# TODAY'S NEUROSCIENCE, TOMORROW'S HISTORY:
A Video Archive Project

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Interviewed by Richard Thomas

Interview Transcript

### Early years exploring the brain

Maybe I could start at the beginning and say that in my first few years here I was working as a PhD student. I was working on a problem of visual processing. I was working on a problem of why patients sometimes complete objects across their blind field, and then quite soon after this, in 1960, I took over the responsibility of providing a clinical service to the neurologists and neurosurgeons here at the National Hospital.

Back in the fifties and sixties I think it's probably fair to say that English neurology was very much concentrated here in Queen Square. There'd be small departments in Bristol and in Oxford but what's happened over the years is that every medical centre now has a department of neurology, but this wasn't the case back then and all manner of neurological cases came here. It was easily the largest neurological centre in the country and probably the world. Rare cases of this or that will come here from all over the country. People seeking a second opinion, people seeking a third opinion. So, from a research psychologist point of view, there was very much a critical mass here so it made it possible to do these group studies comparing thirty patients with right hemisphere lesions, thirty patients with left parietal lesions, which really was not viable to do elsewhere.

Essentially my job was to assess patients for the neurologists, and the neurologists here being European neurologists were interested in all manner of cognitive deficits. These patients might have spatial difficulties, reading difficulties, language difficulties, whatever. So you're seeing a patient for the first time, and you're testing their reading or you're testing this, and you think, 'Ooh, I haven't seen that before. I wonder what the problem is.'

### The pig with no tail

Every time one starts on a single case project, it's usually been triggered by something that sort of caught one's interest or indeed even excitement. Indeed, I remember with my first semantic memory case, he was a very imposing, important man that I was asked to assess, and I was taking him through one of the rather routine tests that we're expected to do. One of these tests is called picture completion and all you have to do is point out what's missing in the picture, and this happened to be the first, easiest item and it was a picture of a pig without a tail, and he said, 'The dog hasn't got a tail.' And I said, 'What?' And he said, 'I'm so sorry, the cat hasn't got a tail.' And that's literally, started it. He really didn't know one animal from another.

### Neuropsychology – first tests to assess information processing

When I came into the field, which, as you know, is fifty years ago, there were practically no tests; there were practically no methods. I came with the outlook of, hopefully, a cognitive psychologist who liked the idea of measuring things, but the actual practice of neuropsychology in a hospital -- one had no tools at all. And so one of the things one had to do, or *I* felt one had to do, was to develop tests that would be useful for clinical practice. In other words, tests that were derived entirely from what the patient could or couldn't do. In other words, tests that were relevant to their problems.

In the domain of perception, I designed the 'Unusual Views Test', for example. In the domain of memory, I introduced formal measures for assessing retrograde amnesia by using public figures going back in time or using events going back in time. I think it's probably fair to say that was the first time anyone was sort of bold enough to try and measure retrograde amnesia, which in fact, I did in order to try and get some evidence about Ribot's Law, which I didn't really believe. So I thought, well, the only way to tackle that was to measure it and so I devised those tests and I think they've been -- other people have got their own versions of these sorts of tests -- and I introduced tests which are, I think, quite widely used. Recognition memory tests for words and faces, which are used a lot as a sort of standard measure of someone's memory. And the language domai -- we produced a test, which is quite widely used, test of naming skills. I've published a test on word comprehension which is, I think, also quite useful.

### Reinterpreting my data

I like to think that empirical observations, new phenomena, will always be of interest even though they may, in the future, be reinterpreted. I myself have reinterpreted my own data in two different domains. One was in the case of a patient who we described as having a sort of

limitation of simultaneous form perception, and I now think the interpretation was incorrect though it was as good as we could do at the time. The actual data that we produced can be replicated perfectly easily -- it's just that the interpretation of it I would now treat differently. Similarly, in the domain of memory, the original interpretation that Larry Weiskrantz and I put on our work with amnesiacs, I was dissatisfied with, and I tried to do experiments to either support it or disprove it, and I think I more or less succeeded in disproving it. And that forced one to sort of move on and think again, which I trust we did.

## The British tradition of experimental psychology

In this country, as distinct from America, there had always been a tradition for cognitive psychology or experimental psychology, and there was -- the origins of this, if you like -- go back to Bartlett in Cambridge and his students. And Broadbent, Donald Broadbent, who was the leading light and head of the APU, was sort of spearheading this venture in this country, and he was also in Cambridge along with Zangwill. So one was -- became aware, fortunately -- that there was another aspect to experimental psychology other than running rats in mazes.

I, along with other English psychologists, were more influenced by Donald Broadbent who was very much an advocate for the information processing approach and I thought that in my work here at the National, that the information processing approach was exactly what was required to sort of impose, if you like, on top of a sort of neurological analysis, and that the two together would make, I hoped, a very sort of powerful tool for understanding more about the brain.

## Perception – brain lesions

The brain has to know that this object, that object, this object, different lighting conditions, its all the same object. So it has to extract, if you like, from various features that this is all the same object. So here we have a canonical view (of a kettle), which patients with right parietal lesions have absolutely no problem in identifying. There's another canonical view (of a paintbrush), and there's the hammer. And now we have the same objects photographed from an unusual angle, and there's the hammer and the paintbrush and the kettle. Patients with right parietal lesions have great difficulty in seeing these same objects but photographed from a slightly unusual angle.

Patients with brain lesions, patients with occipital lobe lesions, really don't have an adequate percept to work on, to achieve a structured volumetric description. Patients who have difficulty in achieving a structured percept are unable to perceive photographic material. They

are unable to perceive sketch drawings; they are unable to perceive vague television programmes, and then patients who have a deficit at achieving or extracting meaning from an object, literally misuse objects. If they go into the kitchen, they wouldn't know – even though they can see perfectly well – they wouldn't know what to use to stir their soup with or whatever. They, these people are in fact quite handicapped.

## Facial recognition and the man who counted sheep

There is the issue, of course, whether there is something special about faces or whether people have difficulty with faces simply because that's perhaps the most difficult percept that we're required to process, and opinion is very divided on this. I myself think that there *is* good evidence for there being a special channel that processes faces.

I want to see how well you recognise famous faces. Now, only one of these is famous. I'd like you to point to the famous one. A patient with a prosopagnosia or indeed an amnesic syndrome will not be able to pick out the famous face.

I myself more recently worked with a patient with prosopagnosia – very classical prosopagnosia – and this particular patient, he, in fact, he was a physician and had to give up his practice after a stroke because he couldn't recognise his patients. So he took up sheep farming and one day he said to me, 'Don't you think it's odd that I can recognise my sheep and I can't recognise my wife.' And I said, 'Yes, I think that's very odd indeed. Let's see if we can't investigate this.' And he very, he entered into the spirit of the enterprise because he took photographs of all his sheep and posted them to me. And we had a … we cut off their identification marks and next time he came to see us we were able to show him photographs of his own sheep and yes, he did know the numbers which we had cut off.

## Dyslexia

Reading, as you understand, is clearly a very complex process. Our experiments or observations of dyslexic patients made it clear that it is a very complex process because our patients with dyslexia take many different forms. And I worked – during the 70s – I worked quite a lot with Tim Shallice on patients who had various kinds of dyslexic problems, and following on, if you like, from the earlier work of Marshall & Newcombe, who had first attempted a taxonomy, if you like, of the dyslexic syndromes by describing deep dyslexia and surface dyslexia. That Tim and I, if you like, followed up and built on, and we summarised our work or tried to revise the taxonomy of the dyslexic syndromes by describing what we termed the central dyslexic syndromes and the peripheral dyslexic syndromes. I was particularly

interested in the peripheral dyslexic syndromes and we were able to identify three such syndromes, all of which we described in some detail and published together.

Central to all theories of reading is that there is a word form unit -- that a group of letters forms a unit, a single entity -- and the peripheral dyslexic syndromes would be when there is a difficulty in achieving that single unit. And the central dyslexic syndromes are those syndromes where it's no good just having a visual unit, if you like, you have to, it has to have meaning. It has … you have to get right through; you have to know what it means and you have to be able to say it aloud. So it's the extraction of meaning and sound from the word form unit that constitutes the central dyslexic syndromes. And the peripheral dyslexic syndromes I think are very interesting because it has … we've been able to identify neglect dyslexias where there is a sort of imbalance between achieving this unit either at the beginning of the word or the second half of the word. Or in other cases we've described the word form unit itself as damaged insofar as these patients are reduced to reading letter by letter because … and sort of piecing it together through their spelling system. And then we've described an attentional dyslexia whereby we think that the output from the peripheral systems to the more central systems is damaged and that there's a problem going from, if you like, the parallel processing of the early systems to the more serial processing which has to take place in order to extract meaning. And, so that is our basic taxonomy.

## Memory: short-term and long-term

In the fifties, it was quite usual for psychologists to take an interest in memory and this was following on from Frederick Bartlett's work in Cambridge. He studied memory, and also the early experimentalists, I think I'm right in saying, in Germany, liked to study or try and derive the rules of memory by getting people to learn word lists or to learn nonsense syllables. And, as I say Bartlett's efforts of studying memory would get people to recall a story, and people hadn't entertained the idea there might be more than one memory system in the brain. And it was under Donald Broadbent's influence that the distinction between what he termed 'short-term memory' and 'long-term memory' was explored. And the point about … the way I think he would regard short-term memory, was that this was a limited capacity system that was very labile and had short duration, whereas a long-term memory system was … had an almost virtually unlimited capacity but had very stable properties. And he thought that short-term memory was not just on a continuum with long-term memory, that these were two systems and that this short-term system, with its limited capacity, provided, if you like, a buffer store so that material could be held while it was being processed in a suitable form for long-term memory. In other words, it was considered not just as a continuum of long-term memory but a store with different properties that provided the gateway to long-term memory.

## Short-term memory, visual and verbal

KF was a very interesting patient that I worked with and was asked to assess quite routinely. He was a young man who'd suffered a head trauma from a motorbike accident, and in my routine assessment of this patient I discovered that he had a digit span -- which is one very conventional measure of short-term memory, as defined in the sort of Broadbentian terms -- of one item. So if you said to him, 'Repeat after me: three,' he could say, 'Three'. If you said, 'Repeat after me: seven, two,' he would say, 'Seven' [clicks finger] – forgotten the other.' Now this young man, he was twenty-three or twenty-four-years-old at this time, had, to my mind, perfectly good memory. He was totally different from the amnesic patients that I was used to working with. He was totally different from the, sort of, ageing patients who were getting memory deficits due to old age, and you could give him formal memory tests like list-learning and he would perform at a normal level. And I thought this -- as I knew the normal literature on the models of short- and long-term memory -- I thought this was sufficiently interesting that I approached Tim Shallice, who was at the time a young lecturer at UC, and said .. I went to him, he says, he says he remembers where we were sitting in the Marlborough pub when we had this conversation [laughs] – I think that may be a confabulation – [laughs] – anyhow I said, 'I think the theories are wrong, because I've got a patient with a short-term memory deficit whose long-term memory is perfectly normal.' And he thought this was really very interesting and came over and met the patient and that triggered our collaboration, which went on – very fruitful collaboration – which went on for many years. And we did a series of experiments with this young man and we published our first paper in 1969 and it was followed up by a more theoretical paper in 1970, where we indeed try to challenge the orthodox model and put forward our own parallel processing view.

Much of the work on short-term memory since then has been devoted to trying to decipher what it is in our cognitive skills that we need this buffer system for. It's also something that at a later stage Ros McCarthy and I worked on in more recent cases of short-term memory deficit, and I think it's generally agreed that it's now part of the language processing system.

If we try and link these various short-term buffer stores -- I've just been talking about the auditory-verbal one -- but if we go back to Alan Baddeley's concept of working memory, he also in his model incorporates a second slave system, which he calls 'visual-spatial sketchpad'. And in our own work, my own work here, I think that we have not only an auditory-verbal short-term store, I think we also have a visual-verbal short-term store, which holds information like written letters. Now, I think it's also probably true to say that each of these stores has its own anatomical underpinnings. The visual-spatial sketchpad is almost certainly impaired by right parietal lesions. There's good evidence in for the auditory-verbal

deficit to be associated with lesions of the inferior lobe of the left parietal lobe, and I think that the visual-verbal deficit is due to lesions more posteriorly at the sort of boundary of the occipital and temporal lobe, again in the left hemisphere. So that means that assessment of these skills does indeed have some diagnostic usefulness.

## Amnesia – implicit and explicit memory

When we were working with the amnesic patients, one in particular that started off this enterprise, was a patient very like the ones that they were working with in Montreal because this was a patient who'd had a temporal lobectomy. And it was a disaster in that she became gravely amnesic, and in trying to study her memory – it's very difficult to study memory in a person who hasn't got any. So I wondered if by using what are termed the Goilin figures – he devised them – which are sets of drawings of common objects, the first one is a very sketchy representation and then it gets more and more complete until you have a perfectly good representation. And I wondered if one could use this as a memory test, if you like, try to pick up the dregs of memory in someone whose memory was very bad.

Here we have a fragmented drawing of an object, and I want you to have a good look at it and see if you can recognise it. Okay, the next picture is more complete. Perhaps you can recognise it now? And here we have the complete version. Yes, you're quite right, that's a pram. Here's another of these incomplete drawings. I want to see if you can recognise this one. Okay. Here it is, it's more complete now. Did you get, recognise it? And there we are, there's the complete drawing. Now, I'm going to take these away for a moment or two and then I'm going to show you them again. Here we are. Do you know what that is now? Good, you're quite right. Yes, it was a pram. Here we are -- here's the next one. Do you know what that is now? Yes, you're quite right. Well done.

She showed good retention of these very sketchily drawn figures, pictures, which she couldn't recognise the first time, and she showed very clear dramatically good learning curves using this material. So it wasn't that I was picking up the dregs of memory. I was the founder, by accident, had found a task at which amnesics appeared to have a normal memory, given you accept, that that is a test of memory. And this, of course, we ourselves explored this by using other techniques to, if you like, to trigger a memory. We used what we called then 'cued recall', what is now called 'stem completion'. We gave a patient some words to learn and then we showed them the first three letters, and lo and behold, they could retrieve the word at a normal level using this technique. But if you gave them two words and said, 'Which of these two words have you seen before?' they wouldn't know. So here we had further evidence for a, if you like, a qualitatively different type of memory, which is now, I

think, gone into the literature as being the difference between implicit and explicit memory. I regret I didn't coin those two phrases myself. [Laughs]

So if we think about the studies of amnesia, when we were able to show these effects with cued recall and indeed picture recall, which is now termed evidence of implicit memory, it was already known that amnesics had normal procedural learning, insofar as Brenda Millner had already described her famous patient HM who could do a motor learning task quite normally. So there are a number of aspects of more sort of automatic skills and habits that are intact in amnesic patients, and the actual, if you like, neural underpinning of these skills is, I would say, not very well understood. But it is undoubtedly a very clear distinction in amnesics that though these various aspects of more sort of automatic behaviours that are intact, and it's when they have to recall or consciously recall events from their own lives or from other people's lives, then they are at a loss.

## Long-term Memory – discontinuity between remembering facts and events

At the time -- this is we're talking about late sixties / early seventies now -- long-term memory, no differentiation was made between recalling what you had for breakfast yesterday, what you're going to do tomorrow, and whether a yellow bird is called a canary. This was all regarded as part of one's long-term memory system that you could retrieve facts and you could retrieve events, and that the same memory system mediated both classes of information. The first person to put a dent in this sort of holistic view was Tulving, working in Toronto. He wrote a theoretical paper saying that these must surely be two very different types of memory, and this as far as I was concerned, fell on very receptive ground because I was already working with amnesic patients, and my amnesic patients, even though they couldn't remember literally from one moment to the next, and indeed, even if I saw them every day, they didn't know who I was, they did not, they could recall facts. Their knowledge of language, their knowledge of things, they could name things, they could recognise pictures, they remembered arithmetic. There were all sorts of things that they could recall. And so then when I actually, at much the same time, came across a patient who I've already described, who seemed to have lost his factual knowledge but his memory for events or knowing what he was going to do, and what he'd done yesterday and so on, was perfectly intact, that it seemed to me that here we did have a very important discontinuity between memory for facts and memory for events. And I pursued this and tried to make the case that patients I was working with had indeed had damaged … had a depleted semantic memory for facts but that their episodic memory -- given event memory -- given you stayed within the vocabulary that was still meaningful to them, were completely intact.

Well, to try and illustrate why you need the intact semantic store as well as intact episodic memory system, let me give you an example. Take the question: 'What is a daffodil?' and compare that with the question, 'Have you ever grown daffodils?' Now, if I was to ask these two questions to an amnesic, they would know what a daffodil was and tell me, but they wouldn't have the faintest idea whether they'd ever grown them. But if I gave the same two questions to one of my patients with a factual memory loss, they would not be able to tell me what a daffodil was, and because of that no longer be able to tell me whether they'd ever grown daffodils because they would say, 'Well I might have, if I knew what a daffodil was.'

**Understanding concrete and abstract words; recognising objects and animate things**
I was first, myself, first alerted to the possibility of category specificity working with my first semantic memory case, and this particular patient had very clear-cut difference in his ability to define abstract words as compared with concrete words. Living things, non-living things, are all concrete objects. Now abstract words are sort of concepts, ideas, emotions. My patient, AB, could give me a beautiful definition of the word 'supplication', not even known to half the population, a hint, I mean, all sorts of words. He had not the slightest difficulty. He even gave me a nice definition of the word 'knowledge', but he didn't know what a carrot was or he didn't know what a cabbage was, or I asked him about frogs and he thought they were things you went and shot in the countryside. And for me … and I documented this quantitatively and I thought that this was an example of categorical organisation within our vocabulary between abstract and concrete words. And then I suppose the next step for me was, in fact, seeing this same dissociation in a patient with a dyslexia, acquired dyslexia. This patient, to my astonishment, could read very obscure abstract words but stumbled completely over trying to read words like 'dog' and 'cat'. So here I presented this also as an example of category specificity. And soon after that I had … I was working, doing a clinical work-up of a patient with a Herpes Encephalitis and this patient was partly confused, partly – heaven knows, maybe had an associative agnosia – anyhow, I was asked to try and adjudicate between whether this patient had object recognition deficits or whether he was just a confused young man. And what I observed was that even though he knew common objects, he was unable to identify any animals or plants or fruit, but his object knowledge was intact. And I worked on this patient with Tim Shallice and soon after that – things always come in clumps – there were several other Herpes cases admitted to the hospital that we were asked to assess, and they all showed this same dissociation of intact object knowledge and impaired animate item knowledge.

We described our findings in these poor patients but people don't like taking, accepting, something, even though you've produced very clear-cut data [laughs], you always have your

critics. So they thought this was because obviously, to the man in the street, recognising animals was far harder than trying to recognise objects, and for me, the only way to really counter these arguments in a way that can't be objected to, is to find the double dissociation. And so in this case, it was one of the few instances, I suppose, that I was actually looking out for something rather than just being led by the patient. In fact, there was another patient in whom I was able to observe the opposite … the opposite. This patient's knowledge of objects was very poor, but her knowledge -- and we could demonstrate this -- of animate things was very, very much better. And she, what pleased me was, she was particularly good in identifying flowers and very poor at identifying objects.

### Understanding nouns and verbs, and the man who remembered countries
Double dissociations I think are important for neuropsychologists who are trying to discover or work out the sort of modular organisation of our cognitive systems. I think this is particularly the case in trying to understand the organisation of our knowledge systems. So by a double dissociation -- take the example of animate and inanimate -- first, we describe patients who had, who were very impaired in their knowledge of animate things, but who had preservation of their inanimate things. Now this pattern of performance gains a lot of strength by the description of the opposite, and it is the opposite pattern with the impairment of inanimate objects and the preservation of the animate, that it's this cross-over that one describes as a double dissociation, and suggests that these two systems must have a degree of independence.

Well, these were the two major and first sort of compelling descriptions of category specificity. I think it's true to say that since then further, more fine-grain dissociation between preservation - selective preservation – or selective impairment categories have been described. And then there's also the slightly sort of orthogonal dimension where we think in terms of parts of speech, rather than in terms of, if you like, taxonomic categories. So we now know, and I think its pretty well-accepted, that the dissociation between nouns and verbs, and this has resulted in a double dissociation. The impairment of nouns particularly is knowledge of nouns is quite commonplace. I think Ros McCarthy and I were perhaps able to describe a patient who had lost the meaning of verbs, and we, this then constitutes a double dissociation and indeed we interpreted, reinterpreted if you like, some of the agrammatic syndromes in terms of loss of comprehension of verbs, rather than of syntax. There are a number of examples of more finegrain categorical effects.

For example, a patient that I studied with Pat McKenna -- this was back in the late seventies actually -- she observed that when she was testing somebody on their proper noun

knowledge, trying to identify people, always identified them by their nationality. So trying to name a picture of Ghandi said 'Indian', and so we wondered whether this patient – this triggered the experiment – we wondered if he had, this patient had, preserved his knowledge of countries. So what we did was - we're still using this test today quite regularly – put together a test that consisted of fifty drawings of common objects. Pat was sent home that night to come back the next day with fifty pictures drawn by hand -- ten objects, ten animals, ten parts of the body, ten countries, and – what was the other one? – there were definitely five categories. Anyhow, this patient was asked (a) to name all these fifty items, and was then asked in array of ten 'Point to the dog, point to the cat, point to…' – colours [laughs] -- and then we had these ten colours: 'Point to the green, point to the red, and then maps: 'Point to Italy, point to United States, point to Wales, etc. And the, he could do the countries. He could both name them and understand their names, and he was at a loss with the other categories, and this effect has now been replicated in several more recent cases, but that's what started that line of enquiry.

## The visual world and verbal knowledge

A further aspect of understanding the organisation - cerebral organisation – of our knowledge systems, is whether or not there are modalities and whether there is an independence of modalities, or whether we have a unified knowledge base that is not specific for one modality or another. Now the only two modalities that have been investigated in any depth are obviously the verbal domain and the visual domain, and so for quite a lot of these categories one can either assess it verbally by asking the person to define a word or you can assess it visually by asking them to identify a picture. In my very first case, my first study of this topic, I thought that we got a double dissociation. One of my patients used the … exactly the same pool of words -- you either present it as a word or you present it as a picture of the word, and one of my patients had very much more difficulty identifying a picture than defining the word. So, say there was a picture of a basket, perfectly clear picture of a basket, he'd say, 'I don't know what that is.' But you say, 'Tell me what a basket is', and he'd say, 'Oh well, I put my things in it when I go shopping.' So that was a, I thought an example of the separation of the two modalities. And the other patients, which perhaps more common, it's the other way round, that they will be able to identify the picture but when faced with the word will say, 'Basket, basket – doesn't mean much to me.' And this has been investigated over the last twenty years and still, I think fair to say, fairly active research in this area and I think its also fair to say that the, if you like, 'two camps', those that think that there *is* reasonable evidence for modality specificity, either the visual world being damaged but retaining your verbal knowledge base, and vice versa.

Karamatsa takes a more unitary position here and he gives primacy to the visual knowledge base and on … by his account, and he admits that he can't account for it, except to say that we got it wrong, that you can't have a visual associative agnosia. This is clearly speculative but I must say I think that the answer to this will come probably from the people doing imaging work. But there's already suggestions that the animate and inanimate are, have different loci in the brain -- that nouns and verbs have different loci in the brain. So yes, I think that there must be numerous circuits. I also assume they interact. I shouldn't think they have total independence but that's why I use the phrase 'a degree of independence' in that one can be, you know, selectively damaged, or selectively impaired, and I assume, though this may not be correct, that this would be because of the location of the physical brain damage.

## The challenge of access

Ros McCarthy and I were studying the residual comprehension skills of a patient who had suffered a major left hemisphere stroke. This is the patient who we were able to demonstrate, by using word-picture matching tests, that her knowledge of objects was more impaired than her knowledge of animals and flowers. But there was another interesting – very interesting – aspect of this patient. When we were trying to film, make a record of this, we noticed that the first time she made a response, say there were three objects on the table, "point to the cup, point to the glass, point to the pen", she would get the first one right and then fall apart. And the question was: how long a gap did you have to leave before something became the first object? And what we did was, we used one of the standard word-picture matching tests, and we did, simply did it at two speeds. Firstly we did it at a natural, normal speed, once she'd picked out a picture, we turned the page and she had to pick out another. But in the other condition, and it was Ros herself who did this heroic experiment, she sat looking at her for thirty seconds before turning the page. So we gave her a thirty second rest before she had to pick out the next item. And this, in doing this, it doubled her score.

So she was clearly very sensitive to temporal factors, and we described this in terms of the system being refractory, that for a certain period of time, the appropriate response was unavailable. So it was this unavailability of the correct response for a period of time that we thought was a very interesting observation, and we carried on investigating this patient, and we were able to show that she was very sensitive to semantic similarity, but she was not the least bit sensitive to phonemic similarity. So we were clearly dealing with a deficit in accessing items at a semantic, meaningful level. And since that case, Ros and I worked with another case a few years later, and more recently Sebastian Crutch -- who I'm working with

at the moment -- and I have been studying a patient with this condition and trying to exploit the, if you like, the semantic distance effects.

## Semantic Organization – the brain's compass points

AZ, the patient I've been working with, was very sensitive indeed to semantic distance effects, and we showed this by comparing, oh, animals and fruits with objects, and if they were all animals she'd make more errors than if there was one animal, one fruit and one object. And we were also interested in whether she would show these close and distance effects within the proper noun vocabulary, because it's very … quite difficult to examine the … like the semantic organisation within the proper noun vocabulary. And we started off with people with different occupations and she would get if you like … make more errors if you used people with the same occupation than if you had one of three occupations, and we were then … this led us on to considering geographical terms, which are also clearly proper nouns. And if you used, shall we say, three Scandinavian countries, three South American countries or three European countries, her error score would be really quite high. All she had to do was, when I said, 'Sweden', she simply had to point to a card that said 'Sweden', etc. But if you had one stimulus from each of the three groups: one Scandinavian country, one European country, and one South American country, she could do it very accurately.

So here we have these very clear-cut geographical similarity effects, and we pushed our luck a little bit here, by seeing whether this, she was sort of sensitive, if you like, to a sort of north, south, east, west arrangement within England. And she, in fact, did. We had three northern towns, three East Anglian towns, three south-coast towns as a group and she had to point to them. Or we had one from east, north and west. And here again we found that she was very sensitive literally to, not so much semantic distance, but actual distance in these, in testing her. And so we used this as evidence that this type of factual information is encoded in our brain in terms of, if you like, the compass points.

I take the view that these patients, studied appropriately, provide a window on the organisation of semantics without having to have more demanding criterion of having an actual deficit or selective impairment. In these patients, one can actually, I believe, observe this very finegrain organisation in patients with relatively large lesions, and this I think is a very, has great potential for the future, and I certainly hope to be able to go on with this, our collaboration well into the future.