The human brain as a slimming club

A new paper describes how much of the workings of the human brain may be seen as a process of slimming down information by reducing unnecessary ‘fat’ in what we see and hear and think about.

Gerry Wolff

When I was a student, studying psychology and other ‘natural’ sciences at Cambridge University in the UK, I attended fascinating lectures by Dr Horace Barlow (now Professor Horace Barlow FRS), who is the great grandson of Charles Darwin.

What I found so fascinating was the main idea in those lectures—that much of the workings of brains and nervous systems may be understood as compression of information, meaning that, to a large extent, brains and nervous systems have the effect of reducing the size of information coming in from one’s eyes and ears and other senses.

This is possible because there is often a lot of unnecessary repetition in information received by one’s eyes or ears. For example, one part of a plain sheet of paper looks much like any other part so that it is only necessary to see one small part of the sheet and its edges, and then assume that everything inside the edges is the same as the small part that one has seen.

Although I found those ideas very interesting, I did not do anything with them straight away. I took a ‘detour’ in my career but then got into research proved to be very useful.

A new paper by Dr Gerry Wolff of CognitionResearch.org, who is also a Visiting Researcher at Coventry University, describes how much of human learning, perception, and thinking, may be seen as a process of slimming down information by looking for patterns that match each other and then merging patterns that are the same.

Some of those things seem so obvious and natural that their ‘slimming’ function is often overlooked. For example, if we are looking at a scene, then close our eyes for a moment and open them again, we normally see the ‘same’ scene as we were looking at before. This means that the ‘before’ and ‘after’ views for a given person have been merged in his or her brain, thus avoiding the need to store the same information twice.

This is shown schematically in the figure where the before and after views are shown on the left and right, the black rectangle shows when the eyes are shut, and the image at the bottom shows the result of merging the before and after views.¹

¹ The landscape reproduced with permission from Wallpapers Buzz (www.wallpapersbuzz.com).
This merging of views is quite different from what happens in an old-style cine camera, or even a modern video camera, where every view of a scene is stored, very inefficiently, in one or more separate frames.

Another thing that seems so simple and obvious that we do not normally think of it as a way of economising in our use of information can be seen in the way we use language. For example, the city of New York is a big complicated thing that would need a large book to describe everything about it: where it is, all its streets, buildings, and open spaces, including the famous Central Park, the people that live and work there and all their activities, the history of New York, and so on. And yet we don’t need to create a copy of that large book on each occasion we want to talk about New York. Instead, we simply use the short name “New York”!

This idea, which is well known in the world of information processing, is called chunking-with-codes. In our example, the big complicated book which describes New York is called a ‘chunk’ of information, and “New York”—the nice short name for the chunk—is called a code.

This idea is used everywhere in every natural language like English, Swahili, Mandarin, and so on. In general, every noun, verb, adjective, or adverb, may be seen as a short code for a relatively large and complicated chunk of information. This means that we can write or talk about things, actions, etc., in a way which is very much more economical than if we had to describe each thing fully every time we wanted to refer to it.

Another example of how we economise with information is how we get to know repeating patterns such as the association of black clouds with rain.

It is true that we could have a separate memory for every occasion that we experienced rain falling from black clouds, but that seems unlikely since that kind of memorising would lead to enormous clutter in our brains, with a new memory for each time we saw a house, a tree, a car, a person, and so on.

And we know from ordinary experience that things we see or hear often are easier to remember than things we see or hear occasionally or only once—unless those rare things have a great psychological impact like getting married, winning big from the lottery, and so on.

And, in addition to the slimming down of information, the merging of repeating patterns brings with it another bonus: the possibility of making predictions and taking steps to gain advantage from those predictions.
With our black clouds and rain example, the way this can work is that, if we see black clouds, we would naturally think that rain is likely. And then we may put on a raincoat, or put up an umbrella, or hurry home, or, if we are needing some fresh water, we might put out some means of collecting the anticipated rain.

An interesting feature of this kind of prediction is that it may also achieve a slimming down of information. This is because it depends on the matching of a pattern like ‘black clouds’ (corresponding to what have seen in the sky) with the larger pattern ‘black clouds rain’ (which we have learned from previous experience), and for the sake of consistency, it seems it seems reasonable to assume that the first pattern would merge with the second one, thus achieving an overall reduction in volumes of information.

From this kind of partial matching of one pattern with another,

These are just a few of many examples of the way the slimming down of information by merging patterns that match each other is integral to how the human brain works, not simply in how we see the world, use language, or learn and exploit regular patterns, but also in how we make plans, solve problems, and more. There is now much evidence that compression of information is the basis for all aspects of intelligence and other kinds of information processing.

This principle—information compression as a basis for intelligence and the processing of information—is bedrock in the SP System, meaning the SP Theory of Intelligence and its realisation in the SP Computer Model. The SP System is an AI system which is radically different from other AI systems, with substantial advantages compared with other such systems.

The SP System is the subject of plans, by Dr Vasile Palade of Coventry University and Dr Wolff, to create a more fully-developed SP Machine for artificial intelligence, with potential applications in science, industry, commerce, administration and elsewhere. The figure shows schematically how this would be done.

Notes
2 The author of the new paper is Dr Gerry Wolff of CognitionResearch.org and also a Visiting Researcher at Coventry University.
3 The ideas in this paper are the basis of the SP System, meaning the SP Theory of Intelligence and its realisation in the SP Computer Model. An introduction to the SP System may be downloaded via bit.ly/2ELqOJq. Details of other papers about the SP System and its potential applications, with download links, may be found on www.cognitionresearch.org/sp.htm.
4 Distinctive features and advantages of the SP System compared with other AI-related systems are described in “Comments on the book ‘Architects of Intelligence’ by Martin Ford in the light of the SP Theory of Intelligence” (PDF, bit.ly/2th7Bze, submitted for publication), and “The SP theory of intelligence: distinctive features and advantages” (PDF, IEEE Access, 4, 216-246, 2016, bit.ly/2qgq5QF).

5 A project to develop a first version of the SP Machine, based on the SP System, is being planned by Dr Vasile Palade of Coventry University and Dr Wolff. A paper by Dr Palade and Dr Wolff describes “A roadmap for the development of the ‘SP Machine’ for artificial intelligence” (PDF, V. Palade and J G Wolff, bit.ly/2tWb88M).

6 Dr Vasile Palade is a Reader in Pervasive Computing in the Faculty of Engineering, Environment and Computing at Coventry University. He previously held academic and research positions at the University of Oxford-UK, University of Hull-UK, and the University of Galati, Romania. His research interests are in the area of machine learning/computational intelligence, and encompass neural networks and deep learning, neuro-fuzzy systems, various nature inspired algorithms such as swarm optimization algorithms, hybrid intelligent systems, ensemble of classifiers, class imbalance learning. Dr. Palade is author and co-author of more than 130 papers in journals and conference proceedings as well as books on computational intelligence and applications. Further information may be found at pureportal.coventry.ac.uk/en/persons/vasile-palade.

7 Dr Gerry Wolff, PhD CEng MIEEE, is Director of CognitionResearch.org. Previously, he held academic posts in the universities of Bangor and Dundee, and in the University Hospital of Wales, Cardiff. He has held a one-year Research Fellowship with IBM in Winchester, UK, and he has worked for four years as a Software Engineer with Praxis Systems plc in Bath, UK. His first degree at Cambridge University was in Natural Sciences (specialising in Experimental Psychology) and his PhD at the University of Wales, Cardiff, was in the area of Cognitive Science. He is a Chartered Engineer and Member of the IEEE. His research interests are chiefly in the development of the SP System. Dr Wolff has numerous publications in a wide range of peer-reviewed journals, collected papers and conference proceedings. Further information may be found at www.cognitionresearch.org/sp.htm.