The use of illustrations when learning to read: a cognitive load theory approach.

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The use of illustrations when learning to read: A cognitive load theory approach

Susannah Torcasio BA MEd

A thesis submitted in fulfilment of the requirements of the degree of Doctor of Philosophy

March, 2009

School of Education
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Abstract

When students are learning to read, the materials supplied typically will include extensive illustrations. The implicit assumption is that the inclusion of such illustrations will assist students in learning to read. Cognitive load theory suggests that this way of formatting learning materials may not be maximally effective as the inclusion of illustrations with written text constitutes redundant information that may interfere with learning. If working memory resources are devoted to the illustrations rather than the text, as is likely with young children, those resources will be unavailable to decipher the text. The elimination of redundant illustrations may thus enhance learning to read.

Three experiments were conducted to investigate the effects of including illustrations in beginning reading materials. Experiment 1 compared reading materials consisting solely of simple prose passages with materials consisting of the same passages plus informative illustrations depicting the content of each passage. Reading proficiency improved more under the no illustrations condition. Experiment 2 compared the informative illustrations with uninformative illustrations. Reading proficiency improved more using uninformative illustrations. Experiment 3 compared uninformative illustrations with no illustrations and found no significant differences between these conditions. These results were interpreted within a cognitive load theory
framework. It was concluded that informative illustrations are redundant and so impose an extraneous working memory load that interferes with learning to read.
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Chapter 1

Introduction

Reading for most educated adults is a skill that is often taken for granted. We consider reading to be almost second nature and forget or do not recall the complexity of the task. In order to commence reading at the most basic level, the beginning reader needs to learn to recognise the arbitrary signs and symbols with which its civilisation has chosen to communicate. That is, the novice reader needs to recognise and learn the letters of the alphabet, the combination of letters that constitute words and the combinations of words that constitute phrases and sentences. As well as being able to recognise text, the novice reader is required to form an association between the shapes of letters and combinations of letters and words with their respective sounds or phonemes in order to commence the complex task of learning to read. Once mastered, reading becomes a tool used to infer meaning from text, but for the novice reader the skill of reading words and simple sentences is a complex task in itself involving much concentration and practice.

Illustrations feature extensively in books designed and intended to teach learners to read. The illustrations are assumed to be helpful to the task of learning to read. However, there are theoretical grounds that suggest that text accompanied by informative illustrations may not be the most effective way for teaching reading. The
skill of reading must be systematically taught. It is vital to the learning process that this skill, together with the many skills associated with learning to read, is taught in a way that is compatible with our human cognitive architecture.

Cognitive Load Theory is concerned with teaching students in a manner compatible with human cognitive architecture. The theory deals with what is known about our limited working memory and how best to reduce the cognitive load which will result in optimum learning. Instructional design and instructional techniques must accommodate the known limitations of working memory. Over the last few decades, research in this area has led to different teaching strategies which have proven successful in reducing the extraneous cognitive load imposed on our limited working memory, therefore resulting in greater and more efficient learning.

The structures and mechanisms associated with human cognitive architecture together with the instructional effects generated by cognitive load theory have the potential to be a key factor in determining the most effective way to design and teach the skills of reading. Reading is a learnt skill and is hence an appropriate task to be analysed within a cognitive load theory framework. Cognitive load theory may inform both the methods of reading instruction and more generally, the design and interpretation of quantitative studies designed to determine the optimal instruction methods.

The focus of this thesis is to determine if the use of illustrations when students are learning to decode text inhibits the acquisition of decoding skills. The current understanding of cognitive architecture and experiments conducted in other areas
involving novice learners suggest that illustrations may detract from acquiring decoding skills in the most effective manner.

Reading skills such as comprehension and inference are not available to novice readers who have yet to learn the skills associated with decoding. Comprehension may only occur once the novice learner is able to decode efficiently. Since this study deals with experiments involving novice readers and their implications, it is not the purpose of this thesis to analyse the effect of illustrations on comprehension once decoding skills have been acquired. The sole focus is in determining whether or not illustrations interfere with a child’s ability to decode text in the beginning stages of learning to read. While comprehension is of vital importance, it cannot be implemented effectively until the beginner reader has the ability to decode simple sentences with a degree of automaticity. If a child is struggling to read a basic sentence, all the cognitive resources available to that child may be involved in decoding individual letters by matching the graphemes with the corresponding phonemes and trying to form words and sentences. Cognitive resources required for comprehension may not be available to the learner if decoding has not become automated at a basic level.

This thesis is concerned with the design of beginner reading materials for students who are at the crucial stage of learning to decode. The implications of cognitive load theory are outlined in subsequent chapters followed by empirical findings concerned with the effects of illustrations on learning to read.
Chapter 2
Reading

2.1 Reading throughout History

Learning to read is a recent development in the history of mankind. Talking, story-telling, and oratory were the means of educating, passing history down through the generations or imparting knowledge for many centuries. In fact true scholars, such as Socrates, were thought to be those who would not use books to serve as memory aids (Manguel 1996). The skill of remembering vast amounts of information and scores of passages was a very common practice and a much sought after skill for the rhetoricians of Ancient Greece.

In Western civilisation, learning to read and write was reserved for the privileged aristocracy and the church throughout the Middle Ages and well into the Renaissance (Manguel 1996). The history of reading in Christian societies is deeply interwoven with religious beliefs and conventions of the times. It was a widely held belief that girls should only be taught to read and write should they choose to join the nunnery, and even then these girls came from richer families who could afford the tuition (Manguel 1996). Students were often read to by scholars and tutors and instructed to repeat what was being read to them, and very often many never learned to
read for themselves. With the advent of the printing press in the mid fifteenth century the availability of reading material saw an increase in those wanting to learn to read. During the 1650’s in Europe, Czech educator John Amos Comenius incorporated pictures with text in his book entitled *Orbis Pictus* in an attempt to teach reading. In America, books containing illustrations used for the specific purpose of learning to read date back to 1729 (Samuels 1970).

The teaching of reading in America flourished in the latter half of the 2nd millennium century with the 19th century investing much time and effort in formal reading instruction. It is around this time and into the early 1900’s that controversy emerged over best methods and practices, and how best to derive meaning from text (Monaghan & Barry 1999). Issues of silent reading versus oral reading as best practice for learning to read emerged, an emphasis of focus on meaning, part word methods versus whole word methods, synthetics phonics approach; and the most well known controversy still relevant in modern education practices, whole-word approach versus a phonics approach.

In 1967 Jeanne Chall completed a three year project that sought to determine which instructional methods were best in the teaching of beginning reading. Her findings which are discussed in her book, entitled *Learning to read: The Great Debate* (1967), concluded that: children who were explicitly taught to read using strategies that employed phonics performed much better than those who were instructed in whole-word teaching methodology both in word recognition and spelling, as well as comprehension. Chall’s discussion (1967) in *Learning to read: the great debate*, which investigated the whole word method vs. a phonic’s approach is still relevant today as
instructional methodologies and strategies concerned with reading instruction continue to vary widely.

Although sight-word recognition is a necessary and essential skill involved in the reading process, it is now very clear and empirically supported that children need to be able to decode words by drawing on their already acquired phonological awareness (Adams 1990, Chall 1967, Dufva, Niemi, & Voeten 2001, Ehri 1992 & 1995, Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan 2001, Gough & Hillinger 1980, Hulme, Goetz, Gooch & Snowling 2007, Osborn & Lehr 1998). The importance of sight reading is acknowledged universally but it is the decoding process which has allowed this ability to sight read to eventuate.

McGuinness (1997) has also criticised the whole-word approach to reading stating that reading skills will not ‘blossom spontaneously’ by simply being immersed in a book-rich environment. Providing good quality literature for beginner readers, sometimes referred to as the ‘real books’ approach, which aims to provide readers with plenty of contextual cues, detailed illustrations, together with stories with meaning does not provide an instructive approach to the task of reading.

Learning through osmosis or discovery learning is not appropriate for the task of learning to read, as it is a learned skill which must be taught and learned in an appropriate and effective manner.
2.2 Reading: A skill that must be learned

It is evident from the history of reading that reading is a relatively new skill that humans have been able to master as a result of instruction and practice. Unlike talking, reading is not something we are biologically hard-wired to do regardless of our environment. It is a complex process involving many different and interacting elements. Steven Pinker (2002) describes the mind as ‘a complex system shaped by evolution’, stating that education must not be viewed as ‘writing on a blank slate’, nor should it be viewed as something that will ‘come into flower’ of its own accord. Pinker states that education is a technologically modern-day invention, which unlike talking or walking needs to be explicitly taught as the human mind is innately unable to do so without any external interference. Pinker includes the teaching of reading in his discussion on evolution clearly stating that children need to be taught which letter goes with what sound. Westwood (2001) also dismisses the erroneous idea that children can become proficient readers without direct instruction. Children need to be taught effective skills and strategies that will enable them to learn to read.

McGuinness (1998) in discussing rates of poor literacy states very clearly that reading and spelling are not biological properties of the brain, and that poor reading skills in the main must be attributed to poor instructional methods. McGuinness (1998) states that both cognitive psychology and educational psychology have shown that children need to be trained in order to hear the phonemes of their given language, by being able to disconnect or ‘unglue’ the sounds in words so that they will be able to access an alphabetic writing system. McGuinness goes on to state that the compatibility between reading and spelling instruction, along with the mastery of the alphabetic code
will lead to the rapid development of learning to read. Coulmas (1996) and Finegan, Blair, and Collins (1997), note the contrast between humankind’s ability to speak for hundreds of thousands of years through the natural process of intellectual evolution, with the very recent invention of writing only in existence for five to six thousand years.

Unlike learning to talk or to walk, codes are constructs which need to be taught systematically. Codes cannot be learned naturally. Mere exposure to any code without explicit instruction and guidance is not helpful in deciphering the code. All the world’s writing systems are highly complex inventions refined over many years. Learning the alphabetic code is no different from learning the signs and symbols required for the task of mathematics, music, or learning a code for programming computers. For example; a mathematics novice provided with the problem $3 + 4 = 7$ can no more understand the question, let alone attempt to answer it without a) having learned what the digits represent, b) what the operators + and = represent, and c) and how the meanings represented by the digits and operators are combined to create a comprehensible numerical expression. As with mathematics, the ability to decode words and sentences can only exist once the code has been deciphered and assimilated. For example, in attempting to decode the word *sheep* children need to learn and have an understanding that the sounds in the word *sheep* comprise the consonant blend ‘sh’, phonetically transcribed as /ʃ/, ‘ee’ phonetically transcribed as /i/, and ‘p’ phonetically transcribed as /p/.

Learning and mastering the alphabetic code is the key to successfully learning to read. Once learners have acquired the knowledge regarding the relationship between the
sounds of the language and the writing system invented to represent these sounds, then the task of learning to read becomes an achievable goal.

Following on from this discussion regarding reading being a task needing to be learned, Chapter 3.1 discusses the differences between biologically primary and secondary knowledge and natural processing systems in its discussion of the human cognitive architecture.

### 2.3 Early Reading: The Decoding Process

Early reading or decoding involves recognising a visual system of letters and learning the relationship between these graphemes and the sounds or phonemes of the language. The relationship between the phonemes and the letters of the alphabet that are used to represent the phonemes in print are of crucial importance in the learning to read process (McGuinness 1998). Breaking a word down into separate phonemes is the most closely related phonological skill associated with decoding words (McGuinness 1998). Hoover and Tunmer describe the different interpretations of what it is to decode, but what remains constant in all interpretations is that decoding involves phonological coding. In their essay Hoover and Tunmer discuss the work of Gough and Hillinger (1980) who state that for beginning readers of alphabetic systems, phonologically based decoding skills must be acquired. To be able to decode new words it is vital that a phonologically based system is in place. There is no possibility of decoding new words without employing a phonological strategy. It is only through learning the relationship
between graphemes and phonemes of the language that producing the correct word can occur.

Decoding must become automatic so that the reader’s cognitive resources can be devoted to the goal of reading-comprehension (Adams 1990). Automaticity is crucial in developing understanding and expertise in the skill of reading (Chall 1979, Samuels 1997). Developing letter-to-sound correspondences and word recognition are necessary in the decoding process, and the faster that this skill is taught and learned the faster reading comprehension ensues (Adams 1990). Decoding eventually leads to sight word recognition which is known to be faster than individually sounding out individual letters or chunks (Ehri 1992). Cunningham (2000), states that children who have strong phonic knowledge are able to learn sight words much more easily than those children who do not have strong phonic knowledge. Learning the relationship between the graphemes and the phonemes of the language is essential to this process of going from a decoder to a sight reader (Ehri et al. 2001). Words become sight words once they have been read several times (Ehri 1995). While children are still consciously decoding individual letters or chunks of words, there is little spare capacity for the other processes involved in reading, such as comprehension, to take place simultaneously (Beech 1985). A child’s level of phonological awareness and skill has been shown to be highly correlated with the child’s reading success (Adams 1990, Dufva et al. 2001).

It is well documented that prior knowledge is crucial to the reading process with the early predictors of reading success being phonological awareness, alphabetic knowledge, letter knowledge in the pre-school years, language development, exposure to print, and parental involvement and guidance (Adams 1990; Aaron, Joshi,
Mahboobeh Ayatollah, Ellsberry, Henderson & Lindsey 1999; Leppanen, Niemi, Aunola & Nurmi, 2004). A lack of phonemic awareness has been shown to lead to poor decoding skills and strategies (Adams 1990; Ehri et al. 2001; Pressley 1998), which are detrimental to learning to read.
Chapter 3

Cognitive Load Theory

Cognitive load theory originated in the early 1980’s as a framework for researchers into instructional methods and design (Paas, Renkl & Sweller 2003). The theory is concerned with the limitations of working memory and its interaction with an unlimited long term memory (Kirschner 2002). Cognitive load can be thought of as the total amount of mental activity that working memory must deal with simultaneously (Chandler & Sweller 1991; Cooper 1998).

Cognitive Load theorists have been investigating the effects of a high cognitive load imposed on working memory in many diverse areas such as science, mathematics, technical areas, IT and multimedia (Chandler & Sweller 1991; Sweller, Chandler, Tierney & Cooper 1990; Chandler & Sweller 1996; Kalyuga, Chandler & Sweller 2004; Leahy, Chandler & Sweller 2003; Pawley, Ayres, Cooper, & Sweller 2005), in the design of computerised instructions for older adults (Van Gerven, Paas & Tabbers 2006), and foreign language learning and comprehension (Diao & Sweller 2007; Diao, Chandler & Sweller 2007; Yeung, Jin & Sweller 1997). Many forms of instructional design have not taken the limitations of Human Cognitive Architecture into consideration (Sweller 1993; Kirschner, Sweller & Clark 2006).
3.1 Human Cognitive Architecture

Human cognitive architecture refers to how cognitive structures are organised and interrelated (Sweller 2003). Working memory and long-term memory function together to process and store information which is able to be retrieved for subsequent use.

Human cognitive architecture has evolved to enable humans to engage in cognitive activities ranging from the very simple to the very complex (Sweller 2003). It is thought that human cognition has evolved based on the Darwinian principles that have driven all biological structures and processes (Sweller 2007). The human brain is biologically hard wired for many specific tasks (e.g. learning to walk and learning to talk), while also being capable of learning many other forms of knowledge (e.g. learning to dance a waltz and learning to read) for which we are not hard-wired. These different forms of knowledge have been referred to as Biologically Primary knowledge and Biologically Secondary knowledge (Geary 2007). Biologically primary knowledge is acquired naturally without any form of explicit instruction as a result of human evolution over many millennia driven by survival and reproductive outcomes (Geary 2007). Biologically secondary knowledge is that part of the human cognitive architecture associated with culturally specific motivations. Biologically secondary knowledge is acquired through explicit instruction and draws heavily on the resources of working memory so that vast amounts of information can be stored in long-term memory.
Those aspects of human cognitive architecture that are relevant to biologically secondary knowledge can be described by five principles that are applicable to all natural information processing systems (J Sweller & Sweller 2006).

The first principle is the information store principle. Skills associated with biologically secondary knowledge derive from a vast amount of information and knowledge stored in long-term memory. The borrowing and reorganising principle suggests that the vast bulk of information stored in long-term memory comes from other people’s long-term memory and is obtained through imitation and observation. The randomness as genesis principle is concerned with the creation of new information stating that novel information is created during problem solving using a random generation and test procedure. The narrow limits of change principle is concerned with the extremely limited working memory when dealing with novel information. The final principle is the environmental organising and linking principle which accounts for the fact that when dealing with information already organised and stored in long-term memory, working memory has no known capacity limits as it is working with familiar information or prior knowledge. Details concerning the functions of working and long-term memory follow.

3.2 Working Memory

Working memory, sometimes referred to as short-term memory, is often equated with consciousness (Sweller 1999). Working memory processes information by organising, contrasting, comparing, or by working with any information in some
manner pertinent to whatever task is being engaged (Sweller, Van Merrienboer & Paas 1998). Research has shown that human working memory is limited in storing and processing information. Working memory has been shown to be limited to storing just five to nine elements of information at a time (Miller 1956, Baddeley 1986). The processing of information simultaneously is even more limited with working memory only being able to process two to four elements at any one time (Sweller 1999, Van Merrienboer & Sweller 2005).

As well as being limited in capacity, any element or elements held, are limited temporally to only a few seconds (Peterson & Peterson 1959). This is why constant revision and rehearsal are necessary for information to be learned so that eventually this information becomes part of long-term memory.

Due to the restrictive nature of working memory’s capacity to deal with information, it is of paramount importance that the cognitive load be managed in such a way that enables optimal learning and understanding. Working memory can become easily overloaded when instructional material is not presented in a manner that takes its limitations into account. When working memory becomes overloaded information cannot be processed and stored adequately to enable learning or understanding.

3.3 Long-Term Memory

Long-term memory is able to store an effectively unlimited amount of knowledge (Sweller 1999, Chase & Simon 1973). Because of long-term memory’s
elusive nature, long-term memory has frequently been thought of as no more than a huge memory store (Sweller 1999).

Long-term memory enables humans to process massive amounts of information previously learned and stored as well as proving vital to other cognitive abilities such as problem solving (Sweller 2003). The contents of long-term memory are not consciously available to humans until they enter working memory (Sweller 2003).

Long-term memory’s importance to learning and intellectual pursuits was demonstrated by Dutch psychologist, De Groot (1965), in his discussion of chess skills and players’ recognition of board configurations. De Groot was interested in what accounted for the differences between expert players and novice players. Experiments involving memory tests of various board configurations taken from real chess games revealed that the more experienced players were able to reproduce the board configurations far more accurately than the less skilled players. Evidently memory played an important part in distinguishing the more skilled from the less skilled. The more skilled players had accumulated and incorporated many more board configurations than the less skilled players and were able to draw on all these configurations which resulted in a superior performance.

Chase and Simon (1973) replicated De Groot’s experiment and also tested memory using random configurations which were not taken from real chess games to test whether there was any difference between the expert players and novice players. It was demonstrated that while the more expert players did have a superior memory for the configurations taken from real games, there was no difference between players when presented with the random configurations. It is therefore apparent that expertise results
from the vast stores of domain specific knowledge which is accumulated in long-term memory, which then allows for a superior performance. The less skilled players have not acquired such knowledge and experience and are utilising a limited working memory to determine what may or may not be a good move or game play.

Further research following from De Groot has also demonstrated that the memory of experts is superior to the memory of novices in their knowledge of problem states in the area of mathematics (Sweller & Cooper 1985), computing (Jeffries, Turner, Polson & Atwood 1981), and electronic circuitry recall tasks (Egan & Schwartz 1979), all providing further evidence of the importance of long-term memory in learning.

3.4 Schemas

The knowledge acquired in long-term memory is in the form of cognitive structures that are known as schemas (Chi, Glaser & Rees 1982).

Schemas are cognitive constructs that allow working memory to deal with multiple elements of information as a single element (Sweller 1999). Schemas are held in long-term memory and reduce the cognitive load placed on working memory. A schema is able to incorporate a huge amount of information which can be treated as a single element in working memory. Information is stored in long-term memory in domain specific schematic form and is brought into working memory when required. This allows an entire schema to be treated as one element by working memory by chunking together individual elements into a single element which effectively increases the amount of information that working memory can process and manipulate (Sweller
In this manner, schemas functioning as storage and organisational mechanisms allow for a reduction in the load imposed on working memory (Sweller et al. 1998).

The acquisition of schemas is crucial to learning as is the automaticity that follows on from material having been learned and stored in long-term memory. Automation of schemas allows the unconscious processing of information resulting in a reduction of cognitive load on working memory (Sweller 1999, Paas et al. 2003). Chi et al. (1982) demonstrated that novices who did not have the appropriate schematic structures were at a considerable disadvantage in being able to solve a physics based problem. Van Gog, Paas and Van Merrienboer. (2005) measured the expert-related differences of performance in various phases of solving an electrical circuit troubleshooting task by utilising eye-tracking techniques. Van Gog et al., (2005) stressed that the ability to classify learners into sublevels of expertise can inform and improve instructional design methods and techniques. Domain-specific schemas are crucial for learning and becoming an expert.

Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977), provided an understanding of how the human mind is able to move from a controlled and conscious effort to the automatic processing of material. The processing of information held in the form of schemas becomes automatic after time and much rehearsal for tasks that are rule-based or algorithmic in nature. Automation frees up the resources of working memory reducing extraneous load. The importance of the role of automation in solving problems was demonstrated by Kotovsky, Hayes and Simon (1985). Using structurally identical problems that only differed in surface features, they were able to posit findings explaining why there were differences in solving problems. The differences were due to
automation. If working memory was able to draw on automated rules then the task became easier than if working memory had to search and retrieve rules. A greater number of automated schemas that a learner is able to access, leads to a greater capacity in working memory resources.

Schema acquisition and automation is vital for the reading process. Aspects of the human cognitive architecture have considerable implications for reading and for learning to read.

Novice readers come to the task of learning to read already having acquired a schema for the letters of the alphabet regardless of the letters’ geometric appearance. This is crucial for initial reading to begin. Children are able to recognise the letter ‘b’ for example in all its different guises (e.g. whether it is hand-written, typed, big or small in size, capitalised, made from play-dough or formed with beads etc).

Despite the complexity and variance that a novice reader may encounter with individual letters, the construction and automation of schemas in relation to these letters allows working memory to focus on the task of combining them into higher order schemas consisting of words, phrases and sentences assuming there are already schemas in place for the recognition of individual letters. This is crucial to minimising the cognitive load associated with learning to read. The construction and automation of schemas within the reading process is the process of learning. Schema development is essential to the novice reader’s ability to develop or attain a system for the recognition of familiar words and patterns of letters as an automatic process so that cognitive resources can be made available for comprehension purposes (Adams 1990).
3.5 Element Interactivity

Schemas can also be defined as elements (Sweller 1999), and it is these elements which are required to be learned so that learning in the form of schema construction, and eventually automation, are able to occur. Many tasks will involve the processing of many elements. These elements interact to differing extents dependent upon the inherent nature of the information. Information can range from low to high element interactivity on a continuum describing the difficulty involved in processing and understanding information (Paas et al. 2003).

Low element interactivity material is easily processed and understood (e.g. learning the letters of the alphabet). Low element interactivity material can be learned serially rather than simultaneously (Sweller, Van Merrienboer, & Paas 1998), and does not impose a heavy extraneous load on working memory. High element interactivity involves many elements interacting simultaneously (e.g. putting the sounds of the letters together to form whole words), and is far more taxing on working memory.

Elements need to connect and interact with other elements in order for students to learn with understanding (Sweller 1999). Marcus, Cooper and Sweller (1996), have suggested that ‘understanding’ only applies when material to be processed is of a high element interactivity. When many elements need to be processed with respect to other elements simultaneously, working memory may become overloaded and unable to process and store information. Tasks involving high element interactivity are difficult in
nature due to the cognitive load imposed on working memory which is required to retain and manipulate many elements simultaneously.

It is not possible to measure element interactivity independent of the learner as the elements are affected by the knowledge of each individual (Sweller 1994). For example, a novice reader needs to process each letter individually, from left to right (as is the case in English) by drawing on the graphophonemic relationship held in long-term memory in the form of already acquired schematic knowledge. Simultaneously, the novice reader needs to combine these letters to form words and eventually simple phrases. Element interactivity is very high and working memory is easily overloaded by such a huge extraneous load. As the novice becomes more expert schemas are acquired, and the process starts to become automated. The elements which were previously required to be processed individually are now able to be processed as a single element, freeing up the resources of working memory. For reading this is vital because it is when working memory no longer has to devote all resources to decoding that comprehension and understanding can take place. As well as the elements that need to be learned varying from low to high element interactivity, the cognitive load associated with learning also differs in nature.

### 3.6 Categories of Cognitive Load

There are three categories of cognitive load that will be discussed in this section; intrinsic, extraneous and germane cognitive load. The intrinsic cognitive load is solely concerned with the intrinsic nature of the material required to be learnt. When non-
interacting elements are learned in isolation, the intrinsic cognitive load imposed on working memory is low. Learning to read is high in element interactivity thus entailing a high intrinsic cognitive load. Learning to read necessarily involves many elements being processed simultaneously. Low element interactivity tasks associated with learning to read include recognising the shape of the letters, naming the letters, and learning the alphabet. High element interactivity tasks include matching the shape of the letter to the sound of the letter and subsequently trying to join these letters together to sound out or form words.

The intrinsic cognitive load of any material to be learnt is not fixed as learners’ abilities and levels differ greatly. What constitutes a single element for one person may be many elements for another. The intrinsic cognitive load associated with reading spans across a huge continuum depending on the amount of knowledge stored in long-term memory. As reading becomes more and more automated, the intrinsic cognitive load and element interactivity decrease more and more. Once there is a schema in place for all the combined elements associated with the reading process the cognitive load is reduced significantly. For example, once a child has a schema in place for the word ‘cat’, working memory no longer has to process each individual letter while simultaneously having to match it up with the corresponding phoneme, as well as having to hold all the letters in working memory to form the word. The word ‘cat’ has been learnt and has become an automated process, no longer drawing on the limited resources of working memory.

The extraneous cognitive load is the load that is imposed by the actual instructional techniques, procedures and materials used during instruction. The
extraneous cognitive load is the additional, extraneous mental effort resulting from poorly designed instructional material (Sweller et al. 1998). It can interfere with schema acquisition and automation, and hence hinder learning. The extraneous cognitive load is able to be varied as it is entirely governed by instructional processes (Sweller 1994). By employing a more effective instructional design a reduction in extraneous cognitive load can be achieved (Paas et al. 2003). By reducing extraneous cognitive load, the surplus cognitive capacity is then available for germane cognitive load involving learning and transfer performance (Pass & van Gog, 2006; van Gog & Paas, 2008). For example, Sweller and Cooper (1985) demonstrated that worked examples were a more effective way of teaching algebra.

While the learner reader is in the process of constructing and acquiring schemas, it is critical that working memory not be faced with an unnecessary extraneous cognitive load. At this point the instructional guidance given can be used as a substitute for the yet to be acquired schemas (Kalyuga et al. 2003). Techniques employed can have a significant impact on learning and acquiring schemas for novices. For example, providing learner readers with familiar vocabulary, together with short and simple phrases makes the task of decoding much simpler. Take the simple sentence ‘I went to the zoo’, and compare it to ‘menageries are the delight of young children.’

Germane cognitive load is concerned with the construction and automation of schemas. It is what is needed for the construction and storage of schemas in long-term memory. The three types of cognitive load add to form the total amount of cognitive load imposed on working memory. This combined load must not exceed working memory capacity if working memory is not to become overloaded. Instructional
guidance and practices will have a direct bearing on extraneous and germane load. If the extraneous load can be reduced then total cognitive load can also be reduced which in turn will free up the resources of working memory. Paas, Tuovinen, Tabbers and Van Gerven (2003) provided a detailed and comprehensive discussion on cognitive load measurement techniques within the cognitive load theory framework.
Cognitive load theory has described various effects associated with instructional designs and teaching methods. The effects which have been generated and described by cognitive load theory are applicable when dealing with high element interactivity material, as it is this material which imposes a heavy load on working memory thus interfering with the processing and storing of information needing to be learned. Some of these effects include The Goal-Free Effect, The Worked Example Effect, The Split-Attention Effect, The Expertise-Reversal Effect and The Redundancy Effect. This particular thesis is solely concerned with The Redundancy effect, and will therefore only mention some of the other cognitive load effects briefly.

4.1 The Goal-Free Effect

Goal-free problems are useful in reducing cognitive load in specific learning areas where most of the information concerning a problem can be found relatively easily. Learners often employ search-based strategies in an attempt to find a solution to a problem, or attain a specific goal. It has been demonstrated that search-based
strategies such as means-ends analysis, whereby the goal becomes the focus, impose a heavy extraneous cognitive load (Sweller 1999). Means-ends analysis is a strategy which requires learners to reduce the differences between each problem state and the goal state (Sweller 1999). Means-ends analysis, along with other search-based strategies, draw heavily on cognitive resources. Using a goal-free strategy entails looking at each problem state with no specific goal thus leading to a massive reduction in working memory as working memory need not devote cognitive resources to the goal itself. Instead, working memory is able to focus on the problem state and any move that will alter that state. For example, instead of presenting learners with mathematical problems which requires them to solve for a specific angle or length, it has been demonstrated to be more beneficial for learning to ask learners to calculate as many angles or lengths as possible without specifying a goal.

Sweller and Levine (1982) described experiments where learners were presented with problems which were modified by removing the specified goal, namely the location of the finish point of maze problems generated on a computer screen, so that the possibility of being able to employ a means-ends strategy was eliminated. Half the students were given maze problems which included the position of the finish point, while the other half were not shown the finish point. The group with no specified finish point, the goal-free group, were able to develop strategies based on previous moves which enabled them to reach the finish point. The group with the finish point did not develop the rules or strategies required to move from one stage to the next. It was demonstrated that more learning occurred for those students who were not given a goal as they were not able to utilise means-ends analysis, and instead were able to learn from each previous move or problem state, thereby developing rules and strategies which
eventually led to the solving of the problem. By removing the goal state working memory is able to devote valuable resources to schema construction and facilitate learning.

As well as solving maze problems the goal-free effect has also been demonstrated in more traditional disciplines such as mathematics and physics. Sweller, Mawer and Ward (1983) demonstrated the goal-free effect in a series of experiments involving geometry and kinematics where the goal of the problem is to determine the value of a particular variable from given information. The variable to be determined was specified for one group, while the goal free group were asked to determine the value of as many variables as possible. The goal group could employ a strategy of attempting to reduce the difference between the current state (or sub-state) and the goal state. The only strategy available to the goal free group was to work forward from the given information. The goal free group performed better than the goal group in both types of experiment.

Owen and Sweller (1985) demonstrated the goal-free effect by comparing students who were presented with trigonometric problems using the conventional method, where students were asked to calculate the length of a particular side, with those who were presented the same problem but with a goal-free format. The goal-free group were asked to calculate the length of as many sides as they could. The results demonstrated that those students presented with the goal-free problems were able to learn faster than the students presented with the conventional problems. The goal-free group demonstrated more rapid processing than the conventional group during the acquisition stage, suggesting a reduction in cognitive load.
Vollmeyer, Burns and Holyoak (1996) further demonstrated the goal-free effect in biology problems given to tertiary students.

Ayres (1993) interpreted the goal-free effect in terms of cognitive load theory. In an analysis of two-step geometry problems it was found that the error rates were significantly higher on the first phase of the problem. There are more interacting elements in the subgoal phase, since the subgoal must be connected to both the given information and to the goal. Since there are more interacting elements in the sub-goal phase the increased error rates can be seen as a consequence of increased cognitive load.

It should be noted that goal-free problems should be presented when there are only a small number of possible variables to be determined. A goal-free approach is not universally applicable since some problems have a very large or infinite number of possible permutations, rendering a goal-free approach problematic (Sweller 1999).

4.2 The Worked Example Effect

The worked example effect is the most comprehensively researched cognitive load effect as well as the best known effect (Sweller 2006). Worked examples have been shown to reduce extraneous cognitive load by eliminating problem solving and instead providing the steps and answers to a problem for the novice. Studying the steps or studying each problem state has been shown to reduce or eliminate unnecessary load and enhance learning by facilitating the acquisition and automation of schemas (Sweller 1999; Van Gog & Paas 2006). The processing of worked examples is an essential part
of learning (Sweller 1999). Worked examples provide learners with additional information that assists learners in understanding the structure of a given problem.

While a goal-free strategy eliminates a means-ends strategy by removing the goal from a given problem, providing students with worked examples also prevents learners from employing a search-based strategy. Cognitive resources are freed up allowing the learner to focus on each step of the problem. This enables schema acquisition and automation to develop as working memory is not unnecessarily overloaded. Learners are provided a blueprint from which they can develop a schema. This simplifies schema acquisition by eliminating unnecessary search-based strategies. The worked example provides a structure from which the schema may be developed, the extra information reducing the number of possible schemas, many of which could be inappropriate.

<table>
<thead>
<tr>
<th>Solve for ‘a’</th>
</tr>
</thead>
<tbody>
<tr>
<td>c (a+b) = f</td>
</tr>
<tr>
<td>(a+b) = f/c</td>
</tr>
<tr>
<td>a = f/c - b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solve for ‘a’</th>
</tr>
</thead>
<tbody>
<tr>
<td>g(a+m) = k</td>
</tr>
</tbody>
</table>

Figure 1 Example of worked example involving algebra.
A worked example provides the step by step process involved in the transformation from one state to another. It enables learners to familiarise themselves with the structure of both the problem itself and the transformation stages. They can then go on to attempt the question after having developed a schema from analysing the worked example. Cooper and Sweller (1987) gives an example (Figure 1) of a worked example involving algebra where learners are required to study the worked example and then attempt to solve a similar problem using the knowledge they have acquired.

Much research has been conducted, particularly in the field of mathematics, and has conclusively demonstrated that using worked examples does decrease the amount of extraneous cognitive load thus resulting in better learning. Sweller and Cooper (1985) and Cooper and Sweller (1987) demonstrated the worked example effect in a series of algebraic experiments where learners studied a series of worked examples. It was shown that the students who were provided with the worked examples were able to learn faster, and also made fewer errors than those students who were presented with conventional problems.

Zhu and Simon (1987) also provided evidence for faster learning in the area of mathematics with one group of learners being presented solely with worked examples and problems, while the other group was engaged in a conventional classroom setting. The group presented with worked examples only outperformed the group who were taught in the conventional classroom setting.

Sweller, Chandler, Tierney and Cooper (1990), further demonstrated the worked example effect in a series of coordinate geometry experiments. The advantages of
worked examples were demonstrated provided that the worked examples were correctly integrated into the example to reduce split-attention (see section 4.3).

Mwangi and Sweller (1998) were able to demonstrate the worked example effect using arithmetic word problems. Learners who were provided with worked examples presented in an integrated format performed better than those learners who were presented the information in a split-source manner in both acquisition and testing phases.

Paas (1992) provided evidence for the effectiveness of worked examples involving statistical data. Paas and Van Merrienboer (1994) demonstrated the effectiveness of using worked examples using geometry problems. As well as demonstrating that learners presented with worked examples outperformed those learners who were presented with conventional problems, Paas (1992) also demonstrated that providing partial solutions was also an effective means of improving learning. A reduction in cognitive load can be achieved by providing learners with some underlying structure of the problem solving strategy required for the task.

As the novice becomes more skilled and acquires more schemas the worked examples can be gradually faded out until no longer required. This ‘fading out’ or gradual reduction in worked examples was described by Renkl and Atkinson (2003) and is important as it addresses the relationship between instructional design and learners’ level of expertise. This ‘fading out’ procedure becomes possible as learners acquire more domain specific knowledge and are therefore less reliant on worked examples. As learners become more expert by acquiring domain specific schemata, extraneous cognitive load is lessened considerably.
Better learning ensues from studying worked examples compared to learning through other problem solving strategies as worked examples significantly decrease extraneous cognitive load, thus allowing working memory to be able to construct a schema for any given problem.

4.3 The Split-Attention Effect

The split-attention effect was derived directly from results obtained while conducting research into the worked example effect (Sweller et al. 1998). While it was clearly demonstrated that worked examples reduced extraneous cognitive load with certain tasks the effect was surprisingly not obtained in others. From these findings, it became apparent that as well as reducing extraneous cognitive load by eliminating means-end strategies, the focus of a learner’s attention was also a factor in lessening the extraneous cognitive load imposed on working memory. Consequently, the ineffective worked examples were reformatted to accommodate the constraints on working memory and remove the need for learners to shift their focus during any given task.

The split-attention effect occurs when learners are required to split their attention between multiple sources of information. When dealing with the split-attention effect, the multiple sources of information are required for understanding and learning to occur but need to be mentally integrated in order to be processed. If multiple sources of information are unintelligible in isolation and must be mentally integrated, cognitive load increases, increasing the total load on working memory, and ultimately hindering learning. By eliminating the need to mentally integrate multiple information sources, a
reduction in extraneous cognitive load can result. This can be achieved by replacing multiple sources of information with a single integrated format. For example, the research of Ward and Sweller (1990) demonstrated the split-attention effect in kinematic experiments involving integrated worked examples. An example of conventional and integrated kinematics problems are shown in Figure 2.

<table>
<thead>
<tr>
<th>a. Conventional Kinematics Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A vehicle moving from rest reaches a speed of 40 m/s after 20 seconds. What is the acceleration of the vehicle?</td>
</tr>
<tr>
<td>$u = 0 \text{ m/s}$</td>
</tr>
<tr>
<td>$v = 40 \text{ m/s}$</td>
</tr>
<tr>
<td>$t = 20 \text{ m/s}$</td>
</tr>
<tr>
<td>$v = u + at$</td>
</tr>
<tr>
<td>$a = \frac{(v-u)}{t}$</td>
</tr>
<tr>
<td>$a = \frac{(40-0)}{20} = \frac{40}{20} = 2 \text{ m/s}^2$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. Integrated Kinematics Worked Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A vehicle moving from rest ($u$) reaches a speed of 40 m/s ($v$) after 20 seconds ($t$): $[v = u + at, a = \frac{(v-u)}{t} = \frac{(40-0)}{20} = 2 \text{ m/s}^2$]. What is the acceleration of the vehicle?</td>
</tr>
</tbody>
</table>

Figure 2  Examples of conventional and integrated kinematics worked examples.
The split-attention effect occurs when the integrated format proves to be superior to the split-attention format. It has been demonstrated using geometric proofs (Tarmizi & Sweller 1988), co-ordinate geometry (Sweller, Chandler, Tierney & Cooper 1990), and computer applications (Sweller & Chandler 1994). By physically integrating a diagram with any pertinent text needed to understand the diagram, split attention can be reduced. By reducing the mental effort required to mentally integrate multiple sources of information, the extraneous cognitive load is lessened considerably, and allows the acquisition and automation of schemas to occur. Yeung, Jin and Sweller (1997) demonstrated the split-attention effect in the area of reading using explanatory notes. Yeung et al. were able to demonstrate that by employing an integrated format using text and explanatory notes, thus eliminating the split-attention condition, students’ comprehension improved.

The split-attention effect demonstrates the need for physically integrating multiple sources of information in order for learning and understanding to occur by facilitating schema acquisition and automation. In order to obtain the effect, the information that needs to be integrated must be essential information that cannot be dispensed with, unlike the redundancy effect, described in the next chapter.
Chapter 5

The Redundancy Effect

There is now much evidence to suggest that redundant material imposes a significant extraneous cognitive load that has negative outcomes for learning and understanding (Sweller 1999). Redundant material interferes with learning rather than proving to be advantageous or even neutral when acquiring new information. By eliminating redundant information the load on working memory is considerably reduced, thus facilitating better learning.

The Redundancy Effect occurs when learners are required to attend to or engage in activities that are irrelevant to the task at hand (Sweller 2005). The effect has been shown to interfere with the core material to be learned due to the extraneous load imposed on working memory (Chandler & Sweller 1991). Increasing working memory load by simultaneously processing redundant information with essential information that needs to be learned, results in the transfer of information into long-term memory becoming problematic.

The Redundancy Effect is associated with materials or information that can be understood in isolation of each other (Sweller & Chandler 1994). Information presented in multiple forms, or information that is unnecessarily elaborated are representative of
redundancy (Sweller 2005). Learners presented with multiple sources of identical or similar information are unnecessarily using cognitive resources to process redundant material. This imposes an extraneous load on working memory. Attempting to incorporate redundant material with essential information inhibit schema acquisition and automation (Pawley et al. 2005). It is far better to eliminate redundant material altogether than to try and integrate it in some fashion (Kalyuga 2003).

The Redundancy Effect will occur when there is high element interactivity and a high intrinsic cognitive load. Reading is one such task that involves a high intrinsic cognitive load with high element interactivity.

Mayer (2008) describes the process and requirements of learning. He describes three essential elements – selecting, organising and integrating the incoming material. In order to learn, new material must be attended to, organised into a coherent structure and combined with existing knowledge from long term memory. Mayer describes the need to reduce extraneous processing as it interferes with the ability to incorporate new information and wastes cognitive capacity. Mayer describes the coherence principle as the reduction of extraneous material leading to better learning. An experiment conducted in multimedia learning (Moreno & Mayer 2000) demonstrated the coherence principle by showing that adding entertaining but irrelevant material was detrimental to learning. They concluded that as there was less of the core material being attended to, the ability to retain this information was lessened by extraneous material. Mayer’s findings and conclusions are thus consistent with cognitive load theory.

Chandler and Sweller (1991) were the first to demonstrate and describe the effect within a Cognitive Load Theory framework, and were responsible for coining the
term “The Redundancy Effect”. They demonstrated that processing redundant material imposes an extraneous cognitive load. It was concluded that presenting redundant text alongside a fully labelled diagram had a negative effect on learning. For example, Chandler and Sweller’s experiments in biology demonstrated that if a diagram of the human heart, lungs and body is provided along with arrows indicating the flow of blood, then a statement such as ‘blood from the lungs flows into the left atrium’ is redundant. Cognitive load is increased because working memory is forced to assimilate the material even though the multiple sources of information are of no assistance to the learner as both sources are intelligible in isolation. Learners should not be expending cognitive resources in integrating two sources of information unnecessarily as it increases cognitive load and hinders schema acquisition and automation.

Sweller and Chandler (1994) further demonstrated the redundancy effect in a task involving learning to use a new computer program. They were able to demonstrate that by providing the manual only, instead of providing the manual together with the computer, a more effective way to learn resulted as those students who were attending to the computer and reading the manual had to process redundant information that interfered with learning. This experiment also demonstrated the split-attention effect, with an integrated diagram and text format reducing the extraneous cognitive load placed on working memory, as well as the learner not having to split their attention between the manual and the computer. This experiment demonstrated that the learners who were required to process multiple sources of information were faced with an unnecessary extraneous cognitive load either through the effects of redundancy or split-attention, which hindered the learning process.
Yeung, Jin, and Sweller (1997) demonstrated both the split-attention effect and the redundancy effect in research involving explanatory notes in reading passages. Explanatory notes given for aiding comprehension when not needed inhibited learning as the learner was required to process non-essential information. Depending on the expertise of the learner, instructional formats which lessened the extraneous load either through removing the split-attention condition, or by removing redundant information were advantageous for learning.

The redundancy effect, along with the split-attention effect, was also demonstrated by Kalyuga, Chandler and Sweller (2000) when providing identical visual and auditory text was shown to be a less effective teaching method than providing only the auditory text. They demonstrated that by employing a dual modality instructive format, the negative effects associated with split-attention could be reduced significantly. They then demonstrated that if the students were required to read and listen simultaneously to identical information that the negative effects of redundancy occurred.

Tabbers, Martens and van Merrienboer (2004) observed the effects of redundancy when investigating the most appropriate guidelines for the design of multimedia instructions in an experiment which compared four different conditions: visual text with no cues in the diagram; visual text including cues in the diagram; audio text with no cues in the diagram and finally audio text including cues in the diagram. Tabbers et al. suggested that some of the instructional materials proved redundant as the students involved in the study did not need to see and read or hear items for a second time.
Kalyuga, Chandler and Sweller (2004) again demonstrated the redundancy effect in a task involving listening and reading identical text in a series of experiments involving training materials for technical apprentices. They were able to demonstrate that it was more effective to provide only the auditory material, than to provide the auditory material together with identical visual text. By removing the identical visual text, which was redundant, the load on working memory was significantly reduced.

Leahy, Chandler and Sweller (2003) conducted an experiment involving a dual modality form of instruction. The results indicated that an audio-visual presentation was more effective than a visual only presentation when both the audio and visual components needed to be understood in order for understanding and learning to occur. This was followed by another experiment where the auditory material was found to be redundant as it was unnecessary when learners were presented with the same information presented in a diagram. There was no information in the auditory material that was needed for understanding to occur. Redundancy has also been observed in a foreign language setting. Diao and Sweller (2007) and Diao, Chandler and Sweller (2007) demonstrated that in presenting simultaneous written and spoken information in English reading comprehension and listening tasks inhibited learning and that it was more effective to eliminate the written source when learning to listen to English as a foreign language.

The redundancy effect has been described in the past as counter-intuitive (Sweller 2005) as it is often assumed that an abundance of information is advantageous to the learner. Cognitive load theory states otherwise asserting that an overload on working memory inhibits learning. Pictures are an additional and unnecessary load for
working memory to process when learning to read, and therefore redundant. Pictures are very likely to distract the child from the text thereby drawing on working memory resources that could be otherwise used for the processing and storing of core information associated with the decoding process.

5.1 The Expertise-Reversal Effect

Different levels of expertise have direct consequences on the cognitive load effects discussed in this chapter as well as in the previous chapter. When novices start acquiring schemas in any given area the cognitive load effects start to disappear as learners become more expert, but at a certain point a reverse cognitive load effect can occur; this is called the expertise reversal effect. Experts have at their disposal previously acquired complex cognitive mechanisms and are hence not limited by the processing limits that constrain novices. These cognitive mechanisms allow experts to monitor and refine performance (van Gog, Ericsson, Rikers & Paas, 2005). For example, take a learning task involving a diagram and text which are not intelligible in isolation. The split-attention effect generated by this task can be ameliorated by integrating the materials or by employing a dual modality presentation. As the learners improve their knowledge and acquire schemas the task becomes easier and easier until they are able to look at a diagram without the text or auditory component which have become redundant at this stage and should be removed to lessen any extraneous cognitive load. Once the learner has become an expert it is better to present the information using a diagram alone as schemas associated with the task are now
automated, and the expert does not need to mentally integrate the information presented using both a diagram and text. The text has become redundant.

The expertise-reversal effect is a cognitive load effect which can occur across several of the basic cognitive load effects and is dependent upon the level of expertise of the learner. Kalyuga, Ayres, Chandler and Sweller (2003) have pointed out that much instructional design fails to differentiate between learners’ knowledge levels, thus compounding the negative effects imposed on working memory.

The effect has been demonstrated when various instructional methods have no effect, or have an adverse effect on learners with more expertise than novice learners. Kalyuga, Chandler and Sweller (1998) were able to show this in an experiment demonstrating the split-attention effect. The more expert the learners became, the more the difference in performance between those students presented with the separate or integrated formats reduced. Eventually, the effects disappeared and then reversed resulting in it being more beneficial for the experts to be presented with the separate sources of information.
Chapter 6

Related Research Involving Pictures and Reading

Earlier chapters have described and discussed research involving cognitive load theory together with cognitive load effects. This chapter discusses research undertaken involving the impact of illustrations on the teaching of reading.

Miller (1937) conducted an experiment with children learning to read in which one group of children was presented with a written word together with the appropriate illustration and with the word simultaneously spoken out loud. Another group was presented the same written word without the illustration and also had the word presented orally. The group presented the words without the illustration outperformed the group given the word with the accompanying illustration on a subsequent test. This result demonstrated that by eliminating redundant or unnecessary information (in this case illustrations), the extraneous cognitive load was lessened considerably and the task was more easily performed.

The following year, Miller (1938) sought to investigate whether illustrations facilitated greater comprehension in a set of primary reading texts for beginner readers, compared to those same texts presented without any accompanying illustrations. The results obtained from these experiments demonstrated that children understood the story
just as well without any illustrations. This experiment was not concerned with the children’s interest or enjoyment, nor with the artistic merit of the illustrations. The purpose was to ascertain whether or not the child’s comprehension of the text was affected by the absence of illustrations.

Samuels (1967) conducted an experiment to test the hypothesis that having illustrations depicting the text may actually interfere with learning to read as the child’s attention is distracted or taken away from the text. Samuels tested this hypothesis by teaching kindergarten children to read four new words; the four words were boy, bed, man and car. The experiment involved two groups. One group was taught to read the words with pictures and the other group without pictures. The children who had the pictures alongside the word offered more correct responses than the children who were only presented with the word. However, when both sets of children were shown the words without pictures the children who were shown the pictures with the words performed much worse than the children who were given the words with no pictures. This experiment showed that the children who were given no visual cues had to rely on and pay attention to the print. In her discussion of this experiment Adams (1990) concluded that if the actual goal of reading is to help the child utter the word then pictures may be helpful but if the goal is to get the child to read the print, which is of course the objective in learning to read, then the pictures may indeed be diversionary.

Samuel’s ‘focal attention theory’ (1967) suggested that picture and context cues would deter acquisition of reading responses in beginning readers as they enabled the student to identify the word in practice without focusing on its graphic features. Samuels suggested that given the word and a picture, beginner readers would shift their
attention to the picture as the picture holds the more meaningful component. Samuels was of the opinion that when a new word to be learned was accompanied by a related picture, the result would be less efficient learning. Goodman (1965) maintained a contrastive viewpoint stating that pictures enhanced learning when they were presented in a meaningful context. In an attempt to resolve this issue Singer, Samuels and Spiroff (1973-74), researched the effects of picture and context cues on reading responses in an attempt to resolve the two differing viewpoints.

They conducted research which studied the effect of presenting four words in four different ways. The words were presented either alone, accompanied by an illustration, embedded in a sentence, or in a combination of an embedded sentence with an accompanying illustration. The results demonstrated that the beginner readers who were presented with the novel words in isolation outperformed those learners who were given words with accompanying illustrations both individually and in sentence form.

Harber (1980) discussed the effects of illustrations on beginner reader’s reading performance, suggesting that erroneous learning results from the beginner reader having to attend to additional and irrelevant stimuli, namely that of the accompanying illustrations. Harber stated that the beginner reader may only attend to the illustration, paying no attention to the printed word in attempting to produce the correct word; or proving more detrimental to the reading process may attend to certain aspects of the illustration which completely distract the child from the task at hand. For example in attempting to decode the word ‘cat’, the beginner reader could become occupied with how many whiskers there are on the cat’s face.
Willows (1978) conducted studies in order to ascertain whether illustrations proved distracting in a reading situation. The participants read a set of words aloud and were tested on speed and accuracy. She concluded that pictures had a negative effect on the speed and accuracy of the young reader’s performance, and that the less skilled readers were much more adversely affected by the accompanying illustrations. It was observed that the poorer readers were affected by the pictures regardless of word difficulty. She also observed that when the child came to an unfamiliar word and looked to the picture for a clue, they were often misled by features of the pictorial representations.

Solman (1986) conducted studies that showed children may be faced with negative outcomes in their reading progress due to the inability of young children’s processing capacity. Solman observed that when a child was presented with both picture and word the child would go to the picture first in order to correctly decipher the meaning. It was demonstrated that pictures did not assist learners in sight word reading tasks and in fact made the task more difficult.

Singh and Solman (1990) conducted research involving mentally retarded children and the effects of pictures in learning to read. They were interested in the picture-word problem whereby the picture was seen to ‘block’ the written word when both word and picture were presented together, claiming that this was the result of prior conditioning in favour of the picture. Their study focussed on reducing the blocking effect by enhancing the salience of the word, hypothesising that where the picture was more salient, slower learning would result. Participants were presented with sixteen words in four different conditions. In condition A, the students were presented with a
picture presented alone and then followed by the presentation of the picture together with the word. In condition B the word was presented alone. In condition C a word was enhanced in size and presented alone and then followed by the word and picture. And finally in condition D the enhanced word was presented alone. The results demonstrated that the students performed better when the blocking condition was minimised, and performed better again when the words were presented in isolation by removing the illustrations altogether.

Similarly, two experimental studies conducted by Solman, Singh and Kehoe (1992) also demonstrated that pictures had a negative effect on learning individual words. Solman, Singh and Kehoe also concluded that the pictures ‘blocked’ the learning of sight words, in effect blocking the acquisition of any link between the written word and the naming response.

Samuels (1970), stated that when a student is unable to identify a word, the teacher often suggests that the student look to the picture as a cue for identifying the unfamiliar word. Samuels suggests that the pictures may miscue and divert attention from the word itself, thus hindering the task at hand, namely the task of learning to read. Samuels (1973) similarly discussed the importance of which cue is employed by the beginner reader, and also stated the importance of where the learner’s attention is focussed during the task of reading.

In her article describing the importance of word recognition prompt strategies, Brown (2003) discussed appropriate word recognition prompt strategies suggesting that students’ reading behaviour is indeed shaped by the various strategies employed. Brown described the different reactions and strategies that students employ when they come
across a new or unfamiliar word. Students who are guided by the teacher to look at the pictures to ‘guess’ the meaning of a printed word do so more than the children who are taught or encouraged to sound it out. She also suggests that over time students will employ the method they are familiar with when encountering an unfamiliar word.

This is why the employment of a correct word prompt strategy is vital to the task of learning to read. If beginner readers are continually encouraged to look at the pictures as a strategy for ‘reading’ an unfamiliar word, then this is the method they will continue to use. If, however, the beginner reader is equipped with decoding strategies involving phonological knowledge which allows them to decipher the code and hence decode the text, then it will be these strategies which remain in place, and reading skills will continue to strengthen and beginner readers will be well on the way to reading proficiency.

6.1 Objectives of this research

Some researchers have claimed that illustrations inhibit word recognition in beginner readers (Miller 1937; Samuels 1967), while other research has demonstrated that illustrations may prove harmful to the reading process in those children who are deemed to be poor readers, younger less skilled readers, or readers with mental retardation (Harber 1980; Samuels 1967; Singh & Solman 1990; Willows 1978). Other researchers have claimed that illustrations can result in a loss or shift in attention away from the text (Harber 1980; Williams 1938; Samuels and Turnure 1974; Willows 1978). All children who come to the task of learning to read are in fact beginner readers or novices who are unable to read. Any child learning to read, including typical children
learning to read, face an immensely complex task that involves many elements interacting simultaneously, and thus imposing a high cognitive load.

While some research has been conducted on the effects of illustrations in recognising and reading individual words, this study was intended to demonstrate cognitive load effects, namely the redundancy effect, on the reading of simple sentences as well as sight words. Previous research has described pictures as a hindrance or as a distraction to the process of learning to read. The research described below uses cognitive load theory and its effects to test why pictures can be an obstacle in the acquisition of the reading process. Three experiments were designed and conducted to see whether illustrations had any impact on the reading of single words and simple sentences within a cognitive load framework. These experiments provide an interpretation as to why illustrations may hamper learning to read, and whether different types of illustrations may be more or less deleterious. These experiments should therefore advance both cognitive load research and reading research. The current experiments advance our knowledge by placing the ‘picture-word’ effect within a cognitive load theory context, by extending the effect from individual words to sentences and ideas, and by indicating the nature of the decrement caused by the presence of illustrations.

Experiment 1 was designed to test whether illustrations interfered with the decoding of simple sentences in a reading exercise, and in correctly decoding single words and simple sentences both in the acquisition phase and the testing phase. Experiment 2 sought to compare informative illustrations with uninformative illustrations in an attempt to discover whether or not the nature of the illustrations was
of importance. The final experiment, Experiment 3, compared uninformative illustrations with no illustrations with the hypothesis that since neither group was presented with informative illustrations, there would be no significant differences between these two groups.

Samuels states “teachers usually accept the fact that beginning reading texts have pictures without wondering what effect pictures have on learning to read” (1970, p. 397). This research is directly concerned with Samuel’s statement, attempting to demonstrate the effects pictures have on beginner readers who are learning to read. It is hoped that this research will provide strong evidence for effective ways to reduce unnecessary and disadvantageous extraneous cognitive load for the task of learning to read.
Chapter 7

Experiment 1

This experiment was designed to establish the impact of illustrations during early reading instruction on learning to read simple prose. It was hypothesised that children given books containing sentences with no illustrations would outperform children presented identical sentences with illustrations on subsequent reading tests. The reading tests consisted of: (a) recognising words from text in isolation; (b) reading several of the sentences from the initial learning text independently of the book itself and; (c) reading novel sentences including the words featured in the initial reading instruction but using novel combinations of those words.

Method

Participants: The participants were 22 Year 1 children attending a public school in Metropolitan Sydney, New South Wales. The children were aged between 6 and 7 years, and were all at the same reading level ‘beginner’, as determined by their class teachers. Within this beginner group, the children were further divided into sub-groups based on their reading ability, again determined by their class teachers. B3, which is the highest ability group, had a total of 6 children, B2 had a total of 8 children, and B1, the lowest ability level, also had 8 children. The grading of children by class teachers
according to reading ability is standard practice and is part of the school curriculum in New South Wales schools.

Children were assigned into two groups of 11 with one group presented with illustrated books (the picture group), and the other group presented with unillustrated books (the no picture group). Each group had an equal number of children from each of the three sub-groups. Within each level of reading ability, participants were randomly assigned to the conditions.

*Materials:* Nine books were selected from the graded series of books, classed as “beginner’s books”, that form part of the available reading material suitable for children at this stage of reading instruction. The nine books ranged in word count from 107 words to 197 words (see Figure 3). The books selected were not previously sighted by any of the children involved in the experiment. The same nine books were then reproduced without the illustrations. Each reproduced book was identical in size, had the same font size, had the same coloured background, retained the same page numbers, with text that appeared in an identical position, as its illustrated counterpart.

![Sample page from one of the illustrated texts used in Experiments 1 and 2.](image)
The test materials included sight words and sentences. The sight words were printed on a laminated white background which measured 9.5 cm x 6.0 cm. The sentence cards which were also printed on a laminated white background measured 21.5 cm x 6.0 cm. All words were typed in black and were typed on one line in lower case letters except for the initial capital in the sentences, and any proper nouns. An example of a sight word and a sentence card are shown in Figure 4.

Figure 4 Examples of a sight word and a sentence card.

play

We will let you play.

Procedure: The experiment consisted of a learning phase (9 days) and a test phase (1 day). It was conducted over 10 school days with each child tested individually.

During the learning phase - reading exercise, each child spent approximately 5-10 minutes each day with the same experimenter. On days 1-9 each child was individually presented with either illustrated books (the picture group) or text only books (the no picture group). Each child read each book aloud to the experimenter, with
the experimenter taking notes of all errors. When the child was unable to produce a correct word or did not attempt a word, the experimenter gave the word in its entirety to the child regardless of which group the child was in. There was no prompting by the experimenter.

The learning phase – testing exercises began immediately after reading each text. Each child was presented with 10 sight words from the text just read and asked to say them out aloud. The words were presented on individual flashcards (word only), and consisted of both function words (such as ‘the’ and ‘a’) and open class words (such as ‘cat’ and ‘play’), with the experimenter taking note of all incorrect responses. The flashcards were identical for each child and presented in the same order.

Immediately following the sight words, each child was presented with 10 sentences (again presented in flashcard style) consisting of 5 actual sentences from the text just read as well as 5 created sentences using the same words from the text but rearranged. These sentences were text only, with no pictures, and identical for each child. There were no new words presented in these sentences. The experimenter again recorded all errors.

The test phase began on the 10th and final day. Each child was asked to read 20 words in flashcard style (text only) which were taken from the 9 readers, and which the child had already been presented with as a flashcard during the learning phase. Again these words consisted of both function and open class words. Each child was then asked to read 21 sentences (text only), again taken from the 9 readers. These sentences consisted of 7 sentences from the books which the child had already seen previously in the learning phase, 7 rearranged sentences also already sighted in the learning phase –
testing exercise during the previous 9 days, and 7 completely novel sentences using no new vocabulary. The reading of the sentences was timed.

Results and Discussion

*Learning phase- reading exercise:* A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted for the reading exercise, i.e. the reading of the 9 books over the nine day learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, with the picture group making more reading errors, \( F(1,16) = 6.65, MSe = 5794.03, p = 0.02, \) partial \( \eta^2 = 0.29 \). There was a significant difference in the errors made between the reading levels with number of errors decreasing with increased ability, \( F(2,16) = 16.67, MSe = 5794.03, p < 0.01, \) partial \( \eta^2 = 0.68 \). There was no interaction between the two groups and the reading levels, \( F(2,16) = 0.39, MSe = 5794.03, p = 0.68, \) partial \( \eta^2 = 0.05 \).

These results demonstrate that the ability to decode was inhibited for the group exposed to redundant pictures imposing an extraneous cognitive load. The no picture group could only decode the words to decipher the text, whereas the picture group had alternate methods (based on the pictures) for deciphering the information contained in the text. Those alternative methods interfered with reading accuracy.

The learning strategy difference between the two groups is further emphasised if we distinguish between the types of errors made. Of interest was a specific type of error concerned with whether or not the initial sound of the incorrect response was correct.
For example, if the word was “moon” and the child gave any word not starting with the sound /m/ it was marked as initial sound incorrect. These errors, referred to as initial sound errors hereafter, are relevant because they can indicate whether a child in the picture group has gathered information from the illustration by guessing or predicting a word. An initial sound error provides an indication that the child is not drawing on already acquired phonological knowledge nor employing decoding strategies.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of initial sound errors for the reading exercise, i.e. the reading of the nine books over the nine days immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, with the picture group making more of these errors, $F(1,16) = 5.89, MSe = 386.28, p = 0.03$, partial $\eta^2 = 0.27$. There was no significant difference in this category of errors between the reading levels, $F(2,16) = 2.67, MSe = 386.28, p = 0.1$, partial $\eta^2 = 0.25$, nor was there an interaction between the two groups and the reading levels, $F(2,16) = 0.94, MSe = 386.28, p = 0.41$, partial $\eta^2 = 0.11$.

The mean errors presented in Table 1 are expressed graphically in Figures 5 to 10 for each reading group with error bars indicating the standard deviation of the mean in each case. Figure 5 shows the total errors against reading group in the reading exercise. Figures 6 and 7 show the sight word and sentence errors respectively against reading group in the testing exercise in the learning phase. Figure 8 presents the total initial sound errors against reading group in the reading exercise. Figures 9 and 10
Table 1  Means and standard deviations (in brackets) of errors in the learning phase in Experiment 1.

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**Reading Exercise**

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<td>(33.25)</td>
<td>(19.18)</td>
<td>(2.65)</td>
<td>(3.37)</td>
<td>(22.38)</td>
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**Testing Exercise – Sight words**

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<td>7.00</td>
<td>12.25</td>
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<tr>
<td></td>
<td>(18.36)</td>
<td>(15.33)</td>
<td>(10.72)</td>
<td>(2.00)</td>
<td>(10.40)</td>
<td>(12.92)</td>
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<tr>
<td>Initial sound</td>
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<td>4.25</td>
<td>2.75</td>
<td>0.33</td>
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<tr>
<td></td>
<td>(2.89)</td>
<td>(3.86)</td>
<td>(2.22)</td>
<td>(0.58)</td>
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**Testing Exercise – Sentences**

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<td></td>
<td>(23.76)</td>
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<td>(39.00)</td>
<td>(4.16)</td>
<td>(12.44)</td>
<td>(36.33)</td>
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<td>Initial sound</td>
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<td>13.75</td>
<td>11.25</td>
<td>0.00</td>
<td>1.00</td>
<td>8.50</td>
</tr>
<tr>
<td></td>
<td>(4.36)</td>
<td>(15.65)</td>
<td>(4.03)</td>
<td>(0.00)</td>
<td>(1.41)</td>
<td>(7.85)</td>
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</table>
show the initial sound errors for sight words and sentences respectively against reading group in the testing exercise in the learning phase.

Figure 5  Total errors against reading group in the reading exercise.

Figure 6  Sight word errors against reading group in the testing exercise in the learning phase.
Figure 7  Sentence errors against reading group in the testing exercise in the learning phase.

Figure 8  Total initial sound errors against reading group in the reading exercise.
Figure 9  Sight word initial sound errors against reading group in the testing exercise in the learning phase.

Figure 10  Sentence initial sound errors against reading group in the testing exercise in the learning phase.
The results indicate a significant difference in initial sound errors between the groups. The picture group had a significant increase in initial sound errors, indicating an absence of a decoding strategy. Evidently, the child’s attention is focused on the picture in order to gain information or a clue, thereby distracting the child from the task at hand, that of learning to read. Even though the child may produce the correct response during the reading exercise, the child may not produce the correct response for the same word when it was presented as a sight word or in a sentence during the test phase where the picture is not available. Such a response would indicate that the child was attending to the picture rather than the written material.

*Learning phase - testing exercise:* A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of sight word errors over the nine days. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, $F(1,16) = 5.14, MSe = 159.84, p = 0.04$, partial $\eta^2 = 0.24$, favouring the no picture group. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group the least, $F(2,16) = 18.63, MSe = 159.84, p < 0.01$, partial $\eta^2 = 0.7$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.18, MSe = 159.84, p = 0.84$, partial $\eta^2 = 0.02$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of sentence errors over the nine days. Means and standard deviations can be found in Table 1. There was a significant difference between the
picture group and the no picture group, $F(1,16) = 5.61, MSe = 862.43, p = 0.03$, partial $\eta^2 = 0.26$, favouring the no picture group.

There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group the least, $F(2,16) = 12.13, MSe = 862.43, p < 0.01$, partial $\eta^2 = 0.6$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.41, MSe = 862.43, p = 0.67$, partial $\eta^2 = 0.05$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total sum of initial sound errors for the sight words and the total sum of initial sound errors for the sentences over the 9 day learning phase. Means and standard deviations can be found in Table 1. For the sight words, there was a significant difference between the picture group and the no picture group, with the picture group making more of these specific errors, $F(1,16) = 4.92, MSe = 5.29, p = 0.04$, partial $\eta^2 = 0.2$. There was no significant difference in the errors made between the reading levels, $F(2,16) = 0.64, MSe = 5.29, p = 0.54$, partial $\eta^2 = 0.07$, and there was no interaction between the two groups and the reading levels, $F(2,16) = 0.65, MSe = 5.29, p = 0.54$, partial $\eta^2 = 0.08$.

With respect to the total sum of the initial sound errors for the sentences, there was no significant difference between the picture group and the no picture group, $F(1,16) = 3.99, MSe = 63.28, p = 0.06$, no significant difference in the errors made between the reading levels, $F(2,16) = 1.49, MSe = 63.28, p = 0.26$, partial $\eta^2 = 0.16$ and no interaction between the two groups and the reading levels, $F(2,16) = 0.86, MSe = 63.28, p = 0.44$, partial $\eta^2 = 0.1$. 
Test phase: A 2 (groups) x 3 (reading levels) x 3 (sentence types) analysis of variance (ANOVA), was conducted on the total errors. The 3 sentence types consisted of 7 actual sentences from the books which the child had previously sighted during the 9 day learning phase, 7 rearranged sentences also already sighted during the 9 day learning phase – testing exercise, and 7 completely novel sentences but using no new vocabulary. Means and standard deviations can be found in Table 2. There was a significant difference in errors between sentence types, \(F(2,32) = 4.89, MSe = 4.88, p = 0.01\), partial \(\eta^2 = 0.23\), with the novel sentences producing the most errors and the rearranged sentences producing the least number of errors. There was no interaction between sentence types and group, \(F(2,32) = 0.14, MSe = 4.88, p > 0.05\), partial \(\eta^2 = 0.009\) indicating that both the picture group and no picture group produced the same pattern of errors on all 3 sentence types and so the test scores were combined in all subsequent analyses.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 3. The test scores indicated no significant difference between the picture and no picture group in the reading of the sight words, \(F(1,16) = 2.17, MSe = 5.40, p = 0.16\), partial \(\eta^2 = 0.12\). There was a significant difference in the errors made between the reading levels with the lowest ability group making more errors than the two higher ability levels, \(F(2,16) = 28.03, MSe = 5.40, p < 0.01\), partial \(\eta^2 = 0.78\). There was no interaction between the two groups and the reading levels, \(F(2,16) = 0.62, MSe = 5.40, p = 0.55\), partial \(\eta^2 = 0.07\).
<table>
<thead>
<tr>
<th>Group (B3 highest)</th>
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<th>B3</th>
<th>B2</th>
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<tbody>
<tr>
<td>No. of participants</td>
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<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Actual sentences</td>
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<td>1.00</td>
<td>0.50</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td>(1.73)</td>
<td>(4.36)</td>
<td>(1.89)</td>
<td>(1.73)</td>
<td>(0.58)</td>
<td>(3.11)</td>
</tr>
<tr>
<td>Rearranged Sentences</td>
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<td>1.00</td>
<td>1.50</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>(2.31)</td>
<td>(3.40)</td>
<td>(5.19)</td>
<td>(0.00)</td>
<td>(1.29)</td>
<td>(4.32)</td>
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<tr>
<td>Novel Sentences</td>
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<td>(1.00)</td>
<td>(2.16)</td>
<td>(3.74)</td>
</tr>
</tbody>
</table>

There was a significant difference between groups in the reading of the sentences, $F(1,16) = 5.86$, $MSe = 76.96$, $p = 0.03$, partial $\eta^2 = 0.27$, favouring the no picture group. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the two higher ability levels making the least, $F(2,16) = 11.77$, $MSe = 76.96$, $p < 0.01$, partial $\eta^2 = 0.6$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.32$, $MSe = 76.96$, $p = 0.73$, partial $\eta^2 = 0.04$. 
A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on all initial sound errors for the test day. Means and standard deviations can be found in Table 3. There was no significant difference between the picture group and the no picture group in reading of the sight words, $F(1,16) = 0.25, MSe = 0.59, p = 0.62$, partial $\eta^2 = 0.02$, or in the errors made between the reading levels , $F(2,16) = 0.92, MSe = 0.59, p = 0.42$, partial $\eta^2 = 0.1$, nor was there an interaction between the two groups and the reading levels, $F(2,16) = 0.27, MSe = 0.59, p = 0.77$, partial $\eta^2 = 0.03$.

There was a significant difference between groups in initial sound errors while reading the sentences, $F(1,16) = 4.71, MSe = 4.46 , p = 0.04$, partial $\eta^2 = 0.23$, with the picture group making more of these specific errors. There was no significant difference in the errors made between the reading levels, $F(2,16) = 0.24, MSe = 4.46, p = 0.79$, partial $\eta^2 = 0.03$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.09, MSe = 4.46, p = 0.91$, partial $\eta^2 = 0.01$.

The test day results for time taken to read the sentences showed no significant difference between the groups, $F(1,20) = 1.023, MSe = 1.069, p = 0.32$.

The mean errors presented in Table 3 are expressed graphically in Figures 11 to 14 for each reading group with error bars indicating the standard deviation of the mean in each case. Figures 11 and 12 show the sight word and sentence errors respectively against reading group for the test day. Figures 13 and 14 show the initial sound errors for sight words and sentences respectively against reading group for the test day.
Table 3  Means and standard deviations (in brackets) of sight word and sentence errors for the test day in Experiment 1.

<table>
<thead>
<tr>
<th>Group (B3 highest ability)</th>
<th>Picture</th>
<th>No picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>B3 3</td>
<td>B2 4</td>
</tr>
<tr>
<td></td>
<td>B1 4</td>
<td>B3 3</td>
</tr>
<tr>
<td></td>
<td>B2 4</td>
<td>B1 4</td>
</tr>
<tr>
<td>Test Day – Sight words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3.67</td>
<td>6.50</td>
</tr>
<tr>
<td></td>
<td>(2.89)</td>
<td>(2.65)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>0.00</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.96)</td>
</tr>
<tr>
<td>Test Day – Sentences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.67</td>
<td>15.75</td>
</tr>
<tr>
<td></td>
<td>(8.33)</td>
<td>(11.09)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>1.67</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>(2.08)</td>
<td>(3.79)</td>
</tr>
</tbody>
</table>
Figure 11  Mean sight word errors against reading group for the test day.

Figure 12  Mean sentence errors against reading group for the test day.
Figure 13  Mean sight word initial sound errors against reading group for the test day.

Figure 14  Mean sentence initial sound errors against reading group for the test day.
It was hypothesized that the test performance of the no picture group would be higher than the picture group providing an example of the redundancy effect due to the presence of pictures imposing an extraneous cognitive load. The results supported this hypothesis. Based on these results, the next experiment was designed to test whether the extraneous load was merely distractive or if readers were using the illustrations as an information source.
Chapter 8

Experiment 2

The presence of pictures when children are learning to read may act as a distracter from the text. If learners are attending to a picture rather than to the words, we might expect a learning decrement compared to a no-picture condition, as was obtained in Experiment 1. An alternative hypothesis is that the pictures did not merely distract readers’ attention but in addition provided learners with information concerning the text. That information may then have been used as a substitute for reading, and so hindering the decoding process. Working memory resources, rather than being used to decode the text that was the purpose of the exercise, instead may have been used to make sense of or interpret the picture. Students may have learned that the picture could be used to provide the same or similar information as the text and so felt no need to decode the text, resulting in reduced learning compared to learners who only had the text available and so practiced reading by focussing on decoding strategies rather than picture interpretation.

These two hypotheses can be compared by using a reading book with potentially distracting but non-informative pictures, and contrasting it with the informative pictures used in Experiment 1. Experiment 2 was identical to Experiment 1 except that a book
with pictures of faces was used as a substitute for the no-pictures condition and compared to a condition that included informative pictures relevant to the text, as in the pictures condition of Experiment 1. It was hypothesised that children given books containing faces irrelevant to the text would perform better than children given informative pictures.

Method

Participants: The participants were 24 kindergarten children attending a public school in Metropolitan Sydney, NSW. The children were aged between 5 and 6 years, and were all at the same reading level ‘Beginner’ as determined by their class teachers. As with Experiment 1 the children were further divided into the 3 sub groups (B1, B2 and B3) based on their reading ability, again determined by their class teachers. They were assigned to two groups of 12 with one group presented with illustrated books (the picture group), and the other group presented with reproduced books having faces (the faces group). Within each level of reading ability, participants were randomly assigned to the conditions.

Materials and Procedure: The materials and procedure were identical to that of Experiment 1 with the only difference being the nature of the books. The same illustrated books were used, but instead of having books with no illustrations, as detailed in Experiment 1, the reproduced books in this experiment were designed with a varied assortment of faces and facial expressions (see Figure 15). Faces were used as they have been demonstrated to be intrinsically interesting, and hence attract the attention of children. The faces used were very different in each reproduced book in order to ensure that the child would remain interested and find the images engaging.
The faces encompassed the entire page and appeared in exactly the same place as the illustrations in the illustrated books. The background colour, font and page numbers were identical to the illustrated books.

![Image](image1.png)

Figure 15 Sample page of reproduced text using faces used in Experiments 2 & 3.

Results and Discussion

_**Learning phase- reading exercise:**_ A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted for the reading exercise, i.e. the reading of the 9 books over the nine day learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 4. There was a significant difference between the picture group and the faces group, with the picture group making more errors, $F(1,18) = 14.43, MSe = 2625.89, p < 0.01$, partial $\eta^2 = 0.45$. There was a significant difference in the errors made between the reading levels with the lowest ability group making the most errors and the highest ability group making the least, $F(2,18) = 26.8, MSe = 2625.89, p < 0.01$, partial $\eta^2 = 0.75$. There
was no interaction between the two groups and the reading levels, $F(2,18) = 2.77$, $MSe = 2625.89$, $p = 0.09$, partial $\eta^2 = 0.24$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of initial sound errors for the reading exercise, i.e. the reading of the nine books over the nine days immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 4. There was a significant difference between the picture group and the faces group, with the picture group making more of these errors, $F(1,18) = 7.41$, $MSe = 900.36$, $p = 0.01$, partial $\eta^2 = 0.29$. There was a significant difference in this category of errors between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 4.19$, $MSe = 900.36$, $p = 0.03$, partial $\eta^2 = 0.32$. There was no interaction between the two groups and the reading levels, $F(2,18) = 3.09$, $MSe = 900.36$, $p = 0.07$, partial $\eta^2 = 0.26$.

**Learning phase- testing exercise:** A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on the total number of sight word errors over the nine days. Means and standard deviations can be found in Table 4. There was a significant difference between the picture group and the faces group, $F(1,18) = 9.66$, $MSe = 92.01$, $p < 0.01$, partial $\eta^2 = 0.4$, favouring the faces group. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 25.32$, $MSe = 92.01$, $p < 0.01$, partial $\eta^2 = 0.74$. There was no interaction between the two groups and the reading levels, $F(2,18) = 3.05$, $MSe = 92.01$, $p = 0.07$, partial $\eta^2 = 0.25$. 
Table 4  Means and standard deviations (in brackets) of errors in the learning phase for Experiment 2.

<table>
<thead>
<tr>
<th>Group (B3 highest ability)</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Reading Exercise**

<table>
<thead>
<tr>
<th></th>
<th>Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>98.00</td>
<td>123.40</td>
</tr>
<tr>
<td></td>
<td>(46.67)</td>
<td>(32.19)</td>
</tr>
<tr>
<td><strong>Initial sound</strong></td>
<td>15.00</td>
<td>21.60</td>
</tr>
<tr>
<td></td>
<td>(4.24)</td>
<td>(6.11)</td>
</tr>
</tbody>
</table>

**Testing Exercise – Sight words**

<table>
<thead>
<tr>
<th></th>
<th>Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>11.50</td>
<td>15.80</td>
</tr>
<tr>
<td></td>
<td>(6.36)</td>
<td>(6.61)</td>
</tr>
<tr>
<td><strong>Initial sound</strong></td>
<td>2.00</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.89)</td>
</tr>
</tbody>
</table>

**Testing Exercise – Sentences**

<table>
<thead>
<tr>
<th></th>
<th>Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>30.00</td>
<td>26.60</td>
</tr>
<tr>
<td></td>
<td>(14.14)</td>
<td>(9.86)</td>
</tr>
<tr>
<td><strong>Initial sound</strong></td>
<td>8.50</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>(4.95)</td>
<td>(2.45)</td>
</tr>
</tbody>
</table>
A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of sentence errors over the nine days. Means and standard deviations can be found in Table 4. There was a significant difference between the picture group and the faces group, $F(1,18) = 14.83, MSe = 398.12, p < 0.01$, partial $\eta^2 = 0.45$, favouring the faces group. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 18.36, MSe = 398.12, p < 0.01$, partial $\eta^2 = 0.67$. There was an interaction between the two groups and the reading levels, $F(2,18) = 4.37, MSe = 398.12, p = 0.03$, partial $\eta^2 = 0.33$. Simple effects tests following the significant interaction indicated a significant difference between the picture group and the faces group for both the B1 students, $t(10) = 3.57, p < 0.01$, partial $\eta^2 = 0.61$, and the B2 students, $t(10) = 2.84, p = 0.02$, partial $\eta^2 = 0.5$. There were too few B3 students to analyse separately. The difference in effect sizes for the B1 and B2 students explains the significant interaction.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total sum of initial sound errors for the sight words and sentences over the 9 day learning phase. Means and standard deviations can be found in Table 4. With the sight words there was no significant difference between the picture group and the faces group, $F(1,18) = 3.0, MSe = 23.24, p = 0.1$, partial $\eta^2 = 0.14$. There was no significant difference in the errors made between the reading levels, $F(2,18) = 3.43, MSe = 23.24, p = 0.06$, partial $\eta^2 = 0.28$ and there was no interaction between the two groups and the reading levels, $F(2,18) = 1.52, MSe = 23.24, p = 0.24$, partial $\eta^2 = 0.14$. 

With respect to initial sound errors when reading sentences, there was a significant difference between the picture group and the faces group, $F(1,18) = 10.44$, $MSe = 118.01$, $p < 0.01$, partial $\eta^2 = 0.37$. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 6.56$, $MSe = 118.01$, $p < 0.01$, partial $\eta^2 = 0.42$. There was a significant interaction between the two groups and the reading levels, $F(2,18) = 4.74$, $MSe = 118.01$, $p = 0.02$, partial $\eta^2 = 0.35$. Simple effects tests once again indicated a significant difference between the picture group and the faces group for both the B1 students, $t(10) = 4.23$, $p < 0.01$, partial $\eta^2 = 0.69$, and the B2 students $t(10) = 3.30$, $p = 0.01$, partial $\eta^2 = 0.58$. There were too few B3 students to analyse separately. The difference in effect sizes for the B1 and B2 students explains the significant interaction.

The mean errors presented in Table 4 are expressed graphically in Figures 16 to 21 for each reading group with error bars indicating the standard deviation of the mean in each case. Figure 16 shows the total errors against reading group in the reading exercise. Figures 17 and 18 show the sight word and sentence errors respectively against reading group in the testing exercise in the learning phase. Figure 19 presents the total initial sound errors against reading group in the reading exercise. Figures 20 and 21 show the initial sound errors for sight words and sentences respectively against reading group in the testing exercise in the learning phase.
Figure 16  Total errors against reading group in the reading exercise.

Figure 17  Sight word errors against reading group in the testing exercise of the learning phase.
Figure 18  Sentence errors against reading group in the testing exercise of the learning phase.

Figure 19  Total initial sound errors against reading group in the reading exercise.
Figure 20  Sight word initial sound errors against reading group in the testing exercise in the learning phase.

Figure 21  Sentence initial sound errors against reading group in the testing exercise in the learning phase.
**Test phase:** A 2 (groups) x 3 (reading levels) x 3 (sentence types) analysis of variance (ANOVA), was conducted on the total errors. The 3 sentence types consisted of 7 actual sentences from the books which the child had previously sighted during the 9 day learning phase, 7 rearranged sentences also already sighted during the 9 day learning phase, and 7 completely novel sentences using no new vocabulary. Means and standard deviations can be found in Table 5. This analysis indicated no significant difference in errors between sentence types, $F(2,39) = 3.09, MSe = 4.07, p > 0.05$, partial $\eta^2 = 0.15$. There was no interaction between sentence types and group, $F(2,39) = 1.09, MSe = 4.07, p > 0.05$, partial $\eta^2 = 0.06$ indicating that both the picture group and the faces group produced the same pattern of errors on all 3 sentence types and so the test scores were combined in all subsequent analyses.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 6. The test scores indicated a significant difference between the picture group and the faces group in the reading of the sight words, $F(1,18) = 8.95, MSe = 5.14, p < 0.01$, partial $\eta^2 = 0.33$. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 22.79, MSe = 5.14, p < 0.01$, partial $\eta^2 = 0.72$. There was no interaction between the two groups and the reading levels, $F(2,18) = 1.67, MSe = 514, p = 0.22$, partial $\eta^2 = 0.16$.

There was a significant difference between groups in the reading of the sentences, $F(1,18) = 13.33, MSe = 25.85, p < 0.01$, partial $\eta^2 = 0.42$, favouring the
Table 5  Means and standard deviations (in brackets) of errors according to sentence types for the test day in Experiment 2.

<table>
<thead>
<tr>
<th>Group (B3 highest ability)</th>
<th>Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>B3</td>
<td>B2</td>
</tr>
<tr>
<td>Actual sentences</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1.51</td>
<td>2.80</td>
</tr>
<tr>
<td>Rearranged Sentences</td>
<td>2.00</td>
<td>2.40</td>
</tr>
<tr>
<td>Novel Sentences</td>
<td>1.50</td>
<td>3.60</td>
</tr>
</tbody>
</table>

faces group. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,18) = 21.17$, $MSe = 25.85$, $p < 0.01$, partial $\eta^2 = 0.7$. There was an interaction between the two groups and the reading levels, $F(2,18) = 4.48$, $MSe = 25.85$, $p = 0.03$, partial $\eta^2 = 0.33$. Simple effects tests following the significant interaction indicated a significant difference between the picture group and the faces group for both the B1 students, $t(10) = 3.62$, $p < 0.01$, partial $\eta^2 = 0.62$, and the B2 students, $t(10) = $
4.75, \( p < 0.01 \), partial \( \eta^2 = 0.74 \). There were too few B3 students to analyse separately. The difference in effect sizes for the B1 and B2 students explains the significant interaction.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on all initial sound errors for the test day. Means and standard deviations can be found in Table 6. There was a significant difference between the picture group and the faces group in the reading of the sight words, \( F(1,18) = 9.8, MSe = 0.25, p < 0.01 \), partial \( \eta^2 = 0.35 \). There was no significant difference in the errors made between the reading levels, \( F(2,18) = 1.75, MSe = 0.25, p = 0.2 \), partial \( \eta^2 = 0.16 \) nor was there an interaction between the two groups and the reading levels, \( F(2,18) = 1.75, MSe = 0.25, p = 0.2 \), partial \( \eta^2 = 0.16 \).

There was no significant difference between the two groups in initial sound errors while reading the sentences, \( F(1,18) = 3.79, MSe = 12.94, p = 0.07 \), partial \( \eta^2 = 0.17 \). There was no significant difference in the errors made between the reading levels, \( F(2,18) = 1.68, MSe = 12.94, p = 0.22 \), partial \( \eta^2 = 0.16 \) There was no interaction between the two groups and the reading levels, \( F(2,18) = 1.26, MSe = 12.94, p = 0.31 \), partial \( \eta^2 = 0.12 \).

The test day results for time taken to read the sentences showed no significant difference between the groups, \( F(1,21) = 0.03, MSe = 0.01, p = 0.87 \).

The mean errors presented in Table 6 are expressed graphically in Figures 22 to 25 for each reading group with error bars indicating the standard deviation of the mean in each case. Figures 22 and 23 show the sight word and sentence errors respectively.
Table 6 Means and standard deviations (in brackets) of sight word and sentence errors for the test day in Experiment 2.

<table>
<thead>
<tr>
<th>Group (B3 highest ability)</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Test Day – Sight words**

<table>
<thead>
<tr>
<th></th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td>2.00</td>
<td>4.80</td>
<td>11.80</td>
<td>0.50</td>
<td>2.60</td>
<td>6.40</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(2.78)</td>
<td>(3.56)</td>
<td>(0.71)</td>
<td>(1.14)</td>
<td>(0.89)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>0.50</td>
<td>0.40</td>
<td>1.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.71)</td>
<td>(0.55)</td>
<td>(0.84)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

**Test Day – Sentences**

<table>
<thead>
<tr>
<th></th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td>5.00</td>
<td>8.80</td>
<td>27.40</td>
<td>0.50</td>
<td>5.00</td>
<td>10.80</td>
</tr>
<tr>
<td></td>
<td>(5.66)</td>
<td>(0.84)</td>
<td>(9.45)</td>
<td>(0.71)</td>
<td>(1.58)</td>
<td>(3.96)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>1.50</td>
<td>2.40</td>
<td>7.20</td>
<td>0.50</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>(2.12)</td>
<td>(1.52)</td>
<td>(7.29)</td>
<td>(0.71)</td>
<td>(0.89)</td>
<td>(0.84)</td>
</tr>
</tbody>
</table>

against reading group for the test day. Figures 24 and 25 show the initial sound errors for sight words and sentences respectively against reading group for the test day.
Figure 22  Mean sight word errors against reading group on the test day.

Figure 23  Mean sentence errors against reading group on the test day.
Figure 24  Mean sight word initial sound errors against reading group on the test day.

Figure 25  Mean sentence initial sound errors against reading group on the test day.
It was hypothesized that the faces group would perform better than the picture group on the test day. The results supported this hypothesis suggesting that the reduced learning associated with illustrations is due to the information contained within the illustrations rather than merely due to their distractive influence. The children in the picture group made significantly more initial incorrect responses in both the learning phase and the test phase. The reduced performance of the picture group in the learning phase suggests that when presented with informative illustrations, the information in the illustrations may be used by children as a substitute for decoding strategies. These decoding strategies are underdeveloped during the learning phase, and hence produce a reduced performance of the picture group in the test phase.
Chapter 9

Experiment 3

Experiment 2 indicated that informative illustrations have a negative effect compared to non-informative illustrations suggesting that it is the information content and not the distracting presence of an illustration per se that is damaging to children learning to read. Nevertheless, while in combination, Experiments 1 and 2 are compatible with this suggestion, it also is possible that both factors have an effect. Uninformative pictures may be distracting while informative pictures may both be distracting and encourage learners to use the information in the picture inappropriately. A combination of a picture that is both distracting and inappropriately informative may be worse than a picture that is merely distracting but does not eliminate the possibility that uninformative pictures may be distracting in their own right.

Experiment 3 was designed to test whether there was a difference in children’s reading ability when presented with books without any illustrations and books presented with faces only which did not pertain to the text in any way. If the uninformative faces are distracting, the no pictures condition should result in higher test scores. If the picture effect requires informative pictures, there should be no difference between uninformative pictures and no pictures. This hypothesis was tested by comparing a no
Method

Participants: The participants were 22 kindergarten children attending a public school in Metropolitan Sydney, NSW. The children were 5 to 6 years in age, and were all at the same reading level ‘Beginner’; which was determined by their class teachers. As with Experiments 1 and 2 the children were further divided into the 3 sub groups based on their reading ability, again determined by their class teachers. They were assigned into two groups of 11 with one group presented with unillustrated books (the no picture group), and the other group presented with reproduced books having faces (the faces group). Within each level of reading ability, participants were randomly assigned to the conditions.

Materials and Procedure: The materials and procedure were identical to that of Experiments 1 and 2. The books with faces were identical to Experiment 2, and the unillustrated books were identical to those used in Experiment 1.

Results and Discussion

Learning phase- reading exercise: A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted for the reading exercise, i.e. the reading of the 9 books over the nine day learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 7. There was no significant difference between the no picture group and the faces group,
<table>
<thead>
<tr>
<th></th>
<th>No Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group (B3 highest ability)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>B2</td>
</tr>
<tr>
<td>No. of participants</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reading Exercise</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>33.00</td>
<td>112.25</td>
</tr>
<tr>
<td>(16.70)</td>
<td>(10.50)</td>
<td>(51.57)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>2.67</td>
<td>7.00</td>
</tr>
<tr>
<td>(2.08)</td>
<td>(1.83)</td>
<td>(6.98)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Testing Exercise – Sight words</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.67</td>
<td>15.25</td>
</tr>
<tr>
<td>(1.16)</td>
<td>(6.70)</td>
<td>(10.92)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>0.00</td>
<td>0.75</td>
</tr>
<tr>
<td>(0.00)</td>
<td>(0.96)</td>
<td>(0.96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Testing Exercise – Sentences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.67</td>
<td>22.50</td>
</tr>
<tr>
<td>(3.06)</td>
<td>(9.11)</td>
<td>(13.90)</td>
</tr>
<tr>
<td>Initial sound</td>
<td>0.33</td>
<td>2.25</td>
</tr>
<tr>
<td>(0.58)</td>
<td>(1.71)</td>
<td>(1.71)</td>
</tr>
</tbody>
</table>
\[ F(1,16) = 0.35, MSe = 1596.81, p = 0.86, \text{ partial } \eta^2 = 0.002. \] There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, \[ F(2,16) = 25.35, MSe = 1596.81, p < 0.01, \text{ partial } \eta^2 = 0.76. \] There was no interaction between the two groups and the reading levels, \[ F(2,16) = 0.55, MSe = 1596.81, p = 0.59, \text{ partial } \eta^2 = 0.06. \]

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of initial sound errors for the reading exercise, i.e. the reading of the nine books over the nine days immediately preceding the reading of the sight words and sentences. There was no significant difference between the no picture group and the faces group, \[ F(1,16) = 0.1, MSe = 20.14, p = 0.76, \text{ partial } \eta^2 = 0.01. \] There was a significant difference in this category of errors between the reading levels with the lowest ability group making most errors and the highest ability group making the least, \[ F(2,16) = 6.46, MSe = 20.14, p < 0.01, \text{ partial } \eta^2 = 0.45. \] There was no interaction between the two groups and the reading levels, \[ F(2,16) = 0.19, MSe = 20.14, p = 0.83, \text{ partial } \eta^2 = 0.02. \]

\textit{Learning phase- testing exercise}: A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on the total number of sight word errors over the nine days. Means and standard deviations can be found in Table 7. There was no significant difference between the no picture group and the faces group, \[ F(1,16) = 0.21, MSe = 83.51, p = 0.65, \text{ partial } \eta^2 = 0.01. \] There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, \[ F(2,16) = 14.42, MSe = 83.51, p < 0.01, \]
partial $\eta^2 = 0.64$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.73$, $MSe = 83.51$, $p = 0.5$, partial $\eta^2 = 0.08$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA) was conducted on the total number of sentence errors over the nine days. Means and standard deviations can be found in Table 7. There was no significant difference between the no picture group and the faces group, $F(1,16) = 0.58$, $MSe = 159.01$, $p = 0.46$, partial $\eta^2 = 0.04$. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,16) = 14.13$, $MSe = 159.01$, $p < 0.01$, partial $\eta^2 = 0.64$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.89$, $MSe = 159.01$, $p = 0.43$, partial $\eta^2 = 0.1$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on the total sum of initial sound errors for the sight words and sentences for the 9 day learning phase. Means and standard deviations can be found in Table 7. With the sight words there was no significant difference between the no picture group and the faces group, $F(1,16) = 0.02$, $MSe = 0.98$, $p = 0.9$, partial $\eta^2 = 0.001$. There was no significant difference in the errors made between the reading levels, $F(2,16) = 1.76$, $MSe = 0.98$, $p = 0.2$, partial $\eta^2 = 0.18$, nor was there an interaction between the two groups and the reading levels, $F(2,16) = 0.59$, $MSe = 0.98$, $p = 0.57$, partial $\eta^2 = 0.23$.

With respect to sentences, there was no significant difference between the no picture group and the faces group, $F(1,21) = 1.15$, $MSe = 5.54$, $p = 0.3$, partial $\eta^2 = 0.07$. There was no significant difference in the errors made between the reading levels, $F(2,21) = 2.35$, $MSe = 5.54$, $p = 0.13$, partial $\eta^2 = 0.23$. There was no significant
interaction between the two groups and the reading levels, $F(2,21) = 0.31$, $MSe = 5.54$, $p = 0.74$, partial $\eta^2 = 0.04$.

The mean errors presented in Table 7 are expressed graphically in Figures 26 to 31 for each reading group with error bars indicating the standard deviation of the mean in each case. Figure 26 shows the total errors against reading group in the reading exercise. Figures 27 and 28 show the sight word and sentence errors respectively against reading group in the testing exercise in the learning phase. Figure 29 presents the total initial sound errors against reading group in the reading exercise. Figures 30 and 31 show the initial sound errors for sight words and sentences respectively against reading group in the testing exercise in the learning phase.

![Figure 26](image)

Figure 26 Total errors against reading group in the reading exercise.
Figure 27  Sight word errors against reading group in the testing exercise in the learning phase.

Figure 28  Sentence errors against reading group in the testing exercise in the learning phase.
Figure 29  Total initial sound errors against reading group in the reading exercise.

Figure 30  Sight word initial sound errors against reading group in the testing exercise in the learning phase.
Test phase: A 2 (groups) x 3 (reading levels) x 3 (sentence types) analysis of variance (ANOVA), was conducted on the total errors made with respect to the different sentence types. Means and standard deviations can be found in Table 8. This analysis indicated a significant difference in errors between sentence types, $F(2,32) = 14.74$, $MSe = 3.23$, $p < 0.001$, partial $\eta^2 = 0.48$, with the novel sentences producing the most errors and the rearranged sentences producing the least number of errors. There was no interaction between sentence types and group, $F(2,32) = 0.26$, MSe = 3.23, $p > 0.05$, partial $\eta^2 = 0.02$ indicating that both the faces group and the no picture group produced the same pattern of errors on all 3 sentence types and so the test scores were combined in all subsequent analyses.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 9. The test scores

Figure 31  Sentence initial sound errors against reading group in the testing exercise in the learning phase.
Table 8 Means and standard deviations (in brackets) of errors according to sentence types for the test day in Experiment 3.

<table>
<thead>
<tr>
<th>Group (B3 highest ability)</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Actual sentences</td>
<td>0.67</td>
<td>2.25</td>
<td>7.25</td>
<td>0.50</td>
<td>3.50</td>
<td>7.33</td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
<td>(0.96)</td>
<td>(2.22)</td>
<td>(1.00)</td>
<td>(2.52)</td>
<td>(3.51)</td>
</tr>
<tr>
<td>Rearranged Sentences</td>
<td>0.00</td>
<td>1.25</td>
<td>4.00</td>
<td>1.50</td>
<td>2.25</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.96)</td>
<td>(2.45)</td>
<td>(1.29)</td>
<td>(1.71)</td>
<td>(1.73)</td>
</tr>
<tr>
<td>Novel Sentences</td>
<td>1.00</td>
<td>2.50</td>
<td>8.50</td>
<td>1.00</td>
<td>4.25</td>
<td>6.67</td>
</tr>
<tr>
<td></td>
<td>(1.00)</td>
<td>(1.29)</td>
<td>(3.11)</td>
<td>(0.00)</td>
<td>(2.87)</td>
<td>(1.16)</td>
</tr>
</tbody>
</table>

indicated no significant difference between the no picture group and the faces group in the reading of the sight words, $F(1,16) = 0.29, MSe = 5.76, p = 0.6$, partial $\eta^2 = 0.02$.

There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,16) = 19.25, MSe = 5.76, p < 0.01$, partial $\eta^2 = 0.71$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.46, MSe = 5.76, p = 0.64$, partial $\eta^2 = 0.05$.  

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There was no significant difference between groups in the reading of the sentences, $F(1,16) = 0.18, MS_e = 22.34, p = 0.68$, partial $\eta^2 = 0.01$. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,16) = 20.38, MS_e = 22.34, p < 0.01$, partial $\eta^2 = 0.71$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.95, MS_e = 22.34, p = 0.41$, partial $\eta^2 = 0.11$.

A 3 (reading levels) X 2 (groups) analysis of variance (ANOVA), was conducted on all initial sound errors for the test day. Means and standard deviations can be found in Table 9. There was no significant difference between the no picture group and the faces group in the reading of the sight words, $F(1,16) = 0.34, MS_e = 0.11, p = 0.57$ partial $\eta^2 = 0.02$, nor was there any significant difference in the errors made between the reading levels, $F(2,16) = 0.98, MS_e = 0.11, p = 0.4$, partial $\eta^2 = 0.11$. There was no interaction between the two groups and the reading levels, $F(2,16) = 2.42, MS_e = 0.11, p = 0.12$, partial $\eta^2 = 0.23$.

There was no significant difference between groups in initial sound errors while reading the sentences, $F(1,16) = 1.32, MS_e = 1.26, p = 0.27$, partial $\eta^2 = 0.08$. There was a significant difference in the errors made between the reading levels with the lowest ability group making most errors and the highest ability group making the least, $F(2,16) = 6.05, MS_e = 7.63, p = 0.01$, partial $\eta^2 = 0.43$. There was no interaction between the two groups and the reading levels, $F(2,16) = 0.22, MS_e = 0.28, p = 0.8$, partial $\eta^2 = 0.03$.  

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Table 9  Means and standard deviations (in brackets) of sight word and sentence errors for the test day in Experiment 3.

| Group (B3 highest ability) | No Picture |  | Faces |  |
|----------------------------|------------|------------------|------------------|
| No. of participants | 3 | 4 | 4 | 4 | 4 | 3 |

Test Day – Sight words

<table>
<thead>
<tr>
<th>Total</th>
<th>1.00</th>
<th>5.50</th>
<th>10.25</th>
<th>1.50</th>
<th>5.25</th>
<th>8.33</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.00)</td>
<td>(1.73)</td>
<td>(3.78)</td>
<td>(1.29)</td>
<td>(3.40)</td>
<td>(0.58)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial sound</th>
<th>0.00</th>
<th>0.00</th>
<th>0.50</th>
<th>0.00</th>
<th>0.25</th>
<th>0.00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.58)</td>
<td>(0.00)</td>
<td>(0.50)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

Test Day – Sentences

<table>
<thead>
<tr>
<th>Total</th>
<th>1.67</th>
<th>6.00</th>
<th>19.75</th>
<th>3.00</th>
<th>10.00</th>
<th>17.00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2.08)</td>
<td>(2.16)</td>
<td>(7.32)</td>
<td>(2.16)</td>
<td>(6.88)</td>
<td>(3.00)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial sound</th>
<th>0.33</th>
<th>0.75</th>
<th>2.00</th>
<th>0.75</th>
<th>1.00</th>
<th>3.00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.58)</td>
<td>(0.96)</td>
<td>(1.63)</td>
<td>(0.50)</td>
<td>(0.82)</td>
<td>(1.37)</td>
</tr>
</tbody>
</table>

The mean errors presented in Table 9 are expressed graphically in Figures 32 to 35 for each reading group with error bars indicating the standard deviation of the mean.
in each case. Figures 32 and 33 show the sight word and sentence errors respectively against reading group for the test day. Figures 34 and 35 show the initial sound errors for sight words and sentences respectively against reading group for the test day.

Figure 32  Sight word errors against reading group on the test day.

Figure 33  Sentence errors against reading group on the test day.
Figure 34  Sight word initial sound errors against reading group on the test day.

Figure 35  Sentence initial sound errors against reading group on the test day.
The test day results for time taken to read the sentences showed no significant
difference between the groups, $F(1,20) = 0.31$, $MSe = 0.18$, $p = 0.58$.

These results indicate that uninformative pictures do not distract learners from
processing the text, or at least, not to an extent that results in significant learning
decrements. Informative pictures providing redundant information relevant to the text
are required for the redundancy effect in this context.
Chapter 10

General Discussion

10.1 Theoretical Overview

The restrictions on learning and the opportunities for learning as described and demonstrated by cognitive load theory are a direct consequence of the existence of structures in the human cognitive architecture and the functional organisation of these structures. Cognitive load theory deals with what is known about our limited working memory and the techniques and strategies which can be implemented in order to reduce cognitive load and optimise learning. The organisation and interrelatedness of the human cognitive architecture allows humans to engage in many tasks, ranging from the very simple to the very complex. Reading is a task that is extremely complex due to the necessity of having to simultaneously process many interacting elements, and is a task that must be learned owing to the fact that it is not innate but rather forms part of biologically secondary knowledge.

Working memory is limited in both its processing and storage capacity, as well as only being able to process two to four elements at any one time. This is why it is crucial to the learning process that working memory not become unnecessarily overloaded with an unnecessarily high cognitive load.
Long-term memory enables humans to process massive amounts of information that has already been learned and stored. This knowledge in long-term memory is stored in the form of cognitive structures called schemas that can be brought into working memory when required. Schemas enable multiple elements of information to be processed simultaneously, thereby allowing for a reduction in the load imposed on working memory. The acquisition of schemas is crucial to the learning process, as it is the automation of these acquired schemas which allows the unconscious processing of information, which in turn results in a reduction of cognitive load. The acquisition and automation of schemas are vital to the reading process. Once working memory is freed as a result of decoding having become automated, more complex skills associated with reading, such as comprehension, can develop.

10.2 Analysis of experiments

The experiments discussed above were designed to demonstrate the negative effects that pictures can have on learning to read within the cognitive load theory framework. The redundancy effect as stated in terms of cognitive load theory was able to account for the findings in the above three experiments.

Experiment 1 demonstrated that providing informative pictures to novice readers adversely affected reading performance compared to a no picture group that performed better due to the removal of redundant illustrations. Experiment 2 established that informative pictures were harmful to learning compared with uninformative pictures consisting of a variety of different faces. Experiment 3 established that uninformative
pictures did not generate a redundancy effect when compared with the no pictures condition.

These experiments indicated that the redundancy effect was generated when informative pictures directly relevant to the text were presented to the child in a reading exercise.

The purpose of obtaining data on initial sound incorrect responses was to determine whether or not the beginning readers were attempting to decode an unfamiliar word using a phonics based strategy. As the results indicate, the participants who were given both pictureless books and uninformative picture books, did not make nearly as many initial sound errors as those participants who were presented with books containing informative pictures.

The results indicated that not only did the novice readers presented with informative illustrations perform poorly in the reading exercise, but that they had not been able to decode words and simple sentences in isolation of the text as well as their no picture or faces group counterparts. This demonstrates that these children were unable to assimilate information and form schemas due to the extraneous load on working memory brought about by the redundant illustrations.

In short, these children had difficulty learning new information that would aid them in the reading process. Phonological knowledge is necessarily vital to the learning of unfamiliar and difficult words, and words that have not yet received the necessary exposure in order to become permanently stored in long-term memory. It is necessary that a beginner reader receive sufficient exposure to a word so that automation can
result. Repetition ensures that the word’s visual and phonological representations are linked to the point of unconscious recall, stored in long-term memory.

Exposure to words in the beginning phases of learning to read should not impose an extraneous load on working memory. An overload in working memory has negative effects for processing and acquiring new information, and ultimately on learning. Working memory should not have to deal with redundant information when trying to process and store new material. In the task of learning to read, the illustrations constitute redundant material.

Working memory is the processing engine where decoding takes place in the task of learning to read. Until decoding becomes automated working memory must individually process letters and words which is a cognitively taxing task in itself. The elimination of redundant material, specifically the removal of illustrations in learning to read materials, allows the child to focus on the task at hand - that of decoding the text. In the absence of illustrations, the novice reader does not simultaneously have to coordinate the illustrations and the text in an attempt to read the text. This considerably lessens the extraneous cognitive load placed on working memory.

The more skilled a child becomes at decoding, and ultimately at reading accurately and fluently, the more the child is able to understand and infer from the text. Once the child does not have to employ working memory consciously for the sole use of decoding the text, then comprehension of the text can become the focus of reading. This is due to the construction and automation of schemas, which allows the child to process the already learned information automatically and unconsciously. The cognitive load
has been reduced significantly and working memory is now able to deal with the meaning of the text, as a result of the decoding having become automated.

Learning is based on acquiring cognitive schemas. If a task is too complex to process, acquiring schemas and tapping into previous knowledge whilst simultaneously assimilating old and new information poses great difficulty and is problematic for the limited capacity of working memory. Learning to read is high in element interactivity and is therefore a difficult task to learn and master.

For the expert reader simultaneously processing many elements or schemas will not prove problematic, however the novice reader is faced with a considerably higher cognitive load. Reducing any unnecessary extraneous load will free up the resources in working memory available to the novice reader. It is therefore the responsibility of the instructional designers to eliminate this unnecessary load based on what is known about the limitations of the human cognitive architecture.

10.3 Limitations of the study

The most serious limitation of the experiments performed was the small number of participants. Experiments 1, 2 and 3 involved 22, 24 and 22 subjects respectively. When spread across the three beginner reading groups (B1, B2 and B3), the number of participants in each defined reading group was small due to factors beyond the control of the experimenter. This study required a significant amount of time (10 days per participant – each participant was tested individually) for both the learning phase and
the testing phase to be completed. Some subjects were lost from the study when a child was absent for any one of the days that the experiment was conducted. If a child was absent for one of the days in the learning or test phase, this excluded that child from the study. As the children are young in age, absenteeism due to sickness is not uncommon.

As is standard teaching practice in New South Wales, the children were assigned a reading level as determined by their class teacher. It would have been preferable to conduct a pre-test and a post-test so that the children’s reading levels were established independently of their class teacher. Pre-testing and post-testing also would have allowed for different statistical measures to be employed which could have provided more accurate findings. Nevertheless, reading level was not critical to the integrity of the study. The purpose of the study was to demonstrate the difference between the two groups in each experiment (between the picture group and the no picture group in experiment 1; between the faces group and the picture group in experiment 2; and between the no picture group and the faces group in experiment 3). Reading levels were only used to remove the variance due to this factor. Therefore, the small n used to analyse differences between reading levels and interactions between reading levels and groups are not an issue since there were neither theoretical nor practical issues associated with this independent variable.

The test day could have been conducted by someone other than the experimenter so as to remove any potential criticisms regarding bias, although this could quite possibly affect the participants’ performance. As the children were young in age, to introduce a different person, especially on the testing day, may have proven to be a major distraction.
10.4 Anecdotal evidence

The limitations outlined in section 10.3 provide ample scope to conduct future research in the area of cognitive load theory and learning to read. Section 10.5 outlines the possible future research that could be performed in this area. This section (10.4) provides some anecdotal information regarding the types of errors that students produced during the study, and are informative of the explanation proffered in terms of cognitive load theory. While this information is anecdotal, it provides a useful insight into why this interpretation of results is likely to be valid. In this section I will therefore speculate about the types of interpretations based on the information gained by performing this research project that did not form the basis of the statistical results presented.
Figure 36 Sample page from one of the illustrated texts used in Experiments 1 and 2.

The text and picture represented in Figure 36 is from one of the readers used for the picture group. A number of students in the picture group tended to make a particular error when reading the phrase “in the carpark” replacing it with “in the garage”. No children in the no picture group in Experiments 1 and 3 or the faces group in Experiments 2 & 3 produced the word “garage”. The use of the word “garage” is clearly not a decoding error. Many children in the picture group were correctly able to produce the word “car”, including the children who were unable to decode the word “carpark”. Some of the children who produced “carpark” were still unable to produce the word “carpark” in the sentence immediately following on from the sentence containing the first instance of the word “carpark”. This example also demonstrates why the inclusion
of initial sound errors was seen to be important as it is evidence of the child not paying attention or focussing on the text. The only way that the child can possibly produce the word “garage” is from a source other than the text, and the most readily available source to the novice reader in the picture group is the illustration. In this instance the illustration has not assisting the reader in the task of decoding as their focus is clearly not on the text.

Figure 37  Sample page from one of the illustrated texts used in experiments 1 and 2.

A second example page from one of the readers is shown in Figure 37. Again the types of errors made by students reading this page provides evidence of children not
focussing on the task of learning to decode text. A few children offered the word “boxes” in the phrase “I will make the space helmets”, replacing “space helmets” with “boxes”. This is another example of an error which is clearly not an attempt to decode. It is apparent that the child has produced the word “boxes” based on the information contained in the illustration. Again it is evident that initial sound errors are indicative of the child not focussing on a decoding strategy, nor is there any attention being paid to the shape of the word or words. In this instance the child replaced one word for two words (“boxes” for “space helmets”).

Figure 38 Sample page from one of the illustrated texts used in Experiments 1 and 2.
Some children in the picture group also demonstrated an inability to draw on pre-existing or available decoding strategies when attempting to read certain words or phrases. For example, for the text and picture in Figure 38 some children in the picture group produced the words “orange juice”, or “cordial” for the word “drinks”. The word “cake” was replaced with “birthday cake”, once again indicating a failure to pay attention to the shape, size or letters of the word.

This anecdotal evidence provides further support for the negative effects that pictures may have on children who are in the beginning stages of learning to read. The children seem to be using informative pictures as a means to ‘read’ the text. These pictures are redundant and hence produce deleterious effects for the task of learning how to decode and read text. The negative effects that informative illustrations have for students who are learning to decode text can be best described in terms of cognitive load theory. When the children look to the illustrations for assistance in decoding unfamiliar or new words, the resources of working memory are being used to process these illustrations. This obviously has a negative effect on learning to read as working memory is then not able to devote resources to develop schemas and to the storage of information in long-term memory. The negative effects associated with an unnecessarily high cognitive load on working memory produces an overload and results in poor learning in all areas including the very complex task of learning to read.

The evidence provided in this section is anecdotal and hence cannot be relied upon on its own. It would be interesting for future research to correlate the type of errors that are made within groups, quantifying the evidence presented here. The experiments used the measure of initial sound errors in order to distinguish errors in
attempting to decode, or using some other means of producing the word or phrase. There was a significant measured difference between the two groups using initial sound errors, supporting the hypothesis presented here. The types of errors produced accords with the strong evidence provided by the experimental design and the statistical analysis performed, which indicates that informative pictures produce a deleterious effect on learning to read whereas uninformative pictures do not. The evidence provided by the types of errors produced is also consistent with the cognitive load theory interpretation.

10.5 Future research

The experiments presented in this thesis allow scope for future research in the analysis of the effects of illustrations on learning to read. It would be useful to conduct similar research on a much larger scale. Experiments 1, 2 and 3 could, for example, be combined into a single experiment with three groups: picture, no picture and faces. The advantage of having 3 experiments was that each experiment partially replicated the preceding experiments.

Ideally, any future research would coincide with the beginning of formal reading instruction (the first year of formal education). It could also be beneficial to conduct similar research with children who have learning difficulties to test whether the redundancy effect can be demonstrated in the teaching of reading.

Another teaching area that could produce similar findings may be in second language acquisition, in particular learning to read. It may be that informative pictures
are a distraction for people attempting to learn another language when they are in the beginning stages of reading that language due to the excessive amount of extraneous cognitive load imposed on working memory. The difference in this case would be that the students are not *learning to read* as such, but rather *learning to read in English*. Learning to read in a first language occurs after the spoken language has been acquired, while learning to read in a second language is almost always synchronous with learning to speak in the same language. Hence, both learning to speak and read in a new language will involve working memory having to simultaneously coordinate new vocabulary, pronunciation and prosodic features; while also having to decode text in that new language. It could be the case that accompanying illustrations may prove detrimental to learning in both speaking and reading in the second language, and that cognitive load theory, in particular the redundancy effect can account for this impoverished learning (Diao, Chandler, & Sweller, 2007; Diao & Sweller, 2007). It would be interesting to see whether the same deleterious effects of illustrations presented in this thesis for learning to read in a first language would be observed in learning to read in a second language.

Research using eye tracking technologies could be employed in further investigative research. This extension of the research would be useful in assessing children’s reading behaviour and reading strategies by correlating whether the concentration of attention on the illustration coincides with reading errors. If, for example, the child was unsure of a word when reading a text, it would be useful to ascertain whether the child looks directly to the illustration and then produces a response without looking back to the text; or if the child is attempting to match the word up with the illustration by moving between both the text and the illustrations. Eye-
tracking technologies could provide further empirical evidence for the hypotheses presented in this thesis for the reduced performance of the picture group. Eye tracking could also be used to determine the relative time during the reading exercise being spent on the text and on the illustrations. The null result from the timing of the reading exercise is illuminating in this regard. The fact that there was no significant difference between the time taken during the reading exercise for the picture group and the no-picture group of Experiment 1 suggests that the total time spent on the text may be reduced for the picture group if it is assumed that some significant time was spent in attending to the illustrations. Eye-tracking could quantify this hypothesis and demonstrate that during the learning phase, the total time spent attending the text is reduced for the picture group.

10. 6 Conclusions and Recommendations

It was not the purpose of this study to deny the importance of pictures in children’s books. Illustrations may be useful in the pre-reading stages, and also may have benefits for readers who have competent decoding skills. But at the crucial stage of learning to read where all cognitive resources are needed for decoding text, pictures may prove to be a hindrance. It is well documented that phonological skills are required for decoding, and hence we should attempt to optimise cognitive resources available for this complex task.

Curriculum designers and educators need to concentrate on focussing and maintaining the child’s attention on the domain-specific task of decoding the text when
it comes to reading instruction. Providing redundant illustrations unnecessarily imposes a heavy demand on working memory and draws heavily on the beginner reader’s cognitive resources. Teachers and curriculum designers need to be acutely aware of instructional designs that impose a high extraneous load on working memory that unnecessarily hinders learning.

Teachers that rely on the illustrations as word prompts and cues are not assisting the beginner reader with developing and improving their reading abilities as those teachers are not encouraging the beginner reader to draw on any decoding strategies that are already in place (pre-existing schemas). While the illustration may assist the beginner reader in producing or guessing the correct word at that time, the negative consequence may be that the beginner reader employs this strategy in the future and thus is not decoding any new or unfamiliar words. This process of guesswork may hinder the learning to read process, whereas if the beginner reader was encouraged to draw on decoding strategies already in place, the reading process may develop at a faster rate.

Beginning readers have been shown to demonstrate qualitatively different things at different points in their reading development (Brown 2003). It is therefore necessary that reading instruction should be tailored specifically to the learner’s reading ability at any one time. The instructional design of reading materials needs to be altered in accordance with the learner’s knowledge at any given point in the learning process. So while pictures may be of assistance to children who are in the pre-reading stages of development and have not yet developed the necessary skills to begin formal reading
instruction, illustrations may prove harmful when developing certain skills such as decoding.

If removing illustrations from beginner reading materials does reduce the extraneous load imposed on working memory, then beginner reading material should be designed without illustrations so as to allow the learner a greater chance of reading success. The benefit of providing the novice reader with pictureless books for the period of mastering the decoding strategies associated with sight word recognition and early reading of simple sentences could be important in improving reading ability and literacy levels. This is not to say that beginner readers not be given illustrated books outside of formal instruction, but rather, that when children are involved in the task of learning to read, that pictureless books may be of greater benefit.
References


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## Appendix A

### Book List

The following titles are the books used in the reading exercise for the three experiments, listed alphabetically. The books are selected from the Springboard series published by Macmillan Education Australia Pty Ltd, 2004.

<table>
<thead>
<tr>
<th>Book Title</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A Visit to the Library</em></td>
<td>Written by Michele Ashley,</td>
</tr>
<tr>
<td></td>
<td>Photographed by Robert Chan.</td>
</tr>
<tr>
<td><em>After School</em></td>
<td>Written by Cory Winesap</td>
</tr>
<tr>
<td></td>
<td>Photographed by Vinnie Riesck.</td>
</tr>
<tr>
<td><em>Dad’s Phone</em></td>
<td>Written by Ruby Maile</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Jane Wallace-Mitchell.</td>
</tr>
<tr>
<td><em>Dinosaur Dan</em></td>
<td>Written by Greg Banks</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Mark Payne.</td>
</tr>
<tr>
<td><em>Mrs Popinpop’s Ghost</em></td>
<td>Written by Michele Ashley</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Bettina Guthridge</td>
</tr>
<tr>
<td><em>Sonny Gets Lost</em></td>
<td>Written by Josephine Selwyn</td>
</tr>
<tr>
<td></td>
<td>Illustrated by Stella Yang</td>
</tr>
</tbody>
</table>
The Moon Landing
Written by Cushla Brown
Illustrated by John Bennett

The Playhouse
Written by Shilo Berry
Illustrated by Mike Moreu

Thumper's Sore Paw
Written by Josephine Selwyn
Illustrated by Helen Humphries
Appendix B

Books with illustrations

The following texts were used by the Picture group in the learning phases for Experiments 1 and 2, and are listed alphabetically. The first image shows the front and back covers of the book containing publishing information. The final image includes the level, word count and high frequency words in the text.
On Friday, we went to the library. We were going to get some books to read.
Dad put the car in the carpark. The carpark is under the library.

We went up the path. We went into the library.
I went upstairs
to look at the books.
I looked at books about pets.
I want to get a pet.
Dad said I can have a pet
one day.

Dad went downstairs
to look at books.
Dad looked
at books about trucks.
Dad likes trucks.
Dad wants
to get a truck one day.
Casey went to look on the computer. She wanted to get a book on cooking. She likes cooking.

Casey got her cookbook. I got my pet book. Dad got his truck book. We went to the librarian. The librarian checked out the books.
We went home.

<table>
<thead>
<tr>
<th>Word Count</th>
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</thead>
<tbody>
<tr>
<td>Text Type</td>
<td>Factual Recount</td>
</tr>
<tr>
<td>New High Frequency Words</td>
<td></td>
</tr>
<tr>
<td>Revised High Frequency Words</td>
<td>we, went, the, going, to, get, some, in, up, look, at, want, get, out</td>
</tr>
</tbody>
</table>
After school I play with my dog. My dog likes playing with me. He gets the ball.
After I play with my dog,
I watch TV.
I like watching TV.
My dog likes watching TV, too.

After I watch TV,
I eat my dinner.
I have meat.

My dog eats his dinner.
He eats meat, too.
After I eat my dinner,
I read my book.
I read my book to my dog.

After I read my book,
I go to bed.
My dog goes to bed, too.

After I go to bed,
I go to sleep.
My dog sleeps by my bed.
He goes to sleep, too.
index

- ball: 2
- book: 10, 12
- dog: 2, 4, 8, 10, 12, 14
- meat: 6, 8
“I can't find my phone,” said Dad. “Where, oh where can it be?”
Josh was in the kitchen.

“I can’t find my phone,” said Dad.

“Where did you have it?” said Josh.

“I don’t know,” said Dad.

Dad and Josh looked and looked.
They did not find the phone.

Shelly was in the bedroom.

“I’m looking for my phone,” said Dad.
“Can you help me?”

“Where did you have it?” Shelly said.

“I don’t know,” said Dad.
Dad and Shelly and Josh
looked and looked.
They did not find the phone.

Luke was outside.

“I’m looking for my phone,” said Dad.

“Where have you looked?”
said Luke.

“I’ve looked inside,” said Dad.

Luke looked and looked.
He looked on the path.
He looked in the bush.
“Here it is,” he said.
“It was on the gate.”
Dinosaur Dan was big. He had big legs. He had a big head and he had big teeth!

One day, Lucy Lizard came to see Dinosaur Dan.

"I saw a big animal," she said.

"Was it as big as me?" said Dinosaur Dan.

"Bigger," said Lucy Lizard.
“Did it have legs as big as my legs?” said Dinosaur Dan.

“It had bigger legs,” said Lucy Lizard.
“I saw them.”

“Did it have a head as big as my head?” said Dinosaur Dan.

“Yes it did,” said Lucy Lizard.
“I saw its head.
It had a BIG head!”
“Did you see its teeth?” said Dinosaur Dan.

“Yes,” said Lucy Lizard.
“I saw its teeth.
It had the two biggest teeth I have ever seen.”

“That cannot be,” said Dinosaur Dan.
“I am the biggest animal here.
I have the biggest legs.
I have the biggest head and I have the biggest teeth.”

“I saw it,” said Lucy Lizard.
“Come with me and you will see.”
Dinosaur Dan went with Lucy Lizard to look at the big animal.

“That animal is not as big as me,” said Dinosaur Dan.

“You saw two animals, you silly lizard.”
Mrs Popinpop lived in a big house. The house was on the hill. There was a big tree by Mrs Popinpop’s house.
Mrs Popinpap had a cat.
It was a big, orange cat.
The cat was called Goldie.

Goldie liked to sit on the rug.
She liked to sit on Mrs Popinpap’s lap.
She liked to sleep on Mrs Popinpap’s bed.

One night, Mrs Popinpap was in bed.
Goldie was on the bed.
There was a “Sreeeeetch!”

Mrs Popinpap sat up.
Goldie sat up, too.
“It’s a ghost,” said Mrs Popinpap.
“There is a ghost in the house.”
“Screeeeetch!”

“The ghost is coming,” said Mrs Popinpop.
“The ghost is coming to get us.”

She got out of bed.
“Come on Goldie,” she said.
“We will get the ghost before it gets us!”

Mrs Popinpop and Goldie went to get the ghost.
They went downstairs.
They looked and they looked.
No ghost.

They went upstairs.
They looked and looked.
No ghost.

“Come on Goldie,” said Mrs Popinpop.
“We are going back to bed.”
“The ghost is out here,” said Mrs Popinpop.
“Look Goldie! Look at the ghost!”
Sonny lives with Sandy.
Sonny is a dog.
A big, black dog.
A big, black, shaggy dog.

Sonny likes to sleep in the sun.
He likes to sleep on the mat
and he likes to sleep on the chair.
Sonny likes men.
He likes it when Greg comes.
He likes it when Mark comes.
He likes it when Dave comes.
And he likes it when Dean comes.

Most of all, Sonny likes cats.
He likes running after cats!
He runs after big cats and little cats.
He runs after black cats and white cats.

One day, Sonny ran after a black cat.
The black cat ran away down the road.
Sonny ran away down the road after it.
Sonny did not come back so Sandy went to look for him.

“Sonny! Sonny! Where are you?” said Sandy.
But Sonny did not come.

Sandy got in her car.
She went way down the road calling Sonny.
But Sonny did not come.

Sandy went all the way to town.
And there was Sonny.
He was sleeping.

“There you are Sonny,” said Sandy.
“You were lost.
Come on. We will go home.”
“No more running after cats!”
“Let’s go to the moon,” Kayla said to Ben one day.

“Yes,” said Ben.
“Let’s go to the moon now.”

“I will make the spaceship,” said Kayla.

So she made a big spaceship.

“I will make the space helmets,” said Ben.

So he made two space helmets.

“Let’s go and get our spacesuits on now,” said Kayla.

So Kayla and Ben went and put their spacesuits on.
“Let’s get some food to take to the moon,” said Ben.

So Ben and Kayla got some food to take to the moon.

“Let’s go,” said Kayla.

So they put on their space helmets and got into their spaceship.

10, 9, 8, 7, 6, 5, 4, 3, 2, 1 - BLAST OFF!

Their spaceship went fast.

Now Kayla and Ben are in space. They are going to the moon. They are going faster and faster.
“Here is the moon,” said Kayla. “Let’s land now.”

“No,” said Ben. “Look out! Look out! There is a big rock in the way!”

BANG! CRASH!
Kayla and Ben crash-landed.

Dad came in. “What is all this?” he said.

“We crash-landed on the moon,” said Ben.
Shari and Amy made a playhouse. They made it in the backyard.

They dressed up. They got hats, and dresses, and shoes. They played and played in the playhouse.

“I like playing in the playhouse,” Shari said to Amy.
Jade and Shelley came by.

“Will you let us play in the playhouse?” they said.

“Yes,” said Amy.
“We will let you play. Come in.”

“You can get dressed up and then we will play,” said Amy.

Jade and Shelley dressed up.
Tracey and Grace came by.
“Will you let us play
in the playhouse?” they said.

“Yes,” said Shari.
“We will let you play.
Come in.”

Chetan and Mark came by.

“Will you let us play
in the playhouse?” Chetan said.

“No!” said Shari.
“No boys in the playhouse!”
Chetan and Mark went away.
They got some apples.
They got some bananas.
They got some drinks.
They got a cake.

“Will you let us play now?”
they said.
Thumper hit his paw.

“Come here, Thumper,” said Igor.
“Let me look at your paw.”
Thumper limped up to Igor.

“I will take you to the vet,” said Igor.
“He will look at your sore paw. Get in the car, Thumper.”
“Come in, Thumper,” said the vet.
“Let me look at your sore paw.”
Thumper limped up to the vet.

“I will have to make Thumper go to sleep,” said the vet.
“Then I will fix his sore paw.”
The vet put Thumper to sleep, and fixed his paw.

“Thumper must take these pills,” said the vet to Igor. “He must take one at night.”
“Come on Thumper,” Igor said.
“I will take you and your sore paw home.”
Appendix C

Books without illustrations

The following texts were used by the No Picture group in the learning phase of Experiments 1 and 3, and are listed alphabetically. The first image shows the front and back covers of the book. The second picture contains publishing information. The final image includes the level, word count and high frequency words in the text.
On Friday, we went to the library.
We were going to get some books to read.
Dad put the car
in the carpark.
The carpark
is under the library.

We went up the path.
We went into the library.
is under the library.
I went upstairs
to look at the books.
I looked at books about pets.
I want to get a pet.
Dad said I can have a pet
one day.

Dad went downstairs
to look at books.
Dad looked
at books about trucks.
Dad likes trucks.
Dad wants
to get a truck one day.
Dad went downstairs.

Casey went to look on the computer.
She wanted to get a book on cooking.
She likes cooking.

to get a truck one day.

Casey got her cookbook.
I got my pet book.
Dad got his truck book.
We went to the librarian.
The librarian checked out the books.

We went home.
Casey got her cookbook. 
I got my pet book. 
Dad got his truck book. 
We went to the librarion. 
The librarian checked out the books.

We went home.
After school I play with my dog. My dog likes playing with me. He gets the ball.
After I play with my dog,
I watch TV.
I like watching TV.
My dog likes watching TV, too.

After I watch TV,
I eat my dinner.
I have meat.

My dog eats his dinner.
He eats meat, too.
After I eat my dinner,
I read my book.
I read my book to my dog.

After I read my book,
I go to bed.
My dog goes to bed, too.

After I go to bed,
I go to sleep.
My dog sleeps by my bed.
He goes to sleep, too.
Index

ball.............................. 2

book............................. 10, 12

dog............................... 2, 4, 8, 10, 12, 14

meat............................. 6, 8
“I can’t find my phone,” said Dad.
“Where, oh where can it be?”
Josh was in the kitchen.

“I can’t find my phone,” said Dad.

“Where did you have it?” said Josh.

“I don’t know,” said Dad.

Dad and Josh looked and looked.
They did not find the phone.

Shelly was in the bedroom.

“I’m looking for my phone,” said Dad.
“Can you help me?”

“Where did you have it?” Shelly said.

“I don’t know,” said Dad.
Dad and Shelly and Josh looked and looked.
They did not find the phone.

Luke was outside.

“I’m looking for my phone,” said Dad.

“Where have you looked?” said Luke.

“I’ve looked inside,” said Dad.


Luke looked and looked.
He looked on the path.
He looked in the bush.
“Here it is,” he said.
“It was on the gate.”
Dinosaur Dan was big.
He had big legs.
He had a big head
and he had big teeth!

One day, Lucy Lizard
came to see Dinosaur Dan.

"I saw a big animal," she said.

"Was it as big as me?"
said Dinosaur Dan.

"Bigger," said Lucy Lizard.
“Did it have legs as big as my legs?” said Dinosaur Dan.

“It had bigger legs,” said Lucy Lizard. “I saw them.”

“Did it have a head as big as my head?” said Dinosaur Dan.

“Yes it did,” said Lucy Lizard. “I saw its head. It had a BIG head!”
“Did you see its teeth?” said Dinosaur Dan.

“Yes,” said Lucy Lizard.
“I saw its teeth.
It had the two biggest teeth I have ever seen.”

“That cannot be,” said Dinosaur Dan.
“I am the biggest animal here.
I have the biggest legs.
I have the biggest head and I have the biggest teeth.”

“I saw it,” said Lucy Lizard.
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Dinosaur Dan went with Lucy Lizard to look at the big animal.

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The cat was called Goldie.

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She liked to sit on Mrs Popinpop’s lap.
She liked to sleep on Mrs Popinpop’s bed.

One night, Mrs Popinpop was in bed.
Goldie was on the bed.
There was a “screeeetch!”

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Goldie sat up, too.
“It’s a ghost,” said Mrs Popinpop.
“There is a ghost in the house.”
“Screeeeetch!”

“The ghost is coming,”
said Mrs Popinpop.
“The ghost is coming to get us.”

She got out of bed.
“Come on Goldie,” she said.
“We will get the ghost before it gets us!”

Mrs Popinpop and Goldie
went to get the ghost.
They went downstairs.
They looked and they looked.
No ghost.

They went upstairs.
They looked and looked.
No ghost.

“Come on Goldie,” said Mrs Popinpop.
“We are going back to bed.”
"The ghost is out here,"
said Mrs Popinpop.
"Look Goldie! Look at the ghost!"
Sonny Gets Lost

Written by Josephine Selwyn
Illustrated by Stella Yang

Sonny lives with Sandy.
Sonny is a dog.
A big, black dog.
A big, black, shaggy dog.

Sonny likes to sleep in the sun.
He likes to sleep on the mat
and he likes to sleep on the chair.
Sonny likes men.
He likes it when Greg comes.
He likes it when Mark comes.
He likes it when Dave comes.
And he likes it when Dean comes.

Most of all, Sonny likes cats.
He likes running after cats!
He runs after big cats and little cats.
He runs after black cats and white cats.

One day, Sonny ran after a black cat.
The black cat ran away down the road.
Sonny ran away down the road after it.
Sonny did not come back
so Sandy went to look for him.

“Sonny! Sonny! Where are you?” said Sandy.
But Sonny did not come.

Sandy got in her car.
She went way down the road,
calling Sonny.
But Sonny did not come.

Sandy went all the way to town.
And there was Sonny.
He was sleeping.

“There you are Sonny,” said Sandy.
“You were lost.
Come on. We will go home.”
“No more running after cats!”
The Playhouse

9a String Things
9b The Old Race
9c The Playhouse
9d Where Does Mrs Brown Live?
9e Who Took the Teacher's Scissors?
9f Hide and Seek With Carla Crocodile
9g Pizza Day
9h Operation Elephant Food

Written by Shilo Berry
Illustrated by Mike Moreau
Shari and Amy made a playhouse.
They made it in the backyard.

They dressed up.
They got hats, and dresses, and shoes.
They played and played in the playhouse.

“I like playing in the playhouse,” Shari said to Amy.
Jade and Shelley came by.

“Will you let us play in the playhouse?” they said.

“Yes,” said Amy.
“We will let you play. Come in.”

“You can get dressed up and then we will play,” said Amy.

Jade and Shelley dressed up.
Tracey and Grace came by.
"Will you let us play in the playhouse?" they said.

“Yes,” said Shari.
“We will let you play. Come in.”

Chetan and Mark came by.

“Will you let us play in the playhouse?” Chetan said.

“No!” said Shari.
“No boys in the playhouse!”
Chetan and Mark went away. They got some apples. They got some bananas. They got some drinks. They got a cake. "Will you let us play now?" they said.
“Let’s go to the moon,” Kayla said to Ben one day.

“Yes,” said Ben.

“Let’s go to the moon now.”

“I will make the spaceship,” said Kayla.

So she made a big spaceship.
“I will make the space helmets,” said Ben.

So he made two space helmets.

“Let’s go and get our spacesuits on now,” said Kayla.

So Kayla and Ben went and put their spacesuits on.

“Let’s get some food to take to the moon,” said Ben.

So Ben and Kayla got some food to take to the moon.

“Let’s go,” said Kayla.

So they put on their space helmets and got into their spaceship.

10, 9, 8, 7, 6, 5, 4, 3, 2, 1 - BLAST OFF!
Their spaceship went fast.
Now Kayla and Ben are in space. They are going to the moon. They are going faster and faster.

“Here is the moon,” said Kayla. “Let’s land now.”

“No,” said Ben. “Look out! Look out! There is a big rock in the way!”

BANG! CRASH!
Kayla and Ben crash-landed.

Dad came in.
“What is all this?” he said.
“We crash landed on the moon,” said Ben.
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
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<tbody>
<tr>
<td>8a</td>
<td>Thumper's Sore Paw</td>
</tr>
<tr>
<td>8b</td>
<td>Life in the Trees</td>
</tr>
<tr>
<td>8c</td>
<td>Walter, the Water Taxi</td>
</tr>
<tr>
<td>8d</td>
<td>A New Place to Live</td>
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<tr>
<td>8e</td>
<td>Dad's Phone</td>
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<tr>
<td>8f</td>
<td>A Visit to the Library</td>
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<tr>
<td>8g</td>
<td>Zippy Zebra Finds a Friend</td>
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<tr>
<td>8h</td>
<td>Trains</td>
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</tbody>
</table>
Thumper hit his paw.

"I will take you to the vet," said Igor.
"He will look at your sore paw.
Get in the car, Thumper."

Thumper limped up to Igor.

"Come here, Thumper," said Igor.
"Let me look at your paw."

Thumper limped up to Igor.
“Come in, Thumper,” said the vet.
“Let me look at your sore paw.”
Thumper limped up to the vet.

“I will have to make Thumper go to sleep,” said the vet.
“Then I will fix his sore paw.”
Thumper limped up to the vet.
The vet put Thumper to sleep, and fixed his paw.

"Thumper must take these pills," said the vet to Igor. "He must take one at night."
“Thank you,” said Igor to the vet.

“Look after your sore paw,” the vet said to Thumper.

“Come on Thumper,” Igor said.

“I will take you and your sore paw home.”
Appendix D

Books with faces

The following texts were used by the Faces group in the learning phases in both Experiments 2 and 3, and are listed alphabetically. The first image shows the front and back covers of the book containing publishing information. The final image includes the level, word count and high frequency words in the text.
On Friday, we went to the library. We were going to get some books to read.
Dad put the car in the carpark. The carpark is under the library.

We went up the path. We went into the library.
I went upstairs to look at the books. I looked at books about pets. I want to get a pet. Dad said I can have a pet one day.

Dad went downstairs to look at books. Dad looked at books about trucks. Dad likes trucks. Dad wants to get a truck one day.
Casey went to look on the computer. She wanted to get a book on cooking. She likes cooking.

Casey got her cookbook. I got my pet book. Dad got his truck book. We went to the librarian. The librarian checked out the books.
We went home.
After school I play with my dog. My dog likes playing with me. He gets the ball.
After I play with my dog,
I watch TV.
I like watching TV.
My dog likes watching TV, too.

After I watch TV,
I eat my dinner.
I have meat.

My dog eats his dinner.
He eats meat, too.
After I eat my dinner,  
I read my book.  
I read my book to my dog.

After I read my book,  
I go to bed.  
My dog goes to bed, too.

After I go to bed,  
I go to sleep.  
My dog sleeps by my bed.  
He goes to sleep, too.
“I can’t find my phone,” said Dad.
“Where, oh where can it be?”
Josh was in the kitchen.
“I can’t find my phone,” said Dad.
“Where did you have it?” said Josh.
“I don’t know,” said Dad.

Dad and Josh looked and looked. They did not find the phone.

Shelly was in the bedroom.
“I’m looking for my phone,” said Dad.
“Can you help me?”
“Where did you have it?” Shelly said.
“I don’t know,” said Dad.
Dad and Shelly and Josh looked and looked. They did not find the phone.

Luke was outside.

“I’m looking for my phone,” said Dad.

“Where have you looked?” said Luke.

“I’ve looked inside,” said Dad.

Luke looked and looked. He looked on the path. He looked in the bush.
“Here it is,” he said.
“It was on the gate.”
10a What Time Is It?
10b Mrs Popinpop's Ghost
10c Dinosaur Dan
10d Bad Weather, Good Weather
10e Sonny Gets Lost
10f The Noisy Spider
10g Places Where People Live
10h The Moon Landing
Dinosaur Dan was big.
He had big legs.
He had a big head
and he had big teeth!

One day, Lucy Lizard
came to see Dinosaur Dan.

"I saw a big animal," she said.

"Was it as big as me?"
said Dinosaur Dan.

"Bigger," said Lucy Lizard.
“Did it have legs as big as my legs?” said Dinosaur Dan.

“It had bigger legs,” said Lucy Lizard. “I saw them.”

“Did it have a head as big as my head?” said Dinosaur Dan.

“Yes it did,” said Lucy Lizard. “I saw its head. It had a BIG head!”
“Did you see its teeth?”
said Dinosaur Dan.

“Yes,” said Lucy Lizard.
“I saw its teeth.
It had the two biggest teeth
I have ever seen.”

“That cannot be,”
said Dinosaur Dan.
“I am the biggest animal here.
I have the biggest legs.
I have the biggest head
and I have the biggest teeth.”

“I saw it,” said Lucy Lizard.
“Come with me and you will see.”
Dinosaur Dan went with Lucy Lizard to look at the big animal.

“That animal is not as big as me,” said Dinosaur Dan.

“You saw two animals, you silly lizard.”
Mrs Popinpop lived in a big house.
The house was on the hill.
There was a big tree
by Mrs Popinpop’s house.
Mrs Popinpop had a cat. It was a big, orange cat. The cat was called Goldie.

Goldie liked to sit on the rug. She liked to sit on Mrs Popinpop’s lap. She liked to sleep on Mrs Popinpop’s bed.

One night, Mrs Popinpop was in bed. Goldie was on the bed. There was a “screeeetch!”

Mrs Popinpop sat up. Goldie sat up, too. “It’s a ghost,” said Mrs Popinpop. “There is a ghost in the house.”
“Screeeetch!”

“The ghost is coming,” said Mrs Popinplop.
“The ghost is coming to get us.”

She got out of bed.
“Come on Goldie,” she said.
“We will get the ghost before it gets us!”

Mrs Popinplop and Goldie went to get the ghost.
They went downstairs.
They looked and they looked.
No ghost.

They went upstairs.
They looked and looked.
No ghost.

“Come on Goldie,” said Mrs Popinplop.
“We are going back to bed.”
"The ghost is out here," said Mrs. Popinpop.
"Look Goldiel! Look at the ghost!"
Sonny Gets Lost

Written by Josephine Selwyn
Illustrated by Stella Yang

Sonny lives with Sandy.
Sonny is a dog.
A big, black dog.
A big, black, shaggy dog.

Sonny likes to sleep in the sun.
He likes to sleep on the mat and he likes to sleep on the chair.
Sonny likes men. He likes it when Greg comes. He likes it when Mark comes. He likes it when Dave comes. And he likes it when Dean comes.

Most of all, Sonny likes cats. He likes running after cats! He runs after big cats and little cats. He runs after black cats and white cats.

One day, Sonny ran after a black cat. The black cat ran away down the road. Sonny ran away down the road after it.
Sonny did not come back so Sandy went to look for him.

"Sonny! Sonny! Where are you?" said Sandy. But Sonny did not come.

Sandy got in her car. She went way down the road, calling Sonny. But Sonny did not come.

Sandy went all the way to town. And there was Sonny. He was sleeping.

"There you are Sonny," said Sandy. "You were lost. Come on. We will go home."
“No more running after cats!”
“Let’s go to the moon,” Kayla said to Ben one day.

“Yes,” said Ben.
“Let’s go to the moon now.”

“I will make the spaceship,” said Kayla.
So she made a big spaceship.
“I will make the space helmets,” said Ben.
So he made two space helmets.

“Let’s go and get our spacesuits on now,” said Kayla.
So Kayla and Ben went and put their spacesuits on.

“Let’s get some food to take to the moon,” said Ben.
So Ben and Kayla got some food to take to the moon.

“Let’s go,” said Kayla.
So they put on their space helmets and got into their spaceship.

10. 9. 8. 7. 6. 5. 4. 3. 2. 1 - BLAST OFF!
Their spaceship went fast.
Now Kayla and Ben are in space.
They are going to the moon.
They are going faster and faster.

“Here is the moon,” said Kayla.
“Let’s land now.”

“No,” said Ben. “Look out! Look out!
There is a big rock in the way!”

BANG! CRASH!
Kayla and Ben crash-landed.

Dad came in.
“What is all this?” he said.
"We crash-landed on the moon," said Ben.
Shari and Amy made a playhouse.
They made it in the backyard.

They dressed up. They got hats, and dresses, and shoes. They played and played in the playhouse.

"I like playing in the playhouse," Shari said to Amy.
Jade and Shelley came by.

"Will you let us play in the playhouse?" they said.

"Yes," said Amy.
"We will let you play. Come in."

"You can get dressed up and then we will play," said Amy.

Jade and Shelley dressed up.
Tracey and Grace came by.
"Will you let us play
in the playhouse?" they said.

"Yes," said Shari.
"We will let you play.
Come in."

Chetan and Mark came by.

"Will you let us play
in the playhouse?" Chetan said.

"No!" said Shari.
"No boys in the playhouse!"
Chetan and Mark went away. They got some apples. They got some bananas. They got some drinks. They got a cake.

"Will you let us play now?" they said.
Thumper hit his paw.

“Come here, Thumper,” said Igor.
“Let me look at your paw.”
Thumper limped up to Igor.

“I will take you to the vet,”
said Igor.
“He will look at your sore paw.
Get in the car, Thumper.”
“Come in, Thumper,” said the vet.
“Let me look at your sore paw.”

Thumper limped up to the vet.

“I will have to make Thumper
go to sleep,” said the vet.
“Then I will fix his sore paw.”
The vet put Thumper to sleep, and fixed his paw.

“Thumper must take these pills,” said the vet to Igor. “He must take one at night.”
“Thank you,” said Igor to the vet.

“Look after your sore paw,” the vet said to Thumper.

“Come on Thumper,” Igor said. “I will take you and your sore paw home.”
Appendix E

Sight words and sentences

Sight words and sentences taken from the books were used in all three experiments in both the reading phase testing exercise and on the test day. An example of a sight word and a sentence card are shown below.

**play**

**We will let you play.**

The following lists are the sight words and the sentences which were derived from each book, and which are listed alphabetically. The final list presents the sight words and sentences which were used on the test day for all three experiments.
A Visit to the Library - sight words

Friday  going

carpark  about

library  went

cooking  some

path  out

A Visit to the library - sentences

I want to get a pet.

Dad got his truck book.

We went into the library.

On Friday, we went to the library.

She likes cooking.

Dad wants a book on cooking.

The car is at home.

She went to get a pet.

We went into the carpark.

I can have a computer one day.
**After School - sight words**

- playing
- with
- like
- goes
- meat
- after
- watch
- have
- dinner
- my

**After School - sentences**

- My dog likes watching TV.
- I have meat.
- I read my book.
- He goes to sleep.
- My dog sleeps by my bed.
- My dog eats meat.
- After school I watch TV.
- I eat my meat.
- I play after my dinner.
- My dog plays with me.
**Dad’s Phone – sight words**

phone    where
kitchen   don’t
find      have
outside   said
bush      was

**Dad’s Phone – sentences**

Where did you have it?
They did not find the phone.
I’m looking for my phone.
I will look outside.
It was on the gate.
Luke was inside.
I’ve looked in the kitchen.
He looked inside.
I’m looking for the bedroom.
They looked and looked for it.
**Dinosaur Dan – sight words**

animal    said
head      have
teeth     here
silly     that
lizard    you

**Dinosaur Dan – sentences**

I have the biggest legs.

Did you see its teeth?

I saw its head.

Come with me and you will see.

Dinosaur Dan was big.

Lucy lizard had big teeth.

That animal had a big head.

You saw its legs.

Did he have two legs?

Dan said Lucy was silly.
Mrs Popinpop’s Ghost – sight words

house  they
orange  are
ghost  out
lived  by
before  was

Mrs Popinpop’s Ghost – sentences

There is a ghost in the house.
We are going back to bed.
The house was on the hill.
It was a big, orange cat.
She liked to sleep.
The ghost went downstairs.
We are going to sit on the rug.
The cat was on the hill.
Goldie lived in a big house.
The ghost went back to bed.
Sonny Gets Lost – sight words

chair     down
shaggy    were
white     after
running   there
road      said

Sonny Gets Lost – sentences

Sonny likes to sleep.
The black cat ran away.
No more running after cats.
He likes it when Greg comes.
Most of all, Sonny likes cats.
The black cat ran to town.
He runs after a black dog.
He likes running.
Where did Sandy go?
Black and white cats sleep.
The Moon Landing – sight words

spaceship   two
helmet      their
fast        here
crash       what
food        going

The Moon Landing – sentences

Let’s go to the moon.
Their spaceship went fast.
There is a big rock in the way.
Kayla and Ben are in space.
I will make the space helmets.
Ben went to the moon.
Dad went to the moon.
They are landing on the moon.
Let’s get our spacesuit.
We will take food into space.
The Playhouse – sight words

play    some
 cake    said
 boys    came
 apples  went
 dressed they

The Playhouse – sentences

We will let you play.
I like playing in the playhouse.
They got some bananas.
They made it in the backyard.
Jade and Shelley dressed up.
No apples in the playhouse.
Will you let the boys in?
I like hats and shoes.
We will let you come.
You can get the drinks.
**Thumper’s Sore Paw – sight words**

- paw
- put
- sore
- your
- fix
- here
- night
- said
- these
- come

**Thumper’s Sore Paw – sentences**

- He must take one at night.
- I will fix his sore paw.
- I will take you to the vet.
- Get in the car.
- Let me look at your paw.
- Thumper limped to the vet.
- Thumper will have to go to sleep.
- Take these pills at night.
- Let me look at the car.
- Igor will take you home.
**Test Day Sight Words**

bush       are
food       before
helmet     where
two        that
chair      here
like       was
out        come
road       have
meat       said
house      about

**Test Day Sentences**

*Existing Sentences (taken directly from the texts used in the learning phase)*

I want to get a pet.
Where did you have it?
The house was on the hill.
Let’s go to the moon.
He goes to sleep.
The black cat ran away.
I have the biggest legs.
Invented Sentences (children previously exposed once to the invented sentences in the learning test phase)

The car is at home.
I’m looking for the bedroom.
The cat was on the hill.
Dad went to the moon.
My dog plays with me.
Let me look at the car.
You can get the drinks.

Brand New Sentences (sentences are new to the child but contain no new vocabulary)

She likes the rug.
The dog went to the vet.
He must go to the library.
Let’s take bananas into space.
The cat had big teeth.
I like running to school.
Do you sleep at home
Appendix F

Journal Article

The following article is in press in the journal *Applied Cognitive Psychology*. The article was accepted for publication on 2\textsuperscript{nd} March 2009.
The Use of Illustrations When Learning to Read: A Cognitive Load Theory Approach

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University of New South Wales, Australia

SUMMARY

Three experiments were conducted to investigate the effects of including illustrations in beginning reading materials. Experiment 1 compared reading materials consisting solely of simple prose passages with materials consisting of the same passages plus informative illustrations depicting the content of each passage. Reading proficiency improved more under the no illustrations condition. Experiment 2 compared the informative illustrations with uninformative illustrations. Reading proficiency improved more using uninformative illustrations. Experiment 3 compared uninformative illustrations with no illustrations and found no significant differences between conditions. These results were interpreted within a cognitive load theory framework. It was concluded that informative illustrations are redundant and so impose an extraneous working memory load that interferes with learning to read. Copyright © 2009 John Wiley & Sons, Ltd.
knowledge is specific knowledge that humans have evolved to acquire over many generations such as learning to listen and speak. We do not have to explicitly teach children to listen and speak their first language because we have evolved to acquire these skills just by immersion in a society. In contrast, we do need to explicitly teach children how to read and write because these skills provide examples of biologically secondary knowledge that we have not explicitly evolved to acquire. Biologically secondary forms of knowledge and competencies are acquired through culturally motivated formal instruction. The cognitive architecture described below applies to biologically secondary knowledge.

The basic logic of those aspects of human cognitive architecture relevant to biologically secondary knowledge (and hence relevant to learning to read) can be described by five principles that apply to all natural information processing systems (Sweller & Sweller, 2006). The information store principle accounts for long-term memory. It suggests that human activity is largely directed by a huge amount of information stored in long-term memory. The borrowing and reorganising principle proposes that the bulk of information stored in long-term memory is obtained from other people by imitating what they do, listening to what they say and reading what they write. The randomness as genesis principle states that novel information is created during problem solving using a random generation and test procedure. The narrow limits of change principle accounts for working memory characteristics when dealing with novel information. It indicates that only a few items of novel information can be dealt with when randomly generating hypotheses and testing them for effectiveness resulting in working memory having severe capacity limits. The environmental organising and linking principle accounts for the fact that when dealing with information in long-term memory that already has been organised to deal with the environment, working memory has no known capacity limits.

Based on this architecture, the function of learning is to store information in long-term memory that can be used to direct activity. If nothing has been stored in long-term memory, nothing has been learned. Cognitive load theory has hypothesised a series of effects that assist learners to process information in working memory for storage in long-term memory (Kalyuga, Ayres, Chandler, & Sweller, 2003; Paas et al., 2003, 2004; Paas & Van Gog, 2006; Renkl, 2005; Renkl & Atkinson, 2003; Renkl, Atkinson, Maier, & Staley, 2002; Sweller, 2003, 2004; Sweller, Van Merrienboer, & Paas, 1998; Van Gog, Paas, & Van Merrienboer, 2006). One of those effects is the redundancy effect.

The redundancy effect occurs when learners are required to attend to information irrelevant to the task in hand that is presented in addition to necessary information (Sweller, 2005). Processing a diagram along with text that re-describes the diagram in words
provides an example (Chandler & Sweller, 1991) with learning enhanced by eliminating the redundant text. Listening and reading the same text provides another example (Kalyuga, Chandler, & Sweller, 2004). Eliminating the written information improved learning. The redundancy effect similarly has been demonstrated with students learning English as a foreign language who were presented with the written and spoken text simultaneously (Diao, Chandler, & Sweller, 2007; Diao & Sweller, 2007). Learning to comprehend spoken English was enhanced by eliminating the written text. These and many other forms of redundancy interfere with learning because unnecessarily processing multiple sources of information imposes an extraneous cognitive load that interferes with learning (Sweller, 2005). By removing nonessential information and decreasing the working memory load, the redundancy effect can be ameliorated.

It can be hypothesised that the inclusion of illustrations with written text constitutes redundant information that may interfere with learning. If working memory resources are devoted to the illustrations rather than the text, as is likely with young children, those resources will be unavailable to decipher the text and, of course, learning to decipher text rather than looking at illustrations is the purpose of the exercise. The elimination of redundant illustrations may enhance learning to read.

Geary’s (2007) distinction between biologically primary and biologically secondary knowledge is directly relevant to this issue. Given a complex task such as learning to read, the novice reader may automatically attend to the more salient features, that in this case are the illustrations, as perceiving objects, whether real or by illustration, are likely to belong to the primary knowledge domain. (While attending to pictures may be biologically primary, further processing of unfamiliar pictures is likely to be biologically secondary.) Furthermore, there may be a biologically primary tendency to seek meaning and for a young, novice reader, the illustrations are likely to reveal the meaning of the text much more easily than the text itself. Attending to an illustration may enhance understanding but reduce working memory resources devoted to processing text. Processing text is essential when students are learning to decode.

Proficiency in reading is the ability to process words and sentences quickly and effortlessly (Adams, 1990). Based on the cognitive architecture outlined above, if the addition of illustrations impairs working memory functioning when learning to read, less information will be stored in long-term memory reducing reading skill. Accordingly, from that architecture, we can hypothesise that the presence of meaningful pictures may inhibit learning to decode.

Of course, comprehension is an essential part of reading, and indeed is the goal of reading. However, when children are in the decoding stage, and are still consciously decoding individual letters or chunks of words, there is little spare capacity for the other processes involved in reading, such as comprehension, to take place simultaneously (Beech, 1985). Our study only focuses on the decoding stage of reading and hence comprehension is not considered, for if a learner cannot decode text, understanding (or comprehension) is impossible.

Using single words, there is some evidence of illustrations interfering with learning to read. Miller (1937) conducted an experiment with children learning to read in which one group of children was presented with a written word together with the appropriate illustration and with the word simultaneously spoken out loud. Another group was presented the same written word without the illustration and also had the word presented orally. The group presented the words without the illustration outperformed the group given the word with the accompanying illustration on a subsequent test. This result is
consistent with a cognitive load theory explanation in that by eliminating redundant or unnecessary information (in this case illustrations), the extraneous cognitive load may have lessened considerably allowing the task to be more easily performed.

Samuels (1967) conducted an experiment to test the hypothesis that illustrations interfere with learning to read words by teaching kindergarten children to read four new words. One group was taught to read the words with illustrations and the other group without illustrations. The children who had the illustrations alongside the word offered more correct responses than the children who were only presented with the word, as might be expected. However and most interestingly, in a subsequent test, when both sets of children were shown the words without illustrations, the children who were shown the illustrations with the words in the learning phase performed much worse than the children who were given the words with no illustrations. This experiment showed that the children who were given no visual cues had to rely on and pay attention to the print. In her discussion of this experiment, Adams (1990) concluded that if the goal of reading is to help the child utter the word then illustrations may be helpful. But if the goal is to have the child read the print, which is of course the objective in the decoding stage, then the illustrations may be diversionary. While illustrations have been shown to be beneficial in the pre-reading stage and once fluency has been achieved, the decoding stage requires that the child focus on the print.

Solman (1986) observed that when a child was presented with both an illustration and word the child would go to the illustration first in order to correctly decipher the meaning. Both Samuels and Solman were able to posit similar findings; that children who were shown words without illustrations were more successful in their ability to decipher words than the children who were given both words and the matching illustrations. These results demonstrated the negative effect that an illustration can have in the decoding process. If decoding is the goal, then presenting illustrations may hinder this process and increase extraneous cognitive load.

Previous reading experiments have demonstrated the redundancy effect for single word recognition. The current experiments tested whether the redundancy effect could be obtained using students reading text rather than single words. Since illustrations are almost universal in reading materials for beginner readers, the effect of redundancy could have a significant impact on this group’s learning. Experiment 1 looked at the consequences of removing all the illustrations from a graded series of beginner reading books. It was hypothesised that the children who were given books containing no illustrations would perform better than those given illustrated books due to a decreased extraneous cognitive load.

Experiment 2 was designed to test whether any extraneous cognitive load identified in the previous experiment was merely distractive or if the illustrations were being used as an information source by the reader. Participants in this experiment were given books containing faces instead of illustrations related to the text. It was hypothesised that the children who were given books containing the faces would perform better at both reading the books, as well as being able to read single words and sentences from the text than the children given relevant illustrations. This result would indicate it is the nature of the illustrations rather than illustrations per se that cause the redundancy effect in this context.

Experiment 3 provided a logical conclusion to the previous experiments by testing whether there was any difference between children’s reading ability when presented with unillustrated books or books reproduced with faces. It was hypothesised that there would be no difference between the groups as there was no redundant material to process by students in either group.
Children in this study were at a beginner reading level which is determined irrespective of age and hence all were in the decoding stage of reading. Although the age level was not important, the age of the participants was consistent within each experiment.

**EXPERIMENT 1**

This experiment was designed to establish the impact of illustrations during early reading instruction on learning to read simple prose. It was hypothesised that children given books containing sentences with no illustrations would outperform children presented identical sentences with illustrations on subsequent reading tests. The reading tests consisted of: (a) Recognising words from text in isolation; (b) reading several of the sentences from the initial learning text independently of the book itself and; (c) reading novel sentences including the words featured in the initial reading instruction but using novel combinations of those words.

**Method**

**Participants**

The participants were 22 Year 1 children attending a public school in Metropolitan Sydney, New South Wales. The children were 6–7 years of age, and were all at the same reading level ‘beginner’, as determined by their class teachers. Within this beginner group, the children were further divided into three sub-groups based on their reading ability, again determined by their class teachers. The grading of children by class teachers according to reading ability is standard practice and is part of the school curriculum in New South Wales schools.

Children were assigned into two groups of 11 with one group presented with illustrated books (the picture group), and the other group presented with unillustrated books (the no picture group). As far as numerically possible, each group had an equal number of children from each of the three sub-groups.

**Materials**

Nine books were selected from the graded series of books, classed as ‘beginner’s books’ that form part of the available reading material suitable for children at this stage of reading instruction. The nine books ranged in word count from 107 words to 197 words. The books selected (an example page is shown in Figure 1) were not previously sighted by any of the children involved in the experiment. The same nine books were then reproduced without the illustrations. Each reproduced book was identical in size, had the same font size, had the same coloured background, retained the same page numbers, with text that appeared in an identical position, as its illustrated counterpart.

The test materials included sight words and sentences. The sight words were on a laminated white background which measured 9.5 × 6.0 cm². The sentence cards which were also on a laminated white background measured 21.5 × 6.0 cm². All words were typed in black and were typed on one line in lower case letters except for the initial capital in the sentences, and any proper nouns.

**Procedure**

The experiment consisted of a learning phase (9 days) and a test phase (1 day). It was conducted over 10 school days with each child tested individually.
During the learning phase—reading exercise, each child spent approximately 5–10 minute each day with the same experimenter. On days 1–9 each child was individually presented with either illustrated books (the picture group) or text only books (the no picture group). Each child read each book aloud to the experimenter, with the experimenter taking notes of all errors. When the child was unable to produce a correct word or did not attempt a word, the experimenter gave the word in its entirety to the child regardless of which group the child was in. There was no prompting by the experimenter.

The learning phase—testing exercises began immediately after reading each text. Each child was presented with 10 sight words from the text just read and asked to say them out aloud. The words were presented on individual flashcards (word only), and consisted of both function words (such as ‘the’ and ‘a’) and open class words (such as ‘cat’ and ‘play’), with the experimenter-taking note of incorrect responses. The flashcards were identical for each child and presented in the same order.

Immediately following the sight words, each child was presented with 10 sentences (again presented in flashcard style) consisting of five actual sentences from the text just read as well as five created sentences using the same words from the text but rearranged. These sentences were text only, with no pictures, and identical for each child. There were no new words presented in these sentences. The experimenter again recorded all errors.

The test phase began on the 10th and final day. Each child was asked to read 20 words in flashcard style (text only) which were taken from the 9 readers, and which the child had already been presented with as a flashcard during the learning phase. Again, these words consisted of both function and open class words. Each child was then asked to read 21 sentences (text only), again taken from the 9 readers. These sentences consisted of seven sentences from the books which the child had already seen previously in the learning phase, seven rearranged sentences also already sighted in the learning phase-testing exercise during the previous 9 days, and seven completely novel sentences using no new vocabulary.

Results and discussion

Learning phase—reading exercise

In order to reduce variances, groups were divided into three reading levels based on teacher recommendations as indicated above and the variance due to those reading levels was consequently eliminated from the total variance, reflecting our use of matched samples. While, as is to be expected, statistically significant differences between those reading levels were obtained, the number of participants in each reading level was too small for those results to be meaningful and in any case, comparisons between reading levels had no theoretical interest. There were very few statistically significant $3 \times 2$ interactions for this or any of the subsequent analyses in this paper. For these reasons, only the differences between treatment groups are reported for the current and subsequent analyses for all three experiments of this paper.

An analysis of variance (ANOVA) was conducted on reading errors made during the reading exercise, i.e., the reading of the nine books over the 9 days learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, with the picture group making more reading errors, \( F(1,16) = 6.65, \) \( \text{MSe} = 5794.03, \) \( p = 0.02, \) partial \( \eta^2 = 0.29. \)

These results are consistent with the hypothesis that the ability to decode was inhibited for the group exposed to redundant pictures imposing an extraneous cognitive load. The no
Use of illustrations when learning to read

Table 1. Means and standard deviations (in italics) for Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>Picture</th>
<th>No Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning phase—reading exercise: Total errors</td>
<td>234.3 (89.4)</td>
<td>190.0 (85.1)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sight word errors</td>
<td>35.6 (14.8)</td>
<td>23.3 (10.1)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sentence errors</td>
<td>68.5 (33.9)</td>
<td>37.7 (23.3)</td>
</tr>
<tr>
<td>Test phase—actual sentence errors</td>
<td>6.5 (3.0)</td>
<td>3.2 (2.1)</td>
</tr>
<tr>
<td>Test phase—rearranged sentence errors</td>
<td>5.9 (3.9)</td>
<td>3.0 (2.7)</td>
</tr>
<tr>
<td>Test phase—novel sentence errors</td>
<td>7.5 (4.1)</td>
<td>4.2 (2.7)</td>
</tr>
<tr>
<td>Test phase—sight word errors</td>
<td>7.8 (2.5)</td>
<td>6.3 (2.1)</td>
</tr>
<tr>
<td>Test phase—sentence errors</td>
<td>19.9 (10.0)</td>
<td>10.4 (7.2)</td>
</tr>
</tbody>
</table>

picture group could only decode the words to decipher the text, whereas the picture group had alternate methods (based on the pictures) for deciphering the information contained in the text. Those alternative methods may have interfered with reading accuracy. A child’s attention may be focussed on the picture in order to gain information or a clue, thereby distracting the child from the task at hand, that of learning to read. Reduced ability to decode words in the test phase where the picture was not available may indicate that the child was attending to the picture rather than the written material in the learning phase.

Learning phase—testing exercise
An ANOVA was conducted on the total number of sight word errors (from the flashcards) over the 9 days. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, $F(1,16) = 5.14$, $MSe = 159.84$, $p = 0.04$, partial $\eta^2 = 0.24$, favouring the no picture group.

An ANOVA was conducted on the total number of sentence errors over the 9 days. Means and standard deviations can be found in Table 1. There was a significant difference between the picture group and the no picture group, $F(1,16) = 5.61$, $MSe = 862.43$, $p = 0.03$, partial $\eta^2 = 0.26$, favouring the no picture group.

Test phase
An ANOVA was conducted on the total errors. The three sentence types consisted of seven actual sentences from the books which the child had previously sighted during the 9-day learning phase, seven rearranged sentences also already sighted during the 9-day learning phase-testing exercise and seven completely novel sentences but using no new vocabulary. Means and standard deviations can be found in Table 1. There was a significant difference in errors between sentence types, $F(2,32) = 4.89$, $MSe = 4.88$, $p = 0.01$, partial $\eta^2 = 0.23$, with the novel sentences producing the most errors and the rearranged sentences producing the least number of errors. There was no interaction between sentence types and group, $F(2,32) = 0.14$, $MSe = 4.88$, $p > 0.05$, partial $\eta^2 = 0.009$ indicating that both the picture group and no picture group produced the same pattern of errors on all three sentence types and so the test scores were combined in all subsequent analyses.

An ANOVA was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 1. The test scores indicated no significant difference between the picture and no picture group in the reading of the sight words, $F(1,16) = 2.17$, $MSe = 5.40$, $p > 0.05$, partial $\eta^2 = 0.12$. There was a significant difference between groups in the reading of the sentences, $F(1,16) = 5.86$, $MSe = 76.96$, $p = 0.03$, partial $\eta^2 = 0.27$, favouring the no picture group.
It was hypothesised that the test performance of the no picture group would be higher than the picture group. We suggest that this result may be explained by the redundancy effect due to the presence of pictures imposing an extraneous cognitive load. The results supported this hypothesis. Based on these results, the next experiment was designed to test whether the suggested extraneous load was merely distractive or if readers were using the illustrations as an information source.

**EXPERIMENT 2**

The presence of pictures when children are learning to read may act as a distracter from the text. If learners are attending to a picture rather than to the words, we might expect a learning decrement compared to a no-picture condition, as was obtained in Experiment 1. An alternative hypothesis is that the pictures did not merely distract readers’ attention but in addition provided learners with information concerning the text. That information may then have been used as a substitute for reading. Working memory resources, rather than being used to decode the text that was the purpose of the exercise, instead may have been used to decode the picture. Students may have learned that the picture could be used to provide the same or similar information as the text and so felt no need to decode the text, resulting in reduced learning compared to learners who only had the text available and so practiced reading rather than picture interpretation.

These two hypotheses can be compared by using a reading book with potentially distracting but non-informative pictures, and contrasting it with the informative pictures used in Experiment 1. Experiment 2 was identical to Experiment 1 except that a book with pictures of faces was used as a substitute for the no-pictures condition and compared to a condition that included informative pictures relevant to the text, as in the pictures condition of Experiment 1. It was hypothesised that children given books containing faces irrelevant to the text would perform better than children given informative pictures.

**Method**

**Participants**

The participants were 24 kindergarten children attending a public school in Metropolitan Sydney, NSW. The children were 5–6 years in age, and were all at the same reading level ‘beginner’ as determined by their class teachers. As with Experiment 1, the children were further divided into the three sub-groups based on their reading ability, again determined by their class teachers. They were assigned to two groups of 12 with one group presented with illustrated books (the picture group), and the other group presented with reproduced books having faces (the faces group). Each group had an equal number of children from each of the three sub-groups.

**Materials and procedure**

The materials and procedure were identical to that of Experiment 1 with the only difference being the nature of the books. The same illustrated books were used, but instead of having books with no illustrations, as detailed in Experiment 1, the reproduced books in this experiment were designed with a varied assortment of faces and facial expressions (see Figure 2). The faces used were very different in each reproduced book in order to ensure that the child would remain interested and find the images engaging. The faces
encompassed the entire page and appeared in exactly the same place as the illustrations in the illustrated books. The background colour, font and page numbers were identical to the illustrated books.

Results and discussion

Learning phase—reading exercise
An ANOVA on the number of reading errors made was conducted for the reading exercise, i.e. the reading of the 9 books over the 9-day learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 2. There was a significant difference between the picture group and the faces group, with the picture group making more errors, $F(1,18) = 14.43$, MSe = 2625.89, $p < 0.01$, partial $\eta^2 = 0.45$.

Learning phase—testing exercise
An ANOVA was conducted on the total number of sight word errors over the 9 days. Means and standard deviations can be found in Table 2. There was a significant difference between the picture group and the faces group, $F(1,18) = 9.66$, MSe = 92.01, $p < 0.01$, partial $\eta^2 = 0.35$, favouring the faces group.

An ANOVA was conducted on the total number of sentence errors over the 9 days. Means and standard deviations can be found in Table 2. There was a significant difference between

Table 2. Means and standard deviations (in italics) for Experiment 2 [Correction made here after initial online publication]

<table>
<thead>
<tr>
<th></th>
<th>Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning phase—reading exercise: Total errors</td>
<td>199.3 (121.2)</td>
<td>110.3 (61.0)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sight word errors</td>
<td>30.1 (22.3)</td>
<td>16.2 (11.4)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sentence errors</td>
<td>58.4 (45.3)</td>
<td>21.8 (15.6)</td>
</tr>
<tr>
<td>Test phase—actual sentence errors</td>
<td>5.0 (4.1)</td>
<td>2.2 (1.8)</td>
</tr>
<tr>
<td>Test phase—rearranged sentence errors</td>
<td>4.4 (3.6)</td>
<td>1.9 (1.4)</td>
</tr>
<tr>
<td>Test phase—novel sentence errors</td>
<td>6.7 (5.2)</td>
<td>2.6 (2.1)</td>
</tr>
<tr>
<td>Test phase—sight word errors</td>
<td>7.3 (5.0)</td>
<td>3.8 (2.6)</td>
</tr>
<tr>
<td>Test phase—sentence errors</td>
<td>15.9 (11.8)</td>
<td>6.7 (4.8)</td>
</tr>
</tbody>
</table>
the picture group and the faces group, $F(1,18) = 14.83$, $MSe = 398.12$, $p < 0.01$, partial $\eta^2 = 0.45$, favouring the faces group.

**Test phase**

An ANOVA was conducted on the total errors. The three sentence types consisted of seven actual sentences from the books which the child had previously sighted during the 9-day learning phase, seven rearranged sentences also already sighted during the 9-day learning phase and seven completely novel sentences using no new vocabulary. Means and standard deviations can be found in Table 2. This analysis indicated no significant difference in errors between sentence types, $F(2,39) = 3.09$, $MSe = 4.07$, $p > 0.05$, partial $\eta^2 = 0.15$. There was no interaction between sentence types and group, $F(2,39) = 1.09$, $MSe = 4.07$, $p > 0.05$, partial $\eta^2 = 0.06$ indicating that both the picture group and faces group produced the same pattern of errors on all three sentence types and so the test scores were combined in all subsequent analyses.

An ANOVA was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 2. The test scores indicated a significant difference between the picture group and the faces group in the reading of the sight words, $F(1,18) = 8.95$, $MSe = 5.14$, $p < 0.01$, partial $\eta^2 = 0.33$ favouring the faces group. There was a significant difference between groups in the reading of the sentences, $F(1,18) = 13.33$, $MSe = 25.85$, $p < 0.01$, partial $\eta^2 = 0.42$, favouring the faces group.

It was hypothesised that the faces group would perform better than the picture group on the test day. The results supported this hypothesis suggesting that the reduced learning associated with illustrations is due to the information contained within the illustrations rather than merely due to their distractive influence, thus removing an alternative hypothesis for the results of Experiment 1. When presented with informative illustrations, the information in the illustrations may be used by children as a substitute for reading.

**EXPERIMENT 3**

Experiment 2 indicated that informative illustrations have a negative effect compared to non-informative illustrations suggesting that it is the information content and not the distractive presence of an illustration *per se* that is damaging to children learning to read. Nevertheless, while in combination, Experiments 1 and 2 are compatible with this suggestion, it also is possible that both factors have an effect. Uninformative pictures may be distracting while informative pictures may both be distracting and encourage learners to use the information in the picture inappropriately. A combination of a picture that is both distracting and inappropriately informative may be worse than a picture that is merely distracting but does not eliminate the possibility that uninformative pictures may be distracting in their own right.

Experiment 3 was designed to test whether there was a difference in children’s reading ability when presented with books without any illustrations and books presented only with faces which did not pertain to the text in any way. If the uninformative faces are distracting, the no pictures condition should result in higher test scores. If the picture effect requires informative pictures, there should be no difference between uninformative pictures and no pictures. This hypothesis was tested by comparing a no picture group identical to the group used in Experiment 1 with a faces group identical to the equivalent group in Experiment 2.
Method

Participants
The participants were 22 kindergarten children attending a public school in Metropolitan Sydney, NSW. The children were 5–6 years in age, and were all at the same reading level ‘beginner’, which was determined by their class teachers. As with Experiments 1 and 2 the children were further divided into the three sub-groups based on their reading ability, again determined by their class teachers. They were assigned into two groups of 11 with one group presented with unillustrated books (the no picture group), and the other group presented with reproduced books having faces (the faces group). As far as numerically possible, participants were evenly distributed on the basis of subgroups.

Materials and procedure
The materials and procedure were identical to that of Experiments 1 and 2. The books with faces were identical to Experiment 2, and the unillustrated books were identical to those used in Experiment 1.

Results and discussion

Learning phase—reading exercise
An ANOVA was conducted for the reading exercise, i.e. the reading of the nine books over the 9-day learning phase immediately preceding the reading of the sight words and sentences. Means and standard deviations can be found in Table 3. There was no significant difference between the no picture group and the faces group, $F(1,16) = 0.04$, MSe = 1596.81, $p > 0.05$, partial $\eta^2 = 0.002$.

Learning phase—testing exercise
An ANOVA was conducted on the total number of sight word errors over the 9 days. Means and standard deviations can be found in Table 3. There was no significant difference between the no picture group and the faces group, $F(1,16) = 0.21$, MSe = 83.51, $p > 0.05$, partial $\eta^2 = 0.013$.

An ANOVA was conducted on the total number of sentence errors over the 9 days. Means and standard deviations can be found in Table 3. There was no significant difference between the no picture group and the faces group, $F(1,16) = 0.58$, MSe = 159.01, $p > 0.05$, partial $\eta^2 = 0.035$.

Table 3. Means and standard deviations (in italics) for Experiment 3

<table>
<thead>
<tr>
<th></th>
<th>No Picture</th>
<th>Faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning phase—reading exercise: Total errors</td>
<td>125.7 (32.9)</td>
<td>115.2 (45.3)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sight word errors</td>
<td>16.3 (7.7)</td>
<td>16.0 (10.2)</td>
</tr>
<tr>
<td>Learning phase—testing exercise: Sentence errors</td>
<td>24.7 (10.1)</td>
<td>26.0 (14.5)</td>
</tr>
<tr>
<td>Test phase—actual sentence errors</td>
<td>3.6 (1.6)</td>
<td>3.5 (2.5)</td>
</tr>
<tr>
<td>Test phase—rearranged sentence errors</td>
<td>1.9 (1.6)</td>
<td>2.2 (1.6)</td>
</tr>
<tr>
<td>Test phase—novel sentence errors</td>
<td>4.3 (2.1)</td>
<td>3.7 (1.8)</td>
</tr>
<tr>
<td>Test phase—sight word errors</td>
<td>6.0 (2.5)</td>
<td>4.7 (2.2)</td>
</tr>
<tr>
<td>Test phase—sentence errors</td>
<td>9.8 (4.7)</td>
<td>9.4 (4.6)</td>
</tr>
</tbody>
</table>
Test phase
An ANOVA was conducted on the errors made on different sentence types. Means and standard deviations can be found in Table 3. This analysis indicated a significant difference in errors between sentence types, $F(2,32) = 14.74$, $MSe = 3.23$, $p < 0.001$, partial $\eta^2 = 0.48$, with the novel sentences producing the most errors and the rearranged sentences producing the least number of errors. There was no interaction between sentence types and group, $F(2,32) = 0.26$, $MSe = 3.23$, $p > 0.05$, partial $\eta^2 = 0.02$ indicating that both the faces group and no picture group produced the same pattern of errors on all three sentence types and so the test scores were combined in all subsequent analyses.

An ANOVA was conducted on the number of errors made in the reading of sight words and sentences on the test day. Means and standard deviations can be found in Table 3. The test scores indicated no significant difference between the no picture group and the faces group in the reading of the sight words, $F(1,16) = 0.29$, $MSe = 5.76$, $p > 0.05$, partial $\eta^2 = 0.02$. Neither was there a significant difference between groups in the reading of the sentences, $F(1,16) = 0.18$, $MSe = 22.34$, $p > 0.05$, partial $\eta^2 = 0.01$.

These results indicate that uninformative pictures do not distract learners from processing the text, or at least, not to an extent that results in significant learning decrements. This result suggests that informative pictures providing redundant information relevant to the text are required for the redundancy effect in this context.

GENERAL DISCUSSION

We have known at least since Miller (1937) that the presence of pictures interferes with initial readers' ability to decode single words. This ‘picture-word’ effect has had little practical consequence for teaching procedures, possibly because it has been treated largely as an isolated effect without an adequate theoretical context. The current experiments advance our knowledge by placing the effect within a cognitive load theory context, by extending the effect from individual words to entire sentences and ideas, and by indicating the nature of the decrement caused by the presence of illustrations.

The redundancy effect is a well-known cognitive load theory effect (Sweller, 2005) demonstrated in many contexts, primarily technical in nature. It appears to be directly relevant to the use of pictures when teaching learners to read. Early readers must devote their working memory resources, at least in part, to decoding the text. If those working memory resources instead are devoted to interpreting redundant pictures, they will not be available for learning to read resulting in less than optimal instruction. This result can be expected to apply irrespective of whether learners are learning to decode single words or entire sentences or groups of sentences. Experiment 1 and to a lesser extent, Experiment 2, provide clear evidence of the negative effects associated with the presence of redundant pictures during early reading instruction.

The next issue concerns the nature of redundant illustrations. Can any illustration generate a redundancy effect? The series of three experiments of the current paper were together designed to test the hypothesis that pictures that learners see as possibly relevant to the text are more likely to be redundant than irrelevant pictures. With this hypothesis in mind, Experiment 1 established that informative pictures reduced learning and so could generate the redundancy effect when compared to no pictures, Experiment 2 established...
that informative pictures reduced learning compared to uninformative pictures consisting of a variety of faces, while Experiment 3 provided evidence that uninformative pictures did not generate a redundancy effect when compared to the no picture condition. Experiments 2 and 3 remove possible alternative hypotheses to the redundancy effect. Together, these three experiments can be interpreted as indicating that the information content of the redundant pictures can be critical in determining whether the redundancy effect is obtained. The negative effects of pictures are more likely to be obtained when those pictures include information directly relevant to the text being used to teach reading.

Since the pictures of faces are redundant, it can legitimately be asked why they also did not have a negative effect. The most plausible explanation is that because they were clearly unconnected to the text, learners felt, correctly, that they could ignore them because they provided no useful information. Furthermore, they could be processed easily and quickly and so presumably imposed a minimal additional cognitive load.

While we have no direct evidence that the effects were caused by cognitive load factors, the experiments and hypotheses were generated by the cognitive architecture described above. We assumed that reading is a biologically secondary task which places a heavy load on working memory. Attending to pictures is a biologically primary task that does not have to be taught and is likely to occur automatically. After a picture has captured a child’s attention, if working memory resources are devoted to processing pictures (a biologically secondary task) rather than text, more meaning may be derived but processing pictures subverts the purpose of the exercise—learning to decode text. It was hypothesised that if working memory resources are used to process pictures rather than text, fewer resources would be available to decode the text and required changes to long-term memory would be reduced. Our results were congruent with this theoretical analysis.

The obvious practical implication that flows from the current experiments is that informative illustrations should be eliminated from texts intended to assist children in learning to read. Of course, as indicated above, we have known of the deleterious consequences of using informative pictures to teach children to read single words for a long time, with little discernible consequence. The explanation of this effect in cognitive load theory terms may make it more interpretable and so more acceptable.

Of course, these results should not be interpreted as indicating that the use of informative pictures can never be beneficial. They may benefit younger learners during pre-reading stages or may provide useful information additional to text for more advanced readers. Nevertheless, for students learning to decode text, illustrations appear to have negative consequences.

As far as we are aware, knowledge of the deleterious effect of pictures associated with learning to read single words also has had no discernible effect on publishers of initial reading texts. Pictures in texts do not just influence children learning to read. They also are attractive to publishers and buyers, mainly parents. Both these groups need to be convinced that informative pictures are deleterious when learning to read.

ACKNOWLEDGEMENTS

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