The memory man

Alan Baddeley talks to Lance Workman about Bertrand Russell, Neanderthals and working memory

I'd like to begin with two basic questions – what led you into psychology and how did you become interested specifically in memory?
I actually applied to Cambridge to do geography and didn't get in, so I started to think again. I was interested in philosophy, but didn't think I'd be able to earn a living as a philosopher. Bertrand Russell said that if he was starting again he would probably be a psychologist so I thought, 'why not?' I borrowed some books and when I asked around I was told the best place was UCL, so I applied and got an interview. By this time I'd read a number of books and was intrigued by one called *Listening with the Third Ear: The Inner Experiences of a Psychoanalyst*. I thought that's what I'd really like to do, but when interviewed at UCL I was too cautious to admit that I wanted to be a psychoanalyst and declared an interest in experimental psychology'. To my surprise it turned out that I was much more interested in experimental psychology than psychoanalysis, and that's continued to be the case.

Why memory? When I graduated I went to the States for a year hoping, when I returned, to do research on partial reinforcement in rats. But when I came back the whole behaviourist enterprise was largely in ruins. The big controversy between Hull and Tolman had apparently been abandoned as a draw and everybody moved on to do something else. On return, I didn't have a PhD place, and the only job I could get was as a hospital porter and later as a secondary modern school teacher – with no training whatsoever! Then a job cropped up at the Medical Research Council Applied Psychology Unit in Cambridge. They had a project funded by the Post Office on the design of postal codes and so I started doing research on memory.

So it was happenstance really. Moving forward, one of the things you're best known for of course is the Baddeley and Hitch model of working memory.

How do you think that changed the way we now think about memory?
I think what we did was to move away from the idea of a limited short-term memory that was largely verbal to something that was much broader, and that was essentially concerned with helping us cope with cognitive problems. So we moved from a simple verbal store to a three component store that was run by an attentional executive and that was assisted by a visual spatial storage system and a verbal storage system. That structure was just guess work, but we seem to have guessed well because the three components are still in there 30 odd years later – although now with a fourth component, the 'episodic buffer'.

Your model with Graham Hitch has a central executive controlling 'slave' systems. People sometimes have a problem with the term 'slave'?
This is presumably because people don't like the idea of slavery. The term was borrowed from electronic engineering, but I tend to avoid the term now. Even the phonological loop, which is probably the most slavish of the three, can be used to control behaviour, the sort of thing that Luria emphasised, in using self-instruction as a means of controlling action. But we can certainly say that the central executive is dominant, controlling and using the verbal and visual storage systems, while the episodic buffer allows information from lots of sources to be combined into a multidimensional code.

Cognitive models seem to evolve. Has your model for working memory changed much in recent years?
Well it has as far as the episodic buffer is concerned. I think that the buffer underpins conscious awareness. I used to think that it was a system for actively binding the information. Richard Allen, Graham Hitch and I have been doing a series of experiments on this, and we now think that the buffer is essentially a passive multidimensional store and that the binding goes on elsewhere, possibly in a number of different brain areas. The phonological loop, which is probably the most widely investigated part, certainly ties in with systems that have evolved for understanding language and generating speech. Similarly with the visual spatial sketch pad, there's a lot of work on fractionating it, understanding in much more detail how information is stored by looking at the neurobiological underpinning. In terms of the central executive, the whole issue of attention and how it's controlled is a massive one, and progress is being made in many directions. I think our model of working memory provides a framework that's sufficiently broad that it helps hold areas together. The basic model is not too hard to understand, but potentially it's expandable. I think that's why it's survived.

These separate systems that you've worked out were very theoretical when you first came up with them 30 years ago. Can we tie these into specific parts of the brain today?

Well, yes and no – there is controversy about the evidence. Initially the lesion evidence and the neuroimaging evidence looked reasonably strong with the phonological loop being in the left hemisphere around about Wernicke's area for storage and further forward around Broca's area for articulatory rehearsal. Also a visual spatial system involving at least three areas appears to be in the right

hemisphere, probably occipital for the more visual aspects, parietal for the more spatial, depending heavily with the central executive on frontal areas. But attempts to further localise have led to less clarity, and if you look at attempted meta-analyses combining results from many studies, then they tend to be a bit 'plum puddingy' – a bit messy. I think it's because of the unreliability of current neuroimaging methods. So there are certainly broad areas that are involved, but it's much more likely that, rather than a specific area, there are networks. In the case of the phonological loop, for example, there are broad white-matter pathways that join together several areas that are involved in the phonological loop. At the moment we can structurally image these pathways but we can't do functional imaging on their operation.

People like to think that when there's a paradigm shift, as there was with working memory, this comes about through a blinding insight – that you wake up in the middle of the night or whatever and it's there. Was it like that for you?

No, it was fairly slowly chipping away. But in the end I suppose the model came reasonably quickly. Graham and I got a three-year grant to look at the relationship between long- and short-term memory just at a time when people were abandoning the study of short-term memory because the concept was running into problems. One of the problems was that patients who seemed to have a very impaired short-term memory, with a digit span of only one or two, nevertheless could have preserved long-term memory. The problem is that short-term memory was assumed to be a crucial stage in feeding long-term memory, so such patients ought to have been amnesic as well. They were not. Similarly, if short-term memory acted as a working memory, the patients ought to be virtually demented because of problems with complex cognition. In fact they were fine. One of them worked as a secretary, another a taxi driver and one of them ran a shop. They had very specific deficits that were inconsistent with the old idea that short-term memory simply feeds long-term memory. So what we decided to do was to split short-term memory into various components, proposing a verbal component, a visual spatial one, and clearly it needed some sort of attentional controller. We reckoned these three were the minimum needed. As we were working on the model I was contacted by Gordon Bower who edited a rather influential annual series, inviting me to write a chapter for it. We hesitated because we thought we didn't really understand the model yet, but it seemed too good an opportunity to miss so we thought 'oh what the hell let's go for it!' Which is just as well, because we still don't fully understand the model!

It's certainly created a huge amount of research since. As well as working memory one of things you've looked at is the effects of changing pressure on divers. I've done a bit of scuba myself and I'd be interested in what happens.

Well, it depends what you're breathing. I'm sure as a diver you know that if you breathe air much below 30 metres you get drunk! I started out because I was an amateur diver with the Cambridge University underwater exploration group, which organised an Easter dive off the Welsh coast and a summer expedition. I thought I might look at nitrogen narcosis as I'd seen a paper by a couple of US Navy people doing work on manual dexterity at a pressure at 30 metres in a dry pressure chamber. They found there was an impairment, and so I persuaded the director of the Medical Research Council unit I was working in, Donald Broadbent, to give me a couple of extra weeks holiday and a little bit of funding to go out and run an experiment underwater at sea. We got a much bigger effect than the US Navy dry land study had done. But why? It turned out eventually, after a few more diving holidays, that the crucial difference was fear. The initial dives had been into the blue in the middle of Famagusta Bay in Cyprus with divers who weren't used to diving to 30 metres in the open sea and were very anxious. We replicated the anxiety effect off the Scottish coast which is much more anxiety-provoking than the Mediterranean, but a rather less tempting experimental environment!

You're also associated with work on ageing and memory. There's lots of gizmos you can buy to train your brain as you get older. Do you think any of these really help?

There is growing evidence to suggest that certain carefully designed and monitored programmes can improve working memory performance in ways that generalise. However there appears to be little evidence that most of the gizmos advertised for so called brain training help very much. In the case of long-term memory, I know of no convincing evidence that training programmes help the memory itself. People can, however, be taught useful strategies, although these are often quite hard work, and it is usually easier to write things down or use reminders.

Is there nothing we get better at as we get older?

The content of semantic memory keeps going up so as you get older you know a few more words, though you don't retrieve them so quickly. Recognition vocabulary keeps climbing, but not much else.

I'd like to finish by coming back to something interesting I read recently about working memory – I read that it is now claimed that this is what sets us apart from the Neanderthals. Can you tell me something about this idea?

There was an article in *Science* recently discussing the proposal that working memory may have been the difference between the survival of *Homo sapiens* and the extinction of Neanderthals. It had been proposed by a psychologist, Fred Coolidge, and a paleoanthropologist, Tom Wynn who were interested in why modern humans had survived while Neanderthals hadn't. They came up with a whole series of examples of evidence for cognitively demanding activities achieved by early *Homo sapiens* but not by Neanderthals. They suggested that the one capacity needed for all of these was working memory. There might well be something in this, but it's difficult to gather more direct evidence for the claim.

I guess the evidence has to be quite indirect – like looking at artefacts?

That's exactly right. You have to start by looking at what the two groups did and didn't produce in terms of artefacts, then working backwards as to what they could and couldn't do in terms of cognitive processes. They decided on the basis of this that Neanderthals may well have lacked working memory and that this was what allowed us to succeed instead of them.

If it turned out that working memory was an important step in our evolution and that it is the thing that sets us apart from the Neanderthals, how would that make you feel?

I'd be happy – but I don't know that I would ever be convinced because the evidence has to be so indirect. But I'm delighted that people find the model useful.