

Donald Broadbent

IN 1991 the Society launched the annual Broadbent Lecture series, with the inaugural lecture being given by Donald Broadbent himself. At the end of the lecture, which was published in *The Psychologist* in February 1993, Donald stated that his own contribution to psychology would probably be forgotten in 10 or 20 years' time. Sadly, two years later Donald died; but the Broadbent tradition is still very much alive in psychology, not only in Britain but throughout the world. I hope that this article will show that Donald Broadbent has had, and continues to have, a considerable influence on psychological science and scientists.

A brief biographical sketch Donald Broadbent was born in 1926 in Birmingham, although he normally identified himself as Welsh, partly because his home was in Wales throughout his adolescence. His family was fairly affluent, but his circumstances changed when his parents' marriage broke up when he was 13. Shortly after this Donald won a scholarship to Winchester College, where he received the remainder of his schooling. Throughout his boyhood he had been fascinated by flying, and he volunteered to join the RAF to train as a pilot when he was 17. After taking a preparatory course in Cambridge, he set sail for the United States in 1945 to learn to fly.

It was at this time that Donald claims to have developed an interest in psychology and realised the importance of psychological problems in practice. One of his favourite anecdotes was of the AT6 planes, which had two identical levers under the seat, one to pull up the flaps and one to pull up the wheels. Donald told of the monotonous regularity with which his colleagues would pull the wrong lever when taking off and crash land an expensive aeroplane in the middle of a field. He admired psychology not only



In the 12th annual Broadbent Lecture at the Annual Conference **DIANNE BERRY** outlined Broadbent's explicit and implicit influences on psychological science and scientists.

because it had the concrete quality that he respected in the physical sciences, but also because it could shed light on human problems and had a clear and economic value.

At the end of the war Donald took a ground job in the RAF personnel selection department. In 1947 he left the RAF and applied to Cambridge University to study psychology. The Cambridge department at that time was run by Sir Frederick Bartlett, who reinforced Donald's views that psychological research should be grounded in real life wherever possible. When Donald graduated, he went to work at the MRC Applied Psychology Unit in

Cambridge, on a navy-funded project to investigate the effects of noise on performance. Eight years later two significant events occurred. He was made Director of the Unit, and he published his most influential book – *Perception and Communication*.

Donald remained as Director of the Unit until 1974 when he decided that he was spending too much time on administration and too little on research. He negotiated a move to Oxford, where the Medical Research Council funded him to set up a small research programme. He continued to investigate the effects of noise, but also started research projects in other areas.



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These he carried through until his retirement in 1991: cognitive strategies in relation to work, the effects of stress in industry, and laboratory studies of attention and memory, and of the control of complex systems, which developed into studies of implicit and explicit learning.

A personal view

Before reviewing Donald's contributions to, and influences on, psychological science and scientists, I thought it would be appropriate to share some of my clearest memories of Donald during the time he supervised me, and the subsequent years when we worked together. I have many images of him sitting in his office, listening to me describing my latest experimental results and then asking the inevitable question 'But what does it all mean?' Donald had an amazing facility for coming up with convincing explanations of what seemed to me to be the most inexplicable results and, more often than not, he would tie it in with the results of a study carried out 20 or 30 years earlier. In particular, he taught me how to plan experiments, to think about the different possible outcomes of the results, to try to design experiments where the results would be interesting whichever way they came out, and to run several projects in parallel so that moments of gloom in one will usually be relieved by moments of success in another.

Donald displayed a mixture of characteristics. In one sense he was conventional: he was an accepted and honoured member of the establishment. But in other ways he was very unconventional and often did not toe the party line. Similarly he was amazingly influential, even powerful, yet at times very unassuming. He had a major influence on psychology and the careers of many psychologists, but he remained extremely

BROADBENT'S INFLUENCE ON PSYCHOLOGY

- *Perception and Communication* pulled together diverse work on information theory and early computational modelling.
- Invented the modern study of attention, launching the cognitive revolution.
- Bridged the gap between the laboratory and the field, giving the discipline a moral imperative of being useful. This increased the prominence of psychology in its modern guise to lay people and to government.

approachable. He always tried to make time for other people, no matter how busy he was and irrespective of their own status. Related to this was his mixture of generosity and thriftiness. In addition to being generous with his own time, Donald was also very generous with his research assistants, allowing them to work on their own projects rather than insisting that they spend all their time working on his. At the same time he was very careful in spending money, particularly money that came from the MRC. He always regarded himself as a public servant and accountable to the taxpayer.

Contributions to psychological science and scientists

To help me assess Broadbent's contributions I consulted a few of the many highly regarded psychologists who worked with him during the different stages of his career. (I am particularly grateful to Pat Rabbitt, Anne Treisman, Graham Hitch, John Duncan, Bob Hockey, Dylan Jones, Charles Hulme and Zoltan Dienes for their open and thoughtful comments.)

Contributions to science I identified three main strands in replies on this point (see box above). The first two strands are actually linked and could be thought of in terms of an explicit and implicit contribution.

What is probably Donald's most

important, contribution can be summarised in three words: *Perception and Communication*. Donald Broadbent was the first person to pull together (in that book) the mass of diverse work on information theory and early computational modelling, and in doing so gave the area the coherence that it was lacking. He demonstrated that it was possible to study attention rigorously and explain it using information-processing constructs. He used data from behavioural experiments to infer functional stages of processing and the order in which they occurred.

The linked implicit contribution is not so much centred on what he personally did, but on how he changed the way science was done. In a nutshell, he invented the modern study of attention. He introduced and popularised the information-processing approach, and in doing so launched the cognitive revolution that Neisser subsequently formulated and consolidated. In fact, it is not an exaggeration to say that he revolutionised the way the whole world did research on mental processes.

Finally, Donald Broadbent not only did all this but, equally important, he emphasised how this inspiration for psychological theory and research could come from considering practical problems. He truly bridged the gap between the laboratory and the field, and was not afraid to ask 'big questions' and work on important, but often difficult, topics. He gave the discipline a moral imperative of being useful and in doing this he increased the prominence of psychology in its modern guise to lay people and to government.

Influences on psychological scientists

During the various stages of his career, Donald Broadbent supervised and worked with a large number of students and junior researchers, many of whom are now senior figures in psychology. In order to demonstrate how Donald's contributions to psychological science had a direct influence on their lives and developing careers, I have selected a number of quotes from the communications I was sent when preparing for my lecture (see box left). In

BROADBENT'S INFLUENCE ON PSYCHOLOGISTS

'He made me realise that cognitive psychology could offer a coherent understanding of a whole range of human behaviour.'

'He instilled in me the conviction that the study of applied issues was the sure road to both advanced theorising and doing something useful, but that this should only be done using good science, i.e. well-developed theory and methods.'

'He was a role model, who led by example. He inspired and excited me and made me think more broadly and deeply.'

'He set the pattern for my entire working life. He provided me with the conceptual tools that I still use, and the problems that I still tackle, in the way he showed us.'

'He provided me with a mental model for how to do research and write papers. I still run my ideas past him and imagine what he would have said – or rather how he would have looked!'

reading through these comments and others I was sent, I was struck by the use of a number of adjectives that seemed to come up over and over again: 'imaginative, inventive, inspirational, exciting, liberating, clever, thoughtful, practical, whimsical, generous, open, moral'. These and other characteristics start to give us some insight into why Donald Broadbent was such a great scientist and person.

Implicit and explicit learning
I thought it would be appropriate to devote the second half of this article to giving a brief review and update on research in the area of implicit learning, the topic on which Donald and I collaborated for many years. Specifically, the following sections summarise current knowledge and thinking, outline key outstanding questions and likely future directions for research and, in good Broadbent tradition, describe some of the important related applied questions that researchers in the area are starting to address.

Many different definitions of implicit learning have been put forward during the last 20 years. A reasonably well-accepted one, however, is: 'learning is implicit when we acquire new information without intending to do so, and in such a way that the resulting knowledge is difficult to express' (Berry & Dienes, 1993). This can be contrasted with explicit learning, where people acquire knowledge in a more conscious and intentional way, and are able to talk about, or otherwise demonstrate, what they know.

The distinction can be illustrated by describing what has become an almost classic study in the area (Berry & Broadbent, 1984). In this study, participants interacted with one of two (mathematically identical) computer-controlled tasks. One was a simplified sugar production factory, in which people had to control the rate of sugar output by varying the number of workers employed.

The other involved interacting with a computer 'person' by selecting adjectives from a given set (e.g. indifferent, polite, affectionate) in order to get the person to respond at a specified level of friendliness. The results showed that practice significantly improved people's ability to control the tasks, but had no effect on their post-task question answering. In contrast, verbal instruction had no effect on control performance, but did significantly improve question answering.

Initially, the finding of this double dissociation seemed like very strong evidence for implicit or unconscious

'we can see that his contribution to psychology is far from forgotten'

learning. However, as is often the case, subsequent research has shown that the picture is rather more complicated. In particular, the early measures that were used to assess the 'implicitness' of the learning have rightly been criticised for being insufficiently sensitive – they might not elicit knowledge that participants are not very confident about, even though the knowledge is factually correct (Shanks & St John, 1994). In more recent years improved methods for assessing the status of the acquired knowledge have been developed, including using forced-choice tests (e.g. Reed & Johnson, 1994), subjective tests, such as those involving confidence-accuracy comparisons (e.g. Dienes & Berry, 1997), comparisons between direct and indirect tests (e.g. Jimenez *et al.*, 1996), and the process dissociation procedure (e.g. Buchner *et al.*, 1998).

Current thinking

Although the topic of implicit learning has generated a considerable amount of debate over the past 15 years, a consensus of opinion has more or less emerged from studies that have used more reliable measures. The majority of researchers in the field would now agree that there are a number of characteristics that appear to distinguish implicit from explicit learning (as outlined by Dienes & Berry, 1997):

- Implicit learning shows specificity of transfer, in that the acquired knowledge tends to be relatively inflexible and bound to the surface characteristics of the material. For example, experience of controlling Berry and Broadbent's

sugar-production task had no influence on ability to control the mathematically identical computer-person task.

- Implicit learning tends to be associated with incidental rather than intentional learning conditions.
- Implicit learning tends to remain robust in the face of: time (in that it lasts longer); lack of attentional resources (in that it is relatively unaffected by secondary tasks); and psychological and neuropsychological impairment.

However the field is much more divided over the following issues:

- the extent to which implicit learning gives rise to unconscious knowledge;
- the extent to which implicit learning produces abstract knowledge; and
- the extent to which implicit and explicit learning are subserved by separate independent memory and processing systems.

One conceptual difficulty in the area has been that learning can be thought of as being implicit in several different ways depending on whether the focus is on the acquisition process, the resulting knowledge, or the retrieval process. During the last five years or so researchers have found it more fruitful to investigate the nature of the processes involved in implicit learning than the nature of the knowledge that is acquired. Interestingly, this is a position that Donald himself advocated in his own Broadbent Lecture (Broadbent, 1993).

In my view one of the best reviews of implicit learning that has been written since that time is by Cleeremans *et al.* (1998). They argue that the results of the more recent studies are consistent with the idea that implicit learning processes occur in parallel with additional processes that are more dependent on the availability of explicit knowledge, on intention, and on attention, but that the evidence is inconclusive regarding the nature of the interaction between these two kinds of process. They further argue that the acquired knowledge is best described as lying somewhere on a continuum between purely exemplar-based representations and more general abstract representations – a characteristic that neural network models are particularly apt at capturing.

Donald himself was a great admirer of this computational modelling work and was also a strong supporter of the type of synthesis approach advocated by Cleeremans. In preparing for this talk,

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If you have been influenced by a psychologist, past or present, why not write about it for *The Psychologist*? Send us your articles outlining their life and your analysis of how their scientific contribution holds up in the light of modern research. Your article should be under 2000 words, and written in an engaging and informative style suitable for a wide-ranging, non-specialist audience.

I reread his original Broadbent Lecture and was struck by how forward-looking it was, and the extent to which it portrays an accurate assessment of the current state of knowledge and of the way the field is progressing.

Returning to Cleeremans *et al.*, they conclude that implicit learning is a fundamental and ubiquitous process in cognition.

The available evidence suggests that implicit learning is best characterised as complex form of priming... distributional knowledge acquired through incidental experience with a stimulus domain can influence processing in the absence of awareness that this knowledge was acquired or that it is currently influencing processing. In information processing terms, [as Donald would have liked] implicit learning involves changes to the functional architecture of continuously learning systems such as neural networks. (Cleeremans et al., p.414)

Outstanding questions

In the final section of their paper, Cleeremans and colleagues highlight that the field should benefit from;

- increasing sophistication in the empirical methods used to study implicit learning;
- further work on computational modelling aimed directly at addressing differences between corresponding direct and indirect tasks;
- more use of functional brain imaging techniques and neuropsychological data; and
- a better understanding of the nature of consciousness.

In fact, they identify the role of consciousness in cognition as one of the outstanding questions in the area, along with the limits of implicit learning, the extent to which implicit learning depends on working memory and attention, and the role of implicit learning in cognitive development.

But it is the consciousness question that is the big one; the one that has attracted the attention of leading researchers such as Reber, Dulaney, Perruchet, and Shanks, to name just a few. Interestingly, a couple of years ago *Discover Magazine* set out what they believed to be the most important questions in the whole of science – questions such as ‘How large is the universe?’ and ‘Does chaos rule the

cosmos?’ Not far down the list was the question ‘What is consciousness and what is its role in cognition?’

So, a big question indeed, and in true Broadbent tradition I hope that it is one that future researchers will keep trying to tackle. However, again following Donald’s creed, in order to progress the field, researchers will have to use a good scientific approach; that is, a well-developed theory and rigorous methods.

Implicit learning in the ‘real world’

During the past 20 years, laboratory concepts and methods have been used to elucidate the role of implicit processing in performance in a range of educational, clinical, occupational, and everyday settings. These include the design of decision support systems, training in a range of education and workplace settings and, linked to this, knowledge assessment (not just in educational settings but also in more complex situations, such as assessing situation awareness in pilots and operators of other types of complex system). These three areas of application were also identified by Donald Broadbent, at a Royal Society meeting on human error in the late 1980s. As he would have predicted, these complex real-world problems are also raising questions that are requiring methods developed in the laboratory to be refined, and theories to be reassessed. In fact, Donald himself pointed out how the design of complex systems and training situations raises important questions about the scope and limits of implicit knowledge (Broadbent, 1990). Similarly, work on situation awareness in our laboratory is raising questions about the role of attention and the nature of underlying memory representations (Berry *et al.*, 2002).

In recent years new areas of application have emerged. Implicit processing has been examined in situations such as early language learning in infants and young children, biased processing in various psychological disorders, stereotyping and prejudice, and consumer behaviour. It is likely that these newer areas will also raise challenging questions that will require further theoretical and methodological developments.

In conclusion

So, 12 years after Donald Broadbent gave the inaugural Broadbent Lecture we can see that his contribution to psychology is far from forgotten. His influence on psychological science and on the work and personal philosophies of many psychological scientists is still considerable. To summarise the extent of this contribution, I could not do better than quote from a letter that Alan Baddeley sent to me a few days after Donald died.

Donald’s greatest contribution was his development and consistent championing over the years of an approach to psychology that blends sophisticated theorising with careful experimentation and a commitment to tackling important real world problems. His achievements are not simply through the many excellent papers and books he has published, but perhaps even more so by his personal example. Cognitive psychology in general, and British psychology in particular, would have been immensely poorer without him.

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