DEVELOPING NEURAL PATHWAYS: MAKING THE MOST OF COMPUTERS

Heather Rendall, Education Consultant

How do we learn? Or more exactly - what has to happen in the brain before new input entering via the senses becomes knowledge? 'Making order out of chaos' probably best sums up this process: the chaos being caused by new input reaching the brain without having obvious areas for storage or connection; the order being the end result where input is fixed and connected.

It is becoming clear from both neurological and mathematical research that states of chaos are not tolerated in the natural world; whenever chaos occurs, systems either arise or leap into action with one intent: making order out of the disparate signals being received. Chaos stimulates the emergence of cells that fall into patterns that appear pre-set.

"The language of science of the future will be patterns not equations" Thus Stephen Wolfram talking in 1999 about his book "A New Kind of Science" published eventually in 2002. He says: " One might have thought - I know I did - that if the rules for a program were simple then this would mean that its behaviour must also be correspondingly simple.. *The pivotal discovery I made is that . this intuition is not even close to correct. .. I found that that despite the simplicity of the rules (governing the programs) the behaviour of the programs was often far from simple."*

Wolfram goes on to propose that our body cells contain simple recipes for reaction to environment, which develop complicated or sophisticated patterns of response and behaviour, which are themselves the organising principles that create function. This theory can be reproduced on computer by the creation of cellular automata, in which we can watch as a random chaos of individual cells organise themselves to produce the 'function' determined by the pattern. It is this, the innate principles of functioning in our brain cells, which allows us to create networks of connectivity.

The activity of learning could be described as the biological organisation of new input. Once the new input is lodged in or connected to as many neurones as the brain sees fit, the repeating or recalling of the content causes the connections to strengthen. After repeated use, these connections will learn to fire in sequential order once triggered:
"Experience sculptures the brain through patterns of connections. After a few repetitions of cell groups firing together they tend to team up. This is called Hebbian learning after the Canadian psychologist Donald Hebb." (Sir David Winkley, "Grey Matters" TES/Keele lecture 1999)
In simple terms Hebbian learning is the basis of our ability to retrieve and make use of the input of our brain.
"We know that everyday experience triggers neuronal development . which means that the more areas of the brain are stimulated and used, the more neuronal pathways and networks are established.. When two connected neurones have been triggered together on several occasions, the cells and synapses between them change chemically so that when one fires, it will be a stronger trigger for the other" (ibid.).
Over time the multiple random connections created in the first immediacy of input are either strengthened and survive to become part of the neural network of the brain or they are not re-used or re-visited and wither away.
"After birth this process (of forming connections) slows and the second component 'experiential selection' begins to dominate. [This] is the process by which certain connections between neurons are strengthened and others are left to die. Those connections that are used most often, because they more aptly help interact with the surroundings, are strengthened." (Gerald Edelman "Neural Darwinism" 1987: summarised by Neil Desai © TSRI 1998)
We are beginning to see some of the essential elements that are required for learning to take place:

- new input;
- minimising random/inapt connections
- repetition of the input:
- prompted recall:
- more repetition until Hebbian learning is achieved i.e. recall is assured *"The driving force behind strengthening is based on satisfaction of certain inherited values" (ibid.)*

Sometimes these driving forces can be negative, as was pointed out in the TV programme "The Human Instinct" in November 2002: *"Our bodies also drive us on to win by making losing feel terrible. And we are more likely to remember our losses - to help us try and avoid doing the same thing again."* (BBC 1 "Will to Win", 6 November 2002) So our brains have a natural tendency not just to learn what to do but also what not to do. The avoidance of error is a strong force. We should take this firmly into account when considering learning environments and materials. What makes the average student feel like a 'loser'? I would suggest *inter alia* the following:

- not being able to understand or follow during a lesson
- making no visible progress
- continuing to make errors
- repeating the same errors without improvement

Similarly what are the 'inherited values' that make school based learning successful?

- ability to understand
- ability to do whatever is required
- being able to see errors minimised

In short - success! How can we as teachers create good learning environments? We can do this by:

- minimising the number of random connections made by our students during the initial learning stages, e.g. by making overt connections to existing experience or common knowledge.
- stimulating the development of a series of neuronal connections, e.g. by creating procedures of thought or set pathways.
- reinforcing the original input, e.g. by revisiting the input in short order and then frequently.
- highlighting errors or inapt thinking, e.g. by instant correction and feedback.

Not all of this is easily achieved in the classroom context. We can certainly control the number and quality of overt connections we make when introducing new concepts and rote learning has, since time immemorial, developed subliminal cognitive procedures, but do we want to rely on discredited methodology? How can we harness ICT to 'modernise' rote learning thereby making it more efficient? *We can do this by creating procedures of thought or set pathways.* Computer programs only work because they are programmed to have a single route. A computer game with random effects would deter even the most computer literate child, because the experience gained with each attempt would be to no avail. As it is, a child is happy to start and re-start the 'game' over and over again, each time progressing a little further than before. It is rote learning in all but name. *We can do this by revisiting the input in short order and then frequently.* A computer exercise can be revisited any number of times. It should therefore not be overly long: better 3 separate exercises containing 10 elements each than one exercise containing 30. It can also be restarted as if from a blank slate, with no image of previous error. *We can do this by instant correction and feedback*. This is where ICT comes into its own. Students can be informed instantly of mistakes e.g. a vocabulary testing program that will not allow a single letter error, forcing the student to re-think each spelling letter by letter. Other alternatives are to count the number of mistakes and offer the student a second, third, fourth etc. chance to reduce the number. Equally effective is timing each attempt so that even when errors are reduced to zero, a student can still gain increasing satisfaction by repeating the right answer ever more quickly. But all this has been known for some time.

"The computer is interactive. The student responds and gets instant feedback: either positive or notification of error. The computer is capable of error analysis: identification and explanation of the source of error, which in turn allows for self-correction. And of course the computer is inhumanly patient with the student, who can go over the materials as much as s/he needs." (John Underwood "CALL in Language Technology" 1988)

Even the effect of computer games is well known.

"Most video games rely on a competitive element in which people try to beat their own scores. This appeals to those who want to raise their self-esteem. They also provide a means of escape, as players often become psychologically immersed." ('The Game is up' a review of types of games, Sunday Mirror January 2003).

It is just unfortunate that much of the CALL/ICT material available to teachers and students, especially on the Web, do not contain these essential elements. When we are designing or evaluating CALL exercises to support learning, we should consider the following:

- There should be a structure that offers a single route through the activity. The content may change but the activity itself should be fixed.

- There should be correction and feedback either as the student progresses through the program or at the end of the activity.
- There should be a results log so that after the first attempt, any progress is immediately visible.
- The activity should not be too long; it should be repeated more than twice in any one lesson.
- It should avoid any unproductive i.e. non-interactive repetition or no repeating of cartoon introductions, jingles or animations.
- Each attempt should be timed and the time logged. In addition it would be preferable if the results log with errors, successes and timings could be saved to the student's own area, so that they can amass a record of their progress.

In order to find CALL material for this talk, I went online on the Tuesday afternoon before the conference. I used the Google search engine, using the string "French grammar exercises". I found 66,700 exercises. The superabundance of material on the Web is clearly illustrated by this result: no teacher is able to sift and evaluate this many exercises. And whilst possibly striking gold with their first few selections, they may also have to trawl for some time to find exercises which fit any of the criteria listed above. I downloaded a number as examples of what to avoid. Here are just a few with the comments I made.

	Practising or Testing	**Problem**	**Comments**
1.	Genders	70 items in the exercise	Although there was instant feedback, this contains too many items. Repetition is only acceptable when it comes in short doses.
2.	Reading comp	5 texts to be matched to 5 pictures	Once the right text is dropped onto the right picture, it remains fixed. Can be achieved by merely moving texts without reading them. Also only 4 texts need to be read because the last has to be a correct match
3.	Labelling body parts	Web search to find famous person, whose body is then labelled	Let alone the obvious misuse that this activity calls to mind, there is no restriction placed on students searching the Net.
4.	Writing a description	Only instructions given of writing to be done in Word	A writing frame of sorts would at least have made this interactive: as it stands it could be done just as well via and on paper
5.	Testing vocabulary	Vocabulary has to be copy-typed from possible suggestions	Takes about 3-5 seconds to type in answer. It takes another 25 seconds to verify. Too long a wait.
6.	Testing adjectives	Using a set format, making turn over cards.	The prompt reads "nouveau (fem. plural)" which is very confusing if you are not aware that the brackets contain instructions and not explanation. The student is required to say the feminine plural form of 'nouveau'. Only visual correction. No oral/aural checking.
7.	Teaching adjectives	Requires students to choose whether a German adjective form is strong or weak	Use of grammatical terms not employed by our teaching methods.

An equal number of good programs were presented. Here is a selection:

	Testing/Practising	**Essential Elements**	**Comment**
1.	Multi-choice vocabulary testing	Instant feed back 10 items per activity	Easily repeatable. Learn to avoid errors by repeating exercise and improving score
2.	Hangman	Instant feedback. Results are logged including the time element	Very addictive because of the time element. Topic can be re-chosen and although words appear randomly, there are a set number of words to each topic.
3.	Idioms	Maximum time given 200 seconds: seconds removed while selecting answer from multi-choice	Again very addictive because of the pressure of seeing the seconds disappearing fast. Multi-choices appear in different order each time the activity is repeated. Forces reading of each possible answer each time.

4.	Gap-fills	Offering choices from drop down menus	Reinforces the possible range of answers each time. Can be used effectively to cover many grammar variables e.g. French genders - each menu contains le, la , l', les : German direct object endings - each menu contains den, die, das, die
5.	Gender (German)	Simple choice of 3 buttons	Short exercises (10 entries): end of exercise feedback: printout of own attempts: final printout of correct answers. Very effective with motivated students
6.	Weather synonyms	Phrases and sentences have to be placed on a spider-gram attached to a graphic	Instant feedback: if wrong it doesn't 'stick' but slides back to the original tray. Printout of correct answers. Timed attempts: printable
7.	Dialogue jumbles	Each sentence has to be re-arranged from individual word tiles	Feedback at the end of each sentence. Student cannot proceed until the sentence is correct. Timed attempts: printable

When I went back the next day to finish gathering material, the same Google search came up with 67,400 exercises. In the intervening 12 hours 700 new French grammar exercises had been uploaded to the Net. The last time I tried the same search the number had risen to 71,500! As the Net grows ever bigger, the chances of being able to locate useful and effective material become slimmer. Good material is there but in order to be able to search and evaluate it quickly and effectively, we must be sure of the criteria by which we are judging. If we can tie these criteria into what we are learning about effective learning environments and the needs of the brain, we may be assured that what we select as activities for our students will have real concrete values and provide a firm basis for good learning and progression.