

## 8th FY Khoo Memorial Lecture 2012<sup>†</sup>—Why Radiologists Need Philosophy

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### Introduction

Firstly, I wish to thank the Singapore Radiological Society and the College of Radiologists, Singapore for deeply honouring me with the invitation to give the FY Khoo Memorial Lecture for this year's Annual Scientific Meeting. Today, I will present you an argument that radiologists should be conscious of philosophy as an integral part of our training and clinical practice. This lecture explores the 5 main branches of philosophy as they apply to radiology. In doing so, I will show that we use these philosophical themes in our work constantly, and hopefully this will highlight the need for some appreciation of philosophy in medical imaging today. As I go through each of these branches, I will highlight how they pertain to medical imaging. And finally, I will conclude (and hopefully you will agree) that we need a more philosophical approach to our learning and practice. Of course, I should make a disclaimer first—as you know, I am not a philosopher, so I am learning as well. Nevertheless, despite my credentials as an amateur student of philosophy, I hope to at least raise the curtain on some philosophical concepts, and along the way show that all the key domains of philosophy are highly relevant to medical imaging.

Dictionaries define philosophy as the study of the nature of knowledge, reality, and existence. It involves critical thinking, through a systematic approach and rational argument, and is aimed at generalisability. Western philosophical thought can be traced back to the Athenian Greek philosopher Socrates (469 BC – 399 BC), over 2400 years ago. Although hugely influential and the originator of the Socratic method of 'dialectic' (using questions to explore the nature of truth, ethics and logic), Socrates never wrote or published anything. Despite achieving great fame during his lifetime, he was famously condemned to death by his fellow Athenians for, in effect, asking too many questions! It was Socrates' student, Plato (423 – 347 BC), who immortalised him in writing. Without Plato, and other Socratic students such as Xenophon, we would have no surviving records of Socratic thought. A classical Greek philosopher and mathematician, writer of dialogues, and founder of the Academy of Athens, Plato explored through

his 'Dialogues' a vast range of concepts and ideas, to elicit the critical thinking that ultimately led to the scientific method and the Western approach to knowledge. These contributions are so profound and fundamental to Western philosophy that it has even been claimed that:

“European philosophical tradition... consists of a series of footnotes to Plato.”

AN Whitehead (1861 – 1947)

This statement does rather underestimate the contribution of Western philosophers in the 18th to 20th centuries, but the point is well made nevertheless. Eastern philosophies such as Tao, Zen Buddhism and Confucianism were not as interested in the nature of truth, knowledge and logic, but rather focused more on the individual's duties to the state, and the state's duties to society, rather than the pursuit of knowledge and truth in its own right.

Plato explored many concepts using allegories. His most famous is known as 'Plato's Cave', which appears in a Socratic dialogue, in 'The Republic'. In this allegory, a group of people live chained to the wall of a cave all their lives, facing a blank wall. They watch shadows projected on the wall by things passing in front of a fire that is behind them. They ascribe forms to these shadows, and the shadows are as close as they get to viewing reality. In time, they misinterpret the shadows for reality. Eventually, the philosopher sets them free, to see the real world. This concept, that our perception of reality and existence may be ephemeral or even imaginary, has found resonance across the centuries, and has been the subject of countless stories, books and movies, such as 'The Matrix' and 'Inception'.

Perhaps Plato had some premonition of the modern radiologist. The proliferation of digital radiology, increasing imaging utilisation and increased volume of images per examination means that many of us live in a "virtual" cave in our dark reporting rooms, effectively chained to our chairs, with our gaze fixed on flickering shadows on our PACS (picture archiving and communication systems) monitors that are created by a distant source. We take

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images we see for reality, and can easily over time lose touch with the reality around us. Perhaps we could benefit from philosophy to help free our minds from this blinkered view of the world.

### Branches of Philosophy

Philosophy can be and has been sliced and diced in many different ways. There are numerous “splinter groups” with their own themes such as evidentialism and empiricism. Traditionally, philosophy has 5 main branches, namely:

- Epistemology, the pursuit of knowledge and truth
- Logic, the understanding of rational reasoning
- Metaphysics, the study of existence and being
- Ethics, the domain of values and moral behaviour, and
- Aesthetics, the appreciation and perception of beauty

Somewhat surprisingly perhaps, all of these domains are highly relevant in various ways to radiology. Despite initial appearances, radiologists use all these aspects of philosophy in routine practice. Better understanding of each of these streams of philosophy has the potential to make us more aware, conscious and effective as practitioners.

### Epistemology

Epistemology is concerned with knowledge, belief and truth. We can paraphrase epistemology with the question, “Is this correct?”. It can be argued that this is what we spent all our time doing, but this is just one (albeit large) part of being a radiologist. Without an appreciation of knowledge, belief and truth, we cannot be as critical and as accurate as we may wish to be as diagnosticians. The 20th century great philosopher, mathematician, historian and social critic Bertrand Russell described knowledge in this way:

“.. knowledge might be defined as belief which is in agreement with the facts. The trouble is that no one knows what a belief is, no one knows what a fact is, and no one knows what sort of agreement between them would make a belief true...”

Bertrand Russell (1872–1970)

So, if there is no agreement on what a belief or a fact actually is, how can we “know” anything? Almost in spite of such philosophical considerations, our body of radiological knowledge has been acquired, systematised, taught and refined over the last century. Yet if we allowed such deep analysis into knowledge too much licence, to demand absolute knowledge in everything we do, we would paralyse our ability to function in a practical clinical fashion, to make judgements based on incomplete information, and to provide an effective clinical service.

### Knowledge

Knowledge has many descriptions. We usually think of it as a collection of information, facts or skills. It can be informal or formal, but is usually systematic. It is acquired through experience, and can be implicit (practical skills and expertise), or explicit (overt theoretical understanding).

‘Radiological Knowledge’ is peculiar. This spans many domains, all of which are essential for effective clinical practice:

- Anatomy
- Imaging physics and instrumentation
- Pathology and pathophysiology
- Appearances of disease processes in the body
- Categorisation of diseases, findings by system
- Diagnostic reasoning
- Imaging safety
- Appropriate investigational pathways
- Communication, advocacy, professionalism, ethics

We know from long experience that a good radiologist must acquire both explicit and implicit knowledge through a combination of study, teaching and practical experience. Understanding the nature and complexity of radiological expertise helps us to resist attempts to trivialise the depth and complexity of what we do.

Knowledge requires an internal system of belief to function, and in order for this to be accepted, must be in general agreement with others. This, in turn, requires us to understand the nature of belief.

### Facts

Facts are “incontrovertible truths”. That is, they are universally agreed upon, are reproducible and stand up to repeated scrutiny without change. Incontrovertible truths have rather rigid characteristics:

1. There are no exceptions
2. The fact is absolute
3. The fact represents a ground truth that cannot be modified or subverted, or incorrect

This is a very high bar indeed, and most of our human knowledge does not reach this standard! How then do we know if something is a fact? For most of medicine, facts are established using the principles of the scientific method, which include:

1. A hypothesis is accepted as the best available
2. The hypothesis can change with new validated, reproducible science
3. The hypothesis is established and validated through best practice research

Radiology has many “facts”, but few of these are incontrovertible; they are mostly empirical, observational, qualified, and dependent on multiple factors. Do we have incontrovertible truths in imaging? Of course. However, most such facts are in disciplines that have absolutes, in particular, anatomy and physics. Such facts include statements such as:

- X-rays are a form of ionising electromagnetic radiation
- Ultrasound uses high-frequency sound waves to create images
- The knee is a synovial joint
- The C5 nerve root forms part of the brachial plexus

In general, most facts in radiology are actually beliefs. There are many beliefs in radiology, and some of them are based on incontrovertible truths. However, the majority of beliefs in radiology are empirical, probabilistic and relative. They are hard-won, based on accumulated empirical observation and description, and hold true for a majority of situations and patients. Examples of such beliefs that have taken on the status of “facts” include:

- Ionising radiation is harmful
- Breast screening saves lives
- Osteosarcomas have a sun-ray periosteal reaction
- Non-ionic contrast agents are safer than ionic contrast agents

There are exceptions and alternative beliefs to each of these statements, so strictly speaking, they do not conform to the philosophical definition of facts.

## Beliefs

In reality, most human knowledge is dependent on belief, at least some of which is based in fact. Without belief, we cannot construct a hierarchy for a body of knowledge, where one area depends on core concepts and facts that underpin the entire discipline. Radiological beliefs are acquired either by receiving (taught by others, or read through reference materials), or through direct experience by the practitioner (as it was for the pioneers of radiology). Requiring only experience to acquire radiological knowledge would be slow, inefficient and highly variable. Today, it would be impossible for anyone to acquire the body of radiological knowledge through direct personal experience alone. Such radiological beliefs have for most people the status of “fact”, are accepted and learned verbatim, and eventually tempered, confirmed or contradicted by one’s own personal experience in the field.

For example, we believe (with excellent experimental evidence) that X-rays are created by the interaction of

high speed electrons with solid materials, that they travel in straight lines, can be scattered or absorbed, and have properties of both an electromagnetic wave and a subatomic particle. Without these beliefs, it would be difficult to fully exploit the X-ray to be the workhorse of medical imaging, to understand its risks and benefits, and to create effective protection and safe practice for their use.

Unfortunately, beliefs are the lowest currency of knowledge. A belief is not a fact, nor is it knowledge. It is a psychological state of mind, where we hold something to be true. Anyone can believe anything, even what is patently false or impossible to others. So, how do we know that a belief is true? In order for beliefs to have any currency in a system of knowledge, they must be “justified true beliefs”. Such beliefs require that (i) one believes the relevant proposition and (ii) one has appropriate justification for doing so. In other words, there must be at least strong empirical evidence to support any belief.

Such justifications must of necessity be reasonable and plausible. They must be backed by reproducible evidence, and if they are, and are accepted at large, can take on the status of “facts”. This can take some time, especially if the new beliefs are in disagreement with accepted “facts”. There are many things people have believed that have been subsequently shown to be wrong. Until Galileo shattered our illusions, we believed that the sun revolves around the Earth. Doctors used to believe that puerperal sepsis was due to “bad air”, until Semmelweis proved it was due to poor hand hygiene, and that women suffered from the psychological disorder “Hysteria”, that was best treated by “pelvic massage” which when successful led to healing “hysterical paroxysms”. More recently, we used to believe that gadolinium-based MR contrast agents could be used with impunity in patients with renal impairment, until nephrogenic systemic fibrosis emerged.

Radiological beliefs function as mental shortcuts that enable us to summarise a wealth of information and even controversy into a single pithy consensus statement. This is efficient and enables us to get our work done without exhaustive analysis. However, such beliefs are rarely absolutely true, there may well be dissenters from these viewpoints, and they usually have exceptions and caveats.

Both facts and beliefs then join with experience to create a range of knowledge learned by an individual. As should be clear, for most of us, such knowledge that is not personally experienced is “received”, either directly through teaching, or by study of various learning resources and reference works.

## Empiricism

Most of our personal knowledge as radiologists is then

primarily experiential—it is unique to each of us, it is acquired through a combination of direct learning and experience, integrated with a large body of received “facts”, beliefs and knowledge, and it is all highly relevant to clinical practice in medical imaging. Received knowledge in imaging includes “Radiological pearls” and “Aunt Minnies”, whereby we learn to recognise a feature or diagnosis through pattern matching and identification of a few key features. Most of us never actually work out why such a diagnosis looks that way from first principles. We just recognise that it is, say, melorheostosis, renal osteodystrophy or osteopoikilosis.

There is nothing wrong with this, but it is important to recognise it for what it is. This type of experiential knowledge is known as empiricism, a branch of epistemology that argues that the basis of knowledge is primarily experiential—that is, one should only believe only what is personally experienced.

### **Evidentialism**

Evidentialism is another branch of epistemology that holds that one cannot believe anything unless there is strong formal evidence for that belief. Although on the surface it is the philosophical converse of evidentialism, in reality both empiricism (the knowledge gained by direct experience and experiment) and evidentialism (the formal analysis of such knowledge to determine if it is valuable) are essential ingredients of the scientific method.

In medicine, the best evidence is that provided by large scale randomised controlled trials. For example, screening mammography is used because multiple randomised controlled trials show that it provides a measurable benefit in a large proportion of women for whom cancer is detected. This has stood us in good stead in many areas where there is genuine uncertainty, for example, over whether a new treatment is superior to or equal to an existing treatment. The vast majority of “evidence-based medicine” is thus focused on therapy, where uncertainties about efficacy are genuine and differences between treatments may have relatively small effects in any given individual.

We are heavily biased as a species to believe the evidence of our own senses, especially our vision. If we see there is a mass in the lung, we do not require a trial to tell us whether it is or is not present. What we need to know are the imaging features that help us to decide whether it is likely to be a cancer, and what steps we need to take to prove it is a cancer, none of which have been subjected to clinical trials. Similarly, in a patient with a severe sudden headache, the visualisation of hyperdensity in the basal cisterns does not require a clinical trial to determine whether the patient has a subarachnoid haemorrhage. Because of the paucity of hard scientific evidence and the reliance in radiology on

direct observations, received facts and empirical beliefs, it would be impractical to insist on formal scientific evidence to underpin the whole body of radiological knowledge.

It is, however, a very different thing to image a single patient with a specific clinical problem for a disease, and to image a very large number of poorly differentiated patients for that same disease. The best example for this is the difference between diagnostic mammography and screening mammography. Diagnostic mammography is typically performed to determine whether a woman’s symptoms are due to cancer. Screening mammography’s primary goal is to reduce the population’s mortality for breast cancer, and secondarily to help a very small proportion of the individuals screened by finding their breast cancers. Since in screening, the vast majority of women are normal and do not have any disease, it is essential for there to be a strong evidence base on which to decide whether we should offer this service. It is important for radiologists to be aware of the principles of evidence in creating new knowledge, to appreciate how evidence is acquired, and what quality of evidence can be accepted, especially if a change in beliefs is required.

### **Rationalism**

This is the third branch of epistemology, and is primarily intellectual. Rationalism argues that we can only believe what can be logically reasoned, deduced or inferred. It is fundamentally a skeptical approach to knowledge, and is primarily mathematical and mechanistic. Although important for formal logical analysis, deduction and induction, it is not, for the most part, directly of much value to radiologists. This is in no small part because radiological beliefs and facts are rarely absolute, and cannot usually be argued in formal logical terms.

One can summarise the difference between empiricism, evidentialism and rationalism succinctly through these phases:

1. “I only believe what I see” (empiricism)
2. “I only believe things with strong evidence” (evidentialism)
3. “I only believe what I can reason” (rationalism)

In reality, of course, we need all 3 of these approaches to knowledge to become effective practitioners. They are not mutually exclusive.

### **Logic**

Let us now move from knowledge to the second branch, logic. Logic is the branch of philosophy concerned with how we think. Broadly, logical thought can be divided into deductive or inductive processes. In deduction, a conclusion must follow from the set of premises if the premises are

true. This is absolute, and non-probabilistic. For example, if we take the statements, “all men are mortal” , and “Joe is a man” to be true, then we can deduce that Joe must be mortal. An example of this reasoning in radiology is seen in Figure 1. Our premise is that on an X-ray, fractures cause linear bony lucencies, deformity and cortical discontinuity. This X-ray of the calcaneum in a patient who fell of his roof shows linear bony lucencies, deformity and cortical discontinuities. Therefore, we can deduce that this calcaneum is fractured.

Induction, on the other hand, is where we generalise a rule based on individual instances. A conclusion most likely follows from the set of premises. There is inherently a probabilistic possibility that the conclusion we draw is false, even if all the underlying premises are true. For example, if our premise is that 90% of humans are right-



Fig. 1. X-ray of fractured calcaneum.

handed, and that Joe is a human, we can induce that the probability that Joe is right-handed is 90%. Of course, we can be completely wrong, and Joe could be left-handed or ambidextrous.

This type of reasoning is the norm in clinical radiology. When we say that a stellate mass in the lung of a chronic smoker is a primary lung carcinoma, we are making a probabilistic judgement. There is a small chance that we are incorrect, but the overwhelming likelihood is that we are right. There is nothing specific about the imaging findings that allow us to make this diagnosis with the absolute confidence required for deduction; a stellate lung mass could also be due to metastatic carcinoma or scarring from reactivation TB (Tuberculosis), and a different clinical history would make us consider such alternatives. An example of such radiological induction is seen in Figure 2. There is a large heavily calcified suprasellar mass producing

hydrocephalus on this CT (computed tomography) scan. Our premises include the following statements:

- Craniopharyngiomas form suprasellar masses
- 90% of craniopharyngiomas contain calcification
- Most suprasellar masses do not contain calcification

We can induce with a high degree of confidence that this mass is most likely to be a craniopharyngioma. Could it be something else? Conceivably, but this is the diagnosis that we would like our trainees to provide in an examination.

### The Diagnostic Process in Radiology

Deduction is not often used in radiology unless the pathology is instantly recognisable. Then, such reasoning is

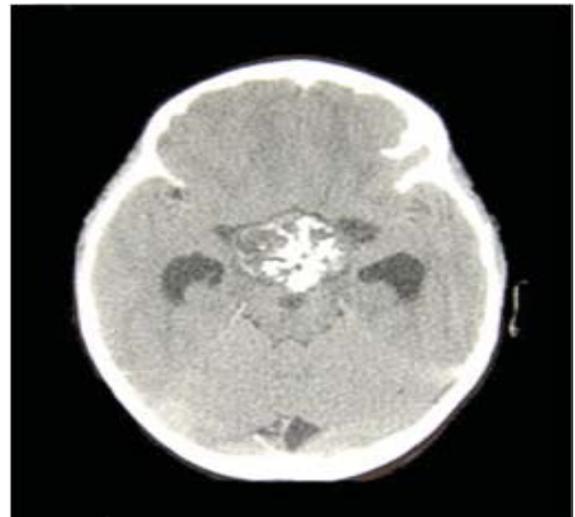


Fig. 2. Calcified suprasellar mass.

short-circuited and the answer comes to mind immediately. We can confirm that we are correct by mentally ticking off all the features that comprise the unique characteristics of the condition that we have recognised—the process is inverted, so that deduction is used to confirm what has already been recognised. Therefore, we do not usually use deduction to diagnose something we have recognised already (hence the radiological adage, “you only diagnose what you know”).

We also use deduction explicitly when we have found something confounding, and search for all the possible alternatives using references such as online websites or textbooks—then we go through a deductive process by eliminating all the conditions that do not fit the case at hand in one or more ways. As Sherlock Holmes said, “when you have eliminated the impossible, whatever remains, however improbable, must be the truth”.

On the other hand, if the diagnosis is not instantly obvious,

then we go through a process similar to what is shown in Figure 3. First, radiologists are trained to search explicitly for features, and to recognise them as being normal or abnormal. Once found, they are accurately anatomically localised, and the imaging characteristics are used to categorise the abnormality into one of a number of broad disease categories. Ideally, the radiologist will be provided with adequate clinical information, and together with information from other investigations, she integrates these findings and facts through a process of analysis and synthesis, discarding unlikely diagnoses rapidly, and converging on a shortlist of potential diagnoses, from which a most likely diagnosis can be selected.

The radiological diagnostic process is thus not readily defined by any single system of thought within philosophy. Yet it is a formal system of search, recognition, analysis and reasoning that all radiologists must master in order to

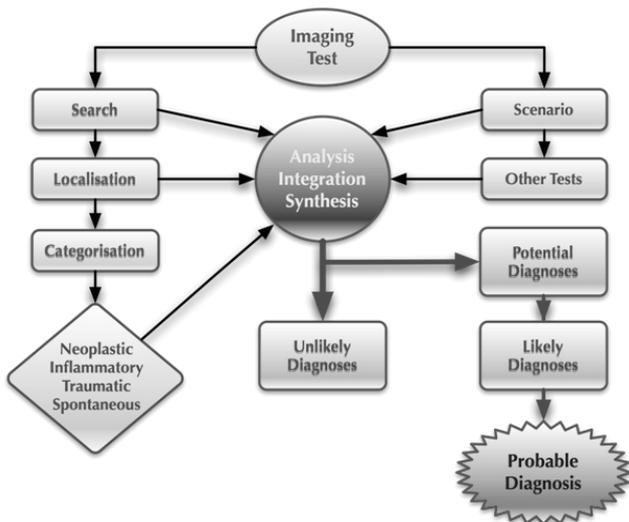


Fig. 3. The radiological diagnostic process.

become proficient. It is efficient, effective and practical. At the same time, we have all experienced situations where the combination of clinical and imaging findings led us to the incorrect conclusion. So how do such logical errors occur?

In the end, logical errors happen because of one or more of 3 occurrences:

1. Incomplete knowledge
2. False premises
3. Faulty reasoning

Errors in deduction occur where one or more false premises lead to a false conclusion. As stated above, logical deduction is an absolute process, and so for most diagnoses in radiology, is inappropriate. Deduction is best

used when imaging findings are so characteristic that no other diagnosis is possible. And this is not very common in routine clinical practice, even if we pretend it is in our examinations.

Most radiological diagnosis is based on inductive reasoning. The diagnoses are based on the available facts and observations, and are probabilistic rather than absolute. Errors of induction occur when we draw a conclusion that is not justified by all available evidence. The statement “all the swans I have seen are white” may well be true if one has never seen a black swan. If this experiential knowledge is used to conclude that “all swans are white”, this would be an inductive error, because black swans do exist.

A radiological example of faulty inductive reasoning would be to use the premise that “90% of central chondrosarcomas of bone contain calcification with surrounding lucency” to conclude that “a calcified tumour with surrounding lucency in a bone has a 90% probability of being a malignant cartilage tumour.” The reason this conclusion is false is that not all calcified bone tumours are chondrosarcomas. The correct induction would require using the additional premise, “90% of all cartilaginous tumours are benign enchondromas”, to conclude that there is a high probability that a calcified bone lesion with surrounding lucency is a benign enchondroma, unless there are other signs either on imaging or in the clinical presentation that mitigate against this diagnosis.

### Metaphysics

We shall now move on to the third branch, metaphysics, which for medical imaging is best thought of as asking the question, “What are we looking at?”. In modern medical imaging, everything we see is a digital abstraction that represents reality. At the beginning of the 20th century, the X-ray had a one-to-one physical correspondence to the object imaged. X-rays passed through the object in straight lines, and exposed a film directly based on the attenuation of beam by each part of the object, and the interaction of X-rays with the film emulsion. Since the middle of the 20th century, medical imaging has become progressively more and more virtual and translated. Today, all medical images are created as a signal in a digital detector that is converted, amplified, propagated and received, processed to form an image that is then displayed, transmitted and stored as a series of bits. What we see is highly dependent on how the many computers in the imaging chain process, translate and present such data. Such images are subject to errors in acquisition, reconstruction, artefacts, storage, transmission, display and electronic communication, not just of interpretation.

Despite this increasing disconnect between the object and the image, modern radiology has enabled huge

advances in our understanding of anatomy and disease. It has affected how we think about developmental disorders, pathophysiology, response to treatment, surgical planning and patient management. Through non-invasive imaging, we have been able to study the progress of disease over time and determine the value of our therapies. We have been able to more accurately distinguish between normal variants and disease, as well as between innocuous and more sinister conditions.

Each imaging modality that we have provides an incomplete or partial representation of pathology in many instances. Because of the widely disparate physical principles on which imaging modalities are based, this is inevitable. Because of this, there is a conceptualisation task that radiologists are particularly adept at, through a combination of training and experience. It is the integration of findings and pathology across modalities and between examinations. This process creates a mental representation of the disease in that particular patient in the mind of the radiologist; part of our training teaches us to explain this clearly to other physicians through verbal and written communication.

## Ethics

Let us now move on to the fourth branch, the study of ethics. This can be paraphrased by the question, “Is this appropriate?”. Ethics is largely concerned with moral behaviour. In medicine, this is predominantly associated with professional ethics, within a profession and between professions. It includes concerns such as patient confidentiality, the patient-doctor relationship, and care and responsibility.

In imaging practice, radiologists have to sometimes step back and ask themselves a question, “Whose best interest is this imaging serving?”. It could be the patient, the referring doctor, society, other people such as the family, or even the radiologist. It is crucial that we appreciate this ethical dimension to our practice, as it will help guide our choices in determining the relevance and appropriateness of our imaging, and even help us to guide selection of imaging test for a specific clinical scenario or indication.

Ethical issues relevant to imaging procedure thus include:

1. Appropriateness
2. Benefit versus risk
3. Safety
4. Informing the patient
5. Privacy and confidentiality

Although modern imaging is overwhelmingly safe for the vast majority of patients, there is still potential to cause harm. This may be unintentional, random and accidental,

but an awareness of the ethics of imaging is important to minimise the risk of such occurrences. We have a duty of care to patients, including ensuring that they have free choice in choosing to undergo the tests and procedures that we perform. Even if we do not require or obtain formal informed consent, we should weigh the potential benefits against the potential harms, provide an appropriate level of information to the patient and understanding what we are “selling” and to whom. The information we provide can be heavily skewed by the desired outcome of the referrer, the patient, her family and carers, or the radiologist. It is important to be conscious of the biases that can be introduced through this process.

## Aesthetics

The final branch of philosophy that we will consider is aesthetics, the formal appreciation and study of beauty. We may well ask what has this got to do with radiology? The brief answer is, “Everything!”. In radiology, the use of aesthetics can be paraphrased by the question, “Is this a good image?”. Without good images, we cannot make accurate diagnoses.

Medical imaging today presents images of exquisite quality so effortlessly and routinely that it is difficult to remember a past when this was not true. Yet we only need to look back 30 years, to images of the first brain CT scans, bimodal ultrasound and X-ray tomography. It was an era before 3D reconstruction, volumetric acquisition, digital signal processing, magnetic resonance imaging (MRI) and molecular imaging. As we discussed above, a large part of our belief and knowledge in radiology is based on the direct visual evidence contained in our images. Some diagnoses today are only possible because of the quality and aesthetics of our images. It can be argued that most of the developments of the 20th century in medical imaging were aimed at achieving better image quality. The inherent assumption, especially in structural imaging, has been that greater image quality will lead to more accurate diagnosis, and in the main this has proven to be true until quite recently.

The advent of molecular imaging of physiological and biochemical processes does not often produce inherently beautiful images, but it does reveal processes and diseases that are occult to routine structural imaging. We have learnt to compensate for the deficiencies of such sensitive imaging tests by combining them with the anatomical localisation inherent in modern structural imaging to produce hybrid tests such as SPECT-CT and PET-CT scans. The advances in image quality have fed back into other aspects of radiological philosophy, including logic (better diagnosis), epistemology (better knowledge), and metaphysics (better understanding of disease). Humans are overwhelmingly

influenced by visual stimuli. Aesthetics is fundamental to the human condition. Of course, sound, smell, taste and touch are also critical. However, these are much less important for medical imaging than vision. Our images are dramatic, realistic, attractive, compelling and ultimately believable.

Although much of our training emphasises diagnosis, logic, reasoning and safety, without good quality images obtained using optimal parameters, presented with the best projections and with high image quality, modern radiology could not exist. We almost assume that the aesthetic part of clinical radiology is automatic, and we often take it for granted. It is easy to forget that without the diligent work of medical physicists, engineers, application specialists, radiographers and radiologists to optimise imaging for specific indications, patients and applications, that the image quality we rely on so heavily could easily be far worse.

### Conclusion

So to conclude, I hope I have shown that an understanding of philosophy is intrinsic to the conduct of one's medical imaging. Each of the 5 main branches I have presented and discussed are highly relevant to good quality clinical practice and to an understanding of what we do as practitioners. The appreciation of epistemology leads us to better understand our system of radiological belief and truth. The understanding of logic and the difference between deductive and inductive reasoning will improve our ability as diagnosticians. Awareness of metaphysics reminds us to

not always believe what we see. The study of ethics will improve our interaction with patients, and strengthen our professionalism. And finally, the active pursuit of aesthetics in obtaining the best possible image quality will ensure that our diagnostic skills will be used to best effect.

If we are honest, we know that new discoveries in imaging, medicine and biology have meant that the same images and apparently once correct diagnoses have had to be reviewed, have opinions revised, and sometimes their diagnoses changed with time. We are only human and we do make mistakes, but I am talking about changes in perception, the reinterpretation of observed findings in the light of new facts, and alterations in our understanding of disease that lead to new interpretations of the same images. As some of you I have talked to and heard me say, "the images remain the same, only the answers change".

So, in this lecture I have argued that philosophy is an integral part of radiology, and that as practitioners and students of imaging, we would do well to appreciate how a philosophical approach to our practice would improve our understanding, our knowledge, our perception, and our clinical service. Once again, I thank the Singapore Radiological Society and the College of Radiologists, Singapore for honouring me with the opportunity to address you in this lecture.