20,21</sup>. It is important that these “simplified mental models”<sup>18</sup> are distinguished from a superficial approach to clinical knowledge. Expert physicians may not use biomedical knowledge explicitly in arriving at diagnoses, but research has shown that it is still there in the background, underpinning their diagnostic knowledge<sup>22</sup>.

The ways in which the two types of reasoning systems work allow both their strengths and their weaknesses to be anticipated. All decision-making requires some form of emotional engagement with the problem and its solution<sup>23</sup>, but, in the face of emotional influences, the associative nature of type 1 strategies potentially makes them more prone to error than type 2 reasoning. For instance, choices that create positive emotions, and are seen as beneficial, will be seen as associated with less risk than objective analysis would justify, and the opposite is true for choices creating negative emotions. Similarly, contexts that evoke images or allow the creation of “stories”, such as numbers of dead individuals, lead to different conclusions from those reached following consideration of more abstract data such as percentages<sup>12</sup>.

The potential biases associated with type 2 reasoning systems are associated with the way rule-based, often mathematical approaches are particularly valued in science. There is a tendency to see patterns where these do not exist, and to create equations to fit the data. This can mean that equations that, at best, have only local relevance and, at worst, are no more than descriptive are used prospectively as rules to guide future decision-making, with sometimes disastrous consequences such as that seen in recent economic planning<sup>24</sup>.

### **The Nature of Expertise**

An understanding of the two categories of reasoning, and the recognition that solutions of previously encountered problems are stored for future use, is key to understanding the nature of expertise. Much of the twentieth century was dominated by a focus on general reasoning skills as the key to human intelligence, and this remained the basic assumption until about the mid-1970’s, when cognitive research revealed that expertise was essentially domain-dependent<sup>25</sup>. By the 1980’s, through studying airline pilots, chess players, car drivers and adult learners of a second language, Dreyfus and Dreyfus<sup>20</sup> were describing five stages in the development of expertise which they characterised as: novice, advanced beginner, competent, proficient and expert.

Passage through the first three stages is associated with increasingly sophisticated, rule-based and analytical approaches to reasoning, as well as a recognition of responsibility for action absent in the novice. In general, when cognitive scientists refer to analytical problem-solving, they are describing the thought processes of the competent individual. In contrast, the last two stages are characterised by rapid “holistic similarity recognition” or pattern recognition. This does not mean that the expert never thinks! However, when the expert does think, it is qualitatively different from the competent person, as a result of the successful deployment of more type 1 approaches to reasoning.

The distinction between “novice” and “expert” (not to be confused, although it often is by students, with “specialist” – a general practitioner can be an expert clinician in their area of practice) is important in understanding how the accomplished professional develops and also the potential “weaknesses of expertise” associated with type 1 systems of thinking! Experts make mistakes in different ways from novices, partly as a result of failures and limitations of expert logic systems, and the vulnerability of these to bias. Yet if an individual never proceeds beyond the stage of competence, however good they may become at analysis and application of rules, they will never excel in any discipline. Some mathematicians who work hard at chess will always be beaten by young more intuitive players as type 1 reasoning outplays the type 2 reasoning approaches which their mathematical brains will not allow them to abandon<sup>20</sup>!

### **Clinical Expertise**

Similar pathways (Table 3) have been described in the development of medical expertise<sup>18,26</sup>. Schmidt's first two (out of four) stages, centred on causal networks, have many similarities to the novice-competent levels of Dreyfus and Dreyfus. The analysis is deliberative, and, in the case of elaborated networks, involves the searching and elimination of much redundant material before a conclusion can be recorded. In contrast, at stage three, the clinician has become problem-focused, and a diagnosis is made as a result of similarity with remembered generic illness scripts arising from experience of past problems. At stage 4, the clinician not only remembers the generic illness scripts but also instance scripts, related to individual past patients. Schmidt's two higher levels of clinical reasoning are, like that of the Dreyfus' expert, associated with rapid pattern recognition. Similarly, Coderre's hypothetico-deductive and schema-inductive levels map to a basic scientific approach and an analytical, but more advanced, problem-oriented approach, and beyond this clinicians are seen as engaging in pattern recognition.

Expert clinicians, like chess players and experts in all other domains, assemble information into “chunks” which aid memory and further learning<sup>18</sup>. They take decisions based on similarities in patterns, and, in many cases, may not be able to explain, in fundamental terms, the reason for the decision. Crucially, to a consideration of education, this means that the expert is not necessarily a good teacher! So this detailed consideration of how to help students develop their reasoning skills is as relevant to the experienced teacher as those new to teaching.

An understanding of expert reasoning confirms that once a problem has been seen and solved it is no longer a problem<sup>27</sup>. It becomes a pattern to be remembered for next time. However, experts demonstrate more evidence of analytical problem-solving when faced with difficult problems<sup>21</sup>. Experts will then indulge in alternate forward and backward reasoning and the use of basic science principles, all behaviour associated with non-experts. This suggests that an expert presented with unfamiliar problems resorts to strategies appropriate to a lower level of the novice-expert hierarchy.

### **Generic Reasoning Skill**

An inevitable question from those whose early schooling took place when generic reasoning models were dominant, is do such skills exist?! As indicated above, much attention, in the last 20 years, has been paid to expert reasoning at the level of pattern recognition, but very little to the behaviour of experts in unfamiliar territory. However, in the 1980's, cognitive researchers identified individuals

who could be classified as “intelligent novices”<sup>25</sup>. Such individuals, who could solve novel problems in unfamiliar domains more expertly than most, seemed to have greater understanding of their own thought processes (metacognition) than others. In particular, they were aware of: the difference between understanding and memorising, the need to solve problems to help with understanding, and areas in which expert guidance was required<sup>28</sup>. Less skilled learners and reasoners did not seem to appreciate the difference between memorisation and comprehension, could not distinguish between difficult and easy texts, and did not use self-questioning and self-tests to help improve deficient learning and reasoning strategies.

Recently, attempts have been made to separately identify "content-independent" ability in clinical problem solving. In a study involving medical students, on ten different clerkships/rotations, structural equation modelling demonstrated that in some contexts nearly 40% of reasoning seemed to relate to general problem solving ability<sup>29</sup>.

### **Combined Reasoning**

The association between metacognition and generic reasoning should not go without comment, as this is critical to both learning and accuracy. A part of early school learning in arithmetic involves the ability to round complex numbers so that the calculation can be performed mentally to cross-check the answer of a fully worked example on the page, to ensure that the answer has the right form and order of magnitude. Simple, low-cost purchasing decisions may be made with little reflection, but although a rapid conclusion may be reached for more expensive items most would triangulate this with an analytical perspective before confirming a purchase. This principle of triangulation is as relevant to establishing the reliability of a decision as it is to the reliability of a piece of information or a conclusion reached during a research project<sup>30</sup>.

The success of a combined strategy, involving pattern recognition and an analytical approach, has also been demonstrated in experimental studies involving novices tackling clinical problems<sup>31</sup>. Participants who were instructed to trust their sense of familiarity, but then cross check by a closer examination of the features of the case, were more successful than those who used either a feature-first or familiarity-based approach alone. Two key educational lessons emerged. In exploring possible reasons for the failure of the feature-first approach, the authors were struck by the possibility that "diagnosticians who try to objectively list features without the guidance of diagnostic hypotheses can be led astray by finding themselves awash in a list of features that cannot be reconciled into a coherent diagnostic entity", probably related to cognitive overload. In contrast, participants were able to revise initial incorrect, familiarity-based diagnoses by a subsequent consideration of the features of the case.

It is also suggested that, particularly once case outcomes are known, this triangulation approach should involve reflection on the emotions associated with pattern recognition, to check whether a preference for a particular decision was justified. This may stimulate and allow “emotional revision” so that these changed associations lead to more appropriate judgements in the future<sup>23</sup>.

Given the success of combined strategies, it is humbling to recognise that the reason that these are not more routinely deployed is the human capacity for “cognitive miserliness”<sup>32</sup>. The cognitive miser will mislead themselves by substituting “the less effortful attributes of vividness or affect” in various

situations for “the more effortful retrieval of relevant facts”<sup>33</sup>, and avoid the cognitively demanding further analysis that a case may clearly require. Cognitive miserliness has led to the inappropriate deprecation of type 1 reasoning, and the suggestion that students should only be taught type 2 approaches. Work on combined reasoning strategies supports the view that type 1 approaches have a central role in clinical reasoning, provided that type 2 data-driven, forward reasoning is always available as a cross-check if there is any doubt.

## **Clinical Education**

With the increased complexity of the clinic as a learning environment and greater “day one skill” expectations of clinical graduates, important considerations for those involved in curriculum design and delivery are the bridges provided between the classroom and the clinics and sequential skills development throughout the professional curriculum<sup>34</sup>. This is made possible with integrated courses. For many years, a key “pivot point” in traditional professional programmes has been seen as a problem for learners; sometimes referred to as “the preclinical/clinical divide”<sup>35</sup>, this is the point at which students stop being taught “backwards”, from textbook lists of diagnoses, and start being taught how to work forwards from problems towards answers. Helping students navigate this change in the way they frame their knowledge, or avoiding the necessity for this transition, is at the heart of our fundamental challenge as educators. One solution is problem based learning (PBL). PBL establishes the problem as the starting point, and trigger for identification of required knowledge and data collection. However, although originally seen as an improved way of developing clinical reasoning, it is increasingly clear that this is not the case or only marginally so<sup>36,37,38</sup>. This may relate to PBL students being taught hypothetico-deductive reasoning as a dominant learning strategy in their early years, and continuing to use this even when the cognitive load becomes difficult to support, impeding the acquisition of data-driven schemata<sup>39</sup>. The main advantages of PBL in medical education appear to be greater engagement of students in their own learning, leading to superior interpersonal skills and retention of knowledge compared to the assessment-driven tendency to a “learn and forget” strategy seen with traditional programmes<sup>40</sup>.

This supports the view that, in all types of course, explicit attention to data-driven, forward reasoning, and how it contrasts with the hypothetico-deductive scientific method, is appropriate from the earliest stages. Students need to be made aware that although they may start by learning about specific diseases, lists of these are not where they should start in solving cases. In the first instance, prototype theory suggests that students should be learning key exemplars, and then turning to how the diagnostic process flows through to these rather than, as was common in the past, long lists of “differential diagnoses”.

## **The Problem-Oriented Case Analysis**

The problem-oriented case analysis is a disciplined approach to collecting clinical data, and framing data-driven forward reasoning. The best known format is the “SOAP” (Subjective Objective Assessment Plan) system used for many years in a number of veterinary colleges. Its periodic application recognises the changing nature of an individual condition and the need to constantly update the treatment plan and prognosis. The distinction between “subjective” and “objective” data

usefully focuses attention on the weakness of each, and regular re-“assessment” highlights changes in the problem list, and thus the list of potential diagnoses. This ensures that the current “plan” is the best available, using the up-to-date evidence.

The exhaustive nature of the problem-oriented case analysis should make it an extremely reliable method of clinical analysis. However, the danger is that it is taken to extremes and for novice students in particular it represents a large volume of “noise”, leading to cognitive overload. The key message for students is the balanced approach of the experienced clinician, for whom clinical experience has rapidly identified areas of redundancy<sup>9</sup>, relating to type of animal, its management, and the past history of the individual or herd involved. The problem-oriented case analysis can easily end up as a “focusing approach”, where a large amount of data of all types is collected, which the clinician uses to narrow down, in some cases, multiple lists of “differential diagnoses”<sup>41</sup>. Most experienced clinicians use a “scanning approach”, which incorporates elements of “pattern recognition”, whereby they simultaneously assemble case data and a possible diagnosis, using the data to inform the diagnosis and the diagnosis to direct data collection. At a later stage, the clinician may apply objective tests for “reassurance” that the working hypothesis was correct. This is more in line with the combined approach of similarity-based reasoning followed by the fundamentals-first analysis demonstrated as effective even for novices<sup>31</sup>.

### **Bridging to the Clinics**

It is increasingly clear that the distinction between pattern recognition and scientific reasoning, as representing all analytical thinking, has been unhelpful. Both the hypothetico-deductive (scientific) approach and inductive logic are analytical, and it is the latter that best supports the development of clinical reasoning skills<sup>9,21,22</sup>. Therefore, as already indicated, the key focus for students needs to be data-driven, forward reasoning, involving analytical approaches that lead progressively to schema acquisition and expertise, rather than hypothesis-driven strategies that frequently lead to poorer quality problem solving<sup>42</sup>. This means that the area in the diagnostic process where students need to work hard is at the level of the clinical signs, and the systems affected in their patients, and not, in the first instance, the level of lists of diagnoses (Table 4). They need to recognise the primary system involved and how it is affected (e.g. structurally and functionally), and in identifying abnormalities in other systems decide if these are secondary to the primary problem or unrelated. They need to ensure that they understand the nature of the signs and how they are connected and refine the list as they proceed. They need to distinguish vomiting from regurgitation, and urinary frequency from urinary leakage/overflow. This allows the student to start to “tell the story of the case”, so that “the signal” starts to emerge from “the noise”. As students become more familiar with these patterns, diagnostic ideas will emerge, and the accuracy of the final diagnosis is associated with clinician use of higher order concepts (linking clinical signs and the temporal nature and distribution of disease) and better understanding of relationships between concepts<sup>19</sup>. An important part of this is the accurate description that preceded the diagnostic ideas, and this emphasises the need for ensuring that students take a disciplined approach to accuracy and precision in describing signs and lesions. A problem well-described is a problem half solved, so it is important that students do not come to think of pointing at abnormal findings on radiographs or sloppy descriptions of pathological material as helpful to their development as clinicians. This sort of discipline means that, as they are assembled, illness and instance scripts are finely tuned in terms of the diseases to which they are attached.



Uncertainty is present throughout the diagnostic process. Many of the data which will form the basis of a diagnosis are subjective (existing in the mind of the person who makes the judgement). Such information is prone to bias of an animal owner, in the case history, and the clinician, in the clinical examination, which will be determined by the knowledge, experience and prejudices of the individuals involved. Therefore, the logical way to progress from the initial physical examination is clinically relevant further tests, such as diagnostic imaging and analysis of biological fluids, in order to confirm the system involved and clarify the nature of the abnormality. Clinical relevance is important in this context, as it has a profound effect on the value of the test results. Diagnostic tests are rarely 100% sensitive and 100% specific for the variable being measured, so these objective data have inherent uncertainties which may be misleading if not properly recognised. If the clinical signs point to a particular condition (the test is being used in "diagnostic mode"), the relative proportion of false positives generated by a test compared to true positives will be small. However, if on admission the call was "let's do bloods" (the test is being used in "screening mode"), the proportion of false positives will be much higher with students often focusing on this "noise" rather than the original presenting signs. Of course, the recognition of this is not new - *"good medicine does not consist in the indiscriminate application of laboratory examinations to a patient, but rather in having so clear a comprehension of the probabilities and possibilities of a case as to know what tests may be expected to give information of value"*<sup>43</sup> - but the tendency to practise defensive medicine in the modern clinic can mean that an approach is modelled for the student that undermines the messages they are receiving about the responsible approach to case-based decision-making.

Introductory classes to clinical reasoning need to take account of the cognitive load for students and immediately move them from hypothetico-deductive methods associated with their basic science backgrounds to an approach that models forward reasoning<sup>9</sup>. It makes sense to start with single system problems, with relatively unambiguous signs, stripped of any un-related patient history, and build from these to more complex multi-system problems. Ultimately, in the clinics, the students must be exposed to the full complexity of the information associated with real patients with real owners, and learn to discriminate between the relevant and irrelevant data as they refine their definition of the animal's problem. Some thought given to the intrinsic cognitive load for students, and the control of any extraneous cognitive load, as they progress, will allow educators to "scaffold" student learning to make their learning in clinical reasoning as effective as possible<sup>44,45</sup>.

### **Biases in Clinical Reasoning**

Bias is defined as a "predisposition, predilection or prejudice" towards a specific outcome (Shorter Oxford English Dictionary), and this distinguishes it from chance, and random errors. As already indicated, clinical reasoning is particularly vulnerable to bias because of the incompleteness of our fundamental knowledge and the data sets on which decisions are being made<sup>46</sup>. In addition, the processes of type 1 and type 2 reasoning are each prone to types of bias that it is useful for all involved in clinical reasoning to be aware of in order to minimise the likelihood of their occurrence.

The non-analytical system is the one in which cognitive miserliness comes to the fore. It links patterns to emotional states so that decisions are made based on the degree of comfort an individual may feel with the chosen solution (in the case of chess this is sometimes the move with which the individual feels least uncomfortable)<sup>20</sup>. This means that emotion can easily mislead individuals into

non-optimal solutions, although novices and experts may be affected slightly differently according to their underlying knowledge and experience. Examples for novices, who lack domain knowledge, are “focus gambling”<sup>41</sup>, seizing on the only possible diagnosis that they know anything about, and confirmation bias<sup>47,48</sup>, when they try at all costs to “prove” that the presumptive diagnosis is correct. At the opposite end of the spectrum, a bias known as “gamblers’ fallacy” may be recognised in experts in their field. This is named after the tendency for gamblers to believe that after a string of heads, a coin is more likely to land tails on the next throw. Thus, a clinician may apply their knowledge of the prevalence of a disease to series of patients, despite the evidence of their individual ailments. A striking example of gamblers’ fallacy was demonstrated in a study performed in New York in the 1930s<sup>49</sup>, in which expert ear-nose-throat surgeons continued to recommend tonsillectomy for a proportion of children in a group despite the previous removal, by other experts, of all children for whom this might have been appropriate!

Type 2 reasoning is regarded as less prone to bias than type 1, and it is essential that experts and novices alike are aware of the need and have the capacity to resort to analytical reasoning when cases are difficult. However, it is incorrect to suggest that analytical reasoning is free from bias. The fact that it uses rules means that it is prone to error in contexts where rules do not apply. For instance, simple rules based on the numbers of abnormal parameters identified in a case of equine colic can be used as an aid to deciding if the case needs surgery or can be treated medically. However, an expert will recognise, based on their series of illness and instance scripts, cases that need immediate surgery despite a failure to reach the threshold in terms of numbers of abnormalities.

### **Case-Based Decision-Making**

It is important that any consideration of professional reasoning does not conclude with clinical reasoning focused on the patient problem. In addition to a primary responsibility to the patient, the veterinarian also has a responsibility to the owner, society and the profession<sup>50,6</sup>. Veterinarians have a difficult balancing act to achieve between their role as “a paediatrician”, in some circumstances acting as a patient advocate in the face of competing owner demands, and their role as “a garage mechanic”, taking into account legitimate owner-related factors while at the same time guarding animal welfare<sup>5</sup>. Their vocation means that veterinary students are more oriented toward the paediatric role (May and Ogden, unpublished data), and a danger of them receiving initial exposure to patients in university teaching hospitals is that they see a high proportion of cases that are hospitalised, so the owner is absent, and a high proportion of cases that are insured or have wealthy owners. This can lead to cases being seen as “a renal condition” as opposed to a whole<sup>51</sup>, and clinical reasoning alone being confused with case-based decision making.

Therefore, in parallel with classes aimed at the sequential development of clinical reasoning, it is important to introduce students to and help them develop systems that aid the resolution of ethical dilemmas<sup>52</sup>. The approach of many veterinary students to ethical issues is to follow the lead of their seniors, or to go, like medical students, with “the time-honoured tradition of using your gut reactions”<sup>53</sup>. While the latter may yield an appropriate outcome in most situations, it is once more the type 1 thinking that should be cross-checked with a type 2 approach, particularly when options seem finely balanced. An ethical matrix can be used to map the stakeholders and their interests in relation to the major theories of normative ethics such as utilitarianism, deontology and individual

autonomy<sup>54</sup>. The matrix approach can also help students resolve issues they themselves may have in relation to legal requirements and the economics of animal care and practice.

## **Conclusions**

Considerable attention has been paid, in recent years, to the development and assessment of technical day one competences, and how clinical skills laboratories can act as bridges from the classroom to the clinic<sup>55,34</sup>. Similar attention has been paid to some of the non-technical skills, in particular communication<sup>56,57</sup>. However, a lot less attention has been paid to the explicit development of clinical reasoning and case-based decision-making, and the pedagogical design of classes that provide the bridge for this skill into the clinics. It is argued that attention needs to be paid to the process of helping students define and refine problems based on clinical signs, identify data redundancy in relation to patient information and thus reduce “noise” that may reduce diagnostic accuracy, and form accurate mind-maps of patterns important to efficient and effective diagnosis.

Many of the problems that students face relate to a lack of clarity on the part of clinicians about the distinctions between pattern recognition and analytical approaches, and scientific and clinical reasoning. Clinicians may not be explicit when they simultaneously adopt more than one approach to reasoning in a case, and may also fail to distinguish between clinically-indicated testing and defensive medicine, both when this is built into hospital protocols and a part of the individual clinician’s approach.

Some of the “mixed messages” students receive relate to clinicians’ practice being so automated that they do not recognise the reasoning processes that they are using themselves, or even incorrectly explain what they are doing (e.g. suggest they are using scientific method when they are using pattern recognition). Others relate to a misunderstanding of the strengths of pattern recognition and its use as a combined strategy, even by novices. Therefore, in addition to including more attention to explicit teaching of clinical reasoning and case-based decision-making in modern curricula, it is important that all involved in their delivery, at both classroom and clinic levels, have a knowledge of the basic processes involved, as well as pedagogical strategies for developing this central, high level skill in their students.

## **Acknowledgements**

I would like to pay tribute to all those great clinical teachers that I have encountered over the years who discovered empirically some of the approaches to teaching clinical reasoning which the evidence now supports. In particular, I would like to thank Jill Maddison and David Church for all the stimulating discussions we have snatched over a cup of tea or coffee, as collectively we have striven to move the agenda forward in this vital area.

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Table 1

### **Graduate Reflections on Clinical Reasoning**

*"I believe that as graduates we would be better equipped if there was more problem solving and application of key knowledge in university, rather than a tendency to rote learn information without context, in order to pass exams."*

Australian school graduate 2005

*"As a new graduate, starting out in practice, my clinical reasoning skills were very limited. During my time at University, there was little thought or time given, either by myself or my tutors, to the acquisition of these skills."*

English school graduate 2000

*"Clinical training at veterinary school immerses students in huge volumes of clinical theory and textbook like instruction on procedures and investigations. At the time these appear overwhelming and complex. As a newly qualified veterinary surgeon, my clinical reasoning skills were minimal and certainly not at a stage that allowed independent work"*

Scottish school graduate 2003



Table 2

**The “Two Minds” of the Practitioner**

<b>Scientific Method</b>	<b>Clinical Practice</b>
Objectivity	More subjectivity
Observer stands outside process (3 <sup>rd</sup> person, abstract discussion)	Clinician is an integral part of process and outcome (1 <sup>st</sup> person, reflection)
Expert	Not an expert in all encounters
Thorough background research	Core knowledge
Choice of area, avoids emotional involvement and prejudice	May find some cases distasteful
Only scientific questions – scientifically framed and technology available	“Messy” problems of real life
Only techniques in which competent/time to achieve competence	Solution may not be one in which operator has optimal practical experience, e.g. emergencies
Saturate data requirements	Incomplete datasets
Conclusion only reached if sustainable	Must act in absence of complete knowledge/data

Table 3

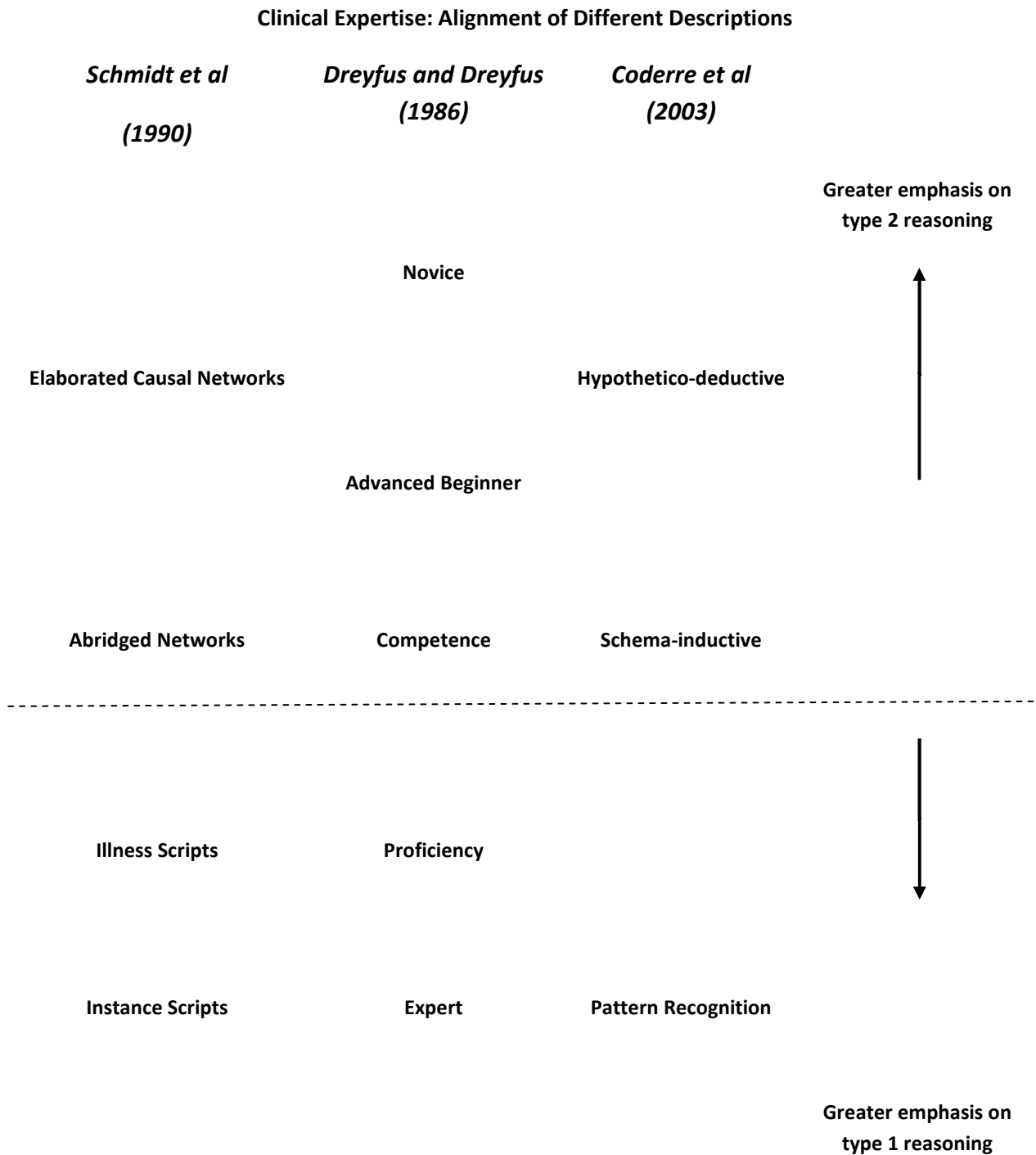


Table 4

### Forward Reasoning Model: Educational Interventions

- Sight
- Hearing
- Smell
- Touch
- [Taste?!]

Observation	Signs	System (Location)	Type of Lesion (and relationship between lesions)	Cause
<ul style="list-style-type: none"> <li>• Need observation skills – innate/developed</li> <li>• In some cases, aided by checklist (systems approach to radiographs)</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Work hard at signs, e.g. regurgitation v. vomiting; frequency v. leakage/overflow</b></li> <li>• Ability to describe accurately (avoid verbal vagueness and pointing!)</li> <li>• Distinguish observation/interpretation                             <ul style="list-style-type: none"> <li>- Fuel gauge</li> <li>- Clouds</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Focus reasoning here, not “differentials”</b></li> <li>• Also other systems:                             <ul style="list-style-type: none"> <li>- Secondly affected</li> <li>- Unrelated lesions</li> </ul> </li> <li>• Start to “tell the story”</li> <li>• Audit – check everything fits:                             <ul style="list-style-type: none"> <li>- Complex system</li> <li>- Individual variations</li> </ul> </li> <li>• Then eliminate other areas; do not just look for confirmation of prejudices</li> </ul>	<ul style="list-style-type: none"> <li>• Honesty on how far clinical diagnosis can go, i.e. mass – cancer / inflammation – will depend on biopsy)</li> <li>• Use “tests” to confirm systems involvement / type of lesion, rather than to “fish” for diagnosis</li> </ul>	<ul style="list-style-type: none"> <li>• Start with prototypes for categories of disease [Need to prevent clever students guessing diagnosis and doing textbook description on rest!]</li> <li>• Do we actually need to know diagnosis of treatment/management already clear? *</li> <li>• Is it appropriate to carry on just to put name to condition? *</li> </ul> <p>[* Both further tests and treatment may be “clinically indicated” but not justified by finances/ethics for animal or owner.]</p>

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