Synapses

So far it is received wisdom in the neuroscience fraternity that memories are saved by synapses that strengthen and increase in size with constant use. This is now questioned. It is suggested that it is not this but the longevity of the synapses. Hardly ever used synapses disappear and frequently used synapses remain. If true, this would mean that the memory storage is not analogous, but digital.

The above has not been verified yet, but would be an interesting development. One of the disciplines that are involved in this subject is optogenetics, the examination and manipulation of the brain with light. The switching on or off manipulates the brain cells. This needs an operation and has only been done with animals. This would also solve one problem: so far brain activities have been examined with electro physical means which means it can be done only for a short time, maybe up to one hour. This is called a 'long term' experiment. After that time the cells tend to die. With the optogenetic method these examinations can last hours and even days and can give better and more reliable results.

(There is no quotation source available for this since this is something I read on a train in a scientific magazine.)

Brain Imaging and Cognitive Neuroscience

Up until fairly recently, the brain was seen as a "black box". Direct evidence of the workings of the brain could only be obtained from examining the injured and the sick with subsequent post mortem examinations.

(…) In the last twenty years, new advances in scanning technology have allowed us to peel away the final wrapping of the black box and look directly at the mind at work through the examination of such factors as metabolic activity, blood flow, and magnetic fields. It is the description of the processes by which the pictures of the mind at work are taken and critical examination of the information provided by such pictures which form the basis of this section.

Along with ERP (event-related potential) which measures electrical potential of parts of the brain from surface electrodes, the two technologies which have provided the most stunning images of the brain at work are positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). Although the two types of scan use different techniques, both work by taking images of slices through the brain showing areas which have increased blood flow at any given moment (PET measures blood flow through the monitoring of a weak radioactive dye and fMRI measures the flow through the magnetic properties of components of water, blood and several chemical compounds in the brain). The argument is that areas in the brain which are actively engaged in a task will have increased blood flow. Thus, “hot spots” with greater blood flow are areas which are processing the information. There are issues concerned with the timing of these slices (the slices are taken after a short time delay in fMRI scans), but the pictures that have been produced by these methods have revealed a great deal of information about areas which are involved in different tasks.

On the most general level, brain imaging has confirmed that language processing is highly lateralized. Most language tasks excite areas located in the left hemisphere of the brain, although it is interesting to note that areas in the right brain are involved in some aspects of processing. Areas in the right hemisphere, for example, have been shown to be activated when listening to music and the processing of intonation patterns will thus use such areas. An interesting investigation into the processing of Mandarin as against English indicated that, in addition to the activation of areas in the left temporal lobe, universally associated with language processing, areas in the right temporal lobe were also activated when listening to Mandarin (Scott et al., 2003). It was suggested that this could be due to the necessity to process tones in Mandarin.

One of the first observations about brain activity is its complexity. Even with the simplest of tasks many areas are activated. This lends a great deal of support to the neural networking models which underlie connectionist thinking about language. In order to be able to isolate the significant areas involved in any particular process (such as reading a word aloud), experimental techniques have been evolved which compare the brain activation patterns under different task conditions and then subtract one image from the other. For example, in a typical task a subject is asked to look at a simple fixed point. A scan is taken of the activated areas under this condition to act as a 'base line' to compare with activated areas on other tasks. The subject could then be asked to read a word silently and a second scan taken. Then the subject could be asked to read the word aloud and finally asked to generate a verb from the noun. At each stage an image is generated and by subtracting the original image (the 'base line" fixation image') from the image generated under the different tasks, a picture can be built up of the areas involved in silently reading, in reading aloud and in generating a new word.

Such techniques have already begun to confirm many ideas about the workings of the brain. On a macro level, in addition to the localisation of language activities in the left hemisphere, the importance of special language processing areas such as Broca's and Wernicke's have been confirmed both in normal subjects and in subjects with brain lesions. However, imaging techniques have also shown that many other areas are also actively involved in the comprehension and production of language, including areas in the right hemisphere. Brain imaging has also shown that functions, predicted by the Working Memory (WM) model such as the differentiation between the maintenance of visual and phonological material, between storage and rehearsal functions and executive functions, such as monitoring, do appear to have different patterns of activity in the brain, see Henson (2001). In particular, there is strong evidence that certain areas are heavily involved in executive tasks. One, called the *anteria cingulate gyros* seems to be activated in tasks which require some sort of target detection or manipulation, suggesting that this area is involved in directing attention, see Byrnes (2001) and Henson (2001). This area is closely connected to structures involved in WM and Semantic Memory and would seem to validate the existence of a Supervisory Attention System as part of WM.

Information about brain activity can thus be built up by varying the task set. Brain activity can be compared across a number of individuals (and the results aggregated) and comparisons can be made between different groups of subjects. For example, readers of different languages can be compared to see if the processing systems for the different scripts are similar (e.g. ideographic versus alphabetic scripts). Dyslexic readers can be compared with normal readers and bilingual subjects can be compared working in their different languages.

Although imaging techniques, especially fMRI, are able to provide much more detailed information than previously, such pictures are still fairly coarse grained. It is still rather like a satellite picture of the earth at night –areas of habitation show up clearly, but to draw inferences about social organization from such images is very difficult. The brain images can provide broad confirmation that macro-processes involved in language do seem to be taking place in certain areas as predicted by theory, but are often not fine-grained enough to tell us about differences on the micro-level.

(Randall, 2007, pp. 23-26)

What’s so special about working memory? An examination of the relationship among working memory, secondary memory, and fluid intelligence.

Working memory capacity (WMC) has received attention across many areas of psychology, in part because of its relationship with intelligence. The mechanism underlying the relationship is unknown, but the nature of typical WMC tasks has led to two hypothesized mechanisms: secondary-memory processes (e.g., search and retrieval) and the maintenance of information in the face of distraction. In the present study,

participants (N 5 383) completed a battery of cognitive tasks assessing processing speed, primary memory, working memory, secondary memory, and fluid intelligence. Secondary memory was the strongest predictor of fluid intelligence and added unique predictive value in models that accounted for working memory. In contrast, after accounting for the variance in fluid intelligence associated with the secondary-memory construct, the working memory construct did not significantly predict variability in fluid intelligence. Therefore, the secondary-memory requirements shared by many memory tasks may be responsible for the relationship between WMC and fluid intelligence, making the relationship less unique than is often supposed.
(Mogle, Lovett, Stawski, & Sliwinski, 2008)

Working memory and intelligence are highly related constructs, but why?

Working memory and the general factor of intelligence (g) are highly related constructs. However, we still don't know why. Some models support the central role of simple short-term storage, whereas others appeal to executive functions like the control of attention. Nevertheless, the available empirical evidence does not suffice to get an answer, presumably because relevant measures are frequently considered in isolation. To overcome this problem, here the authors consider concurrently simple short-term storage, mental speed, updating, and the control of attention along with working memory and intelligence measures, across three separate studies. Several diverse measures are administered to a total of 661 participants. The findings are consistent with the view that simple short term storage largely accounts for the relationship between working memory and intelligence. Mental speed, updating, and the control of attention are not consistently related to working memory, and they are not genuinely associated with intelligence once the short-term storage component is removed.

Working memory and intelligence: The same or different constructs?

Several investigators have claimed over the past decade that working memory (WM) and general intelligence (*g*) are identical, or nearly identical, constructs, from an individual-differences perspective. Although memory measures are commonly included in intelligence tests, and memory abilities are included in theories of intelligence, the identity between WM and intelligence has not been evaluated comprehensively. The authors conducted a meta-analysis of 86 samples that relate WM to intelligence. The average correlation between true-score estimates of WM and *g* is substantially less than unity ($\hat{\rho}$ = .479). The authors also focus on the distinction between short-term memory and WM with respect to intelligence with a supplemental meta-analysis. The authors discuss how consideration of psychometric and theoretical perspectives better informs the discussion of WM–intelligence relations.

Neural Systems of Second Language Reading Are Shaped by Native Language

Reading in a second language (L2) is a complex task that entails an interaction between L2 and the native language (L1). To study the underlying mechanisms, the authors used functional magnetic resonance imaging (fMRI) to visualize Chinese–English bilinguals' brain activity in phonological processing of logographic Chinese and alphabetic English, two written languages with a sharp contrast in phonology and orthography.

In Experiment 1, they found that phonological processing of Chinese characters recruits a neural system involving left middle frontal and posterior parietal gyri, cortical regions that are known to contribute to spatial information representation, spatial working memory, and coordination of cognitive

resources as a central executive system. They assume that the peak activation of this system is relevant to the unique feature of Chinese that a logographic character has a square configuration that maps onto a monosyllabic unit of speech. Equally important, when their bilingual subjects performed a phonological task on English words, this neural system was most active, whereas brain areas mediating English monolinguals' fine-grained phonemic analysis, as demonstrated by Experiment 2, were only weakly activated. This suggests that their bilingual subjects were applying their L1 system to L2 reading and that the lack of letter-to-sound conversion rules in Chinese led Chinese readers to being less capable of processing English by recourse to an analytic reading system on which English monolinguals rely. Our brain imaging findings lend strongest support to the idea that language experience tunes the cortex.
(Tan et al., 2003)

Long-range EEG synchronization during word encoding correlates with successful memory performance

Distinct cortical activity during memory encoding of words, which were either recalled or not, was reported by a number of studies. This activity was mainly found at frontal and temporalparietal brain regions. However, it was not clear if these regions interact with each other or work independently. In order to get a functional measure of the degree of neuronal large-scale cooperation, we calculated EEG coherence, which provides a statistical measure of synchronization between two EEG signals per frequency band. Therefore, coherence enables us to assess the functional interaction between cell assemblies of distant brain regions. The purpose of our study was to investigate if successfully recalled words show enhanced cortical synchronization compared with not recalled ones. Additionally, the influence of stimulus modality and the way different EEG frequencies participate in this process was examined. The EEG of 25 participants was recorded during memory encoding of concrete German nouns, either presented

auditorily or visually and stimuli were separated according to the participant's memory performance. Recalled nouns exhibited overall enhanced synchronization but showed typical patterns, especially between anterior and posterior brain regions in all frequency bands except the alpha-1 band _8–10 Hz. Recalling nouns was accompanied by increased synchronization between more distant electrodes in relation to an increase of synchronization between adjacent electrodes. Moreover, the degree of intrahemispheric synchronization was higher for recalled nouns. The pattern of EEG coherence and amplitude changes during verbal memory encoding allowed us to assess the probability that nouns would be recalled or not.
(Weiss & Rappelsberger, 2000)

The contribution of EEG coherence to the investigation of language

The contribution of EEG coherence analysis to the investigation of cognition and, in particular, language processing is demonstrated with examples of recent EEG studies. The concept of EEG coherence analysis is explained, and its importance emphasized in the light of recent neurobiological findings on frequency-dependent synchrony as a code of information processing between nerve cell assemblies. Furthermore, EEG coherence studies on naturally spoken and written word and sentence processing are reviewed and experimental results are presented giving new insights into the occurrence of ‘‘transient functional language centres’’ within the brain.
(Weiss & Mueller, 2003)

Reading Aloud Activity in L2 and Cerebral Activation.

This article explores the cerebral mechanism of reading aloud activities in L2 learners. These activities have been widely used in L2 learning and teaching, and its effect has been reported in various Asian L2 learning contexts. However, the reasons for its effectiveness have not been examined. In order to fill in this gap, two studies using a brain-imaging technique, near-infrared spectroscopy, were conducted in order to determine a cerebral basis for the effectiveness of reading aloud activities.These studies show that reading aloud in L2 results in a higher degree of cerebral activation than reading aloud in L1.Reading material beyond learners' L2 ability aloud results in low brain activation. Repetition of the same normal reading aloud activity in L2 does not necessarily increase (or decrease) the level of cerebral activation. However, including a repetitive cognitively demanding reading aloud activity does cause high brain activation. On the basis of these findings, this article provides a cerebral basis for the effectiveness of reading aloud activities in L2 learning.

(Takeuchi, Ikeda, & Mizumoto, 2012)

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