Chapter 3
Decision Theory and Aids to Medical Decision Making

“Not everything that counts can be counted, and not everything that can be counted counts.” (Einstein).

3.1 Introduction
In keeping with the hermeneutic phenomenological approach of this thesis, I begin this section by briefly describing some of the prejudices or prejudgments that I brought to the research. As a practising dentist I had been engaged in practical clinical reasoning and decision making every working day for several years. These were practical, mainly cognitive skills embedded in workplace experiences. I eventually developed a professional interest in computing and from that an interest in the applications of computers in medical education. This, in turn, led me into the world of designing computerised systems to support or teach clinical reasoning, which held my interest for some time. I was convinced that computers held great promise for significant improvement both in the teaching of clinical reasoning and in assisting clinicians reason in practice. Over time, a growing unease led me to question this conviction. This was due to the realisation that, in the general excitement over the new technology, too much was being expected from it. The computer was expected to provide solutions to many problems, such as turning novices into experts. I eventually realised that a large part of the problem was that the computer was being used as a metaphor for the function of the human mind. At first, this seemed like a promising way to think of cognition, but, as my understanding of computers grew, I realised there was a major underlying weakness of this approach. This limitation is that human beings rarely think in a manner comparable to the operations of a computer, particularly not in relation to the types of human concerns that arise in clinical practice. I now believe the metaphor of cognition as computation is misleading. This metaphor is oversimplistic, superficial, and too mechanistic. This awareness in turn led me to read more widely in other subjects such as medical anthropology and philosophy. I came to the belief that we need new and better metaphors for cognition and clinical reasoning than the computer. It was in this frame of mind that I approached the literature on clinical reasoning.
Mainstream medicine tries to be scientifically objective and to explain subjective symptoms in terms of an empirico-analytical view of knowledge. This view and its assumptions can be inappropriate when applied to conditions which need a broader understanding of what is happening to patients, especially those with chronic conditions where mind, culture and body all interact strongly (Chiong, 2001). Aronowitz (2001) discussed the extent to which social influences largely determine which symptom clusters become labelled as diseases, presenting examples to show the degree to which historical accident and epistemology influence disease concepts. Maudsley and Strivens (2000) reviewed the concepts of science, critical thinking and competence, arguing that the scientific basis of medicine is fallible, and that clinical reasoning can be characterised as either art or science. It is my view that much more attention needs to be paid to clinical reasoning as a professional art, an art based within the meaningful lifeworld of the clinician involved, and learned within an intersubjective community of practice. However, this view of clinical reasoning appears to be a minority view, judging by the work published on the topic.

There is a substantial body of literature which views clinical reasoning, especially diagnosis, as a strictly utilitarian process, involving rationality and logic almost to the exclusion of other factors; and that the computer offers a way of both conceptualising and implementing this process. In this chapter I critique this body of literature. To many in the world of medicine in particular, clinical reasoning research means the research which forms this body of literature. Indeed, when I discussed this research with medical colleagues, nearly all immediately presumed I was involved in conducting the type of research that uses probability mathematics and logic as a theoretical lens. There is an underlying assumption that there exists a standard of idealised rationality, which can achieve a maximisation of expected value (Elstein, Schwartz, & Nendaz, 2002). In other words, clinical decisions can be assessed in a quantitative manner, with decisions that achieve higher scores being judged as better. Another assumption that appears to underlie this literature is that the probability approach is the obvious and only way in which

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1 The single word lifeworld is a direct translation of the German *lebenswelt*. German is an agglomerative language that permits such practice. A strict English translation should be life world. However, it seems that lifeworld has now become accepted usage in English phenomenological texts, and this practice will be adopted in this thesis.
clinical reasoning will ever be understood or improved. I now disagree with this approach
to clinical reasoning. Rather, it is my contention that probability data is one of the many
sources and types of information that needs to be considered in making clinical decisions
that are best practice for a given patient in a given situation. Despite this stance, and since
probability is the basis for such a substantial portion of clinical reasoning research,
together with the background from which I came, I feel it is incumbent upon me to
discuss and critique it.

The probability-based body of literature on clinical reasoning can be grouped under the
general heading of medical decision making, and it constitutes a distinct paradigm within
the clinical reasoning literature (Sox, Blatt, Higgins, & Marton, 1988). It is derived from
economics, which is another field where decisions must be made under the influence of
many variables and a great deal of uncertainty. The literature on the subject can be
subdivided into three groups. Firstly, there is work that seeks to be normative or
prescriptive. That is, there is an attempt to establish what clinicians should be doing to
make the best decisions within the paradigm. Secondly, there is so-called descriptive
work, the aim of which is to describe how and why clinicians make the decisions they do.
Finally, there is work on prescriptive decision supports, of one sort or another. In that
work there are attempts to close the perceived gap between the normative and the actual
situation as conceptualised within this paradigm. These various approaches to
understanding medical decision making are discussed below.

3.2 Normative Decision Making
Normative decision making emphasises quantifying the key decisions that comprise
diagnoses, treatment plans and patient management, and determining formal,
mathematical procedures that can optimise patient management outcomes. In this
approach it is recognised that dealing with uncertainty is frequently a key aspect of
clinical reasoning. However, this approach uses probability mathematics to deal with this
uncertainty, with the claim that “numbers express uncertainty precisely” (Sox et al., 1988,
p. 3). There is an assumption that, no matter how much uncertainty there might be, there
is a number that can accurately quantify that uncertainty; although it could be argued that
this is a contradiction in terms. The quantification of uncertainty is one of the foundations of Bayes’ Theorem which is used in much of this research.

The Bayesian approach is relatively simple. Bayes devised a method in which it is purported that decision-makers can update their opinions (expressed as a mathematical probability) with imperfect information. The usual example in the realm of diagnosis is the way a clinician’s certainty as to whether a patient has a particular condition changes before and after a particular diagnostic test. The interpretation of a test result depends heavily on the pretest probability of disease (Sox et al., 1988). Pretest probability is the quantitative degree of certainty of a clinician that the patient suffers from a particular condition, before conducting the diagnostic test. If the posttest probability is likely to be substantially different, then the assumption is that there is a good case for conducting the test. However, if the posttest probability is little different from the pretest probability then the test is more likely to be a waste of both time and resources. The Bayesian approach can apply to both diagnosis and treatment planning.

Treatment planning in normative decision making is seen as an issue of mathematically deciding between the risks and benefits of different treatment options, as few treatments are invariably successful, and nearly all come with some side effects. In diagnosis, the two key parameters needed are the pretest probability of disease and the strength of the evidence both for and against that disease being present. In treatment decisions the decision-makers must quantify the outcome of each treatment and its desirability. The outcomes are given as mathematical probabilities and the effects are quantified as “utilities”. The probabilities and utilities are then mathematically combined. Calculations can be conducted with simple two by two tables (Elstein et al., 2002). According to Elstein et al. the major advantage of this approach is that it encourages an evidence-based approach, and even if a formal decision analysis cannot be conducted it promotes a systematic appraisal of the tradeoffs that need to be considered in a difficult decision. For example, a patient in severe pain may gain relief from opioids but may be unwilling to tolerate side effects such as nausea and itching. In theory, this approach offers a quantitative solution to making a choice of treatment.

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2 Bayes’ theorem is an account of how to update opinion based on probability theory, in the light of incoming evidence. Propositions are assigned a numerical prior probability. This is then adjusted mathematically, according to new evidence, to a posterior probability.
Decision analysis is a formal method for implementing this approach, and there have been attempts to introduce it into many medical specialties (Rouse & Owen, 1998). The basic steps are as follows (Elstein et al., 2002). First the decision-maker must describe the patient’s state: what is the clinical situation? For example, a patient with cancer in extreme old age may have a different set of possible outcomes to a much younger patient with the same condition. Aggressive treatment may be more likely to kill one patient but may give the other many years of normal life.

Relevant options should be considered and the likelihood of each outcome needs to be formally assessed. At this point it is assumed that the decision-maker will use evidence-based medicine to supply relevant information, and it is further assumed that any clinician using this approach would search relevant literature databases such as Medline to establish appropriate facts.

A formal utility assessment then follows, in which the decision-maker compares and contrasts the values of the possible outcomes. In order to do so, qualitatively different outcomes need to be compared on a common scale so that mathematical comparisons can be made. Patients’ preferences and valuations can be included at this stage, and this is claimed to be a particular strength of the approach (O’Meara, McNutt, Evans, Moore, & Downs, 1994). There is a trend in all health care professions to adopt a less paternalistic attitude to patients and take their opinions into account when formulating treatment options. By including patients’ preferences it can be claimed that this probabilistic approach accommodates this trend. Typical methods of evaluation could include direct scaling, time tradeoffs and standard gambles. Direct scaling makes use of a visual analogue scale on which outcomes are given a position, with the most desirable outcome at one end and the least desirable at the other. An evaluation of time tradeoffs of various options might, for example, require a decision-maker to declare the number of years in perfect health that are equivalent to a number of years in diminished health. The standard gambles approach requires the decision-maker to choose between different gambles. For example, one gamble could offer a slightly improved state of health without definitive cure, but also little risk of death, whereas a second gamble might involve a considerable risk but offer a more definitive outcome of either total cure or death. The standard
gambles approach is an attempt to calculate the probability of options in a manner that will allow a decision-maker (patient and/or clinician) to make a dispassionate choice between options.

Bradley (1993) has detailed the above process of formal decision analysis as a three stage procedure that occurs in the following manner. First, a decision tree is formulated. This is an attempt to summarise options and outcomes in a graphic manner. Points at which decision-makers make choices between options are marked as nodes, as are the points at which various outcomes occur. Then desired outcomes are defined and finally the decision tree is “folded back”. This means that expected values for each decision are calculated in terms of the outcome variables selected (e.g. life expectancy, cost, etc.). Thus the effects of a decision are calculated, taking into account the various potential outcomes and the possibility of each one occurring. The decisions can then be numerically compared. Bradley noted that creating the decision tree is the most difficult part of the process but it does provide an opportunity to clarify the overall problem. He pointed out that a criticism of formal decision analysis is that it takes the art out of medicine. Those who espouse the decision analysis approach might see this as an advantage, and as a way of removing “guesswork”, thus allowing medical decisions to be completely quantitative. For those with a reductionist or deterministic view of the world this is seen as highly desirable. However, Bradley admitted that considerable art is required in constructing a decision tree. This is an interesting remark as it shows that even some of those in favour of the decision analysis approach concede the need for professional artistry and expertise in clinical decision making. It can also be argued that without the underlying professional expertise required to design a decision tree the decision analysis approach is fundamentally unsound. It could also be said that, at best, this approach might be simply an aid to decisions that are essentially based on professional artistry and expertise derived from reflective experience. This implies that the notions of professional artistry and expertise are more fundamental to clinical reasoning than would be acknowledged in a purely mathematical approach, and that the decision analysis approach is superficial as it simply fails to engage with the need for judgments to be made in conditions of such complexity that purely logical thinking is insufficient and judgment artistry is required.
Decision analysis allows for the fact that people can have a number of conflicting goals at the same time. A simple example is where the desire for a long life may conflict with the desire for good health: it may not be possible to have both. Concepts such as quality adjusted life years (QALYs) are an attempt to rationalise and quantify these ideas. QALYs are defined as “a period of time in perfect health that a patient regards as equivalent to a year in a state of ill health” (Bradley, 1993, p. 118). Choosing the best alternative for that person becomes largely an exercise of calculating health possibilities and quality of life preferences. The probability of each outcome is multiplied by its utility, and these are then simply summed. The alternative with the maximum expected value then becomes the option of choice. There are computer programs available to do these calculations. It is recommended that a sensitivity analysis is also conducted (Elstein et al., 2002). This involves changing the values of the uncertain variables through a plausible range to see what effect this might have on a decision. This procedure attempts to identify which factors are the truly important ones in a particular case, and to allow the clinician and patient to cope with the inherent uncertainty of decisions more rigorously. Elstein, Schwarz and Nendaz (2002) recommended a normative approach as a way of encouraging clinicians to think through problems systematically. They maintained that this is a coherent way of comparing and contrasting values, risks and benefits. They also claimed that decision analysis can be useful for developing clinical guidelines that incorporate patients’ preferences.

Elstein et al. (2002) pointed out some highly controversial assumptions of the decision theory approach. The first of these is that a decision should not be judged by its outcome. As outcomes are always uncertain, even “correct” decisions can have unsatisfactory outcomes. Therefore it is claimed that the only criteria for judging the value of a decision are its logic, coherence and the rigour with which relevant variables were selected and evaluated. Secondly, the procedure is generally assumed to be appropriate for both single and repeated decisions. This is a recognised weakness of the decision theory approach, in that it entails an assumption that each decision is a “one-off” and that events occur only once. This is clearly not the case in the real world. Markov models are an attempt to rectify this deficit. They incorporate a temporal element in which it is assumed that a patient is always in one of a finite number of discrete health states (Sonnenberg & Beck, 1993). However, even with modifications such as Markov models, there is, in this approach, no sense of patients having a history, nor that any clinical decision is but one
event in the ongoing narrative and lifeworld of a patient. Neither is there any sense that
each clinical decision is an event in the ongoing narrative and lifeworld of the clinician
concerned, and that success or failure can influence how a clinician views such decisions
in future. Cultural and historical context factors seem to be ignored as being irrelevant,
but there is a strong case for arguing that such factors are fundamental to the roles that
health, illness and interventions will play in a person’s life (Morris, 1998).

Van den Ende and Van Gompel (1996) have also pointed out that clinicians are often in
situations of opting to do a confirmatory test where the probability of a disease is already
close to 99% (based on biopsy results) or less than 0.1% (as in many HIV tests). This
contradicts the assumptions of the decision analysis approach, where such small changes
in certainty are seen as being insignificant and/or not cost-effective. However,
confirmatory information may be considered highly significant in these situations, and of
major importance in making a clinical decision. Indeed, a clinician could be considered
negligent for failing to conduct these investigations under some circumstances. Van den
Ende and Van Gompel interpreted this finding as showing that clinicians seem to think in
terms of a logarithmic scale rather than a linear one, as small changes at the extremes are
seen as more important than large ones in the middle. This suggestion undermines the
metaphor that certainty in clinical reasoning lies on a linear scale, and can be calculated
as lying on such a scale. It can also be argued that while it might be appropriate to talk of
being 50% or 90% or 100% certain in conversation, these numbers often lack the
precision which they seem to embody. Nobody says that they are 55% certain of a
decision in normal conversation. In Wittgenstein’s terms, these percentages are part of a
language game that does not pretend to precision, but are no more than a manner of
speaking (Wittgenstein, 1958). Confusion can arise when we attempt to interpret this
language game as being precise and technical in a context where technical precision does
not belong. However, it is conceded that repeated decision analysis for a population of
patients can be utilised for developing health policy and developing clinical practice
guidelines. Medical decision analysis may have an important role to play, but for
populations of patients rather than individuals.
3.3 Descriptive Theories of Clinical Decision Making

Within the medical decision analysis paradigm it is assumed that its mathematical approach best describes how clinicians should make decisions. But it is widely acknowledged that most clinicians do not make decisions this way (Bergman & Pantell, 1986; Bradley, 1993; Detsky, Redelmeier, & Abrams, 1987; Elstein et al., 2002; Wartofsky, 1986). Descriptive theories comprise a closely related body of work, the aim of which is to describe how and why clinicians vary from this desired norm. Descriptive theories of decision making are almost invariably modelled on cognitive and behavioural lines. The term “descriptive theories” is somewhat confusing in this context. An assumption of this thesis is that the term “descriptive” is an aspect of the interpretive paradigm. These theories clearly do not belong to the interpretive paradigm, and are the result of an experimental, laboratory-based approach, which attempts to measure and uncover cause and effect relationships. However, these laboratory studies have yielded a number of interesting findings over the years. These are generally referred to as heuristics and biases. Heuristics are understood to be useful “rules-of-thumb”. It is accepted that heuristics are frequently useful as aids for clinical reasoning and decision making. However, this body of literature is generally prejudiced against heuristics because they can sometimes have an adverse influence on decision making, by inadvertently prejudicing a clinician towards certain decisions. A number of authors have described and discussed heuristics, such as Smith and Paauw (2000) and Elstein (1999). Elstein described four heuristics that are commonly used to make probability estimates. These are availability, representativeness, anchoring and adjustment.

The availability heuristic relates to the ease with which features are called to memory. For example, a recent incidence of a rare disease predisposes clinicians to be inclined to diagnose it again (Hatala, Norman, & Brooks, 1999). This is closely related to the representativeness heuristic. This calls for judging the probability of a disease by estimating how similar a set of findings is to a particular disease. It can lead to error because a clinical feature might be seen in many diseases. The example used by Elstein et al. (2002) is that a patient with meningitis is highly likely to have headache. However, this does not mean that a patient with headache is likely to be suffering meningitis, as headache is an extremely common feature of many frequently occurring conditions whereas meningitis is relatively rare.
Anchoring and adjustment heuristics refer to the ways in which an initial judgment of the probability of a disease can be changed. Anchoring is the choice of an initial diagnosis, and adjustment the tendency to change from this first diagnosis to alternatives as more information becomes available. Error can arise from choosing an initial anchor that is wrong and being unwilling in the light of evidence to adjust the anchor adequately.

Elstein et al (2002) claimed that this bias is seen when a clinician over-orders laboratory tests in order to achieve a particular level of diagnostic certainty when a formal statistical analysis shows these tests are unnecessary. The clinician is judged to be anchored (fixed) on his or her initial judgment, and as having made inadequate adjustments. The Bayesian approach also uses the notions of anchoring and adjustment, but the adjustment is then made on the basis of formal mathematical probability.

The literature also describes biases in values used to make clinical decisions. The most commonly described are “framing” effects (Tversky & Kahneman, 1981). Framing refers to the context in which a decision is posed. Changing the frame or the way in which a problem is perceived can significantly change the decisions made. Framing and the language used to posit frames can change the meaning of decisions. An excellent review of this topic is that of Kühberger (1998), who argued that the way in which the phenomenon of framing is investigated is flawed, as most options are presented as simplistic either/or choices. Tversky and Kahneman (1981) used laboratory experiments of the “Asian Disease” problem to demonstrate the framing phenomenon. Essentially subjects were asked to make a decision between options with the decision worded in terms of lives saved or lives lost. Framed as “lives saved”, most subjects opted for risk aversion, but with the same situation framed as “lives lost”, subjects opted for a more risky option. For example, a 10% chance of mortality sounds more ominous than a 90% chance of survival. Bradley (1993) also pointed out that, when it comes to health, people tend to opt for choices that appear not to be gambles. So a 30% chance of cure is preferred over a 0-80% chance of cure. It is clear that the language in which a decision is offered has a profound effect on the option chosen. This issue of language is explored in more detail in the next chapter.
Under normative decision theory it is assumed that choices are not affected by changes in their description. Framing effects clearly violate that assumption. Some investigators claim that framing effects can be demonstrated in actual clinical decisions made in practice (McNeil, Pauker, Sox, & Tversky, 1982; Percy & Llewellyn-Thomas, 1995). However, the extent to which framing occurs is disputed. As mentioned, Kühberger (1998) showed that the conventional approach to studying this phenomenon is flawed. Presenting clinical decisions as either/or situations and altering probabilities is an ineffective way to provoke a framing effect. According to Elstein et al. (2002), clinicians seem to have well-established habits for dealing with many clinical problems, and it seems that the familiarity of clinicians with the reality of decision making in these contexts protects them from the artificial nature of a framing effect in experimental situations. The methods of eliciting utilities to make clinical decisions, mentioned earlier, were time tradeoffs, standard gambles and rating scales. According to normative decision theory there should be no difference between these approaches as a means to the end of making a clinical decision. However, some studies clearly show that the method used to establish the mathematical probability or utility does have an effect on the score obtained (Lenert, Cher, Goldstein, Bergen, & Garber, 1998; Stalmeier & Bezembinder, 1999).

This discrepancy between results utilising different methods may well be an inherent feature of a laboratory-based approach to researching human decision making which ignores intentionality. It is a problem echoed in the wider literature of human cognition. Shotter (1989), taking a Vygotskian view, discussed experiments designed to assess aspects of cognition. It is clear that the way in which such experiments are set up has a profound effect on how human subjects can respond to the tasks placed upon them. As Shotter pointed out, human subjects always have to interpret their position in an experimental situation within a wider social context. They have to actively interpret the role they are given, the kinds of answer that are permissible, and the way these must be expressed. So, rather than uncovering and revealing mechanisms of cognition, these experiments force subjects to construct their responses along pre-determined lines which may be prone to confirming what the researcher has set out to prove. Most descriptive research into clinical reasoning utilises a laboratory approach and is therefore prone to this flaw.
Another bias that can occur in the descriptive model of clinical decision making is omission bias, which refers to the belief that an undesirable outcome caused by intended action is worse than the same outcome caused by inaction. This bias therefore encourages people to choose options that favour inaction. It has been argued that this may be part of the reason that some parents opt not to vaccinate children (Mezaros et al., 1996). An adverse event resulting from a vaccination is seen as being more culpable than the same event arising from lack of vaccination. In normative decision theory it is assumed that people would opt for vaccination, as the evidence clearly shows that serious adverse events are far more common in the non-vaccinated population. This effect has also been described in gynaecologists’ decisions about the use of hormone replacement therapy (Baron, Holzman, & Schulkin, 1998) and the inclination of many clinicians to consider iatrogenic complications as more severe than the same outcome occurring naturally (Cohen & Pauker, 1994). The way in which a clinician perceives a clinical encounter can also introduce bias. Nimnuan (2000) showed that a positive perception of a patient encourages clinicians to err on the side of believing symptoms to have a medical explanation, rather than psychosocial, and vice versa. Elstein, Christensen, Cottrell et al. (1999) showed that treatment decisions for critically ill patients are not greatly affected by prognostic estimates. Clinicians are inclined to give patients the best care they can. This implies that, from a cost-effective viewpoint, utility-maximisation is not pursued in intensive care; expensive high-tech medicine is used even when there is little chance of success. Such dilemmas have led to the development of measures designed to aid clinicians in making rational, optimal decisions.

3.4 Decision Aids

Many interventions have been developed over the years to assist clinical decision making. These range from straightforward education in subjects such as biostatistics, epidemiology, decision analysis, clinical reasoning and evidence-based medicine to the development of what are essentially cognitive tools that can be used by clinicians in a variety of ways to aid decision making. These tools include clinical practice guidelines, algorithms, and decision support systems.
Guidelines and algorithms have been developed in almost all fields of medical practice, for example pain management (National Health & Medical Research Council, 1998). They seek to embody best practice based on what is claimed to be the best available evidence. Some studies have been conducted to evaluate their use in practice with somewhat mixed results. For example, Grimshaw and Russell (1993) reviewed 59 studies of guideline compliance, finding that there were significant improvements in care after guidelines were introduced. However, other researchers have identified poor compliance. For example, Grunfeld et al. (1997) found wide variations in the management of asthma.

This issue of compliance with guidelines is one which has stimulated a number of studies in an attempt to explain this variability.

Elstein et al. (2002) discussed at length the factors affecting compliance of practitioners with practice guidelines. Firstly, the way compliance is measured can have an effect, and this reflects the expectations of the investigators. Elstein et al. also speculated that compliance may improve gradually over time, as the younger generations of clinicians entering into practice have been trained in a culture in which guidelines are an accepted fact of life. The assumption is that older generations of clinicians are less familiar with the notion and are more likely to see guidelines as intrusive and interfering with their autonomy, and as policy, policing or cost-cutting measures (Berger & Rosner, 1996; James, Cowan, Graham, & Majeroni, 1997). A criticism of guidelines is that while they might define benefit for an average patient in a particular population they may not apply to individual patients, and should not be used in a prescriptive manner. Guidelines are supposed to be valid, flexible, clear, defensible, and usable (Eddy, 1990; Institute of Medicine, 1990; Owens, 1998). It seems that social factors have a strong influence on compliance. Thus guidelines are more likely to be accepted if produced locally, and if they reinforce a local consensus rather than require a change in routine (Fairhurst & Huby, 1998). Unfortunately, this is somewhat counter-productive. Guidelines are intended to promote better clinical reasoning and better care on a community-wide basis. Merely reinforcing local practice may not lead to practice according to the best available evidence. The issue of guideline compliance is ongoing. On one hand there are regular calls for clinicians to be informed users of guidelines so that patient care is improved, but at the same time clinicians are encouraged to critically judge the quality of guidelines and not accept them at face value (Hayward, Wilson, Tunis, Bass, & Guyatt, 1995; Wilson, Hayward, Tunis, Bass, & Guyatt, 1995).
One popular form of guideline is the clinical algorithm. Clinical algorithms are intended to be user-friendly. The literature on clinical algorithms exemplifies the situation of guidelines in general. Algorithms usually come in a flowchart format and present clinical decisions in diagnosis or treatment as a stepwise procedure, in an attempt to simplify decision making. They are categorical, replacing probability analysis in an attempt to simplify clinical decision making and to aid clinicians in making speedy, standardised, high quality and cost-effective decisions (Gottlieb, Margolis, & Schoenbaum, 1990; Margolis, 1983). However, algorithms need to be adapted for specific settings (Wabitsch, Margolis, Malkin, Abu-saad, & Waksman, 1998). There are complaints that algorithms are tedious to use and too rigid to be applied to individual patients (Margolis et al., 1992). It seems that novices will use guidelines as a tool to aid decision making while experts often find them too restrictive and rigid. This may be because novices have yet to develop depth of experience and professional artistry, and guidelines might help compensate, especially in situations where such a cognitive tool can help, such as being inexperienced and working alone. Experts who have depth of experience may well have unconscious personal algorithms, and these may be richer, more detailed and more relevant to their practice than the formal algorithms supplied by official bodies.

Another tool that some novices seem to find helpful is a clinical decision support system (DSS). DSSs are an attempt to optimise clinical decision making with the use of computers. Computer support can, of course, come in many forms. Databases, such as Medline or the Cochrane Collaboration, can undoubtedly be useful aids to clinical reasoning as they provide a resource of information. However, DSSs tend to be more sophisticated and are designed to directly assist or even replace the human clinical reasoning process.

Early DSS models were seen as “oracular” (from the ancient Greek oracles which foretold the future) in that the clinician would simply input relevant information and the computer would provide the definitive diagnosis and/or treatment plan (Miller, 1994). Ideas evolved so that more recent models are seen as decision supports rather than decision makers. This leaves the responsibility with clinicians and therefore makes DSSs more acceptable on ethical grounds. The first models were based on algorithmic processes using “IF … THEN” statements, which lend themselves naturally to a computer programming approach. These can be combined with heuristics and Bayes’ theorem. For
example, one of the earliest Bayesian systems was devised to assist clinicians to diagnose the cause of acute abdominal pain, which can be notoriously difficult for novices (Adams, 1986; de Dombal, Leaper, Staniland, McCann, & Horrocks, 1972). This system for diagnosing abdominal pain was widely evaluated and shown to improve patient outcomes significantly. However, it has been speculated that much of the improved patient care was due to the rigorous information gathering required for the computer analysis to occur. The meticulous information gathering aided clinicians in organising their own clinical reasoning in these cases (Bradley 1993). Therefore, it can be argued that this DSS, rather than a decision making tool was more of a training aid that helped inexperienced clinicians to organise their thoughts and information gathering in the same way as more experienced clinicians.

Expert systems have also been developed which use an information base, stored as propositions, that can then be combined according to a set of production rules in a computer program called an inference engine. These are similar to the algorithmic systems mentioned earlier, but the inference engine decides which rules are to be used and in which order. The first was MYCIN3 (Davis, Buchanan, & Shortliffe, 1977). Expert systems do have a limited ability to explain how they reach their decisions, as the rules used can be made available to the user. In theory this makes them useful as teaching tools. The novice can follow the decision path taken, and see how information was combined and analysed. It is true that the basic principles of dealing with many professional problems can be reduced to a list of rules, which almost anyone can apply with the assistance of an expert system. This forms the basis of commercial expert systems today. There is an underlying assumption that clinical experts always use such rules in clinical reasoning in just this way. However, there is little room in these systems for the subtlety of expert professional judgment that comes with experience and which experts frequently find difficult to articulate, if they can articulate it at all (Schön, 1987).

This problem of articulating professional judgment and artistry goes back to ancient times. Plato tells the tale of Socrates asking people for the rules of expertise in various fields. Because nobody could supply Socrates with the rules underlying their expertise he

3 It is unclear how the name MYCIN was derived. However, the system was designed to select antibiotics for infectious diseases. Many antibiotic names end with “… mycin”.
concluded that nobody knew anything (Bradley, 1993). Socrates, like the designers of expert systems, wanted professional judgment to be reduced to a list of explicit and precise rules that anyone could apply. It may be possible to provide beginners with some rules to help them gain basic competency. But professional expertise entails the ability to understand why a particular case is subtly but significantly different from other cases that appear to be the same. Expert systems are incapable of coping with the subtlety required for this level of expertise. Another major weakness of expert systems is the difficulty in devising precise production rules. Further, they are limited to narrowly-defined areas. The first such system, MYCIN, was excellent at choosing antibiotics to deal with cases of septicaemia but could do nothing else, and this narrowness of context remains a major flaw to this day.

In more recent years, systems have been introduced that are based on more sophisticated ideas such as neural networks or statistical regression models (Rolfe, 1997). Neural networks are a class of algorithm devised to allow computers to adapt to perform new tasks through learning by repeated examples. Other DSS programs have been built on decision analysis models. Some researchers have reported successful implementation of these newer models, such as the program that estimates risk profiles of patients with depression (Surtees et al., 1997). However, although these programs are satisfactory in the contexts in which they were developed they do not seem to translate easily to other situations. The “knowledge engineering” process required for a new context is necessarily time-consuming and exhaustive, Elstein et al. (2002) also speculated that the reluctance of many clinicians to use DSSs may be that the clinicians may disagree with the diagnostic and treatment recommendations that these programs produce, or they might see DSSs as inadequate.

Many systems seek to emulate the hypothetico-deductive reasoning model because it is supposed that this is the way that clinicians reason. Examples include QMR\(^4\) (Miller, Masarie, & Myers, 1986) a descendant of INTERNIST\(^5\) for general medicine, and DXPLAIN\(^6\) (Barnett, Cimino, Hupp, & Hoffer, 1987). These use semi-quantitative scales to express the association of findings with specific diagnoses. Other systems such as

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\(^4\) QMR stands for Quick Medical Reference.

\(^5\) A doctor practising general (or internal) medicine is often known as an internist, hence the name.

\(^6\) DXPLAIN derived from Diagnosis eXPLAIN.
ILIAD (Warner, 1989) and MEDITELE (Waxman & Worley, 1990) use combinations of Boolean and Bayesian logic.

A number of researchers have sought to evaluate these various systems and compare and contrast them with each other and human expert performance. Initial evaluation was focused on validating the content and implementation of individual systems, whereas later efforts became more comparative (Friedman & Wyatt, 1997). Berner et al. (1994) compared QMR, ILIAD, DXPLAIN and MEDITELE and found that none of these programs performed better or worse than a human clinician. Kassirer (1994) criticised this study as it was conducted in a laboratory context and did not compare the systems against clinicians in practice dealing with real cases, who have to interpret the results and make final decisions. Other studies have shown improvement in performance when these DSS systems were used to assist novices as compared to experts (Friedman et al., 1999). However, there are other studies which refuted these same findings (Arene, Ahmed, Fox, Barr, & Fisher, 1998). Thus the literature presents a confusing picture of contradictory reports, making it difficult to judge the value of these DSSs.

There is still much debate about the usefulness of DSSs and their future promise. They are still accepted with uncritical enthusiasm by some (Frank, 1998) despite the equivocal nature of the research about them. It is reasonable to ask why these DSS systems are not in widespread use if they are as good as their proponents claim. Clinicians using DSSs can be as good as experts, but to justify the expense in developing DSSs they need to be somewhat better. The systems are time-consuming to use. Simply entering the information into the computer takes up valuable consultation time, although it is argued that they are useful tools in difficult cases where an expert is not to hand. However, this claim is questionable. The underlying algorithms of the DSSs are open to question. For example, some DSSs use Bayesian probability. Bayesian methods depend on the user being able to assign a mathematical prior probability to every proposition. It can be argued that assigning this probability is simply implausible for every user in every case. Assigning a realistic prior probability is likely to be most difficult in the troublesome cases where a DSS might be relied on most.

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7 George Boole devised an algebraic method for Logic. Boolean algebra now forms the basis by which the integrated circuits in computers switch on and off.
Proponents of DSSs argue that as computer technology continues to improve the use of these systems for individual patients will become inevitable (Lurie & Sox, 1999). However, this is little more than a “promissory note” and the outcome is not inevitable.

DSSs may have a role in education (Gozum, 1994) where they can give students practice in solving realistic cases in a safe environment where patients will not be harmed. According to Elstein et al. (2002) it could be that in these situations the DSSs are only providing additional clinical experience rather than teaching clinical reasoning skills as such. It is not clear what they meant by this, as one of the factors that makes for expertise is exposure to many cases, allowing students to enhance their clinical reasoning skills and appreciate subtle but significant differences between similar cases. Presumably these authors were adopting a computational model of reasoning, in which case an improvement in clinical reasoning would need to be attributable to better usage of the algorithms that are supposed to be activated when a clinician solves a clinical problem.

The evaluation of DSSs and other aids to clinical reasoning needs to be improved. Round (2001) has pointed out that all too often in this kind of research into clinical reasoning, outcome measures are derived from the same conceptual framework as the interventions, i.e. they tend to be self-fulfilling. Teaching our clinicians to use ideas like Bayes’ theorem may sound like a good idea but there is no evidence that clinicians actually think in this way when solving problems. A number of studies have highlighted the extent to which people in the real world use intuitive approaches rather than those based upon decision analysis (Baumann & Deber, 1989; Bergman & Pantell, 1986; Detsky et al., 1987; Peters, 1995; Wartofsky, 1986). Therefore, it can be argued that the decision analysis approach is artificial and unrealistic. There are even claims that the medical decision analysis approach discourages clinicians from accepting moral responsibility for patient care (Randall & Downie, 1996). As Elstein and Schwarz (2002) recently emphasised, expert judgment will still be needed to apply general principles to specific cases despite the increase in statistical methods and evidence-based medicine. Professional judgment and Bayes’ theorem can conflict with each other. Medical decision analysis encourages clinicians to adopt a mechanistic approach to problem solving, and not to rely on what they have learned from past experience. It can be argued that the perceived difficulty of a particular case, based on past experience, should determine the diagnostic strategy utilised. Lucey (1997) made the case that the medical decision analysis approach
encourages the application of algorithms that are frequently imprecise, and that a
conventional systematic differential diagnosis is more rigorous. Therefore it can be
argued that the medical decision analysis approach is a useful tool in determining the best
solution for groups of related problems, such as a population of patients, but when an
individual clinician is dealing with an individual patient professional judgment should
take precedence.

3.5 Conclusion
In the end the main criticism of the use of aids (computer programs, algorithms, etc.) in
the medical decision analysis approach is philosophical. Such strategies are too
reductionist and assume a mechanistic world view, where facts are acontextual, value-free
and exist only in so far as they can be mathematically manipulated. Proponents of
medical decision making based on decision theory are deeply suspicious of other
approaches, such as those based on phenomenology and professional artistry, seeing them
as unscientific, not quite respectable and something we should be trying to escape if we
are to be truly scientific (Lamond & Thompson, 2000). However, this attitude is scientism
and not science. Scientism has been defined as “unwarranted overconfidence in the
established methods of science to deal with all questions, and the tendency to displace
other ‘ways of knowing’ even in domains where conventional scientific approaches are
inappropriate, unavailing or destructive of other goals, values and insights” (Rosenberg,
2000, p. 7). Scientism entails the simplistic assumption that only quantifiable entities can
be studied scientifically. This proposition is discussed in more detail when examining
other approaches to the study of clinical reasoning, such as those based on
phenomenology. Even scholars publishing in “mainstream” psychological literature are
now admitting that there have been too many oversimplistic assumptions about rationality
that people commonly and systematically violate fundamental principles of rational
decision making in everyday life and professional contexts. These violations cannot be
dismissed as random or trivial or due to experimental errors. Therefore there is a need to
research clinical reasoning in a manner that can account for these apparent violations. My
view is that an interpretive approach which includes notions such as intuition, subjective
judgment and artistry, together with the role of sociocultural factors, offers a way of
understanding clinical reasoning that avoids the pitfalls of the medical decision analysis
approach, in particular its highly questionable assumptions based on reductionism and
determinism. It is argued in the methods chapter that an approach such as hermeneutic
phenomenology is more appropriate, as it is directly concerned with ontological issues,
such as how individuals can experience and interpret being health care professionals,
engaged in clinical reasoning in real world scenarios. It is further argued that such an
approach, informed by the insights of scholars such as Vygotsky (1978) and Wittgenstein
(1958), can provide a theoretical lens that will give insights into the phenomenon of
clinical reasoning.

In this thesis I endorse the view of writers such as Miettinen (1998) that scientific
knowledge is not the same as, or the sum total of, evidence. In mainstream medicine there
is a belief that evidence is purely objective and is identical with propositional knowledge.
This viewpoint neglects the fact that evidence needs interpretation in order to become
scientific knowledge and that the process is fundamentally intersubjective. The
application of scientific knowledge to clinical practice is a skill learned as part of
professional judgment. The decision theory approach, together with the related fields of
DSSs, fails to conceptualise this element of artistry and professional judgment, even when
implicitly relying on it, as when a decision tree has to be formulated or an algorithm is
applied to an individual patient. There is also a failure to appreciate that humans, both
clinicians and patients, come to any clinical encounter with their individual histories and
narratives. These histories and narratives make up a hermeneutic circle from within which
a person makes sense of a clinical problem and devises a possible solution. We turn our
attention next to the more qualitative studies of clinical reasoning.