

ALPHABET HEADACHES
HONG KONG'S ENGLISH LITERACY CHALLENGE

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CHAPTER FIVE

THE GROWING CONTRIBUTION OF COGNITIVE SCIENCE TO THE STUDY OF READING

The formation of a Chinese character stress on the “meaning” or the “shape”. It is easy to get the meaning, but you will never get the pronunciation just by looking at it. An English word is based on the pronunciation, but you might not get the meaning by looking at it.

(44) *Word Wizards* course participant, 2004.

We cannot guess a Chinese character. The Chinese character has less relation with its pronunciation.

(75) *Word Wizards* course participant, 2004.

In Chinese you can never guess the writing merely from hearing the sound. We learn the characters first and then its pronunciation. In English we learn the sounds that help us to write the word. We need not to remember every spelling, but Chinese on the contrary, we need to remember all the “strokes”.

(57) *Word Wizards* course participant, 2004.

In Chinese you cannot write the word by “sound”, but in English you have!!

(41) *Word Wizards* course participant, 2004.

In 1967 Jeanne Chall’s influential book, *Learning to Read: The Great Debate* (1967, p. 98), stressed the need for studies of the reading process to become more systematic and scientifically grounded, with “a firmer theoretical basis from other disciplines, particularly psychology and linguistics”. More than three decades later, a pediatrician specialising in dyslexia, has repeated the same call, noting that, “until quite recently, research in reading instruction was often quite descriptive” (Shaywitz, 2002 p. 519). The recent development is the one to which Shaywitz herself belongs: cognitive science. This interdisciplinary field of scientific research dates back to a symposium held in the United States in 1956, when researchers in very different areas such as psychology, neurobiology, linguistics, computer science, philosophy, anthropology and sociology became aware that they were working on similar problems related to human perception, thinking and learning. The field of cognitive science has since been founded on the notion that the mind is an information processor, which receives, stores, retrieves, transforms and transmits information (Matlin, 1998). This thesis chapter takes a layman’s look at the new and improved technologies that have become available for

reading research in the last two decades, and it will show the enormous potential that these technologies offer for comparing the processes of reading different types of written scripts. These technologies have already been applied in landmark studies of Chinese-language readers in the UK, the USA, China, Taiwan and Hong Kong.

EYE-MOVEMENT STUDIES

Some of the first scientific studies of reading took place in the early twentieth century, when researchers attempted to study the movements of readers' eyes while they were reading (Dearborn, 1906; Buswell, 1937). Technological advances since then have revived this earlier interest, and a number of more sophisticated studies of eye movements were carried out in the 1980s (Just and Carpenter, 1980, 1987; Rayner and Pollatsek, 1989). From these studies it has emerged that, contrary to our personal experience, readers' eyes do not move smoothly across the letters, words and phrases of a text while reading. Instead, they move in a sequence of jumps, called *saccades*, of about eleven letter-spaces, along a line of print, followed by brief periods of gazing or *fixations*, when the eye rests on a point in the text to assimilate information. These "moving windows" take in about three letters to the left of the fixation point and about seven to its right, which often corresponds to one word plus a fragment of the following word. A study by Inhoff (1989) showed that subjects who were permitted to preview the first three or four letters of the next word in a controlled visual display, read faster than those who were denied this opportunity. While one word is being read, it seems that the next is being preread. Some people have been found to read more letters per fixation, particularly to the right of the fixation point. Far from gaining an advantage, such people often suffer from *dyslexia*, a specific impairment of reading. They see far too many words at once, and have trouble separating them (Geiger, Lettvin and Zegarra-Moran, 1992).

During the saccade movements of the eyes, vision is suppressed so that no new information is acquired. In this way, reading resembles a kind of slide show in which the text is "on" for about a quarter of a second and then "off"

for a brief period of time while the eyes move forward. In addition to making the forward-moving saccades, skilled readers will move their eyes back in the text to reread material about 10-15 percent of the time (Just and Carpenter, 1980). These *regressions* are often driven by comprehension needs. Fixations account for roughly 50-80 percent of our total reading time, depending on the purpose of the reading and the nature of the material. Nouns, verbs and adjectives attract longer fixations than do function words like articles or prepositions (Perfetti, 1995, p. 107).

By studying the eye movements of both skilled and unskilled readers, researchers can get a clearer picture of what constitutes efficient reading. Those aspects of text that slow the reading process down can also provide insights into how this information is processed. Good readers and poor readers often display the same number of fixations, but what separates the less-skilled, the beginning and the second-language readers, is their much higher levels of regression, or looking back. Longer fixation times are also a shared characteristic of these less-skilled groups (Just and Carpenter, 1987, p. 27). By carefully examining the locations and durations of eye fixations, Just and Carpenter (1987) showed that individual letters are the major cues that good readers use to recognise words. By contrast, “speed readers” are not fully processing the text that they skim at all, rather they are only operating at the level of gist. When reading for comprehension, skilled readers tend to look at each individual word, with their eyes even “catching” on the slightest misspellings (McConkie and Zola, 1981). In proficient reading, this process is carried out with remarkable speed and ease, within hundredths of seconds.

Today, eye-movement studies continue to be important in the study of the reading process, with many university cognitive science departments having their own eye-tracker laboratories. One such laboratory is available at the Chinese University of Hong Kong, in the Centre for Cognition and Brain Studies, under the direction of Hsuan-Chen Chen. In a recent publication, he described the application of eye-movement studies to the Chinese language (Chen et al., 2003). As Chinese text is formed by strings of equally spaced, square-shaped characters, and alphabetic scripts have linear words of varying lengths and shapes, Chen and his colleagues investigated whether the

saccade-fixation patterns in Chinese reading would be different from those during English reading. The internal complexity of Chinese characters is very high, in both a visual and an informational sense. As mentioned earlier, word boundaries are not indicated in Chinese and there are no tense, number or gender markers. It is difficult at such an early stage in this new field to draw any broad conclusions, but the forward saccades of undergraduate students in this study covered 2.6 character spaces between fixations, with a regression rate of 15 percent (Chen et al., 2003, p. 159). The visual field, or visual span, within which information is gathered, and the amount of overlap between successive spans found in this study were smaller than those found in English reading, probably reflecting the complexity of the visual information.

In the few, but growing number of studies that have been done in this area, Chen et al. note that it is variables at the character-level that have the most impact on eye-movement data. In a comparison study, involving primary school students, these researchers found that younger children's saccades were roughly the same as older readers', but their fixation times were longer. By sixth grade, there was a great deal of similarity with older readers. In general, research with older and younger readers in English has found similar patterns, with children making longer fixations and more regressions than adults, but with shorter saccades (Rayner, 1978). In English, these differences continue to change from primary school to college, but adult patterns in Chinese seem to have become established by the end of primary school. These differences are possibly due to the very different layouts of the two scripts, with the Chinese layout remaining constant, and English word-lengths continuing to vary (Chen et al., 2003).

THE ROLE OF SOUND

Research with skilled alphabetic readers shows clearly that phonological information is activated quite early in each eye fixation (Rayner, Sereno, Lesch and Pollatsek, 1995). This is an important observation, for it lends weight to the argument that alphabetic scripts draw on sounds in order to gain access to meanings. If beginning readers can sound-out unfamiliar

words, these can then be matched with their knowledge of words from speech, their lexicon. This is the self-teaching function of reading, the *sine qua non* of reading acquisition espoused by Share (1995). If a reader is relying on a word's form or shape, or letter-names, there will be limited or no connection to sound.

In a carefully devised experiment, Van Orden et al. (1988) presented subjects with pseudowords and homonyms of familiar words and noted the mistakes that they made in tests of associations. The pseudoword *sute* was often associated with clothing and *rows* with flowers. These errors would not have occurred unless these subjects had phonologically recoded the words that they saw. Cognitive scientist Charles Perfetti has found that phonological information also plays an important part in reading Chinese script, although the terminology used in studies of alphabetic readers' phonological processes does not completely suit the unique features of the Chinese writing system (Perfetti and Zhang, 1995; Tan and Perfetti, 1998).

The so-called Stroop Effect has long fascinated cognitive researchers. When colour-words such as *red*, *blue* and *yellow* are printed in colours other than their own, and subjects are asked to name the ink-colour not the word, there is a great struggle to ignore the printed word. This test clearly activates two cognitive pathways at the same time, one activated by the ink-colour, the other by the printed word. The test is far easier to do in an unfamiliar language (MacLeod, 1991). The process of recognising the written words in one's own language is so highly automated that subjects find it difficult to suppress their need to read the words in order to perform the task. This shows how quickly people have learned to react to printed words. Stroop tests have also been used with Chinese subjects reading Chinese characters, and these studies have added weight to the notion of dual pathways (phonology and semantics) in the activation of meaning in Chinese reading.

Homophones (same-sounding words) are abundant in Chinese and, as many of them bear no visual resemblance to each other, they provide excellent choices for Stroop colour-word tests. Spinks et al. (2000), in a series of tests, used the characters for colour-names, homophones of these characters, and

semantic associates of colour characters (e.g. *blood* and *red*) in various combinations. If phonological interference was possible, then the homophones of colour-names should also interfere with ink-colour naming. A further element of tonal difference was also added to the colour characters and their homophones in the test. The results of this investigation showed the usual Stroop-effect of interference with colour-names and ink colours. Homophones of the colour characters also interfered with the speed of response, suggesting that phonology had been activated. Tone-interference was stronger for homophones with the same tone, suggesting that tone is included in the phonological code. The semantic associates interfered when they were incongruous with the ink-colour name (e.g. *blood* written in green), and helped when the colour was “correct” (e.g. *grass* written in green), although these effects were smaller than those of colour characters. This indicates that the semantic links to meaning are probably indirect. This ingenious experiment showed that there are two pathways to meaning in Chinese, one direct from orthography, as has long been suggested in the literature, plus another, from orthography to phonology to meaning (Spinks et al., 2000, p. B9). This is a most important finding.

BRAIN-IMAGING TECHNOLOGIES

Cognitive neuroscience is a relatively new field of scientific study that has been fuelled by the rapidly developing technologies of brain-imaging techniques. These technologies permit researchers to record brain activity during cognitive tasks. To date, the main advances in this field have been in locating *where* an activity takes place, more than *how* that process works (Matlin, 1998, p. 11). Research in this field has helped to identify the regions of the brain that play some role in the reading process. One such method is the PET scan (positron emission tomography), which involves injecting a small amount of a radioactive substance into the blood, which will attach to the molecules that are observed during brain activity. The gamma rays that are given off can be recorded by sensors and analysed by computers to build up a picture of just where in the brain an increased use of the molecules is taking place (Greenfield, 1996, p. 28).

A less invasive technique for investigating the ways in which the brain processes language is MRI (magnetic resonance imaging), during which researchers will pass a strong, but harmless, magnetic field through a subject's head. The MRI scanner can pick up changes in the metabolic activity of the brain while the subject performs a cognitive task. In the 1990s, neuroscientists developed an important modification of this technique, called *fMRI* (functional magnetic resonance imaging), which can note changes over a five-second period, as against the ninety-second period for MRI. The *fMRI* also produces more detailed images than the PET scan, at a much lower cost. PET scans and *fMRI* techniques can provide maps of brain activity, but they are still too slow to provide precise information about its *timing*. Another type of investigation, known as the ERP technique (event-related potential), can record tiny fluctuations of under a second in the electrical activity of the brain in response to a stimulus. Also known as the "evoked-response potential technique", this research tool involves placing electrodes on a subject's scalp to record electrical signals (Matlin, 1998; Rayner et al., 2001). In principle, this kind of imaging is relatively simple. When a subject is asked to perform a particular cognitive task, this places demands on specific neural systems in the brain. These systems need to be activated, and this can be observed by monitoring changes in cerebral blood flow. Because this oxygenated blood has different magnetic properties, this can be captured in coloured imagery (Shaywitz, 2001).

Until the advent of these technologies, researchers had no firm indicators for the ways in which the brain processed language input. Unlike many other human behaviours, reading cannot be studied in animals, and researchers previously had to infer the location of cognitive processes from the effects of brain injuries on research subjects who had survived them. Functional MRI has made it possible, in a very non-invasive way, for researchers to identify the regions of the brain that are engaged when healthy subjects are reading, or carrying out experimental tasks.

Functional MRI has also been used by researchers investigating the differences, if any, between readers of Chinese and readers of English (Chee, Tan and Thiel, 1999; Tan et al., 2000a). Since 2002, annual International

Symposia on Cognitive Neuroscience have been held at the University of Hong Kong, with the majority of presenters reporting on findings informed by the use of fMRI (e.g. ISCN, 2004). Because the Chinese script is so very different from alphabetic scripts in its shape (square, not linear) and phonology (tone, but no letter-sound correspondences), cognitive neurological research with the Chinese language is important for the advancement of our understanding of the subsystems of the human brain – what is universal and what is particular to certain aspects of language. Brain imagery is an ideal platform from which to do this.

In a combined ERP-fMRI study of Chinese readers, Tan et al. (2000b) asked subjects to read two types of Chinese characters: those in which the phonetic component of the character was identical to the character name (and meaning), and those in which it was different. Despite the fact that reading Chinese would appear to be such a different cognitive challenge from reading English, this study found that many of the same areas of the brain were activated. They also found that the right hemisphere was heavily involved when subjects read the Chinese characters aloud, particularly the right inferior frontal gyri, which are associated with the close analysis of spatial features, and the right superior temporal lobe, which is known to be relevant to the perception and analysis of pitch and tone. The researchers attribute these differences to “the unique visual-spatial and tonal analyses demanded by Chinese”, and suggest that, “different native languages may shape different neural systems” (Tan et al., 2000b, p. 88).

In a keynote address at the 2003 ISCN conference in Hong Kong, Kochunov et al. (2003) reported on their use of fMRI and DFM (deformation field morphometry) to examine differences in brain shape between English-speaking Caucasians and Chinese-speaking Asians. The brain areas that were chosen for close examination were very specific, and they were chosen because each of them had been implicated in earlier studies of Chinese language processing as being more active than the same areas in English speakers. Acting on the premise that early childhood experiential differences could influence “plasticity”, or anatomical changes, these researchers wanted to explore whether form is shaped by function. One of the group had

previously reported such structural differences in highly skilled musicians (Amunts et al., 1997), finding a high correlation between a very early age of commencement of musical training (as early as 36 months) and the magnitude of these structural differences. As language processing begins very early, and the reception and production of sounds are shaped by exposure not ethnicity, this study hypothesised that plasticity would be found in the key neural structures. Such differences were indeed found between the two sets of subjects in the gyri in the frontal, temporal and parietal lobes, the regions that are known to differentiate Chinese speakers from English speakers; three in the left hemisphere and one in the right hemisphere. Three of these areas were larger in the Chinese speakers (middle frontal gyrus in the left frontal lobe, the anterior portion of the inferior middle temporal gyrus in the left temporal lobe and the superior parietal lobule of the right parietal lobe) and one was smaller (the superior parietal lobule of the left parietal lobe). The average difference in surface area was in the order of two millimeters. The authors claim that these findings are novel and that theirs is the first report of an acquired anatomical difference due to the early learning of a cognitive strategy (Kochunov et al., 2003).

Another study by some of this same group of researchers (Tan et al., 2003) found some interesting *fMRI* contrasts between Chinese-English bilinguals and English monolinguals in a series of tasks that involved the detection of rhyming between pairs of Chinese characters and pairs of English words. The bilingual subjects were all Chinese-educated and were late-starting, but fluent users of English. The bilinguals' brain activations were the same for both English and Chinese stimuli, but the native-English speakers' activations were "in striking contrast". The differences were related to the degree of activation, rather than location. One of the areas of greater activity for the Chinese subjects was the middle lateral frontal cortex, which is known to mediate spatial information storage and spatial working memory, so the researchers concluded that the unique, square configuration of Chinese characters required "elaborated analyses of the visual-spatial locations of the strokes in a logograph". One area of inactivity for the Chinese subjects was the left mid-superior temporal cortex, which the research team attributed to "the monosyllabic nature of written characters that does not call for automatic

phonemic analysis" (Tan et al., 2003, pp. 163-164). Phonological analysis in Chinese peaked in the left middle frontal cortex, reflecting its close links to visual features. The similarity of patterns in the bilinguals' two languages "suggests that the processing of L1 phonology (where logographic characters are processed monosyllabically) carries over to L2 processing. The Chinese subjects ... were applying the strategy of processing Chinese to processing English words. They did not automatically use the letter-to-sound conversion rules to pronounce English words". The research team believes that these experiments "have produced the most compelling data in support of the hypothesis that language experience tunes the cortex" (Tan et al., 2003, p.164).

Despite the fact that these Chinese subjects had learned *pinyin* in primary school in China, their exposure to this alphabetic system was only for a matter of months and this, clearly, did not contribute to their phonemic-level processing of English words. Tan et al. (2003, p. 164) believe that their brain mapping studies "lend strong support to the prominent theory that reading involves language-specific neurocognitive systems in which L2 reading is shaped by L1 for bilinguals".

Some *fMRI* studies have been carried out to specifically focus on the comparative neural processing of *pinyin* and Chinese characters. In mainland China, all school-aged children are required to learn the *pinyin* alphabetic writing system in their first few months of their first grade, but, as a written script, it is not widely used outside schools. It is not used by adults for new character learning, but it might be used to look up a Chinese dictionary organised along alphabetic lines, to facilitate the input of Chinese characters into computer systems using alphabetic keyboards, and in some foreign name spelling (He et al., 2003, p. 2). According to Siok and Fletcher (2001), children's knowledge of *pinyin* helps in developing fine sound-discrimination skills, or phonemic awareness, which is a strong predictor of later reading success. It is important to note that a reader "cannot decipher the meaning of a single word in *pinyin* script solely from its visual form, as homophones are very common in Chinese" (Fu et al., 2002, p. 1539). Just the same, it offers very regular grapheme-to-phoneme correspondences, unlike the regular

Chinese script, in which sound is sometimes suggested by the presence of a phonetic element in characters at the level of a syllable.

An fMRI study of Chinese readers compared their brain activations for reading *pinyin* and those for regular Chinese characters (Fu et al., 2002). The subjects for this study were native Chinese speakers studying in the UK. Using fast and slow presentation times and both character and *pinyin* stimuli, the researchers found many common regions of brain activation, but some distinct differences. Generally speaking, the Chinese character reading showed more bi-hemisphere involvement, but greater overall activation was recorded for the *pinyin*. Fu et al. comment several times in their report that the reading of *pinyin* was very “effortful” for these adult readers, as this alphabetic script is not something they use on a regular basis. These researchers describe *pinyin* as “assembled phonology” and Chinese characters as “addressed phonology”. This is an interesting distinction, and they use it to account for the slower reaction times of their *pinyin* readers. In their view, *pinyin* reading involves an assembling procedure and is associated with greater brain activation than the more addressed procedure likely used for Chinese character reading. They claim that the assembly of *pinyin* demands phonological processing, whereas “for Chinese characters there is a learned (and therefore directly addressed) association with meaning in which semantic processing remains important, but phonological processing is less so” (Fu et al., 2002, pp. 1539-1546). It is still conceivable that their subjects were struggling with the differences between a very familiar and a not-so-familiar writing system, but the suggestion remains that word-form might influence the brain’s processing mechanisms.

READING IMPAIRMENT STUDIES

Functional MRI has also provided invaluable insights for researchers and practitioners in the area of reading difficulty, notably in studies of the disability known as *dyslexia*. Developmental dyslexia is characterised by an unexpected difficulty experienced by children and adults who otherwise possess the intelligence and motivation considered necessary for accurate and

fluent reading. Estimates of the presence of dyslexia in school populations vary greatly, but the proportion of school-aged children with *reading problems* has been estimated to be as high as 20 percent in the USA (Gorman, 2003, p. 35) and 14 percent in Hong Kong (Education Commission, 1990), depending on definitions. A significant proportion of these students may be dyslexic, and they will demonstrate problems in the area of phonological processing and display distinct neural differences (Shaywitz, 1996; Stanovich, 1998).

Shaywitz and her colleagues at Yale's Center for the Study of Learning and Attention have studied the neurobiology of reading with hundreds of dyslexic and non-dyslexic children since 1994 (Shaywitz, 2001). Their studies have tracked the identification of letters to sites in the extrastriate cortex within the occipital lobe, phonological processing to the inferior frontal gyrus and access to meaning to areas within the middle and superior temporal gyri of the brain (Shaywitz, 1996, p. 103). Dyslexics have difficulty in phonemic awareness, the ability to segment written words into their underlying phonological elements. As a result, the reader experiences difficulty in decoding the word and then in identifying it. This deficit is completely separate from other abilities that the reader may have, and it offers an explanation for the paradoxical situation of a student who, for example, can describe and fluently explain the nature of volcanoes, but cannot summon up the word "volcano" when they see it in print (Shaywitz, 1996, p. 102). The reading of these children is less automatic, more effortful and slow, and fMRI images suggest that there are significant differences in brain activation patterns from regular readers (Shaywitz, 2001). An fMRI study of dyslexic children conducted by Temple et al. (2001), found an unanticipated "large group difference between dyslexic and normal-reading children in brain regions involved in single-letter orthographic processing" (p. 306). As many studies have shown that knowledge at the level of the single letter is a strong predictor of reading success (McConkie and Zola, 1981; Just and Carpenter, 1987; Adams, 1990), this is a very significant finding.

In non-Western societies and in linguistic systems that use non-alphabetic scripts, dyslexia has only recently been recognised and acknowledged. While dyslexia is now known to be universal, its prevalence varies among different

language groups. In mainland China and Japan, dyslexia rates are claimed to be as low as 5 percent, compared to 10-20 percent in the USA (Spaeth, 2003, p. 42). The accuracy of such figures is probably a matter of debate, as children with learning disabilities in Confucian-heritage societies may not be readily diagnosed by teachers or parents who see increased effort as the primary route to success. Catherine Lam (1999, p. 26), a pediatrician working with Hong Kong children who have specific learning disabilities, is concerned that "dyslexia and other learning disabilities are seriously under-identified in Hong Kong", and that even children who are identified "have difficulty getting the help they need within current structures". She comments that, "sadly, many Hong Kong [medical and educational] professionals ... claim that these conditions are rare or unimportant ... and often put blame on these children and their parents for wanting to 'use labels' as excuses for school failure".

A paper presented by W.T. Siok at the 2003 ISCN Conference in Hong Kong showed, via *fMRI* studies with reading-impaired Chinese children, that a central cause of their impairment is a functional disruption of the left middle frontal gyrus. This is the very same location that has been shown in other studies to be the "Chinese reading center" in adults (Kochunov et al., 2003; Tan et al., 2000a, 2000b). Siok describes Chinese readers with problems in this region as having "double deficits", because this brain region is vital for both orthography-to-phonology mapping and orthography-to-semantics mapping (Siok, 2003).

In a widely publicised article in the journal *Nature* in September 2004, Siok, Perfetti, Jin and Tan announced that Chinese speakers who suffer from dyslexia have different brain abnormalities than dyslexic English speakers. Following up on an earlier study (Tan et al., 2003) which found differences in patterns of brain activity between readers of Chinese and readers of English, these researchers speculated that these differences might also hold for reading disorders in the two languages. While "behavioural research has established that impaired reading of the English language is caused by phonological deficits ... reading difficulty in Chinese evolves not only from a poor quality mapping of orthography to phonology, but also from a

substandard connection between orthography and semantics” (Siok, Perfetti, Jin and Tan, 2004, p. 72).

At the University of Hong Kong, several fMRI experiments were conducted with dyslexic and non-dyslexic Chinese readers. In one task, they had to decide if two different characters had the same pronunciation. In another task, they were presented with real and pseudo characters and asked about their meanings. The impaired readers consistently displayed different activation patterns from the non-impaired group. These differences were exhibited in the left middle frontal gyrus, the very area that had earlier been found to be crucial to normal Chinese reading (Tan et al., 2000a), and the area that Kochunov et al. (2003) had found to be anatomically larger in Chinese readers than English readers.

These findings are hugely important because they support the notion that the cognitive strategies undertaken in early reading development “tune” the cortex in particular ways. The findings also pose a challenge to any unitary theories of a common biological origin for dyslexia across languages, a point that the worldwide electronic news media seized upon at the time of the *Nature* article in 2004. The study also suggests that researchers need to be wary of making sweeping cross-cultural generalisations regarding the reading process, particularly between alphabetic and non-alphabetic orthographic systems.

CONCLUSIONS

The founding of the Society for the Scientific Study of Reading (SSSR) in 1996 has, through its annual conferences and quarterly journal, steadily built up a large and scholarly research-base on the reading process and its problems. The weight of such overwhelming research, conducted according to rigorous standards, has led to the National Institute of Child Health and Human Development (NICHD) in the United States insisting, through the Congress-appointed National Reading Panel, that reading instruction in US classrooms must be “based on scientifically based reading research to ensure

that every student can read at grade level or above not later than the end of Grade Three” (quoted in Shaywitz and Shaywitz, 2002, p. 520). This has become part of the “Reading First” component of the “No Child Left Behind” legislation signed into US law in January, 2002. If reading problems persist beyond the primary school years, it becomes increasingly difficult and time-consuming to remediate, and it becomes increasingly likely that poor readers will go on into adulthood with their reading problems left unaddressed.

Here in Hong Kong, it is particularly ironic that so much neuroscientific research has been conducted in the HKSAR’s state-of-the-art university facilities, but so little of the findings has been disseminated among or interpreted by the territory’s language teaching community. While it has to be acknowledged that due caution must be exercised in extrapolating from the findings of brain research to classroom practices, there must surely be some acknowledgement that *biscriptal literacy* is by no means easy. The claim by whole-language second-language educators that “we only learn to read once” is not looking too good at all in the face of so much scientific evidence to the contrary, but such beliefs still persist, as the following anecdote will demonstrate.

Exactly one week after the publication of the ground-breaking article in the journal *Nature*, referred to above (Siok et al., 2004), I met two champions of the whole-language school of thought about reading. These two have worked closely with Kenneth Goodman, its leading proponent, for several decades. David and Yvonne Freeman of the University of Texas-Pan American had been invited to my international school in Hong Kong as ESL consultants. In a three-way discussion with our school psychologist and David Freeman, I presented them with newspaper accounts of the *Nature* article. The psychologist, who was relatively new to the school and had struggled to come to grips with the subtle reading difficulties displayed by many of our students, was intrigued. Not so David Freeman. He dismissed it outright as having “no classroom implications” that we needed to be concerned about. I reminded him that many of our students were reading across two very different written scripts, but he insisted that reading skills are “always transferable, regardless of language” (personal communication, 2004). The

location of the Freemans' university in the south-easternmost corner of Texas would suggest that their ESL experience is almost entirely with Spanish-speaking students, for whom this generalisation would still hold. I now consider this encounter to have been a rather sad, but contemporary example of Jean Chall's 1967 claim that "belief systems" ruled the reading debate (Chall, 1967, p. 98).

This chapter marks the end of the background chapters of this thesis. It should now be clear that Hong Kong's Chinese students, who are expected to become *biliterate* in Chinese and English and *trilingual* in Cantonese, Putonghua and English, face a daunting educational challenge in a rigid and pedagogically unenlightened school system. There is no doubt that both teachers and their students are "working really hard" in the Confucian sense, to improve the learning situation, but they are also proceeding in the Confucian style of "more of the same" (Bunce, 2005b). The situation truly calls for a paradigm shift in thinking about *biscriptal literacy*. Two entirely different writing systems demand two completely different sets of reading skills. To teach alphabetic literacy, "Chinese-style", is not only problematic, it can be positively counter-productive, as the research study at the core of this thesis will demonstrate.

The students who will become the central focus of the following chapters are some of the brightest young people in Asia today. They have already won their places in top Band One EMI schools, they have been nominated by their schools to take part in an English enrichment programme and they have survived an entrance test with only a 50 percent acceptance rate to be able to attend a summer school programme at one of Hong Kong's leading international schools.

The next three chapters of this thesis will follow these high-flying Hong Kong students through a three-week "research intervention"; an educational programme which has been designed to assess and improve their understanding and appreciation of the alphabetic principle. Chapter Six provides details of this project's research design, and Chapters Seven and Eight will examine its outcomes. Throughout these chapters, continual

reference will be made to the *Word Wizards*® word-study programme, full lesson-by-lesson details of which are provided on the enclosed CD-ROM.