Introduction to Health Informatics

Information, Knowledge and Wisdom

Contents

1.1 Learning outcomes check list for the session

Each of the sessions aims to provide you with skills (the 'be able to's' below) and information (the 'know what's' below). Details are listed below. After you have completed the session you should come back to these points ticking off those you feel happy with.

This session contains a large amount of information, partly because its an area I'm particularly interested in and wish I knew more about compared to the little I feel I know. I've tried to make the learning outcomes below reflect what is considered to be useful for you rather than what I think is interesting.

Learning outcome	Tick box
Know what the information pyramid is	❑
Be able to classify data/ information in one of the three levels of the information pyramid	❑
Know the dependency between the levels in the information pyramid	❑
Have an awareness of the possible benefits and problems of data entry at 'point of service'	❑
Be aware of the range of contrasting definitions of 'information'	❑
Be aware of some of the additional characteristics of information that are not found in data as described by Devlin using the Infon concept	❑
Be aware of the centrality of the human brain in converting data into information	❑
Be aware of the large amount of pseudo science around concerning this subject	❑

1.2 Introduction

The discussion concerning 'data' will undoubtedly have appeared to some readers as rather dry and devoid of any humanity. You may be asking yourselves that surely there is more to human knowledge and wisdom beyond that which can be expressed in one enormous data dictionary. Rather surprisingly, you may think, I would be the first to agree with you. To understand what is the 'human' aspect, by which I mean information, knowledge and wisdom we will need to consider each in turn.

1.3 Information

Smith 1995 provides a starting point with a clear definition:

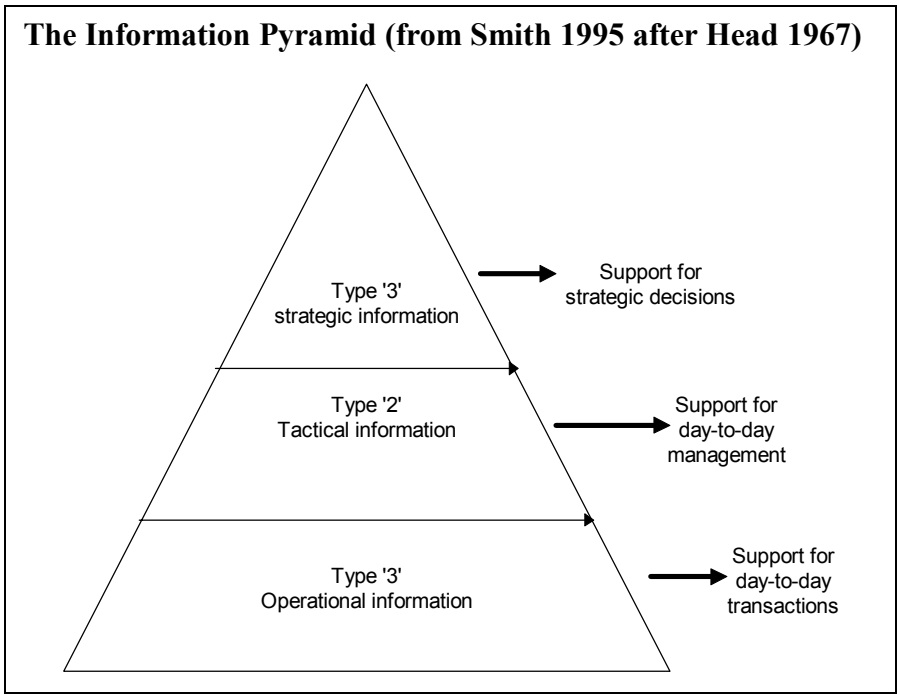
> **Key Point:**
>
> Information versus Data:
>
> Data is information stripped of its potential value. Data is random fact, whilst information is the ability to earn (or learn) from such random facts.

Smith 1995 continues:

> *"Information, in short must be appropriate. But that is a complication in itself, because even appropriacy is relative. It varies with the managerial level concerned. In other words, managerial information means different things to different people. This notion goes back to at least Head (1967) and Nicholls (1969)[1] They pointed out that the nature (and therefore the appropriacy) of information invariably depends upon the "seniority" of the manager who is using it. They both resorted to the concept of the information pyramid to convey the differences. According to this model, there are three major levels of information, namely, operational, tactical, and strategic. These levels of information are defined in more detail below, and also shown diagramatically.*
>
> ***Operational information:*** *This is information needed by those at the bottom of the corporate hierarchy. It is detailed information relating to the day-to-day running of the divisions of the corporation. [Authors note: Within the health care arena this can be considered to be the few clinical, and many administrative, systems that exit]*
>
> ***Tactical Information:*** *This is the information needed by those part-way up the corporate hierarchy (who will usually be the managers of the ones at the bottom) It is not as detailed as type '1' information. In fact, it frequently summarises it (by group, perhaps, or over time period). For this reason, it is often termed* ***derived data****, and the systems which provide it are termed* ***feeder systems****. [Authors note: Within the health care arena this can be considered to be audit or casemix systems]*
>
> ***Strategic Information:*** *This is information needed by those at the top of the corporate hierarchy. It is highly abstracted and summarised, and typically relates to the organisation as a whole rather than to its individual divisions. It to, may be termed*

[1] I have become fascinated with trying to find out exactly how far back it goes. In the paper by Mason & Mitroff 1973 'A program for research on management information systems' they refer to the three levels as 'management problems' citing the paper by Anthony Robert 1965 'Planning and control systems: A framework for analysis.' Harvard. Additionally Mitroff et al, in a footnote, say that the three levels are themselves similar to that of Talcott Parsons 1960 'Structure and process in modern societies.' The free press. New York in which he distinguishes between the institutional, Managerial and Technical levels of organisational decision-making

derived data, *but it bears little resemblance by now to the type '1' information it fundamentally derives from".* [Authors note: This is where it gets rather muddled in the health care arena with so many managers!]



Exercise - Information types

Consider which category of information (operational, tactical or Strategic) each of the following belong to and to whom the information would be most appropriate?

Present pulse rate of a patient

Occupancy on a daily basis for a single hospital ward over the past month

Details of Incidents of disruptive behaviour in the A&E department in the past week

Total number of admissions to the paediatric department at the RVI for diarrhoea and vomiting by month for the past year

Total number of perinatal deaths in each of the ECC states in the past year

Last months Peak flow recordings for a asthma patient

Daily urine output for a ward based renal patient

Number of Incidents of disruptive behaviour in the A&E department on a monthly basis for the past year

Last hours urine output for a patient in ITU

Total reported number of new HIV infected individuals in the UK in the past year

1.3.1 Derived data

The above exercise demonstrates some of the characteristics of derived data. That is it is usually distillation or in other words **aggregated** from lower level data. The aggregation can be over one or more aspects, but is often over time periods, and/or a number of age bands (e.g. all those over the age of 65 years). Another popular aggregation is over a particular single diagnosis or a group of them. Hospitals are often also very interested in various sources of admission for various diagnoses.

Smith 1995 makes the very important point that it must be remembered that this aggregated information must be collected from feeder, preferably operational, systems. In the operational system the collection of

the aggregated data should whenever possible be **transparent**. That is the operational user should only collect, by and large, data that is relevant to them. For example for each patient that comes into a hospital ward the admitting doctor and nurse should provide the relevant information to the operational system. It is the computers task to aggregate the data in order to provide the necessary reports for such things as the number of admissions in the past week or number of males in the age range of 50 to 65 years.

These aspects will be considered in far greater depth in the sections on social issues and databases during the course.

Exercise - Derived data collection

List the main advantages and disadvantages of encouraging the entry of data into a computer system by the people who first collect it (i.e. nurses, doctors etc.).

1.3.2 Data entry at point of service

The idea of obtaining data at the point when it is first collected is called data entry at point of service, or point of sale. Needless to say their are acromyns for it:

POS = Point of sale / service

POS terminal = Computer terminal at a point of sale /service, used to provide detailed product information and connected to a central computer to give immediate stock control information.

EPOS = Electronic point of sale. A system that uses a computer terminal at a point of sale site for electronic funds transfer as well as for product identification and stock control.

1.4 Towards a more rigorous definition of information

The above definition of information is rather rough and ready, what exactly does, stripped of value mean? There are literally hundreds of more detailed definitions / theories etc. around it is clearly the case of quality versus quantity. The vast majority could be easily considered to be armchair pseudo-philosophy and would more appropriately belong in pseuds corner of Private Eye (except for their length which would usually preclude them from entry!). You will therefore be getting a very slimmed down version of the voluminous bibliotheca available.

Christoff 1990 (p.3) takes it slightly further providing a list of the differences between data and information:

Data	**Information**
stored facts	presented facts
inert (it exists)	active (it enables doing)
technology based	business based
gathered from various	transformed from

sources	data

Christoff sees the relationship between data and information as a process of **transformation.** The process being the **meaningful interpretation of data** and again provides a list of how this can be achieved (p.4):

- Extraction = aggregation as described above (e.g. number of various types of cases admitted over a year obtained from general admission data)

- Analysis = creating new numbers from old (ITU APACHE score from a set of raw data)

- Presentation = sorting or graphing the data in a particular way (histograms, boxplots etc.)

[note Christoff also states that *'capture - storing new occurrences or new facts based on events in the real world'* is another method. I don't see this.]

Interestingly Christoff appears to equate the **meaningful interpretation of data** as the **presentation in a meaningful or actionable way**. This would imply that the conversion is one of the tasks of the computer, more specifically an organising and presenting function. I feel this is missing the point to a significant degree and would argue the way particular data is presented on screen is only, up to a point, the process of transformation of data into information. For a more complete explanation, which considers the human factors we have to look in the unexpected area of pure mathematics.

Mathematicians have always had an interest in information, one of the most famous books concerned specifically with human data transfer is C E Shannon's 1948 "The mathematical theory of communication" which paved the way for the Bell telephone company's various developments. It should be noted that while Shannon used the term information it does not equate with our understanding of the term which we should read it to mean data transfer. This is because Shannon was purely interested in the signal and noise associated with communication rather than what meaning would be attached to the signal.

Another pure mathematician - Keith Devlin - has investigated information in terms of the meaning that is ascribed to it.

Devlin 1991 embraces several strands of thinking besides mathematics to develop his definition of information (which takes approximately 250 pages to unravel - so I will only be giving you a very small taster). Among the areas he takes ideas from are:

- **Situation theory** - This is a branch of logic and linguistics developed in the 1980s principally at the Stanford based Centre for the Study of Language and Information (CSLI). Barwise was its first director and has published widely on the subject (references in Devlin's book) including the seminal text "Situations and attitudes" 1983

- **Situation Semantics** - This is yet another new area of scientific investigation. It is concerned with coming to terms with the nature of meaning in language using linguistics as a basis of explanation.

- **Propositional logic** - This is the classic logic of Aristotle (e.g. true/false propositions). Devlin, rather than embracing it, actually develops it, believing that the traditional straitjacket of pure logic needed extending in the present situation concerning information.

Devlin 1991 presents both a proposed process of conversion of data into information within a given situation and a clear definition of what information is. We will first consider the definition and then discuss the process and situation at some length. Devlin, for various reasons, calls **a package of information** an **infon.**

1.4.1 The Infon

Devlin 1991 defines an infon to be:

Infon =

$$\langle\langle relationship, one\_or\_more\_objects, Location, Time, Truth\_indicator \rangle\rangle$$

Do not worry if this looks rather abstract, after all he is a pure mathematician! Lets consider each symbol in turn:

$\langle\langle$ These just represent the beginning and end of the infon definition. Equivalent to the capital letter and full stop at the end of a sentence.

Relationship This relates to the *one_or_more_objects* found in the infon. Examples could be:

$$\langle\langle less\_than, 2, 4, 1 \rangle\rangle$$
$$\langle\langle Patient\_of, David\_Smith, DR\_Grieves, 1 \rangle\rangle$$

These respectively say:

'2 is less than four'

David_Smith is Patient_of Dr_Grieves.

The '1' is explained below.

one_or_more_objects These can be thought of as things in the world, such as people or even relationships. Devlin also considers these to be physical (i.e. actions) or mental states including, perception, belief, desire and intention. This is done partly to address the intentionality of meaning embedded in information which is not usually modelled in much of the work surrounding the empirical analysis of information. The ability to take into account such emotional aspects as intentionality in Devlin's model therefore directly deals with the criticisms of much of this type of work.

The above issues are part of the wider qualitative/quantitative debate. If you are interested in this area read Winograd & Flores classic book "Computers and cognition" 1987, representing the qualitative/phenomenological side of things and Devlin's response to their criticisms on p.145 - 186. I personally have little time for Winograd & Flores being a keen quantitativist.

Location This is the spatial location. The 'where'. It can be either a point (second intercostal space) or a region such as a ward in a hospital, or a operating theatre.

$$\langle\langle nursed\_by, Joan, Paul, Ward\_11\_RVI, 1\rangle\rangle$$
$$\langle\langle performs\_peripheral\_block\_type, Dr\_Jones, brachial, 1\rangle\rangle$$

These respectively say

'Joan is nursed by Paul. Location=Ward_11'

'Dr Jones performs peripheral block type. Location=brachial'

The '1' will be explained below.

Time This is the time. Again it can be either a point (9am 12/12/1997) or a region such as January 1997.

$$\langle\langle nursed\_by, Joan, Paul, Ward\_11\_RVI, 01/01/1997, 1\rangle\rangle$$
$$\langle\langle performs\_peripheral\_block\_type, Dr\_Jones, brachial, 9am\_01/02/1997, 1\rangle\rangle$$

These respectively say:

'Joan is nursed by Paul. Location=Ward_11. Time=01/01/1997'

'Dr Jones performs peripheral block type. Location=brachial. Time=9am 01/02/1997'

The '1' will be explained below.

Truth_Indicator This simply informs the reader if the infon is true (=1) or false (=0).

Inspecting the above infons it would therefore appear that they are all true.

Key Points:

An infon = a packet of information which has the following characteristics:

- One or more relationships (usually verbs)
- One or more objects (usually nouns)
- A location
- A time
- A truth indicator

This seems to make intuitive sense. Consider a patients blood pressure. What you consider acceptable is basically dependent upon the patient, the context (i.e. the time, place and your state!) and you decide if the information is ultimately true or false. I wonder if you are surprised how much humanity can be find in a mathematical formulae!

Exercise - Devlin's Information Characteristics

List ten signs and symptoms that are only important in a particular context (i.e. time, location, patient type etc.). Also specify the context (you do not need to try and use the equations above - sentences will do).

1.4.1.1 Situations and scenarios

Devlin, as I mentioned earlier develops this theme for more than 200 hundred pages (we got to page 15). He develops the idea of a situation as being a group of infons which are themselves related in a particular way. He them goes on to attempt to define scenarios at which point he throws in the towel!

Devlin uses the findings of Situation theory of which I will provide a very short description. If you are interested in this particular area I recommend that you consult Devlin's book which has a selection of references.

Cognitive agents (often just called agents) acquire information from a situation which depends upon those **constraints** of which the agent is aware, or which the agent is **attuned**.

Constraint = This is something that defines meaning for information to a particular situation (Devlin p12).

Attunement = Behaviour guiding awareness of some information (Devlin p16).

> *"Information is obtained from a situation by means of some constraint, and awareness of, or atttunement to, that constraint is what enables the agent to acquire that information" (Devlin p15).*

The above characteristics of an infon can be used to inform the process of beginning to develop some pragmatic method of categorising scenarios. For example it would be possible to classify BP recordings meanings dependant upon the various (and probably more) described above to define an infon. We will now move on to discuss Devlin's cognitive process model of information acquisition.

1.4.1.2 Devlin's cognitive process model

Devlin draws on the work of Dretske (1981) at MIT to provide a model of information cognition which has basically two phases:

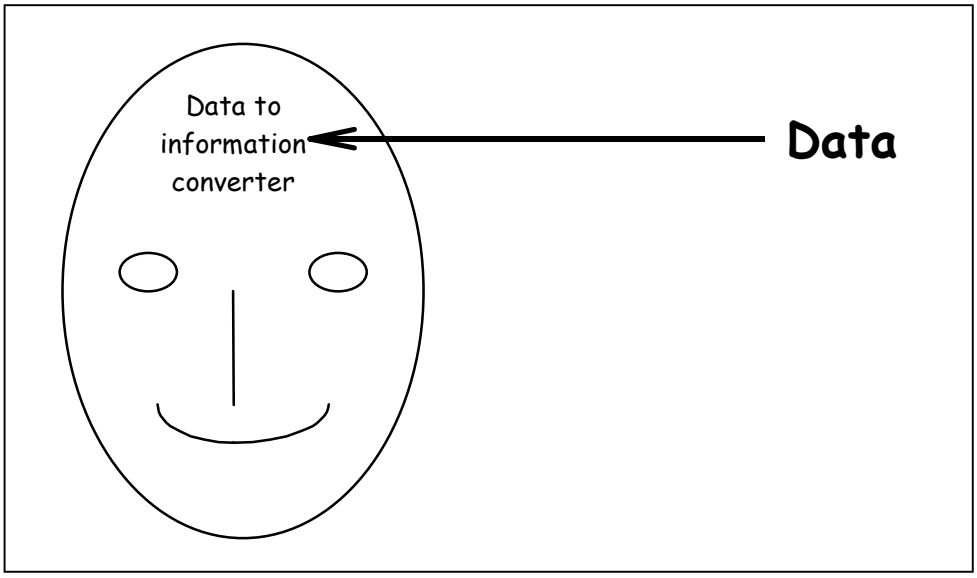
Analog coding - This is 'perception' in which the agent obtains some data via a sensor. This is automatic. It may be conscious or unconscious.

Digital coding - This is the extraction of meaning from the analog coded data. For example think of the analog coding as taking in the total sound of a room full of people. However you cognize the words the person next to you has just uttered. It is you that has classified and added meaning to the noise by digital coding. Devlin suggests that the process of classifying involves the attunement to stored concepts.

The important point to take away from the above paragraphs is that Devlin firmly puts the transformation of data into information in the hands of the human not the computer. This view has also been clearly expressed by McDonough 1963 (quoted in Everest 1986 p.10):

> *"data - is used here to represent messages that can be available to the individual but which have not as yet been evaluated for there worth to him/her in a specific situation.*
>
> *Information - is used here as a label for evaluated Data in a specific situation. When the individual singles out one of his problems and finds among his data materials that help him solve the problem, he is converting or isolating information from data. Note that a given message may remain constant in content yet, under this approach, change from data to information when it is put to use in making a decision." (McDonough cited in Everest p10).*

The last sentence is particularly interesting concerning constant messages yet intermittent transformation into information dependent upon the state of the cognitive agent. Possibly a good example of this is the new breed of minimalist composers/artists where repetition is used not for the sake of repetition but to cause some gradual change in the persons perception - similar to chanting. This actually goes back a long way in music - just think of the multiple chords in most of Beethoven's and Tschaikowsky's music.



Key Point:

Devlin and McDonough puts the transformation of data into information as part of the human cognitive process after data has been received. Therefore, the most a computer can do is, only enhance/facilitate this process not take it over.

(However there are exceptions which we will discuss when considering neural networks and robotics.)

As I mentioned at the beginning of this section pseudo-science abounds in this area of work. The question comes down to 'Is Devlin's or McDonough's model, confirmed by any experimental evidence?' To answer this question we will now consider some relevant modern cognitive theories and experimental results.

If you who are interested in the more theoretical aspects carry on reading the following optional sections if not

Please move onto section 1.5 **Knowledge and Wisdom** ***page 17***

Thanks!

1.4.2 Modern Cognitive theories

At this point I may be accused of teaching my granny to suck eggs. However I did stress that this course was about shared learning and hopefully this is an area where I can learn from you!

All the information provided below is from Derek Smith 1996.

The brain can be thought of as a set of highly complex inter related processing units. For example cognition can be thought of as consisting of four basic modules (perception, memory, behaviour and awareness) (see Smith 1996 p10-11). Various empirical experiments have supported this structure. The diagram below describes the transfer of sensory data into awareness. The sensory module is where data (a lot of it) is received from the outside world (1). Fortunately most of it (2b/2c/2d) gets dealt with subconsciously, being used to monitor and correct skilled motor acts, to trigger automatic reflexes, or to provide feedback to a variety of homeostatic behaviours being controlled by the autonomic nervous system. Meanwhile, information which is going to be consciously attended to is passed along pathway (2a) to….

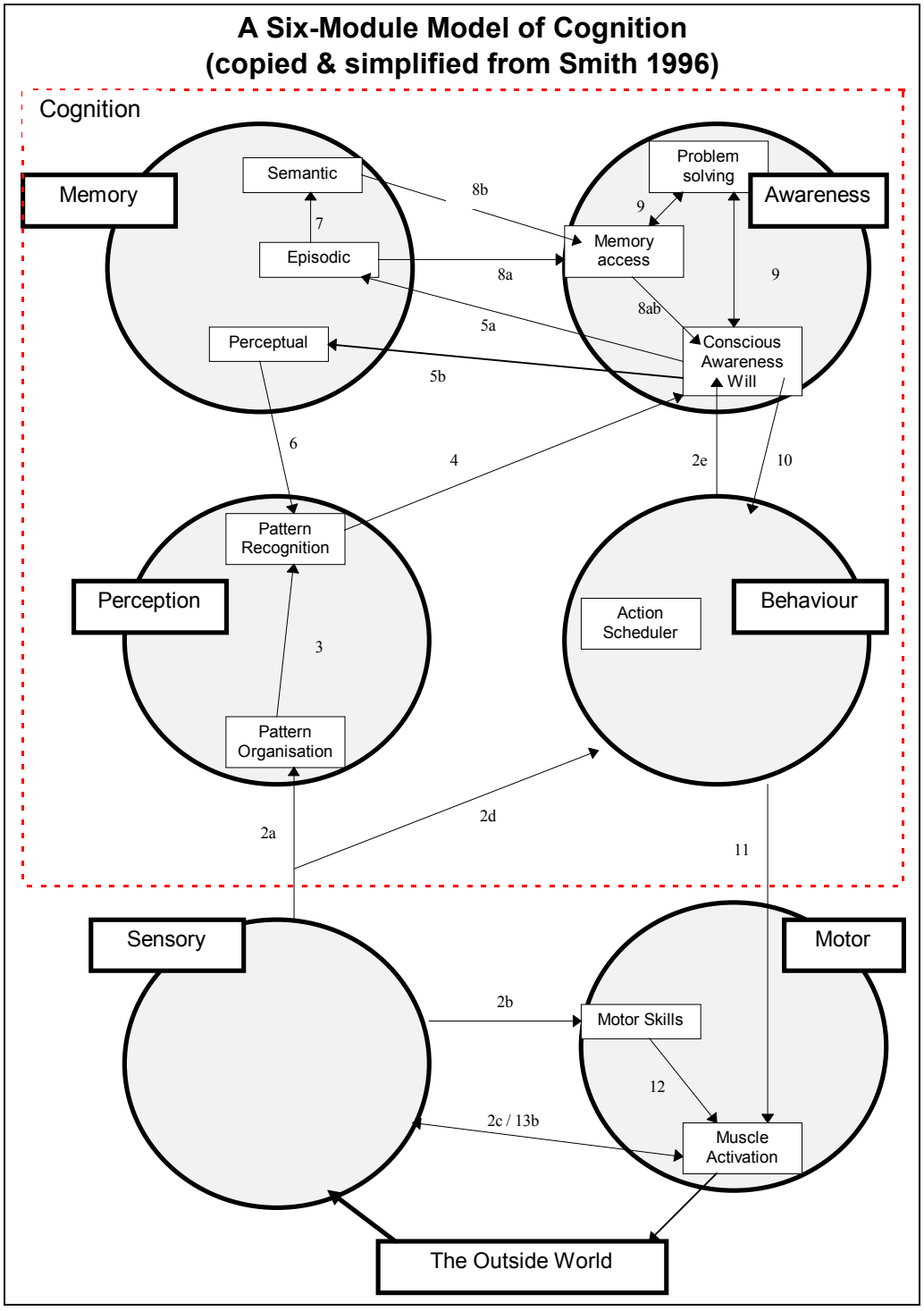
Cognition - Perception: This module is where sensory input is analysed in the light of past experience, that is to say, *perceived*. Perception takes place in two main phases:

- **Pattern organisation** - incoming data is organised into its most likely natural cluster. This is best described as applying the various gestalt laws, and ensures that the pattern recognition phase is given as good a start as possible.

- **Pattern recognition** - Each successful recognition is called a **percept**, and the individual percepts - or, more usually, scenes made up from many percepts - are passed along pathways (4) to the awareness system (see below). For pattern recognition to work, of course, the process needs access to previous experience with the stimuli in question. This type of memory is called perceptual memory, and it follows that whenever external objects are encountered for the first time, new perceptual memories need to be created (5b). There is also an element of perceptual expectancy set up along pathway (6). This allows the pattern recognition process to be speeded up, by enabling it to take educated guesses at what it is likely to be presented with next.

Awareness/Memory: This is the module where the stream of images provided by the perceptual system is analysed, and judgements made as to what is going on in the outside world. This creates a short term awareness of that outside world, and requires both short term continuity of consciousness and significant reference to long term memory. In other words, *awareness per se adds little value to an organism: for an experience to be worth having, it needs to be remembered*. It also needs to be tagged in some way as "nice" (and therefore to be repeated whenever possible) or "nasty" (and therefore to be avoided), and this information is provided along pathway (2e). The current best guess is that there are two types of long term storage available to assist in the decision making process. The first type is episodic memory - your memory of your personal life, and the second type of storage is semantic memory - your general knowledge. Past "frames" of awareness move into episodic memory along pathways (5a) and, over time, the episodic traces are analysed (7) to provide semantic memory with new general knowledge. When using memory to make decisions, either episodic or the semantic memory store can be referred to(8a/8b). If additional resources are required (that is to say, if you have a problem to solve before you can make your decision), then a temporary "problem space" is set up in working memory and accessed as needed (two way path 9). The end result of all this is that some sort of willed behaviour is decided upon, and the necessary instructions are now passed down pathway (10) to initiate it.

Behaviour: Consciously initiated behaviour (10) can often conflict with behaviour initiated via the subconscious routes described above (2b/2c/2d), so somehow the best balance of willed and unwilled behaviours needs to be "authorised". We recommend the term scheduling to describe this operation, and what the subject ends up scheduling is usually a compromise of several often conflicting demands. This implies that some sort of pleasure-pain evaluation(see above) has been going on using pathway (2d-2e). This in turn, implies that the primary function of "the Will" is to adjust current sensory input, using behaviour, in the direction of maximum net pleasure. The final selection - whatever it happens to be - is passed down pathway (11) to the motor system to "deliver the goods" (Derek Smith 1996).



The above description based upon modern research indicates that perception is very much about, filtering and then classifying incoming impulses. This appears to be very much in line with Devlin and McDonough's ideas.

1.4.3 Experimental basis

While the above description of cognition provides a basis for Devlin and McDonough's ideas it itself is also based upon numerous research findings. I will only describe a few of the relevant ones in the next few pages.

Once again the information is taken virtually word for word from Smith 1996.

1.4.4 Pleasure-Pain signalling and Value systems

The British anatomist John Young, work on memory in cephalopods goes back to the late thirties. He investigated the relationship between octopus vision, octopus problem solving, octopus hunting behaviour and the various lobes of that species' brain…. In short he discovered (adapted slightly from Smith 1996)

> *"..at least in the octopus's vertical lobe and the mammalian cerebral cortex memory is both everywhere and nowhere in particular" (Boycott 1965)*

It is the words " everywhere and nowhere" which are the most significant, because they drew the Naples team strongly towards the idea of neuronal net memory mechanisms. Engrams laid down in widely distributed networks of neurones would behave in precisely the required fashion. But such widely distributed networks could only function at all if part of the network could somehow be kept informed as to the good-bad nature of the current input. That is to say, it was not enough merely to recognise a stimulus: engrams[2] needed also to be coded either as to-be-approached or as to-be-avoided. Memory was only worth having if it was biologically adaptive; if it was going to help survive. And the necessary coding could only take place, Young argued, if there existed results indicator pathways in the CNS capable of tagging each engram with some sort of pleasure pain evaluation. (Smith 1996 p.66).

> *"In fact, in Young's analysis at least five types of neurones were needed for such a memory system to work effectively" (Smith 1996 p.66).*

Considering the Octopus, these included the following types:

Sense cells: Those sort of neurones involved in receiving the stimulus of some sort (e.g. optic fibre).

Classifying cells: Those sort of neurones that carry out the Initial perceptual analysis of the stimulus.

Memory cells: Those sort of neurones that detect and store known patterns in the perceptual material. In turn they can activate particular Command cells.

Command cells: Those sort of neurones which convey instructions on how to behave (in the case of the octopus whether to attack retreat). Before learning takes place, memory cells have access to both types of command cell (attackers and retreaters), and the essence of learning is to close off one of these pathways. The vital decision can only be safely achieved with input from Results Indicator cells

Results Indicator cells: Those sort of neurones which convey pleasure-pain instructions to both the memory cells and the command cells, thus allowing appropriate behaviour to be associated with a given memory.

Motor Ganglion cells: The task of finally delivering the overt behaviour is then taken over by motor ganglia dedicated to controlling the muscle groups involved. (from Smith 1996 p.67).

[2] Engram = A biological representation of a memory. See Smith 1996 p13

More recently this idea of attaching (tagging) some pleasure pain aspect to the sensory input has been developed by Gerald Edelman, of the Neurosciences Institute, New York. Who postulates (e.g. Edelman 1994) what he calls a **value system**, the role of which he describes as follows (Smith 1996 p66):

> *"What the value system does is it sends a chemical signal to the rest of the brain such that those connections that were just being used to produce [an] action which was valuable will become strengthened" (Edelman 1994, p11.)*

1.4.5 Neural Network Studies

Neural networks are basically computer imitations of how it is believed the brain works at the neuronal level using such ideas as thresholds, and inhibitory excitatory neurones etc.

Quoting Smith 1996 once again:

> *"The beauty of neural networks is that each electronic synapse is purpose-built to care for its own weighting. The network in other words, is free to acquire its knowledge in much the same way that biological brains acquire theirs - by learning from experience. In computing terms, they are important because they need no (very expensive) programming. As a result, neural networks are now being put to a growing variety of commercial applications, such as telling coin from coin in vending machines (they "recognise" the different bounces), checking your credit card spending pattern, and steering robots"*

Neuroscientists now see neural networks as validating the traditional cell assembly concept: the neural network's weighted connections are simply the electronic equivalent of biology's variable synaptic strengths ... the new science even has a new name **Connectivism** (according to McClelland (1988) the term was coined by Feldman (1981)."

> *"Representations in connectionist models are patterns of activation over the units in a framework" (McClelland 1988 p109).*

Allport (1985) calls the process of developing these frameworks as **auto-association.**

In relation to the Devlin cognitive model Allport 1985 provides several important consequence of auto-association:

> *"..it would demonstrate "part-to-whole" retrieval, such that the whole engram could be activated by stimulating part of it"*

That it would take longer to recognise a given input according to how similar it was to other stored engrams (especially if there were several potential matches to be sorted out) that it would be able to recognise previously unknown inputs automatically including some as an example of the most similar known input (a process known as "generalisation", or "categorical capture")

The issue of categorical capture is further explored in the following extract:

> *"….matrix memory systems automatically respond to the common elements, or prototypes, from a set of related, learned instances, there the 'prototype' is the pattern having the highest correlation with [the] entire set of instances, even though the prototype pattern itself was never previously encountered[.] To put the point in a slightly different way,* ***matrix memory systems extract 'semantic memory as an automatic by-product of the encoding of particular, related, 'episodic' instances****." {Allport 1985 p49 quoted in Smith 1996 p70 italics original, but bold added)*

1.4.6 Human studies

Further support is given that our internal representations of the world are categorised by both case histories and experiments on normal subjects.

Succhett and Humphreys (1992) describe a patient CW, a male (born 1949) who had suffered a large left frontal-parietal CVA. Generally speaking, CW's comprehension was only moderately impaired, and recognising and naming visually presented animals, fruits, and vegetables was relatively good. Performance was much more seriously impaired, however, when the items shown were artefacts (common objects such as tools, kitchen utensils, etc.) or body parts. (again quoted from Smith 1996)

Brown (1968) asked two groups of subjects to write down the names of as many of the 50 American states as they could in five minutes. One group of subjects had previously heard 25 of those names read out to them, and this group, not surprisingly, scored more right answers than control subjects who sat the test "cold". Nevertheless, when the unread states were counted in their own right, the list-heard group actually did worse than the list-not-heard group. Apparently, "priming" part of a category in some way inhibits retrieval from the unprimed part, a phenomenon known as "**category exhaustion**". (again quoted from Smith 1996)

1.5 Knowledge and Wisdom

As you can imagine from the tangle of the above attempting to define information that any attempt to define knowledge is even more tricky. Obviously it is not made any easier without a clear understanding of its prerequisite (i.e. information). Devlin attempts by way of considering states of mind, belief in particular. However I shall not push you any further.

Well, wisdom, let that fall into the realms of metaphysics!

I recently came upon this simple description of wisdom on the net. All it really demonstrates is the naiveté of most people:

> Data on its own has no meaning, only when interpreted by some kind of data processing system [i.e. the human brain] does it take on meaning and become information. For example, the number 123454657.99 is data but if it is output as your bank balance then that is information because of your interpretation. It provides a basis for decision making.
>
> 123454657.99 is data.
>
> "Your bank balance has jumped 8087% to 123454657.99" is information.
>
> "Nobody owes me that much money" is knowledge.
>
> "I'd better talk to the bank before I spend it, because of what has happened to other people" is wisdom.
>
> [*FOLDOC - Free on-line dictionary of computing Http://wombat.doc.ic.ac.uk/ - adapted*]

1.5.1 Conclusions

This topic may have seemed rather muddled and lacked any relevance. However it is pivotal to my job (and probably yours) as I'm supposed to be a health Informatician. That is someone who knows about information in the health arena?

We will be returning to the area of cognition again when we look at the clinical method and particularly medical decision making.

From the above findings it would appear reasonable to tentatively accept Devlin's model of information description and processing. However it must be stressed that this is a very fast moving area - and my notes are probably already out of date?

Letting Devlin have the last word:

> *"Undoubtedly there will one day be a theory of meaning and a science of information. Whether it will bear any resemblance at all to the work presented here is another matter. But we certainly will not find it all the time we continue to crawl around under the one available street-lamp, however brightly it might shine on one particular patch of pavement. [referring to those who still use pure logic] … there will be a science of information, and logic, of some form or other, will be a major part of that science. We just have to find it." (p301)*

Exercise:

Write short notes from the contents listed below:

1.6 References

Christoff Kurt A 1990 Managing the information centre. Scott, Foreman/Little, Brown Higher education, London.

Devlin Keith 1991 [1995 paperback] Logic and information. Cambridge University Press

Smith Derek 1995 System Engineering for Healthcare professionals - Half module 216 workbook. Cardiff institute of higher education. Tel. 01222 551111

Smith Derek 1996 Memory, Amnesia and Modern Cognitive Theory Coursebook. Cardiff institute of higher education. [ISBN 1 900666 00 6] Tel. 01222 506070

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