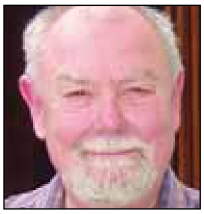
Tales of the unexpected

25 years of cognitive gerontology



Patrick Rabbitt *on a long and winding road of research.*

MY excuses for starting what eventually turned out to be a 22-year longitudinal study of cognitive changes in old age are that I had no idea that it could possibly last that long, and it seemed like a good idea at the time. That naivety turned out to be the most valuable intellectual asset that I brought to the task – I have been educated entirely by my mistakes. I thought sharing them might cast some light on what happens when people, and research, grow old.

First faltering steps

My first mistake was the apparently reasonable assumption that if we wanted to discover what cognitive changes people experience as they grew older the simplest thing was to ask them. Accordingly Vicki Abson and I used various questionnaires to give all of the 2000 volunteers (then aged from 41 to 93) a chance to tell us whether, how, and why they had become less efficient at coping with everyday events as they grew older (Rabbitt & Abson, 1990). We found ourselves having to explain why the older our volunteers were, the fewer lapses of memory and attention they reported. This forced us to recognise that because there is no absolute standard of memory against which we can compare ourselves, we can only evaluate our memories in terms of our ability to cope with our daily tasks or against others. But as people grow old their lives change, they generally face fewer demands, they no longer have to compare themselves against the briskly competent young and, also, sometimes they forget that they forget. It is not that people necessarily become less able to judge their own success in relation to the demands that they meet, because when we asked volunteers to rate their own performance on tests of memory and intelligence they gave sensible approximations and the higher their intelligence test scores the more accurate they were at self-appraisal (Rabbitt *et al.*, 1995).

Another discovery was forced on us simply because of our mistake in using tape recorded words in free-recall tasks, missing the point that most older people have some degree of hearing loss. This provoked the further insight that even mild hearing losses make it harder to remember words that have been correctly heard and repeated because the additional effort needed to make out what has been said prevents people from deeply processing, and, perhaps also from rehearsing material (Rabbitt, 1991). We later extended this to reading. Lenses inducing artificial astigmatism do not reduce the rate or accuracy of reading aloud, but do impair memory for what has been read because of the additional taskload that they impose (Dickenson & Rabbitt, 1991).

After some more egregious but useful methodological errors the project trundled on and the first longitudinal data began to expose more naive misconceptions. There are, essentially, four main questions to be asked of longitudinal data: When does change first begin? Do all individuals change at the same rate? Do all mental abilities decline at the same rate? And do all individuals show the same patterns of changes in abilities? A project for the US Air Force, in which we taught young men aged from 18 upwards to play a very complex video game, made it clear that age-related changes begin remarkably early. Very fit young men aged from 30 to 35 were much less competent at learning and playing than those aged between 18 and 25 (Rabbitt *et al.*, 1989).

The second question, do individuals change at the same rate, was much more difficult to answer. To compare individuals' trajectories of change during longitudinal studies we must recognise that people who are repeatedly given the same tests over many years improve with practice, so that the effects of ageing are cancelled out. Trajectories of change are also seriously miscalculated if deaths and dropouts are not taken into account. Fortunately Peter Diggle and Fiona Holland, at the Department of Statistics at Lancaster, found new ways to take both practice and dropout into account (see Rabbitt *et al.*, 2004) and the resulting models showed that people do indeed have very different trajectories of cognitive decline. Variance between members of a population increases as it ages, so that differences between the most and least able 70-year-olds become much greater than between the most and least able 50-year-olds.

Also, practice effects are substantial and robust. Remarkably volunteers who missed one of our quadrennial testing sessions nevertheless showed gains from a single, 10 minute experience of an intelligence test when they returned even eight years later. This effect is a remarkable achievement of the ageing human brain. It also casts new light on Jim Flynn's famous observation that, in many countries, intelligence test scores have increased over successive generations. Growing exposure to and awareness of the kinds of problems found in intelligence tests is enough to account for the small increases observed.

The occurrence of deaths and dropouts is also a difficult methodological problem but, when solved, it leads to unexpected discoveries. As the study continued, regrettably, but inevitably, more than 2000 of our volunteers died. This gave us the opportunity to use archival data to track changes before death. We showed that if dropouts are neglected the extents of changes before deaths are seriously miscalculated (Rabbitt *et al.,* 2005). An extension of this work has shown that volunteers who neither dropped out before the study ended in 2003, nor died before our census date in 2004, showed almost no decline on any of the 15 different cognitive tests that we gave them.

This was our first evidence that nearly all of the cognitive changes that our volunteers experienced as they grew old were due to pathologies severe enough to kill them or to cause them to withdraw from the study. Looking at the time courses of effects of different terminal pathologies we found that while cardiovascular problems (particularly if accompanied by diabetes) and infections caused the most marked and rapid declines, other causes of death had much smaller effects.

These results also help us to better interpret a very large number of previous studies comparing groups of elderly people who suffer from particular pathologies (such as hypertension, diabetes, cardio-vascular problems and respiratory illnesses) with matched, healthy controls. Most such studies have found significant, but very modest, deficits for patient groups. The issue here is that because they selected individuals who were still distant from death all these investigations only studied relatively mild pathological states. Of course death is an excellent marker for the severity of pathology, so if the studies were to include people who went on to die from their pathologies, the negative relationship between cognitive status and pathologies is much greater. This supports the general conclusion that most of the cognitive losses in later life occur because of illnesses rather than because of simple increases in age. This is encouraging, because it means that improvements in geriatric medicine will not only lengthen our lives but ensure that we preserve our abilities as long as possible.

The longitudinal study was only one of the ventures that supported the University of Manchester Age and Cognitive Performance Research Centre for 21 years. Another was a MRC project, with Brian Stollery, that examined how older people benefit from practice over periods of a year or longer. One useful finding was that as we get older, it's not really a case of a simple slowing of average decision times – it's more that there are marked increases in variability of performance from moment to moment, day to day and week to week (Rabbitt *et al.,* 2001). Brian's ingenious development of video games that could be used by the elderly also allowed us to discover that older people become worse at judging distances and speed, supplementing applied work on the problems of elderly drivers and pedestrians carried out in other contexts on the pavements and streets of Manchester.

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A fortuitous convergence

In idealised accounts of scientific research, brilliant investigators seem to be able to move directly from devising a hypothesis or recognising that a result is unexpected to making precisely the right experiment to give them an answer. In our experience this is rare in real life. Questions raised by examinations of one data set are obliquely, rather than directly, answered by analyses of quite another, and resources obtained and experiments made to answer a particular question often also resolve other problems.

For us, two separate issues converged in this way. One was that we, like all our predecessors in longitudinal studies, had assumed that all healthy older people show similar patterns of cognitive change. It became apparent that, in fact, people have different patterns of change – 13 per cent of our volunteers showed marked declines in scores on memory tests over periods of up to 11 years, but with no greater declines in intelligence or information processing speed than their age-peers. Another key issue in cognitive gerontology has stemmed from a suggestion by Jim Birren in the late 1970s that slowing of decision times in old age is the most sensitive index of the progress of global changes in most other cognitive abilities. Between 1985 and 1996 this idea was taken up, extended and formalised by Tim Salthouse as the hypothesis that 'general slowing' of the speed with which all decisions can be made is not merely a *marker* for the progress of all other cognitive declines, but their actual *functional cause.*

This means that the rank of older people in terms of their decision speeds is a good approximation of their rank order in performance on tests of memory, intelligence, and attention. Examining all of the tests that we had used we found that scores on intelligence tests, or on simple tests of information processing speed, accounted for 80 per cent to 100 per cent of all of that proportion of the total variance between individuals on all other tests that was associated with differences in their ages between 41 and 93 years.

This age-related variance is, of course, the central topic of investigation in cognitive gerontology. The finding that age-related slowing of performance accounts for age-related changes in most other cognitive tasks is extremely discouraging for investigators, like ourselves, who hoped to use behavioural data to tease apart differential changes in different mental abilities. For this reason it has aptly been termed 'the dull hypothesis' by Tim Perfect and Elizabeth Maylor (2000) and much time has been spent trying to find exceptions that give promise that behavioural comparisons can be more analytic of the functional processes underlying cognitive ageing (e.g. Rabbitt, 1997, 1999).

Luckily investigation of individuals who suffered memory loss without any other apparent problems attracted funding from the Wellcome Trust. They supported structural brain scans of 90 of these individuals and 90 controls individually matched for intelligence, age and sex. We found that the memory impaired had much smaller left hippocampi, and also slightly smaller right hippocampi than their matched controls. It is a plausible guess that their declining memory efficiency is due to a greater than average rate of loss of hippocampal volume as they have aged. However the brain scans also gave us other data on our volunteers' gross percentage age-associated losses of brain volume. This is because while brain volume shrinks skull volume remains constant through adult life into old age. This allows us to calculate individual differences in percentage losses of gross brain volume with age. Differences in age-related gross losses of brain volume account for all of age-related variance between individuals in information processing speed, but for no significant part of the age-related variance in scores on intelligence tests and for only some of the age-related variance in performance on tests of memory and on frontal and executive tasks. Measurements of cerebral blood flow and of white matter lesions give similar patterns of results. Age-related changes in different mental abilities can, after all, be clearly disassociated, but we need neurophysiological evidence to do this, and to liberate ourselves from the dull hypothesis. Behavioural data alone gives us relatively crude insights into the functional determinants of cognitive change in old age.

This is not true of investigations of lifestyle and demographic factors. Lynn McInnes has been examining cognitive, health and demographic determinants of successful ageing in our panel. Sex differences are particularly interesting. It is overwhelmingly clear that women live longer than men and experience slower declines. But it is also clear that both the sizes of differences between the sexes, and rates of cognitive ageing, are significantly related to cities of residence and so to mortality and health factors, but also to the availability of educational and social advantages. Women have slightly higher scores than men on depression inventories such as the Beck or Yesavage questionnaires, and even slight increases in depression scores are associated with lower performance on most cognitive tests (Rabbitt *et al.*, 1996). Our accumulated data allow us to begin to unravel the associations between depression scores, the incidence of stressful life events, and the social and economic advantages that protect older people from depression and stress and so from some part of the cognitive declines experienced by less fortunate others.

'women live longer than men and experience slower declines'

Off into the sunset

This would not be a bad ending, but it seems that there may still be more to be learned from the data that it has taken us so long to collect. I am excited by new analyses of the effects of mild unhappiness on cognition in old age, now funded by Unilever. And then there are accumulating results with (amongst others) Tony Payton, Bill Ollier and Neil Pendleton in Manchester who are analysing DNA collected from the entire Newcastle and Manchester samples to identify genes associated with maintenance of mental abilities in later life (Payton *et al.*, 2003; Pendleton *et al.*, 2002).

Most members of our wonderfully helpful and cheerful volunteer panel are now too old to wish to attend gruelling testing sessions in laboratories in Manchester and Newcastle, but are regularly screened by telephone tests that will alert a medical team to risk factors of dementia so that the records of any who may be so unfortunate can be examined to detect early signs in terms of accelerated rates of change or other factors about health, lifestyle and demographics that we have documented over the years. In the Departments of Psychology in Oxford and in the University of Western Australia our analyses of data from newly acquired brain images goes on. So, though my personal cognitive decay remorselessly accelerates, there is still no shortage of new things to find out and a great deal of fun still to be had.

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DISCUSS AND DEBATE

We find one possible 'normal variant' of ageing: accelerated memory loss that is not associated with loss of intelligence and is, apparently, not a risk factor for dementia or mortality. Can readers suggest others they have met with in their practice?

Why should people of equivalent socio-economic advantage decline faster and die earlier in Newcastle than in Manchester?

In what way can longitudinal studies inform social policy?

What social factors may particularly contribute to surviving and keeping your wits about you in old age?

Have your say on these or other issues this article raises. E-mail 'Letters' on psychologist@bps.org.uk or contribute to our forum via www.thepsychologist.org.uk.

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