The dimensions of mental models created by a listener's mind

Thesis submitted by Rebecca Ong Hui Shan

22 October 2012

This thesis is presented in partial fulfilment of the requirements for the degree of Bachelor of Arts in Psychology with Honours in the School of Psychology at Murdoch University, Western Australia, 2012

DECLARATION

I declare that this thesis is my own account of my research and contains, as its main content, work that has not previously been submitted for a degree at any tertiary educational institution. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references given.

Signature:

Name: Rebecca Ong Hui Shan

Date: 22 October 2012

COPYRIGHT ACKNOWLEDGEMENT

Signed:

Full Name of Degree: Bachelor of Arts in Psychology with Honours

Thesis Title: The dimensions of mental models created by a listener's mind

Author: Rebecca Ong Hui Shan

Year: 2012

Acknowledgements

I would like to sincerely thank my supervisor, Associate Professor Dr. Jeffrey Coney for his invaluable advice, supervision, guidance and report throughout the past year. He has taught me a lot and supported me throughout the whole project.

I thank my friends and family members who have supported and encouraged me throughout the past year. Without them, I would not have been able to complete this project.

Table of Contents

Abstract

A substantial number of studies on mental models have examined spatial accessibility in mental models during narrative comprehension. Accessibility of objects was dependent on how close they were to the current protagonist's location with closer objects being more accessible than further objects. This gradient of accessibility was conceptualized as the *spatial distance effect* (Morrow, Greenspan, Bower, 1987). Previous studies had used artificial designs and measures that made it difficult to generalize the results obtained. These included: memorizing a visual map before reading the narrative, using short or simple narratives and interrupting the natural reading process of a narrative for probing to occur. Furthermore, these studies focused on mental models constructed from written text. Few had attempted to explore mental models constructed from an audio narrative. The purpose of the present study was to use a naturalistic audio narrative to demonstrate the spatial representations in mental models. The setting of the narrative was on a deserted island and consisted of nine separate episodic events (episodes). The nine episodes were used to create prime-target word pairs that were used for probing during the lexical decision task. Forty participants from Murdoch University participated in a computerized go/no-go lexical decision task (LDT) where reaction time was documented to measure spatial proximity in mental models. Participants were assessed on reading enjoyment prior to the LDT. The findings showed evidence of the *spatial distance effect*, faster reaction times were observed for episodes that were located closer together than those further apart. There was unexpected sex differences observed. The *spatial distance effect* was observed for male participants but not for female participants. Interpretation and implications for future research were discussed.

Keywords: Mental models, spatial distance effect, spatial dimension, lexical decision task, sex

In the story of Harry Potter and the Prisoner of Azkaban (Rowling, 1999), Harry Potter, a wizard and the main protagonist of the story attended the Hogwart's School of Wizardry and Witchcraft and chanced upon a magical item called the Marauder's Map.

> It was a map showing every detail of the Hogwart's castle and grounds. But the truly remarkable thing were the tiny ink dots moving around it, each labeled with a name in minuscule writing. Astounded, Harry bent over it. A labeled dot in the top left corner showed that Professor Dumbledore was pacing his study; the caretaker's cat, Mrs. Norris, was prowling the second floor; and Peeves the Poltergeist was currently bouncing around the trophy room. And as Harry's eyes traveled up and down the familiar corridors, he noticed something else. This map showed a set of passages that he had never entered. (p.193)

How does a reader of the novel comprehend all this spatial information? Is there a mental map being built to store all this information? Much like how Harry possessed the physical Marauder's Map, each individual possesses their own mental Marauder's Map that enables them to form an organized representation of their own spatial environment, and aid them in their navigation through reality. This mental Marauder's Map is called a mental model (van Dijk & Kintsch, 1983). The concept of the mental model was first proposed by Kenneth Craik (1943) in his book, *The nature of explanation,* where he defined it as a sort of "small-scale model" of the real world. It has since been updated to represent an integrated model that reflected the events in a text, and the reader's own inferences and general knowledge (Rinck, et. al., 1996; Johnson-Laird, 1983; Noordman & Vonk, 1998; van Dijk & Kintsch, 1983). Like the Marauder's Map, the mental model is not static, and can be updated based on new information provided by the spatial environment (de Vega, 1995; Bower & Morrow, 1990).

Information about the spatial environment can be obtained in many ways, through audio means (Rubins, 1995) or through written texts (Graesser, Millis & Zwaan, 1997). Extensive research over the past thirty years had mostly focused on mental models based on text comprehension. Few studies had attempted to explore mental models based on audio text comprehension (Jahn, 2004; Bransford, Barclay & Franks, 1972), which is rather surprising given that a great amount of spatial information is captured via audio means in daily life, e.g. obtaining directions from someone. To fill this gap in the current literature, the present study used an audio narrative to explore the construction of mental models.

A large number of situation model studies have shown that readers typically represent the events in a narrative on five separate dimensions: time, space, causation, intentionality and protagonist (Gernsbacher, 1990; Givon, 1992; Johnson-Laird, 1983; Zwaan, Langston & Graesser, 1995). These dimensions were often examined separately by researchers. However, Zwaan, Langston & Graesser (1995) argued that the five dimensions were not mutually exclusive and should be integrated into a multi-dimensional model which they called the event-indexing model.

Event-indexing model

The model described how readers or listeners constructed their mental models during narrative comprehension by using the five dimensions as a framework. While comprehending the first few lines of the narrative, an initial model of the narrative was constructed (*current model*), the initial model was updated if something changed in the narrative or if there was an introduction of a new object. The integration of this new piece of information formed the basis of the *integrated model* which became the new *current model* until it was updated again (Zwaan & Radvansky, 1998).

The different dimensions were updated in accordance to what was happening in the narrative. For example, the introduction of a new character involved the updating of the protagonist dimension while a change in location initiated the updating of the spatial dimension (Zwaan, Langston & Graesser, 1995).

Zwaan, Magliano and Graesser (1995) noted that participants displayed increased sentence-reading times when there were situational discontinuities. They attributed this to the fact that a situational discontinuity on any of the dimensions would cause an updating of the *current model* in order to maintain the narrative coherence. The extra processing puts an extra cognitive load on the reader and resulted in increased sentence-reading time.

Furthermore, De Vega (1995) demonstrated that the updating of the mental model happened through a backward process. He noted that when only motion information was provided in the narrative, individuals do not update the spatial information in their mental models. To update the mental model, it was necessary that a target object (e.g. marble staircase) be introduced after the protagonist's motion had been narrated. The results indicated that the updating of the mental model followed a cue-based inference process rather than the automatic actualization of the protagonist's movement. The target objects acted as cues for the protagonist's surroundings, allowing the listeners or readers to effectively update their situation model.

A number of studies have examined the event-indexing model and its five dimensions (Zwaan, Magliano & Graesser, 1995; Zwaan, et al., 1998; Scott, Rich & Taylor, 2000; Rinck & Weber, 2003), reliable effects for the temporal, causal, intentionality and protagonist dimensions have been found, but evidence was less reliable for the spatial dimension. Research conducted by Zwaan and his colleagues (1998) used a paradigm originally developed by Morrow, Greenspan & Bower (1987) and modified by Rinck and Bower (1995),

where people would first memorise the map or layout of a building before reading a narrative, and texts from Rinck and Bower (1995) found that participants only monitored spatial changes if they had memorise a map of the narrative beforehand. Without the memorized map, no effects were found. The findings indicated that spatial information was not automatically included in mental models. Could it be that spatial information was not important? This was highly unlikely as location played an important role in the comprehension of narratives, even more so for oral narratives (Rubin, 1995). Given its importance, it should be strongly implied that readers would track and integrate spatial information into their mental models. There was a mismatch between experimental findings and common experience which this paper is seeking to address.

Spatial Dimension

Some studies have shown that readers of written text do include spatial information in their mental models (Haenggi, Kintsch & Gernsbacher, 1995), unfortunately, these studies have explicit instructions that encouraged participants to pay attention to the spatial details in the narrative. Therefore, findings from these studies may not generalize to natural reading conditions. Zwaan and van Oostendorp's (1993) showed that participants took a longer time to read sentences with spatial information when asked to pay close attention to spatial information, indicating that participants were doing more processing than they would usually do under natural reading conditions. Hakala (1999) demonstrated that participants did not pay attention to spatial information when reading for comprehension and only paid attention to spatial information if specifically told to do so, indicating extra effort on the part of the participant to process spatial information which they would not have done under naturalized settings.

Alternatively, some researchers like O'Brien and Albrecht (1992) found that individuals do integrate some spatial information into their mental models. In their study, they had participants read a short narrative, the narrative had a sentence that said: Kim stood outside the health club and a few sentences later, a sentence that said: Kim decided to go outside the health club. They noted that their participants took a longer time to read the second sentence, and concluded that the longer time reflected the extra processing that occurred to address the inconsistency of the spatial information in their mental model, providing evidence that some spatial information was tracked during narrative comprehension. These effects were observed despite the fact that participants were not explicitly instructed to pay attention to spatial information.

As can be seen, evidence for the spatial dimension is not straightforward, certain studies (Zwaan and van Oostendorp, 1993; Hakala, 1999) subscribe to the idea that spatial information was only encoded in mental models under certain conditions, while others (O'Brien and Albrecht, 1992) have argued that spatial encoding also happens under natural reading conditions. No research has yet been able to establish an answer for this debate, but a possible reason for the differing results could be due to methodological and design flaws of the previous studies.

The spatial dimension is different from the other four dimensions and there is an interesting mismatch between how space is described in the written language and how space is conceived by an individual. As Zwaan and Radvansky (1998) noted:

> Two objects can be close in space and yet be described as far apart in the text. When the objects in the room are described in a circular fashion, the first mentioned and the last mentioned object may be next to each other spatially. By making use of the mismatch between spatial organization and linguistic structure, researchers can assess

> whether a reader has created a mental representation of the text or of the described situation. (p.168)

The other four dimensions do not experience this mismatch in the written language, so even though previous methods and designs had successfully demonstrated reliable effects for the other four dimensions, the same designs and methods may not have worked for the spatial dimension. There is a need to consider whether the current designs and methodologies are adequate for studying spatial encoding in mental models. In addition, the highly artificial reading conditions in previous studies (Zwaan, Magliano & Graesser, 1995; Zwaan, et al., 1998; Scott, Rich & Taylor, 2000; Rinck & Weber, 2003; Morrow, Greenspan & Bower, 1987; Rinck and Bower, 1995) call the generalizability of results into question (Jahn, 2004). In view of these considerations, the present study would adopt a novel method and design that would overcome the aforementioned shortcomings to assess the spatial dimension in mental models. The next sections cover an overview of the previous methods and designs used by researchers to study spatial relations in mental models.

Spatial Distance Effect

A mental model is not physically observable, so in order to study it, researchers had to come up with an objective conceptualization that reflected the processes of the spatial component. Researchers proposed that objects that are spatially close to the protagonist became more primed and accessible compared to objects that are further away (Bower & Morrow, 1990; Haenggi, Kintsch & Gernsbacher, 1995; Rinck & Bower, 1995; Wilson, Rinck, McNamara, Bower & Morrow, 1993; Bestgen & Dupont, 2003). Morrow and colleagues (1987, 1989) reported a gradient of accessibility of spatial locations in the narrative. This spatial gradient was known as the *spatial distance effect* (Morrow, Greenspan, Bower, 1987). Accessibility of objects was dependent on how close they were to the current

protagonist's location with closer objects being more accessible and showing shorter reaction times than further objects. The *spatial distance effect* provided an innovative way of capturing observable, quantitative evidence for the spatial component in mental models.

Although those experiments showed promising results of the spatial distance effect in mental models being real and replicable, there were still some doubts over whether these results could be generalized to the general population. Most replication studies either used similar narratives that were short and simple in nature (de Vega, 1996; Hakala, 1999; O'Brien & Albrecht, 1992), or similar methods in getting participants to acquire spatial information such as getting participants to memorise a map before reading a narrative (Morrow, Greenspan & Bower, 1987; Rinck and Bower, 1995). This meant that the mental model was not built during the reading of the narrative, but via the memorizing and studying of a map beforehand, and in many natural reading situations, individuals do not have the opportunity to study the spatial layout of the narrative before reading it (Denis & Cocude, 1989; de Vega, 1995). These similarities made it difficult to determine if the spatial distance effect was limited to certain experimental conditions or if it could be generalized to the wider population. Furthermore, as Jahn (2004) pointed out that there were certain conditions found in natural reading conditions that aided spatial construction in mental models which were not found in the studies.

Conditions for spatial construction in mental models under natural reading conditions

There were two main conditions that allowed for spatial representation in mental models under natural reading conditions, firstly, it should not be too difficult to construct the spatial representation from the text. Secondly, tracking the spatial information must seem to be worth the effort to the reader or listener (Jahn, 2004).

Difficulty level was dependent on the structure of the spatial descriptions in the narrative. Descriptions were easier to construct if they were determinate (Baguley & Payne, 2000; Mani & Johnson-Laird, 1982), continuous (Denis & Concude, 1992) and condensed (Zwaan & van Oostendorp, 1994). Furthermore, under natural reading conditions, narratives with spatial descriptions usually followed a structure that supported the comprehension of descriptions. For example, spatial descriptions were usually focused on a static reference object.

The effort to track spatial information in a narrative was mainly dependent on the goals of the listener or reader (Graesser & Kreuz, 1993). The main goal of the listener or reader was to understand the meaning of what the author was trying to convey through the narrative (Foertsch & Gernsbacher, 1994). Individuals were more likely to form spatial representations if the author emphasized the importance of spatial relations. Authors usually accomplish this by using textual cues to implicitly bring spatial relations to the foreground of the narrative and to encourage readers or listeners to pay attention to them (Jahn, 2004).

Jahn (2004) argued that narratives created for experiments often failed to follow the natural reading conditions that aided in the construction of mental models, resulting in an artificial reading condition. Only a few studies have tried to use complex narratives (Denis & Cocude, 1992; Langston, Kramer & Glenberg, 1998), so difficulty level is not as much of an issue as is the second condition. It was not enough to present a story with spatial information if participants have no need to encode it into the mental model, in natural reading conditions, spatial information is usually important for narrative comprehension and bears great relevance. For example, the spatial information provided by Harry Potter's Marauder's map played a big role in the plot of the story. Knowing where each landmark was located was beneficial to the reader by allowing them to comprehend what was going on in the story.

Readers were more likely to track the spatial information in the Marauder's Map given its relevance to the story.

In view of these considerations, the narrative constructed for the present study would emulate the natural reading conditions as much as possible. The next section addresses the measurements used in previous studies of spatial representation in mental models and the issues with them.

Lexical Decision Task

Previous studies on spatial dimensions in mental models typically adopted explicit measurements such as reading times (Jahn, 2004; Rinck & Weber, 2003; Glenberg, Meyer & Lindem, 1987; Hakala, 1999; Zwaan, et. al., 1998) and recognition tests (Bestgen, Dupont, 2003; de Vega, 1995; O'Brien & Albrecht, 1992). These measures were often not sensitive enough to measure the kind of cognitive processes that occur. Furthermore, these measurements required participants to consciously compare the stimuli probe with their mental model. The mental model is not a permanent model (de Vega, 1995; Bower & Morrow, 1990) and can be affected easily by external stimuli, such as conscious comparisons to stimuli probes. This meant that it was almost impossible to identify if the results observed reflected the cognitive processes occurring during narrative comprehension, or processes that were activated in response to the stimuli probe (Potts, Keenan & Golding, 1988).

A measure that overcomes this flaw is the lexical decision task. The lexical decision task was a standard priming paradigm first used by Meyer & Schvaneveldt (1971) in a priming context. In the task, a word is first presented on a screen (prime) followed shortly by a second word (target). Participants merely had to provide a go/no-go response in deciding whether a letter string was a word; the switch was pressed if the target was a word and the

switch was not pressed if the target was a non-word. Therefore, participants had no reason nor need to consciously compare the letter string to their mental models. Reaction times were captured in milliseconds and were used to measure the differences between word pairs.

The measurement tool to be used in the present study should be able to capture the implicit and automatic cognitive processes that happened in response to changes in spatial relations in the narrative. The lexical decision task was a tool that fulfilled these criteria and had previously been used in language comprehension and text inferences studies (Potts, Keenan & Golding, 1988; Glenberg, Meyer & Lindem, 1987; Sharkey & Mitchell, 1985). However, Seidenberg, Waters, Sanders, and Langer (1984) have rightly pointed out that the lexical decision latencies could contaminated by the relationship between the prime and target word. Hence, it was important to ensure that the prime and target words used in the study were in no way associated with each other.

Overview of experiment

In the present study, I hypothesized that a *spatial distance effect* would be observed, with faster mean reaction times for episodes that are closer in spatial distance. This would provide support for the existence of the spatial information in mental models.

Although many studies have been conducted on the *spatial distance effect*, there are doubts as to whether the results were generalisable to natural reading conditions. Most of the studies followed the paradigm created by Morrow, Greenspan & Bower (1987) which required that participants first examine and memorise a map, a narrative was then constructed around the map and objects in the map were then probed during the reading of the narrative. This was a very artificial way of exploring how mental models were constructed in the natural environment as it disrupts the natural reading patterns. As Millis, King & Kim (2000)

noted, updating of the mental model during narrative comprehension was a highly resource consuming process, and probing during narrative reading could result in the masking of any spatial effects due to the cognitive overload.

The primary goal of this study was to use a novel design and method to explore the *spatial distance effect*. I would be addressing the unnatural reading conditions and design flaws of previous studies. This is the first study to explore how listeners construct mental models from an audio narrative under natural reading conditions. This study would be exploratory in nature and there were two key deviations from previous designs.

Firstly, participants would listen to an audio narrative and develop a mental model in their mind. In the natural environment, not all spatial information are obtained from written texts or visual images, a casual observation of daily life would demonstrate that a great amount of information is captured via audio means, for example, getting directions to a certain location. Surprisingly, there are few studies that have used audio narratives (Jahn, 2004; Bransford, Barclay & Franks, 1972) to study mental models. For the present study, an audio narrative was used given its huge untapped potential and its relevance to natural information gathering conditions in daily life.

O'Brien and Albrecht (1992) noted that participants needed to image themselves as the protagonist before any encoding of spatial information can occur. Hence, in order to facilitate this, the audio narrative would be written in first person. As pointed out earlier, it was important to take into consideration the conditions for spatial construction in mental models under natural reading conditions. The narrative would focus on nine well-defined episodic events throughout the story. The episodic events were static (i.e. the events do not experience location shifts), with no overlaps and the protagonist goes through each episode in a unidirectional manner.

Secondly, a computerized lexical decision task would be used in place of previously used reading time/recognition tests. Previous research had relied on measurement tools that required conscious processing of the presented stimuli. The mental model is not static (de Vega, 1995; Bower & Morrow, 1990) and can still be updated and manipulated by external stimuli even after its formation. This raised the possibility that the results were reflecting processes that happened in reaction to conscious processing of the stimuli and not results from probing the spatial information that was already stored in the mental models. The lexical decision task had been used in previous studies (Potts, Keenan & Golding, 1988; Glenberg, Meyer & Lindem, 1987; Sharkey & Mitchell, 1985), and was able to capture the implicit and automatic cognitive processes that happened in response to changes in spatial relations in the narrative.

It is important to note that the present study is one of the first to explore how individuals encode and construct spatial information in their mental models in a natural reading condition using an audio narrative with no visual maps or aids. The study is fundamentally exploratory in nature and it was expected that the outcomes would contribute to the current literature and produce greater understanding of spatial information in mental models by overcoming the flaws and designs of the previous studies, filling up the research gap of audio information gathering by using audio narratives to construct mental models, and potentially paving a new paths for future research.

Method

Participants

Forty participants (16 males, 24 females, M_{age} = 23.9, SD = 6.3) were recruited for the study via the Murdoch University Subject Pool System and through personal contacts. Participants who were Murdoch psychology students received 1.5 psychology credit hours for

their participation. To be selected for the study, participants had to have English as their first language.

Design and Materials

Audio Narrative

The audio narrative was forty minutes long, and was written specially for this study by Associate Professor Jeffrey Coney at Muroch University. The story was written as a first person narrative and followed a unidirectional path. The narrative told the story of a protagonist who was shipwrecked on a deserted island and his adventures in encountering nine separate episodic events before being rescued. Special care was taken to emphasis the spatial relations, such as using textual cues (e.g. “I must have covered something like 7 or 8 kilometres of coastline by mid-morning…”). To minimize temporal interferences, the episodes all happened with the same day. It was important to note that participants would not be shown the map of the island at any stage of the study. The story was divided into three locales, with three episodes in each locale. Each locale was separated from each other by a distance in the narrative (refer to Appendix C for narrative).

The narrative was subjected to some restrictions to satisfy design requirements. Firstly, there were no overlaps among episodes i.e. if the protagonist was currently at the “coconut” episode, no other episodes (e.g. reef, bamboo etc) may be referenced while he was there. This was to prevent verbal priming of spatial associations. Secondly, the episode names should not generate any priming effects through orthographic, phonological, associative, or semantic relationships i.e. there should not be any obvious association between “coconut” and “reef” or “reef” and “ruins”. This was to prevent any confounding priming effects during the LDT.

Thirdly, each episode name needed to be mentioned nine times during the narrative. This was to ensure that the episodes were firmly and evenly represented in the participant's mind.

A one-way within subjects repeated measures design was used to analyze the independent variable of separation with eight conditions. S1 (measures spatial priming across a distance of one episode); S2 (measures spatial priming across a distance of two episodes); S3 (measures spatial priming across a distance of three episodes); S4 (measures spatial priming across a distance of four episodes); S5 (measures spatial priming across a distance of five episodes); S6 (measures spatial priming across a distance of six episodes); S7 (measures spatial priming across a distance of seven episodes) and S8 (measures spatial priming across a distance of eight episodes). Dependent variable was mean reaction times (RT) measured in milliseconds.

Between group differences were also analyzed using a between subject ANOVA for the independent variables of gender (female/male), reading enjoyment scores (high/low), spatial comprehension scores (high/low), locale comprehension scores (high/low) and general comprehension scores (high/low) and the dependent variable of reaction times (RT).

Stimulus

Prime-target probes

To measure spatial relations in a mental model, 72 pairs of prime-target probes (prime and target were both words) were generated from all possible bi-directional combination of the 9 episode names in the narrative. In the neutral condition, 18 prime-target probes were generated. The words used as the neutral primes were not found in the narrative, they were external words that were matched to the episode names on the basis of word frequency,

similar phonetic and orthographic levels (refer to Appendix F for list of words). The neutral condition was meant to act as the baseline comparison.

70 prime-target non-words probe pairs (prime was a word, target was a non-word) were created by modifying at least one letter in each of the 9 different target word to produce phonetically and orthographically similar nonsense words (CACONET, ROINS, BIMBOT, PAGS, POAL, CUVE, REET, FIRT, CLOOF). The non-word targets were created to balance out the word condition and the result produced was of no great interest as its main purpose was to serve as distracters for participants.

An original stimulus file was created with the 160 prime-target probes pairs divided into eight sets. Each set consisted of nine non-word prime-target probes, nine word prime-target probes, one neutral word prime-target probe and one neutral non-word prime-target probe. The only exception was the eighth set which had nine word prime-target probes and eight non-word prime-target probes. There were nine matched neutral primes but only eight sets were available. Hence, one of the non-word target probes from the eighth set was substituted with a neutral probe. The stimulus file was then counterbalanced by using a Latin square procedure to reorder the sets eight times and to create eight new files. The 160 probe pairs in each file were then doubled to a total of 320 pairs in order to increase the power and reliability of the data collected. Each file was randomized five times by a computer program in the cognition lab at Murdoch University to produce a total of 40 randomized and balanced stimulus file for each participant. An extra stimulus file was created as a practice file. It consisted of 20 word and non-word pairs that were not found in the narrative, and was used for all participants. The purpose of it was to get participants familiarized with the instructions and sequence before the actual LDT.

Apparatus

LDT program

A FORTRAN control program was developed in-house and installed on a 256MB Ram Intel Pentium three processor with a Windows 98 SE operating system. The control program ran the stimulus files and was connected to a two-button (left/right) micro-switch response box, which recorded reaction times. The probes were presented on a 17 inch ViewSonic VA721 anti-glare monitor with a pixel resolution of 1280X1024, 32-bit colour and a 75 hertz refresh rate.

Questionnaires

Reading Enjoyment Scale

The reading enjoyment scale, which has yet to be published, was developed in Murodch University for use in the cognition lab. It has high internal consistency (α=.924) and a high test-retest reliability score, r=0.712. The scale assesses participants' attitudes and behaviours with regards to reading. It is a 12-items questionnaire with a 5 likert point scale (Strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, strongly agree =5). Three items are reversed-scored. The 12 items are totaled to produce an overall score ranging from 12 to 60.

Comprehension Questionnaire

This questionnaire consists of eight open-ended questions related to the narrative. It was created to measure the participant's understanding of the narrative. One mark was given for each correct response, with a maximum score of 8.

Event Sequencing Questionnaire

This questionnaire required participants to append episode word cards to the nine blanks provided in the order the episodes occurred. It was created to assess the spatial dimensions of the narrative. Correct scores were totaled to give two scores, a spatial comprehension score, and a locale comprehension score. The spatial comprehension score referred to the number of correct spatial linkages. One point was given for each correct response for a maximum of 8 points. The locale comprehension score referred to the number of episodes correctly placed into each locale. One point was given for each correct response for a maximum of 9 points.

Procedure

Participants were invited into the cognitive lab on the Murdoch University campus and seated in individual computer cubicles. The room had fluorescent and natural lighting, and was located in a quiet area of the school. Each participant was given an information sheet which explained what the study was about and an informed consent sheet to sign.

Participants were then asked to complete the Reading Enjoyment Scale. After the questionnaire was completed, participants were briefed on the instructions for the lexical decision task and asked to complete a practice session, where they were given an opportunity to clarify any doubts and questions about the LDT. The practice was scheduled before the narrative to ensure that there were no distractions when transiting from the narrative to the actual lexical decision task. On completion of the practice task, noise-cancelling headphones were placed over the participant's ears and they were instructed to listen to the audio narrative. After the narrative, participants proceeded into the lexical decision task. The lab

developed FORTRAN computer program was used to run each participant's unique stimulus file. The program also captured demographic information such as gender and age.

The prime-target probes were presented in black Verdana font against a grey background. All probes were presented in the centre of the screen. A cross would appear in the centre of the screen for 500ms to indicate the start of each trial. The screen was then blank for 200ms. This was followed by the presentation of the prime word for 750ms. The screen would then turn blank for 250ms after which the target word was shown for 1500ms or until the participant responds.

As the LDT was a go/no-go task, participants were asked to press both micro-switches simultaneously as quickly as possible if they thought that the target was a word. If the target was a non-word, participants were instructed not to respond. For every false response to the non-word probe or should the participants fail to respond within 1500ms for the RWORD trial, the word ERROR, Verdana font size 26, would be displayed in the middle of the screen in red, uppercase letters.

Each session was divided into eight blocks of 40 trials each and feedback was provided once every 40 trials. The feedback screen displayed the reaction times and any errors made. Participants were monitored for their speed/accuracy rate, with the idea rate being no more than three mistakes per block. If participants made more than three mistakes per block, they were asked to adjust their speed/accuracy rate (reduce the speed of answering, but improve accuracy of response). The feedback screen acted as a self-timed break between blocks, when participants were ready to move onto the next block, he/she was asked to press the ENTER button on the keyboard.

After the LDT, participants were given a comprehension questionnaire and an event sequencing questionnaire to complete. Participants were then thanked for their participation and debriefed.

Results

In all analyses reported, an alpha level of .05 was used. All reaction times were recorded in milliseconds. To examine the spatial distance effect, episodes were grouped into 8 conditions (from S1 to S8). S1 referred to spatial priming distance across one episode, while S8 referred to spatial priming distance across eight episodes (see Appendix D for more details). Analyses were done for both backward and forward priming conditions. The backward priming condition consisted of word probe pairs that ran counter to the order of episodes stated in the narrative. The forward priming condition consisted of word probe pairs that followed the order of the episodes in the narrative. For example, COCONUT was mentioned before RUINS in the narrative, the backward priming condition would display RUINS as the prime and COCONUT as the target. Whereas the forward priming condition would display COCONUT as the prime and RUINS as the target.

Neutral condition

The neutral condition (M=460, SD=56) had reaction times that were significantly faster than the backward priming (M=469, SD=52) condition (t(39)=-2.24, p=0.031). This was not in line with results observed from previous LDT studies, where the neutral condition displayed a slower reaction time compared to the other word/non-word prime conditions (Stanovich & West, 1983; Wenture, 2000). It was strongly implied that the neutral condition in the present study was not functioning as expected, and hence it was omitted from further analyses. The discussion section will cover more on this issue.

LDT Reaction Time Analyses (Backward Priming)

Reaction times increased with increasing spatial distance for the backward priming condition. A paired-samples t-test was conducted to compare the reaction times in the backward priming and forward priming conditions. There was an overall significant difference in the mean reaction times for backward priming (M=469, SD=52) and the forward priming (M=460, SD =60) conditions; ($t(39) = 2.67$, p =0.011).

A one-way within subject repeated measures ANOVA was conducted to compare the effects of spatial separation on reaction time in the LDT task for backward priming. Mauchly's Sphericity test was significant (p<0.5), so the Huynh-Feldt epsilon results were used. The main effect of separation levels on reaction times were significant, ($F(5.13, 199.9) = 3.08$, p=0.01, $\eta_p^2 = 0.073$) episodes that were separated over a longer distance had slower reaction times than episodes that were separated over a shorter distance (Figure 1). The linear contrast analysis showed that not only was there significant results, the results were distributed in a linear order (F (35005.35, 2821.85) =12.41, p=0.001, η_p^2=0.241). The results supported the hypothesis that a *spatial distance effect* will be observed, with faster mean reaction times for episodes that are closer in spatial distance. Paired comparisons were conducted for S1 to S8, but no significant results were observed. The limited sample size in the present study meant that there was not enough data to demonstrate significant differences at this fine grain level of analyses.

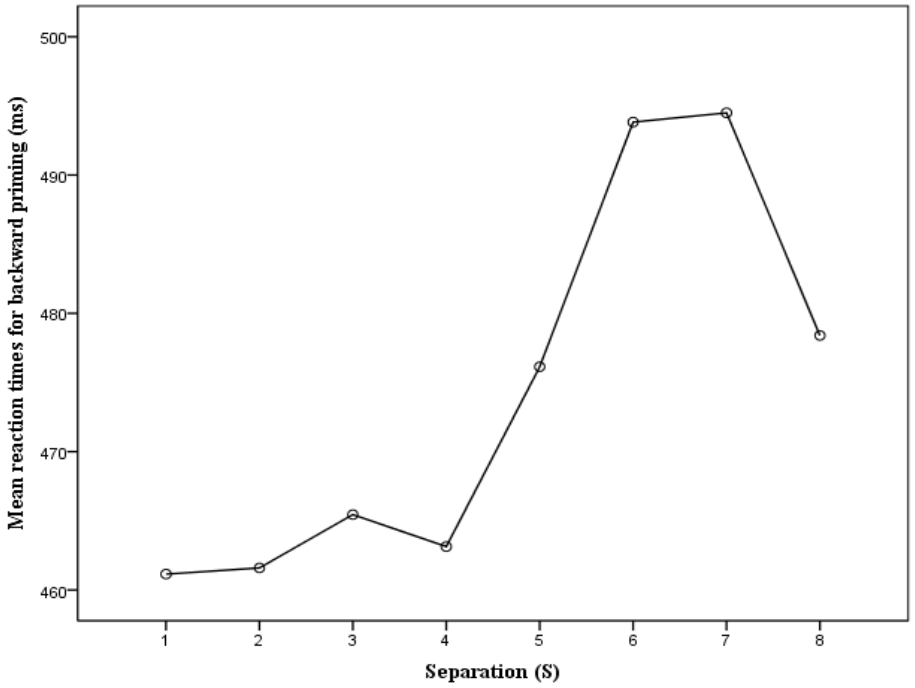

Figure 1: Mean reaction time for conditions S1 to S8 for backward priming condition

LDT Reaction Time Analyses (Forward Priming)

One-way repeated measure ANOVA conducted for the forward priming condition produced no significant results. This meant that the *spatial distance effect* was not observed for the forward priming condition, indicating that the main hypothesis was only partly supported. A visual inspection of Figure 2 shows a marked decrease in reaction times from S5to S7, though the results were not significant, it is nevertheless still an interesting trend. This issue will be discussed in more details in the discussion section.

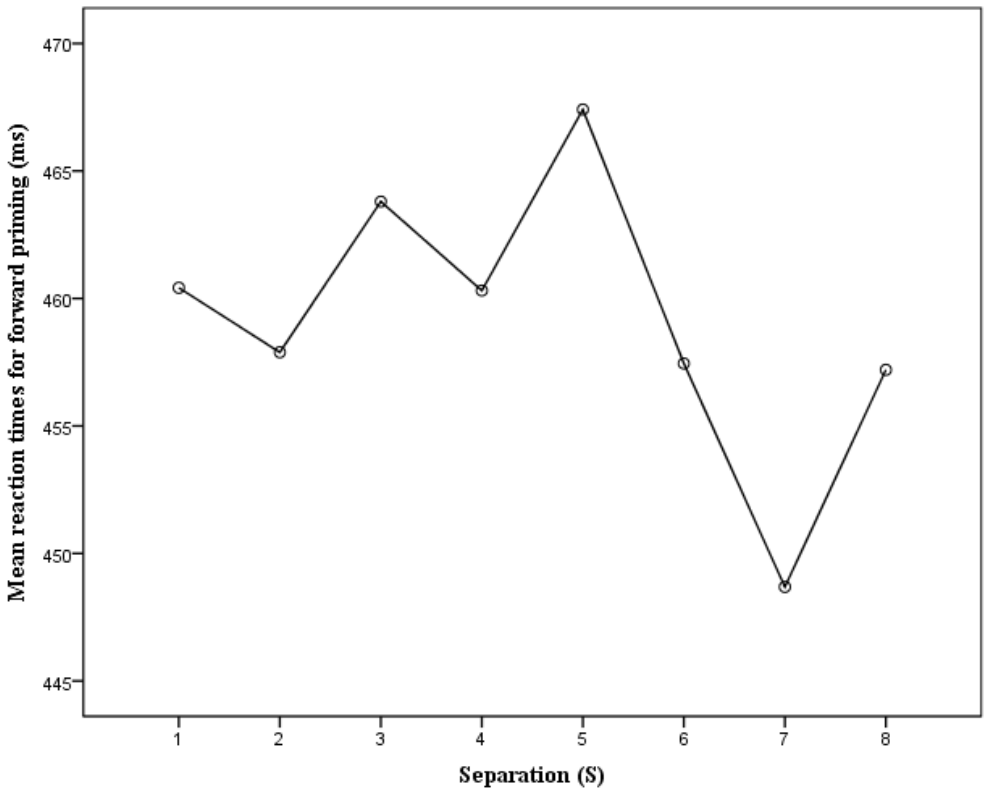

Figure 2: Mean reaction time for conditions S1 to S8 for forward priming conditions

Further analyses were conducted on locale differences, gender, reading enjoyment and comprehension scores to examine if the main hypothesis was supported.

Locale differences

The nine episodes were grouped into three locales depending on where they were mentioned in the narrative. Locale A consisted of the first three episodes, locale B, the next three episodes, and locale C, the last three episodes. A pairwise comparison was conducted to compare the reaction times among within locale episodes, for example, *coconut-ruins*, and different locale episodes, for example *bamboo-pigs* spans across locales A and B. There was no significant difference in mean reaction times for the within locale (M=458; SD=49) and between locale (M=461; SD=57) for the backward priming condition ($t(39) = -.660$; *n.s.*).

Neither was there a significant difference in mean reaction times for within locale (M=459; SD=64) and between locale (M=462; SD=57) for forward priming ($t(39) = -.440$; *n.s.*).

Gender effects (Backward priming)

A 5x2 SPANOVA, was conducted with separation as the within subject variable, and gender as the between subject variable. Mauchly's Sphericity test was significant (p<0.5) so the Huynh-Feldt epsilon results were used. There was a main effect for separation (F(5.19,197.4)=4.10, p=0.001, η_p^2 =0.097) and gender (F(1,38)=6.01, p=0.019, η_p^2 = 0.137) for the backward priming condition (refer to Figure 3). There was no significant interaction between these two variables (F(5.19,197.4), p=0.063, *n.s.*) although interaction results approaches significance. However, a visual inspection of Figure 3 seemed to contradict the analysis. The non-significant results were due to the way ANOVA was conducted. Figure 3 showed that there were no significant difference in reaction times for S1 to S4, however, there was a marked difference in reaction times after S4. ANOVA calculates the overall mean of the eight conditions, thereby masking the significant effects seen from S4 onwards. This explained why analysis turned up no significant interaction results although a visual inspection of Figure 3 states otherwise.

To explore the gender effects, one way repeated measures ANOVA were performed on the genders. Females showed no significant differences in reaction times (F(5.15,118.5)=0.510, p=0.774, *n.s.*). Males showed a significant differences in reaction times across separations (F(4.82,72.35)=3.08, p=0.015, η_p^2 = 0.171). Pairwise comparison using a manual Bonferroni correction of α<0.007 found no differences in mean reaction times across separation levels for males. It is important to once again emphasis that the limited

sample size in the present study meant that there was not enough data to demonstrate significant differences at this fine grain level of analyses.

The results supported the main hypothesis that a *spatial distance effect* will be observed in the present study. It was interesting to note that this effect was only observed for the male participants but not the female participants in the backward priming condition. This will be explored further in the discussion section.

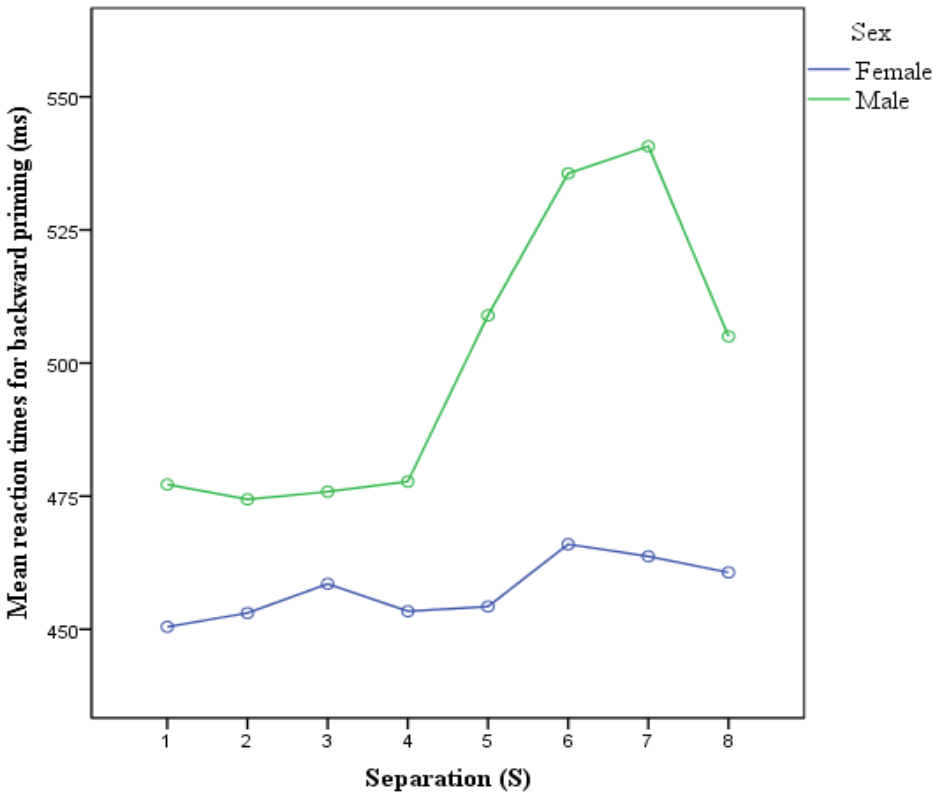

Figure 3: Mean reaction times for backward priming condition for females and males

Gender effects (forward priming)

A main effect was found for gender (F(1,38)=6.85, p=0.013, η_p^2 = 0.153). There was no main effect for separation levels. A significant interaction effect was found between gender and separation levels (F(6.08,230.86)=2.70, p=0.014, η_p^2 = 0.066) (refer to Figure 4).

To explore the significant interaction, one way repeated measure ANOVAs were conducted for both genders. There was a small significant effect of separation levels for males ($F(5.65,84.72)=2.29$, $p=0.046$, $\eta_p^2 = 0.132$), but females showed no significant effects, ($F(5.05,116.19)=0.721$, $p=0.610$, *n.s.*). Pairwise analyses for interaction effect using a manual Bonferroni correction of $\alpha<0.007$ found no significant results.

It is important to note that the overall effect for the forward priming was established as being non-significant. Furthermore, separation effect for the male participants was barely significant. Hence, the presence of a *spatial distance effect* for the forward priming condition was not supported.

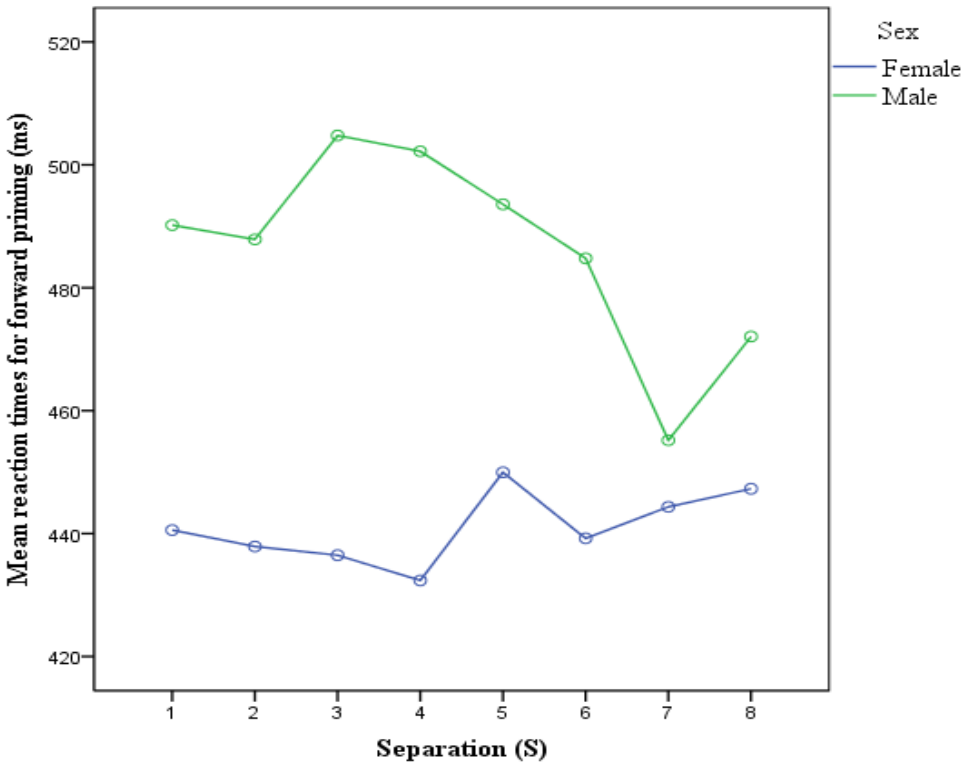

Figure 4: Mean of reaction times for forward priming condition for males and females

Reading Enjoyment Scale

Scores of participants were arranged in a descending order and a median split was conducted. A 8x2 SPANOVA, with the within subject variable of separation levels and the between subject variable of reading enjoyment scores (high/low) was conducted for the backward and forward priming condition. Mauchly's Sphericity test was significant (p<0.5) so the Huynh-Feldt epsilon results were obtained. For the backward priming, there was a main effect for separation levels (F(5.12,194.62)=3.14, p=0.009, η_p^2 = 0.076) and reading enjoyment (F(1,38)=5.45, p=0.025, η_p^2 = 0.125). High scorers (M=455, SD =12, scores >= 42) had mean reaction times that were 40ms faster than the low scores (M=494, SD =12, scores <=42). There was no significant interaction between these two variables. Forward priming had no main effects. There was a significant interaction effect (F(6.05,230)=2.27, p=0.037) but further ANOVA tests revealed no significant results.

Comprehension

A median split data was used to run the 8x2 SPANOVA analysis with separation levels as a within subject variable and comprehension scores (high/low) as the between subject variables. Mauchly's Sphericity test was significant (p<0.5) for all comprehension SPANOVA so the Huynh-Feldt epsilon results were obtained. For comprehension scores (locale) for the backward priming condition, there was a main effect for separation levels (F(5.26,120)=3.06, p=0.010, η_p^2 = 0.075). There was no significant effects for scores or any interaction effects. Forward priming had no significant results

For the backward priming condition, SPANOVA for comprehension scores (spatial) produced main effects for separation levels (F(5.23,198.6)=3.03, p=0.011, η_p^2 = 0.011) and

high/low scores ($F(1,38)=4.97$, $p=0.032$, $\eta_p^2 = 0.116$). There were no significant interaction effects. There were no significant effects for the forward priming condition.

Comprehension scores (general) referred to the scores obtained on the open-ended comprehension questionnaire. Comprehension scores (all) referred to the total score obtained from comprehension (locale), comprehension (spatial) and comprehension (general). SPANOVA for comprehension scores (general) and comprehension scores (all) did not produce any main effects for separations, high/low scores, or any significant interaction effects for both the forward and backward priming conditions.

The comprehension tests were meant to assess an individual's understanding of the narrative. It was expected that individuals who had a better understanding of the narrative would be better equipped to construct a spatial mental model. The results do not support this; this meant that a detailed and advanced understanding of the narrative understanding may not be a necessary criterion for the construction of spatial mental models. People can still construct mental models even with a basic and general understanding of the narrative.

Discussion

The main focus of this study was to explore if the spatial distance effect was demonstrated when comprehending an audio narrative. A demonstration of the effect would provide support for the idea that spatial information was encoded in mental models.

Spatial distance effect

The main hypothesis that a spatial distance effect would be observed was supported. However, the spatial distance effect was only observed for the backward priming condition and not the forward priming condition. As mentioned previously, the difference between the backward priming and forward priming condition was the order in which the episodes were

presented as prime and target. In forward priming condition, the order of presentation followed the sequences of events in the narrative. In the backward priming condition, the order of presentation was the reversed. For example, COCONUT was mentioned before RUINS in the narrative, the forward priming condition would display COCONUT as the prime and RUINS as the target. The backward priming condition would display RUINS as the prime and COCONUT as the target.

Statistical results have established that there was a significant overall linear trend for the backward priming condition. However, a visual inspection of Figure 1 would reveal that the exact nature of the trend is still unclear. Firstly, the graph did not follow a linear pattern for all eight separation conditions. The differences in reaction times for the first four conditions were small, with a marked difference seen only from S4 onwards. Future studies could clarify the exact trend of the graph (e.g. logarithmic or exponential), but in order to draw a reliable conclusion, more observations than the 40 participants used in the present study are needed. Secondly, the tail end of the graph did not reflect a significant linear trend. The changes in reaction times between S6 and S7 were small, and there was a reverse in the trend from S7 to S8, with S8 displaying a faster mean reaction time compared to S7.

Unreliable data could be a possible explanation for the results observed at the tail end of the graph. The number of word probe pairs in each condition decreases as the condition number increases. For example, S7 consisted of two word probe pairs (CLIFF – RUINS, FIRE – COCONUT) while S8 consisted of one word probe pair (CLIFF – COCONUT). As there were limited observations for the conditions at the tail end (S6, S7, S8), results were not as reliable as those in conditions up front of the graph (S1, S2, S3 etc.), and should be interpreted with caution. In order to increase the reliability, more data will have to be collect.

There were no significant results for the forward priming condition. At this moment, no explanation has yet to be found for the results. The present study was of a novel design, it was difficult for the results be validly compared to those cited in previous research. Measures used for previous studies were different from the present study and very few studies have used the LDT as a measure (Potts, Keenan & Golding, 1988; Glenberg, Meyer & Lindem, 1987; Sharkey & Mitchell, 1985). Hence it was difficult to draw a firm conclusion about the forward priming condition results of the present study.

Threshold level

As mentioned previously, a visual inspection of Figure 1 would show that there was a marked increase in reaction time from S4 and onwards in the backward priming condition. It was proposed that there was a threshold level for the number of activated entities in mental models at any one time. No previous studies in the current literature on mental models had observed such a threshold level. As such, an explanation for the results observed could not be found. A possible novel explanation then had to be proposed in order to fill up this gap in the literature. It was proposed that individuals have an optimal level of entity activation, and entities that fell outside this level experienced reduced activation. The proposed explanation was inferred from current literature on mental models and narratives.

As Millis, King & Kim (2000) noted, the construction of mental models is a highly cognitive resource consuming process. Given that people have limited cognitive capabilities, certain strategies may be adopted to process spatial information in mental models. Furthermore, Jahn (2004) noted that under natural reading conditions, no more than four entities were relevant at any given time during narrative comprehension. By combining the two reasoning, it was strongly implied that an individual's mental model was naturally inclined to maintain a high level of activation of around four entities or less, as that was how

the reading environment shaped it to be. Furthermore, by adopting the four entities strategy, it was possible to overcome an individual's limited cognitive processing capability during the formation of mental models. In order to maintain the optimal four entities activation zone, a first-in, first-out approach was used. If there were already four entities activated in the mental model, the inclusion of a new entity (fifth entity) will trigger a reduced activation of the first entity, thereby maintaining the optimal four entities activation level.

Hence, when prime-probe pairs with spatial distance of four entities or above were presented, participants took a longer time to respond as the first entity was not as highly activated as the latter entities. A follow-up study can be conducted to test this proposed optimal four entities activation zone. Results from the study would have implications on the study of mental models and memory, and refine the current *spatial distance effect* concept (Morrow, Greenspan, Bower, 1987) which would impact any future studies that uses it as a measure.

Within and between locales

No significant differences were found for episodes located in the same locale and episodes located in different locales. The *spatial distance effect* proposed that the closer the episodes were in distance, the faster the reaction time on the LDT. The event-indexing model also noted that events that occurred in the same space frame were more closely associated with each other than events that occurred in a different space (Zwaan, Langston & Graesser, 1995). Given that each locale was separated by quite a distance in the narrative, it was implied that reaction times for episodes within the same locale and episodes located in different locales would show significant differences. However, as the present study was of a novel design, it was difficult for the results be validly compared to those cited in previous research. Hence, the non-significant results of the within and between locale comparison did

not necessarily mean that the main hypothesis was not supported, it could just be due to the different design of the present study.

Neutral condition

The neutral condition was expected to display a slower response time compared to the other conditions (Stanovich & West, 1983; Wenture, 2000). This expectation was based on previous LDT literature which noted that the prime should affect the response to the target only if the words are associated with each other (McNamara, 1994). A neutral, non-word or unrelated word prime should not have any effect on the target word. It was surprising that participants reacted faster to the neutral probes instead, indicating that in the present study, the neutral condition was not functioning as expected. Future studies could look into using other possible neutral primes.

Pronounceable nonwords (e.g. BINK) may serve as a possible alternative for neutral primes (Evett & Humphreys, 1981). Previous studies have found that pronounceable non-words will require some level of lexical processing as they follow the English language orthographic laws (Meyer & Schvaneveldt, 1971; Taft & Forster, 1975). Furthermore, non-word primes are meaningless and do not have semantic value attached to them, and are therefore not associated the narrative used or the participant's personal knowledge and will not affect response to the target word (Page, 1999). A recommendation for future experiments would be to replace the nine episodic neutral word primes used in the present study with nine non-word neutral primes.

Sex effects

Besides the main findings of a spatial distance effect, significant differences were found between males and females in the construction of spatial mental models for both the

backward and forward priming conditions. Males showed significant results for the *spatial distance effect* while results were non-significant for the females. This was surprising as current literature had made no mention of gender differences in the construction of mental models. One drawback of the study was the limited sample size (16 males, 24 females), this made it difficult to establish if the gender effects observed were reliable. A replication study could be done as a follow-up with a bigger group of participants (30 males, 30 females) to eradicate this drawback.

Should significant gender effects be observed in the follow-up study, the next issue then to think about would be the source of the differences. It is important to establish if the difference observed was due to exposure to different environmental influences for the genders, or due to fundamental gender differences in cognitive spatial abilities.

In order to test the idea of different environmental influences, there was a need to first identify the possible environment influences that differ for males and females. The influence should be capable of shaping spatial cognitive ability, and the different genders should have different levels of exposure to it. The first thing that came to mind was the playing of video games. It fitted the criteria as firstly, males were more likely to play video games than females (Philips, et al., 1995). Secondly, the current literature in relation to video-gaming and cognitive spatial ability have shown that video gaming improves mental rotation time and spatial visualization time (Okagaki, 1994), and practically eliminates gender differences in spatial attention (Feng, Spence, Pratt, 2007). Thus, video game playing patterns of the different genders could act as a possible predictor as to whether spatial information was represented in mental models.

The latter question on fundamental gender differences in spatial cognitive abilities suggested that males and females have mental cognitive abilities that were fundamentally

different in nature. Past literature backed up this claim, a meta-analysis of 286 studies on gender spatial abilities showed consistent sex differences among males and females, with males consistently outperforming females on spatial ability tests (Voyer, Voyer, Bryden, 1995), and when de Vega (1994) conducted a spatial mental model study with recognition task as a measure, he noted that spatial ability skills were a predictor of a person's reaction time performance on the recognition task. It was strongly implied that there were fundamental natural sex differences in spatial representation in mental models. Unfortunately, due to scheduling reasons (participants would have to come back for two sessions instead of one, increasing the chance of drop-outs), the present study did not include any spatial ability tests as part of the procedure, so no firm conclusions could be drawn about the differences in spatial abilities between genders. A follow-up study that included a spatial ability test could be done to confirm the reliability of the results.

To test which of these two explanations was more plausible, it is proposed that a new mental model study on gamers versus non-gamers for both genders be conducted. Ideally, 40 females and 40 males would be recruited for the study with an equal number of gamers and non-gamers within both genders. Gamers are classified as individuals who play video games such as first-person shooter, RPG or casual games such as Tetris (Okagaki, 1994). The procedure and materials for the study would be similar to the present study. The study would be 8X2X2 factorial design, with 8 levels of episodic separation, 2 gender groups (females and males) and 2 gaming levels(non-gamers and gamers). Detailed analyses would reveal any significant results between genders or gamers or an interaction between both. Results from this study would have implications on the universality of the construction of mental models as well as text comprehension. The construction of mental models may not be as universal as previously thought. Text comprehension may differ between genders; this could imply that

different delivery modes are required for the different genders in order to get the same information across.

In conclusion, the novel design of the present study has contributed to the body of literature on spatial mental models. The results have demonstrated that people do construct spatial representations in mental models when listening to a naturalistic narrative. This was of great importance as the highly artificial reading conditions (Zwaan, Magliano & Graesser, 1995; Zwaan, et al., 1998; Scott, Rich & Taylor, 2000; Rinck & Weber, 2003; Morrow, Greenspan & Bower, 1987; Rinck and Bower, 1995), made it difficult to generalize their results to a naturalistic setting. Furthermore, few studies have examined mental models constructed from audio text comprehension. The results and the novel design of the present study partly helped to fill in the gap in the current literature on mental models constructed from audio narratives.

However, some areas of the study can be improved on. Firstly, the neutral condition did not function as expected, its purpose was to be a baseline and it was expected to display a slower reaction time compared to the other conditions which had more activated word primes (Stanovich & West, 1983; Wenture, 2000). It was in fact, faster than the other conditions. It is recommended that future research use alternate neutral primes, such as pronounceable nonword primes (Evett & Humphreys, 1981). Secondly, a spatial ability test should be included for future studies as it has been shown to predict performance on measures of spatial mental models (de Vega, 1994). Thirdly, more research is recommended for the forward priming condition. Lastly, future research is recommended for the gender difference observed, implications of these results could mean that gender effects may also be observed in the other four dimensions of the mental model (Zwaan, Langston & Graesser, 1995). This could suggest an underlying gender difference in overall text comprehension which would have

implications on the development of reading programs for different genders. As the present study was a novel study, follow-ups and replication study are recommended to support the reliability of the results.

References

Baguley, T., & Payne, S.J. (2000). Long-term memory for spatial and temporal mental models includes construction processes and model structure. *Quarterly Journal of Experimental Psychology Section A, 53*, 479–512.

Bestgen, Y. & Dupont, V. (2003). The construction of spatial mental models during reading. *Psychological Research, 67*, 209-218

Bower, G. H., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science, 247*, 44-48

Bransford, J. D., Barclay, J. R., & Franks, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology, 3*, 193–209

Craik, K. (1943). *The nature of explanation*. Cambridge: Cambridge University Press

de Vega, M. (1994). Characters and their perspectives in narratives describing spatial environments. *Psychological Research, 56*, 116-126

de Vega, M. (1995). Backward updating of mental models during continuours reading of narratives. *Journal of Experimental Psychology: Learning, Memory and Cognition, 21*, 373-385

Denis, M., & Cocude, M. (1989). Scanning visual images generated from verbal descriptions. *European Journal of Cognitive Psychology, 1*, 293–307

Denis, M., & Cocude, M. (1992). Structural properties of visual images constructed from poorly or well-structured verbal descriptions. *Memory and Cognition, 20*, 497 – 506

Evett, L.J. & Humphreys, G.W. (1981). The use of abstract graphemic information in lexical access. *Quarterly Journal of Experimental Psychology, 33A*, 325-350

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science, 18,* 850-855

Gernsbacher, M.A. (1990). *Language comprehension as structure*. Hillsdale NJ: Erlbaum

Givón, T. (1992).The grammar of referential coherence as mental processing instructions. *Linguistics, 30*, 5–55

Glenberg, A.M., Meyer, M., Lindem, K. (1987). Mental models contribute to foregrounding during text comprehension. *Journal of Memory and Language, 26,* 69–83

Graesser, A.C., Millis, K.K. & Zwaan, R.A. (1997). Discourse comprehension. *Annual Review of Psychology, 48*, 163-189.

Haenggi, D., Kintsch, W., Gernsbacher, M.A. (1995). Spatial situation models and text comprehension. *Discourse Process. 19,* 173–99

Hakala, C.M. (1999). Accessibility of spatial information in a situation model. *Discourse Processes, 27*, 261-279

Jahn, G. (2004). Three turtles in danger: Spontaneous construction of casually relevant spatial situation models, *Journal of Experimental Psychology*, *30*(5), 969-987

Johnson-Laird, P. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness.* Cambridge MA: Harvard University Press

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press

Langston, W. Kramer, D.C., & Glenberg, A.M. (1998). The representation of space in mental models derived from text. *Memory and Cognition*, *26*, 247-262

Levin, W.H. & Klin, C.M. (2001). Tracking of spatial information in narratives. *Memory and Cognition*, *29*(2), 327-335

McNamara, T.P. (1994). Theories of priming: II. Types of primes. Journal of Experimental Psychology: Learning, Memory and Cognition, *20*(3), 507-520

Meyer, D.E., & Schvaneveldt, R.W. (1971). Facilitation in recognizing pairs of words: evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, *90*, 227-234

Millis, K.K, King, A., & Kim, H.J. (2000). Updating situation models from descriptive texts: A test of the situational operator model. *Discourse Processes*, *30*, 201–236

Morrow, D. G., Greenspan, S. L., & Bower, G. H. (1987). Accessibility and situation models during comprehension. *Journal of Memory and Language*, *26*, 165-187

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1989). Updating situation models during narrative comprehension. *Journal of Memory & Language*, *28*, 292-312

Noordman, L. G. M., & Vonk, W. (1998). Memory-based processing in understanding causal information. *Discourse Processes*, *26*(2/3), 191–212.

O'Brien, E.J., & Albrecht, J.E. (1992). Comprehension strategies in the development of a mental model. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *18*, 777-784

Okagaki, L. (1994). Effects of video game playing on measures of spatial performance: Gender effects in late adolescence. *Journal of Applied Developmental Psychology*, *15*(1), 33-58

Page, D.J. (1999). Single word context effects: facilitation or inhibition? (Doctoral dissertation). Retrieved from http://library.usask.ca/theses/available/etd-10212004-002153/unrestricted/NQ37906.pdf

Phillips, C.A., Rolls, S., Rouse, A., & Griffiths, M.D. (1995). Home video game playing in schoolchildren: a study of incidence and patterns of play. *Journal of Adolescence*, *18*, 687-691

Potts, G.R., Keenan, J.M., & Golding, J.M. (1988). Assessing the occurrence of elaborative inferences: Lexical decision versus naming. *Journal of Memory and Language*, *27*, 399-415

Rinck, M., Williams, P., Bower, G.H., Becker, E.S. (1996). Spatial situation models and narrative understanding: some generalizations and extensions. *Discourse Process*, *21*, 23–56

Rinck, M., & Bower, G. H. (1995). Anaphora resolution and the focus of attention in situation models. *Journal of Memory & Language*, *34*, 110-131

Rinck, M., & Weber, U. (2003). Who when where: An experimental test of the event-indexing model. *Memory and Cognition*, *31*, 1284-1292

Rowling, J. K. (1999). *Harry Potter and the prisoner of Azkaban*. New York: Scholastic Books

Rubin, D.C. (1995). *Memory in Oral Traditions: The Cognitive Psychology of Epic, Ballads, and Counting-Out Rhymes*. New York: Oxford University Press

Scott Rich, S., & Taylor, H. A. (2000). Not all narrative shifts function equally. *Journal of Memory & Cognition, 28,* 1257–1266

Sharkey , N. E. Mitchell , D. C. (1985). Word recognition in a functional context: The use of scripts in reading. *Journal of Memory and Language, 24,* 253-270

Stanovich, K.E., & West, R.F. (1983). On priming by a sentence context. *Journal of Experimental Psychology: General, 112,* 1-36

Taft, M. & Forster, K.I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior, 14,* 638 - 647

van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.

Voyer, D., Voyer, S., & Bryden, M.P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin, 117*(2), 250-270

Wentura, D. (2000). Dissociative affective and associative priming effects in the lexical decision task: Yes versus no responses to word targets reveal evaluative judgment tendencies. *Journal of Experimental Psychology: Learning, Memory and Cognition, 26,* 456-469

Wilson, S.G., Rinck, M., McNamara, T. P., Bower, G.H., & Morrow, D. G. (1993). Mental models and narrative comprehension: Some qualifications. *Journal of Memory and Language, 32,* 141-154

Zwaan, R. A., & van Oostendorp, H. (1993). Do readers construct spatial representations in naturalistic story comprehension? *Discourse Processes*, *16*, 125–143

Zwaan, R. A., Langston, C. M., & Graesser, A. C. (1995). The construction of situation models in narrative comprehension: An event-indexing model. *Psychological Science*, *6*, 292-297

Zwaan, R. A., Magliano, J. P., & Graesser, A. C. (1995). Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning Memory and Cognition*, *21*, 386-397

Zwaan, R.A. & Radvansky, G.A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123,* 162-185

Zwaan, R. A., Radvansky, G. A., Hilliard, A. E., and Curiel, J. M. (1998). Constructing Multidimensional Situation Models During Reading. *Scientific Studies of Reading, 2*(3), 199 – 220

Appendix A

Information Letter

The dimensions of mental models created by a listener's mind

I invite you to participate in a research study looking at the effects of an auditory narrative on the development of spatial linkages in a situational model in a listener's mind. This study is part of my Honours Degree in psychology, supervised by Jeffrey Coney at Murdoch University.

Background and aim of the Study

Research has shown that individuals form spatial linkages in mental models when listening to a narrative. A few studies have been conducted on University students in the US demonstrating that individuals do indeed form spatial linkages in mental models when reading a narrative. I am interested to learn whether this is the case with university students in Australia, so I am inviting you to participate in my study over the next one and a half hours.

The aim of this study is to investigate whether an audio narrative can affect the development of spatial linkages in a situational model in a listener's mind.

If you consent to take part in this research study, it is important that you understand the purpose of the study and the procedures you will be asked to undergo / tasks you will be asked to complete. Please make sure that you ask any questions you may have, and that all your questions have been answered to your satisfaction before you agree to participate.

What the Study will Involve

To participate in this study, English must be your first language.

If you decide to participate in this study, you will be asked to complete the following tasks:

- Listen to a narrative for 45 minutes
- Complete a computer-based lexical decision task
- Complete 3 questionnaires, one that ask about your understanding of the narrative, one questionnaire that asks you some questions regarding personal reading patterns and the third will ask some questions about the events that occurred in the narrative

It is estimated that the narrative will take approximately 45 minutes. The computer task and questionnaires should take around another 45 minutes making it 1 and ½ hours in total.

Voluntary Participation and Withdrawal from the Study

Your participation in this study is entirely voluntary. You may withdraw at any time without discrimination or prejudice. All information is treated as confidential and no names or other details that might identify you will be used in any publication arising from the research. If you withdraw, all information you have provided will be destroyed.

Privacy

Your privacy is very important to us. Your participation in this study and any information will be treated in a confidential manner. Your name and identifying details will not be used in any publication arising out of the research. Following the study the data will be kept in a de-identified format, in a locked cabinet in the office of the Chief Investigator.

Benefits of the Study

You can benefit from this study by gaining exposure to current methods of research in a cognitive laboratory. And by understanding the advantages and disadvantages of choosing a thesis project topic in this area when entering the 4th year of your degree.

Furthermore, the knowledge gained from your participation may help others in the future as it will allow researchers to better understand an individual's cognitive processes when it comes to situational models and provides opportunities for future researchers to find a way to improve our cognitive processes.

Possible Risks

There are no specific risks anticipated with participation in this study. However, if you find that you are becoming distressed you will be advised to receive support from Murdoch's University campus counselor / psychologist / medical practitioner. Alternatively, we will arrange for you to see a counselor / psychologist / medical practitioner at no expense to you.

Reimbursement

Participants will be awarded 1.5 Murdoch University subject pool credits for participating in the study.

If you have any questions about this project please feel free to contact either myself, Rebecca Ong Hui Shan at 0413 633 693, email: rebeccaong88@gmail.com or my supervisor, Dr Jeffrey Coney, at +61 (0)8 9360 2387. My supervisor and I are happy to discuss with you any concerns you may have about this study.

Once we have analysed the information from this study I will put on the summary of my findings on the Murdoch University School of Psychology website. You can expect to receive this feedback in 4 months after the completion of data collection.

If you are willing to consent to participation in this study, please complete the Consent Form

Thank you for your assistance with this research project.

Sincerely

Rebecca Ong Hui Shan

This study has been approved by the Murdoch University Human Research Ethics Committee (Approval 2012/118). If you have any reservation or complaint about the ethical conduct of this research, and wish to talk with an independent person, you may contact Murdoch University's Research Ethics Office (Tel. 08 9360 6677 (for overseas studies, +61 8 9360 6677) or e-mail ethics@murdoch.edu.au). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Appendix B

Informed Consent Form

The dimensions of mental models created by a listener's mind

1. I agree voluntarily to take part in this study.

2. I have read the Information Sheet provided and been given a full explanation of the purpose of this study, of the procedures involved and of what is expected of me. The researcher has answered all my questions and has explained the possible problems that may arise as a result of my participation in this study.

3. I understand I am free to withdraw from the study at any time without needing to give any reason.

4. I understand I will not be identified in any publication arising out of this study.

5. I understand that my name and identity will be stored separately from the data, and these are accessible only to the investigators. All data provided by me will be analysed anonymously using code numbers.

6. I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.

Signature of Participant: _____ Date: ….../..…../…….

(Name)

Signature of Investigator: _____ Date: ..…../…..../…….

(Name)

Appendix C

The Castaway

I hit the floor of the cabin with a painful thump and came to full consciousness in a fraction of a second. Mere moments before, I had been sound asleep in my bunk. I knew instantly that something very bad must have had happened. It seemed only minutes before that I had finally judged it safe to engage the autopilot and tumble gratefully into bed, but the grey light filtering through the port-hole told me I'd been asleep for at least two or three hours. I had only partially undressed before falling into bed and so was quickly dressed again and on my way up the companion-way and out on to the deck. My yacht seemed to be rapidly losing way despite the stiff breeze, and was very obviously listing to port. I looked astern and the flash of rust-red bobbing in the waves some distance back told me all I needed to know: shipping container! The scourge of the small-boat ocean voyager; the encounter we hope will never happen. I had clearly been very badly holed. I suspected that my hull had connected at speed with a sharp corner of the container. Cursing the wretched vessel that had lost the container over the side, I turned back to the boat. She was already starting to settle in the water and I knew I would have to act fast. I unleashed the liferaft and pulled the cord that initiated the automatic inflation. Heaving it over the side, I tied it off to the railing and turned to dash down the companion-way to gather supplies. Suddenly, the boat lurched and began to sink rapidly. The hull must have been giving way under the pressure of the in-rushing ocean. I quickly untied the liferaft and jumped into it. As I paddled away, my boat slid gracefully into the depths.

I had no clear idea of where I was. I had been battling stormy weather for the last two days and had had my hands full keeping my yacht afloat in the high winds and rough seas, without worrying about the niceties of navigation – especially since my GPS had clearly developed some problem over the last week. My best guess was that I was somewhere around 100kms or so north of Vanuatu, but the storm could have blown me well off course. I knew that there should be some islands in this general area, but could not see anything on a careful sweep around the horizon.

This was bad. With no time to pack food and water, I would be lucky to last more than a few days on the open ocean. Quelling the panic welling up in my chest, I inserted the rudimentary oars into their even more rudimentary rowlocks and began rowing in the direction that the wind was nudging me. After a couple of hours of wearying work, I realised that what I had initially taken for a low cloud formation on the horizon might actually be land. A distinct greenish smudge had appeared on the horizon roughly in the direction I was travelling, although I was initially unwilling to dare hope that it might represent land. I set out with renewed energy and determination to generate enough course correction with the oars to crab the liferaft in the direction of the smudge.

The wind died down during the day and the seas were quite slight, but it was dusk before I wearily paddled into a sandy bay on an apparently deserted beach. The rather flimsy rowlocks had broken some time ago, and I had to use an oar to paddle the last few kilometres. I was thirsty and tired beyond measure, but it was clearly too late to find any food, water, or shelter. So I pulled the liferaft up onto the beach, climbed into it, and made myself as comfortable as I could for the night.

I awoke shortly before dawn, my back aching from the discomfort of the liferaft, and suffering from a now quite intense thirst. During my approach to land the previous day, I had seen no other craft, and no sign of people or habitation of any kind along the coast. I had no idea at all where I might be. I knew it was Friday today, but had lost track of dates over the last couple of weeks and fervently hoped that it wasn't Friday the thirteenth!

Rising, I examined the contents of the liferaft. There was very little in the way of useful supplies, though. It seemed that my whole boating career had been one of lessons learnt the hard way. I guess I had never anticipated that disaster could strike so quickly and so devastatingly – too quickly for me to radio a distress call, or even find and activate the electronic distress beacon that had cost me so much to buy. Now, I was paying the price for failing to stock the liferaft in any sort of adequate fashion. The total inventory came to nothing more than a packet of waterproof matches and one small bottle of water tucked away in a pocket of the liferaft. I didn't have a compass, or even a watch. I drank greedily from the bottle, but forced myself to save some for later even though my thirst was far from quenched. I suppose I had just tacitly assumed that in this era of electronic safety equipment, a well-equipped liferaft would never be necessary. But now I had no idea when, or even if, I would be rescued and the thought of having no tools for survival other than a water bottle and packet of matches made my heart sink.

I was also feeling very hungry. I'd had little time to prepare meals while battling the storm, and so had survived on some rather basic rations for the previous two days, grabbing what I could from the galley cupboards in occasional quick dashes away from the helm. Dense tropical jungle fringed the beach, but I could not see anything in the way of edible plants or fruit. There were, however, a number of coconut palms in a small grove and some appeared to have clusters of ripe coconuts. But how to get one? I tried shinning up the trunk of one of the palms, but slipped and fell heavily before getting more than a couple of metres off the ground. I decided that this was both hopeless and dangerous and turned miserably back to the beach. On the way, I cursed as I tripped over what I presumed was a hidden rock. Peering down, I was overjoyed to find that it was a ripe coconut that had fallen to the ground. I kicked myself for not realising that the coconuts must fall off some time, and there should be at least some on the ground around the palms.

The next problem was to open the coconut. It proved to be difficult to remove the outer husk. I carried the coconut down to a rocky outcrop on the beach. Smashing the coconut repeatedly against the sharp edges of the outcrop, I managed to strip away the husk and expose the kernel inside. It was easy to crack this open on a rock and I ravenously attacked the delicious white chunks of copra I found inside. I had eaten copra before, but now wondered why I had not thought it the most mouthwatering delicacy in the world. But although this coconut grove was a god-send, I knew I couldn't stay here forever. I wondered how common coconuts were along this mysterious coast. Certainly, there were no other groves in sight as far as I was able to see.

I walked around under the palms, hoping to stumble over another hidden coconut. Unfortunately, there didn't appear to be any more to be had. All I found was an obviously very old and decayed coconut that was beyond salvation as a source of food.

Placing the remaining copra in my pockets, I looked around carefully and immediately spotted a curiously shaped rock through the trees. Pushing my way toward it through the tangled vegetation, I suddenly came upon some stone ruins almost swallowed up by the

jungle. The ruins covered an area about the size of an average house and it wasn't too difficult to pick my way around them. On the far side of the ruins, I found a doorway set into a wall. I cautiously peered in and was startled by a snake suddenly slithering away into the stonework of the ruins. The ruins appeared to consist of one large room with several smaller rooms adjoining it, although much of the structure was choked with vegetation and windblown sand.

I was uncertain about the significance of the ruins for my survival in this land. There could be no doubt now that people had once inhabited this region, but the decrepitude of the ruins suggested that they had not been used by anyone for a very long time. I did not think that this discovery gave me much reason to hope for any kind of imminent rescue from my predicament.

It was pretty clear that there was nothing in the way of tools or other artifacts in the ruins – whatever they may have been in the past, they were obviously now the kingdom of the snakes. All I could see were a few small bent sheets of rusty old metal of some kind, probably the remains of some kind of container used by previous inhabitants of the ruins. As I gazed at these sheets of metal, though, a sudden idea struck me. Perhaps they might be used to fashion a primitive blade. I was acutely conscious of my lack of tools for survival in a wilderness, and a blade could only enhance my chances of surviving on this apparently deserted coast. I pulled a long and narrow piece free of the sand drift in which it was embedded and sat down beside some lumps of stone that had fallen from the ceiling of the ruins. I tore off part of my trouser leggings and wrapped the material around one end of the metal to protect my hands, I began using a stone block to hone an edge on one side of the metal. The stone block made quite an effective grindstone, being rough and abrasive, and I soon had a serviceable blade. I was now the proud possessor of a rudimentary knife!

I left the ruins with my blade proudly sheathed in my belt, feeling rather piratical. As I returned to the beach, I passed through an extensive stand of bamboo of varying heights and thickness. I stopped to examine the bamboo quite carefully. As a child, my friends and I had used bamboo to make all kinds of useful objects and tools. We would make bamboo water containers out of hollow segments, bamboo swords – even bamboo bombs filled with gunpowder collected from old firecrackers. It was odd the way my plight quite suddenly thrust me back into the world of my childhood. It was as though arriving on this island was a step back through a magic portal into a much earlier and more technologically-basic era in my life. Musing on this, I realised that I might be able to apply my newly-acquired blade to the bamboo to fashion another, perhaps even more useful, tool: a spear. How strange to think that childrens' play with something as simple as bamboo might help to keep me alive so many years later. I quickly selected a sturdy pole about 2m long and managed to snap it off at the base by working it back and forth. I found a spot shaded by the bamboo and sat down to use the new blade to fashion a lethal point at one end of the bamboo pole. I had soon fashioned a sharp point that looked as though it would quite durable and resistant to blunting. It amused me to think that I seemed to be recapitulating early human weapons development. First a knife – now a spear. Extrapolating from my present rapid rate of technological progress, I could expect to test my first atomic bomb within a year or two!

Before leaving the stand of bamboo, I spent a little while practicing throwing the spear. I felt that it was important to be in a position to use it effectively if any creature that might be edible crossed my path. My copra wouldn't last long, and I would need more food to keep my strength up. I was thirsty again and badly needed to drink, but as I drained the last of my

water from the bottle, I realised that I could start to be in serious trouble if I failed to find some more today. In this tropical heat, dehydration could occur very rapidly.

I could see nothing else of any interest or use to me on or around this part of the beach, and no indication at all of a water supply of any kind. I realised that I was going to have to get going quickly, preferably before the sun climbed higher into the sky. The coast of this unknown land appeared to run in a roughly north-south direction, and so, more or less at random, I set off in a northerly direction up the beach.

I walked along the beach in a brisk and energetic fashion at first. My spirits were buoyed by the speed with which I had outfitted myself with a blade and a spear and I covered a good deal of distance quite quickly. I walked as close to the edge of the ocean as possible, partly because the sand was harder there and easier to walk on, but also because it gave me the broadest view of the fringing jungle as I passed. I was keeping a very careful eye open for any sign of life, animal or human, or for anything else that might present a further opportunity for survival.

As I walked, I also periodically scanned the ocean and the sky, hoping to see some indication of a boat or a plane. I wasn't sure, though, how I would be able to attract attention if I did spot anything of that kind. I supposed all I could do would be to dance around and wave my arms like a crazy man. This was not very encouraging, but it didn't matter for the moment at least: I saw no signs at all of human activity on the water or in the air.

Progress was not always easy along the beach because rocky outcrops were not uncommon and I had to find a way to detour around them. Sometimes, I could wade through the water around such obstacles, but at other times the water was too deep and I would have to make my way around them rather painfully through jungle vegetation that was often dense and thorny.

I must have covered something like 7 or 8 kilometres of coastline by mid-morning and had seen nothing that gave me reason to stop and investigate. I was getting very hot, weary, and thirsty. While I was wondering whether it might be wise to take a short break, I suddenly detected some odd sounds coming from the jungle nearby. It was difficult to say what I was hearing, but it seemed very likely that some bird or animal must be making the sounds. I crept quietly into the jungle toward the noise, moving branches and leaves aside as gently as I could. After travelling a short distance, I detected a distinct snuffling coming from behind a thicket that lay just in front of me. There was a light wind, but it was blowing more or less towards me and so I wasn't concerned about being scented by whatever creature or creatures lay behind the thicket. I edged into the thicket as quietly as I could until I reached a position that allowed me to peak through into a small clearing in the jungle. The sight that met my eyes astonished me! There, before me, lay a large wild pig with four little pigs greedily suckling from her.

I had been on short rations for a total of three days, including my time on the boat, and had expended a lot of energy, and was now very hungry. Visions of roast pig flooded my imagination. I literally salivated at the thought – and reflected momentarily on how desperate circumstances can so rapidly and radically alter one's outlook on life. I, who had never even been quite comfortable viewing the contents of a butcher's shop, was now trying to work out how I could catch and kill a little pig for dinner!

I began to stalk the pigs, edging very cautiously around the thicket, hefting the spear in my hand as I went, trying to find the right balance. My plan was to take them by surprise and skewer one of the little pigs before they all bolted. When I judged the moment right, I suddenly dashed out into the open and instantly targeted the nearest little pig and flung the spear at it. Unfortunately, the spear merely bounced off the tough hide of the pig. Too late, I realised that the mostly hollow shaft simply didn't contain enough mass to drive the point of a thrown spear into the hide of even a small animal.

I had no time to luxuriate in anything as mild as disappointment, though. With a terrifying squeal of outrage, the mother pig lurched to her feet and made toward me. I abandoned my spear and ran for my life back through the jungle. I didn't know how much damage a large wild pig might be able to inflict on me, and didn't intend to stay around to find out. After I had dashed about 50m or so, I risked a quick look back and realised that she had given up the chase to return to her babies. I crept back, checked that the pigs had disappeared into the jungle and somewhat ruefully retrieved the spear. I might have missed out on my roast pork dinner, but I wasn't going to leave my spear behind.

I was pushing my way back through the undergrowth in the direction of the beach when I suddenly seemed to run out of ground to walk on and plunged headlong into space. The next thing I knew I was underwater and struggling to get back to the surface. As I spluttered and gasped for air, I realised I had literally stumbled on a deep rocky pool of water concealed in the undergrowth. My first thought was that this must be some kind of rocky depression that was filled by the ocean by occasional very high tides. My immediate second thought was that this couldn't possibly be true, because the water that I was trying to blow out of my mouth and nose was very obviously quite fresh. It was clear that I had had the wonderfully good fortune to chance upon a spring-fed pool of fresh water almost on the beach.

I gulped water thirstily from the pool. Although redolent of rotting vegetation, the water was not only quite fresh, but seemed to be tolerably clean. The barely acknowledged fear that had gnawed at me since landing – dying of thirst – was put to rest for the moment by this wonderful source of water. I had been hot, dirty, salty, and sweaty, as well as very thirsty. It was nothing short of heaven to lie back and float lazily around the pool, letting the aches and pains ebb out of my body. I realised how very lucky I was to have found this pool of fresh water so soon. I had seen no other sign of fresh water in my journey up the coast, although I now realised that all manner of things might lie concealed in this almost impenetrable jungle.

While I was lying quietly in the pool, a small deer or deer-like creature ambled out of the surrounding undergrowth and bent to drink from the pool. I suppose I was an unfamiliar, and in any case barely visible, object in the pool and raised no alarm bells. My first thought was to try to get to my spear, but as soon as I moved the animal started in fright and bolted back into the jungle. I sighed. Never mind. I now knew that there was little chance of my thrown spear being used to any effect in bringing down an animal. I sank back into the pool and relaxed again.

But time was passing, and although it was wonderful to have the physical relief afforded by the pool, I needed to press on in the interests of survival. Hauling myself rather regretfully out of the pool in my sopping clothes, I filled my water bottle. I didn't wait to dry out: the tropical heat would accomplish that quickly enough.

I made my way back to the beach in order to continue my northward march. Before being able to resume my walk along the beach, I had to climb over another of the rocky outcrops

that regularly interfered with my progress. I barely begun my ascent, though, when I came upon a large cave set into the rock. Curious, I peered cautiously into the cave, wary of snakes, but the cave appeared to be empty. As I entered, though, I startled a flock of roosting bats who, with a furious fluttering of wings and much high-pitched shrieking, fled the cave. I made my way to the back of the cave where I noticed what appeared to be a small hole in the wall. The hole was large enough to allow me to crawl through into a smaller chamber of the cave which was dimly lit by light filtering down from a crack in the rock ceiling. I stood upright and began to move toward the rear of the chamber. Suddenly, I heard a crackling sound and felt my shoes crunch something underfoot. I peered down – and flung myself back in horror! I had stepped on the ribs of a skeleton. As my eyes adjusted to the dim lighting, I made out the unmistakable gleam of a human skull some distance away from the body of the skeleton – presumably detached from the skeleton by some foraging animal. My initial assumption was that the skeleton belonged to some original inhabitant of this land and had probably lain in the cave for many decades, even centuries. At least: that was my assumption until my eye was caught by the very rusted, but unmistakeable, outline of a watch and metal band on a bony wrist. A cold horror and despair coiled around my heart as the implications came home to me: this skeleton must have belonged to a castaway like myself. I knew very little of the history of wristwatches, but from what I could tell this skeleton was sporting a distinctly modern-looking watch. I didn't think that he could have lain in the cave for much more than a decade or so, at most. Was this to be my destiny? To die of hunger, thirst, or injury and have the flesh of my corpse eaten and my bones dispersed by passing animals?

When I had first come upon the cave, it had crossed my mind that I might be able to use it as a temporary base of operations while I explored the surrounding area more thoroughly. It offered shelter from wind and rain, and could be a cozy place to bed down at night. But after my horrific discovery, I shuddered to think what it would be like to spend a night in this cave, knowing that the skeleton of some poor soul lay only a few metres away.

Very depressed, I left the cave and made my way down the other side of the outcrop to the beach. I recommenced my weary march up the coast. I badly needed to eat something. I was using a lot of energy, but had no way of fueling up my body for the afternoon ahead. I resumed my regular scan of the sea, sky, and adjacent jungle.

I walked for a long time – perhaps "trudged" is a better word. It was starting to become almost painful to put one foot in front of the other. I had seen no sign of human life on my travels so far and my misery deepened as I realised that I could be hundreds of kilometres from any kind of civilisation. Expeditions to uninhabited regions of the world with proper supplies and equipment were one thing; to be shipwrecked with little more than the clothes I stood up in was quite another. I wondered how long I could survive on this coast.

It was very hard to judge how much distance I was covering. The coast was increasingly segmented into a series of relatively small bays and I often couldn't see very far up or down the coast. Fortunately, there seemed to be fewer rocky outcrops intruding into the sea on the part of the coast through which I was now travelling, and this made the going rather easier.

As before, I tried to stick as close to the edge of the water as possible in order to take advantage of the firmer sand. Over some time, though, I began to become aware that the ocean appeared to be slowly retreating. I knew this because in order to keep tracking along the edge of the water, I found myself moving further and further away from the jungle vegetation fringing the beach. I realised that it must be approaching low tide.

Eventually, I came to a large area of reef that lay under very shallow water. I decided to see if there might be any shellfish I could find to eat. I waded gingerly out on to the reef. I had to take care because my boat shoes were beginning to get a bit frayed by this time. At one point, I lost my footing and fell into a shallow depression, scraping my leg in the process. I dragged myself out of the depression and back up on to the reef. My leg didn't seem to be badly hurt, and so I continued my exploration. As I neared the outer edge of the reef, I came upon some deep holes in the rock. I peered into one of the holes and was gratified to see some quite large fish apparently grazing on weed near the surface. These inhabitants of the reef were remarkably fearless, presumably having had little or no experience with fishermen. I realised that this reef could be an excellent source of protein, if I could only find a way to catch the fish.

I had nothing I could use as a net and even if I'd had any fishing tackle or bait, it was not clear that these fish would be interested in anything other than seaweed, and they already had as much of that as they could eat. It was clear that my only hope would be to try to use my spear. I returned to the beach, retrieved the spear, and returned to the hole. I approached the hole as stealthily as I could, bending down and wading slowly and carefully through the water. My plan was to get close enough to drive the spear into the fish, rather than to try throwing it. When I reached the edge of the hole, I could see several fish grazing near the surface. Taking aim, I thrust my spear toward the nearest fish – and was astonished to see it miss completely. I had missed my target so badly that the fish appeared to be barely perturbed by my murderous intent and went on grazing happily. I quickly understood what had happened – I had failed to account for the effect of refraction of underwater images, exaggerated as they were by my cautiously low angle of approach. I retreated to another, less populated, hole in the reef and practiced thrusting the blunt end of my spear at various stationary underwater targets.

After half an hour or so, I thought I knew the trick and walked back across the reef to the fishing hole. After a couple of tries, I was delighted to feel my spear hit flesh and to feel a fish writhing on the end. Unfortunately, the fish almost immediately slipped off and swam unsteadily away trailing a cloud of blood. I sighed with the realisation that I hadn't yet climbed the ladder of weapons technology to the level of barbs: there was nothing to fasten the fish to the spear after initial penetration. I was nevertheless determined not to leave this reef without a fish, and kept stabbing fruitlessly at hapless reef grazers until I finally learnt to follow through with my initial thrust by moving the spear point in a rapid nonstop arc of motion into the water, through the fish, and then up and out into the open air before it could slip off.

I caught two fish in this way, both a reasonable size. Carrying them on my spear over my shoulder, I made my way back across the reef to the shore. Hungry I might be, but I was very reluctant to eat them raw and needed to find a way to get a fire going on which to cook them. It was quite easy to find enough kindling and larger pieces of wood to start a fire. The upper reaches of the beach were littered with driftwood and there were quite a few dead branches lying around in the vegetation fringing the beach. I used my waterproof matches to get a small flame going with pieces of kindling. Slowly, I built up the fire until it was burning quite vigorously. There was obviously a good deal of moisture in the wood, because the fire gave off a lot of smoke, but it was also generating plenty of heat. While the fire was settling from a healthy blaze into a bed of glowing coals, I devoted myself to using my home-made knife to scale and gut the fish. I then went back into the jungle and returned to the fire with a green and tough-looking branch on which I skewered both fish. I held them out over a corner of the

glowing bed of coals until I judged them to be nicely grilled. I then pulled the fish from the fire and ate them directly from the branch. Never had fish tasted so delicious! I knew little about fish in this part of the world and hoped they weren't poisonous. But by this stage I was rather fatalistic. What choice did I have? Better a quick death from poisoning than a slow death by starvation. Anyway, if it was poison, it was great-tasting poison. Finishing my lunch, and conscious that the afternoon was slipping away, I reluctantly rose to my feet.

Before leaving the fire, though, I flung all remaining wood on to the coals. The considerable quantities of smoke generated by the moist logs would ensure that this fire would serve as an excellent signal beacon, at least during the remaining hours of daylight. Anyone familiar with the barren and deserted nature of this coastline would surely be alerted to investigate a column of smoke rising from the beach. I waited until the fire was once more blazing quite fiercely before wiping my knife clean and sheathing it in my knife in my belt and picking up my spear. I then strode away from the fire with at least something in my stomach other than water and copra.

There was, however, a quite serious obstacle that had to be surmounted before I could resume my progress along the coast. The north end of the bay in which I was currently located was bounded by a headland that rose majestically from the jungle and terminated in a high cliff overlooking the ocean. I began to make my way painfully up the side of the cliff. I had thought of approaching the cliff from behind by climbing up through the jungle enshrouding the headland, but the vegetation seemed to be even more thorny and impassable than any I had previously encountered. So, I scaled the cliff face by slow degrees, carefully choosing each foothold in advance. At one point I slipped and, for a few terrified moments, imagined myself lying broken but conscious at the bottom of the cliff – waiting in agony for the end, knowing that I was utterly alone on this desolate coastline and far, far beyond any help.

Finally, though, I managed to make it to the top of the cliff and was struck dumb by the vista that lay before me: miles and miles of ocean stretched out to the horizon. I wondered how far I could see from up here. I had completed a basic course in navigation at one stage, and knew that at 2m height, the horizon is about 5km distant. I also knew that if the height of one's viewpoint increased by a factor x, then the distance to the horizon increased by a factor proportional to the square root of x. I estimated that the cliff must be close to 100m high and so x must equal 50, and the square root of that was a little over 7. So, the horizon must be something on the order of 35km distant from my present vantage point. That's a lot of water, in anyone's book – but I could make out nothing but endless emptiness stretching out before me. The immense barren waste that lay before me brought home a sharp and dismal appreciation of just how utterly alone and isolated I was.

Worse, looking northwards from the cliff I had an eagle's eye view of much of the coastline I had yet to traverse – and there was no sign of anything that might give me hope of salvation. For the first time, I was forced to confront the full reality of my predicament: it appeared that there was little chance that I would survive this misadventure. With a very heavy heart, I decided to make my way down to the beach on the other side of the headland. The sun was not far off setting and I didn't want to be caught out at night in this exposed position. Making my way down from the cliff proved to be somewhat easier than coming up the other side had been. I was able to find a natural pathway of sorts between the rocks and jungle, and managed to climb down to the beach relatively quickly and easily. This was fortunate, because I had pretty well exhausted my reserves of energy for the day. It would be all I could do to find a reasonably sheltered place for the night before collapsing on the spot.

At the bottom of the cliff, I walked down to the beach and looked for a place to huddle away from the weather in the rocks at the cliff base. Suddenly, I ran full tilt into another human being! As I gaped in astonishment, he shouted excitedly and a number of other men came running around the rocks. Chattering in some language I didn't recognise they smiled and laughed and led me around the rocks to a section of beach on which some quite large fishing boats were drawn up. They were clearly in the midst of preparing their evening meal and my mouth watered as I saw the array of rice, vegetables, and meats set out on mats. These men were clearly fishermen who had made camp for the night on this sheltered part of the beach. They were immensely kind and solicitous and could clearly see what an ordeal this unshaven, and hollow-eyed man had been through. They sat me down on a comfortable mat, and plied me with food and water until I had to beg them to desist.

Later that evening, as I relaxed with a full belly under the makeshift shelter the fishermen had erected for the night, we exchanged as much information as we could using the few words of English the fishermen knew. With the aid of much gesticulation and pantomime and drawing of maps in the sand, I was able to convey the essence of my ordeal. In turn, I learnt that these fishermen came from some land over the horizon and that the coastline we were on was essentially uninhabited as far as they knew. It was their habit to go some distance out in the ocean to fish, and to camp overnight whenever they were near a convenient shore. I had been very lucky to come across them.

This was the most extraordinary day of my life, and I could scarcely believe the adventures I had had since first waking in the early dawn. But one thought resounded joyfully through my mind as I fell asleep that night: I was saved! I was going to live, after all!

The End

Appendix D

List of stimulus prime-target word pair probes for S1 to S8

Condition	Definition	Episodes		Legend
		Backward Priming (target-prime)	Forward Priming (target-prime)	
S1	Measures spatial priming across a distance of one episode	12 23 34 45 56 67 78 89	21 32 43 54 65 76 87 98	Locale A: 1 – coconut 2 – ruins 3 – bamboo Locale B: 4 – pigs 5 – pool 6 – cave Locale C: 7 – reef 8 – fire 9 – cliff
S2	Measures spatial priming across a distance of two episodes	13 24 35 46 57 68 79	31 42 53 64 75 86 97	
S3	Measures spatial priming across a distance of three episodes	14 25 36 47 58 69	41 52 63 74 85 96	
S4	Measures spatial priming across a distance of four episodes	15 26 37 48 59	51 62 73 84 95	
S5	Measures spatial priming across a distance of five episodes	16 27 38 49	61 72 83 94	
S6	Measures spatial priming across a distance of six episodes	17 28 39	71 82 93	
S7	Measures spatial priming across a distance of seven episodes	18 29	81 92	
S8	Measures spatial priming across a distance of eight episodes	19	91	

Appendix E

List of stimulus prime-target word pair probes for within and between locales

Condition	Definition	Episodes	
		Backward Priming (target-prime)	Forward Priming (target-prime)
WLLAS1	Measures spatial priming across a distance of one episode within locale A	12 23	21 32
WLLAS2	Measures spatial priming across a distance of two episodes within locale A	13	31
WLLBS1	Measures spatial priming across a distance of one episode within locale B	45 56	54 65
WLLBS2	Measures spatial priming across a distance of two episodes within locale A	46	64
WLLCS1	Measures spatial priming across a distance of one episode within locale C	78 89	87 98
WLLCS2	Measures spatial priming across a distance of two episodes within locale C	79	97
BLS1	Measures spatial priming between locales across a distance of one episode	34 67	43 76
BLS2	Measures spatial priming between locales across a distance of two episodes	24 35 57 68	42 53 75 86

Locale A:
1 – coconut
2 – ruins
3 – bamboo

Locale B:
4 – pigs
5 – pool
6 – cave

Locale C:
7 – reef
8 – fire
9 – cliff

Appendix F

Episode name primes and matched neutral primes

Episode names	Word frequency level	Neutral primes	Word frequency level
Coconut	276	Vinegar	275
Ruins	639	Crust	638
Bamboo	269	Cowboy	267
Pigs	881	Maid	881
Pool	4358	Star	4441
Cave	856	Drum	865
Reef	418	Pill	427
Fire	12955	Hair	14443
Cliff	962	Bride	950

Appendix G

List of stimulus for neutral prime-target pairs

Neutral pairs:

Maid – Coconut

Maid – Pags

Pill – Ruins

Pill – Bimbot

Hair – Fire

Hair – Caconet

Drum – Cliff

Drum – Cloff

Bride – Bamboo

Bride – Reet

Vinegar – Reef

Vinegar – Roins

Star – Cave

Star – Cuve

Cowboy – Pool

Cowboy - Poal

Appendix H

List of non-word probe pairs

Target	Prime
caconet	cave
roins	fire
bimbot	coconut
pags	cliff
poal	ruins
cuve	reef
reet	pigs
firt	bamboo
cloff	pool
caconet	ruins
roins	reef
bimbot	fire
pags	pool
poal	coconut
cuve	cliff
reet	cave
firt	bamboo
cloff	pigs
caconet	pool
roins	fire
bimbot	coconut
pags	reef
poal	ruins
cuve	pigs
reet	cliff
firt	cave
cloff	bamboo
caconet	ruins
roins	pool
bimbot	cliff
pags	coconut
poal	reef
cuve	pigs
reet	fire
firt	cave
cloff	bamboo
caconet	pool
roins	cave
bimbot	reef
pags	fire
poal	cliff

Target	Prime
cuve	coconut
reet	ruins
firt	bamboo
cloff	pigs
caconet	pigs
roins	cliff
bimbot	reef
pags	ruins
poal	coconut
cuve	fire
reet	cave
firt	bamboo
cloff	pool
caconet	reef
roins	bamboo
bimbot	fire
pags	coconut
poal	cliff
cuve	pigs
reet	ruins
firt	pool
cloff	cave
caconet	cave
roins	fire
bimbot	cliff
pags	coconut
poal	reef
cuve	ruins
reet	pool
firt	bamboo

Appendix I

Reading Enjoyment Scale

This survey seeks to identify your attitudes and behaviours relating to reading. Please indicate how each statement applies to you by circling the appropriate statement.

1. I often like to read before I go to sleep.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
2. When I have the time I will often choose to read for leisure.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
3. I only read when I have to.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
4. Reading is one of my favourite activities.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
5. I find reading to be enjoyable.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
6. I tend to find that I enjoy the book better than the movie.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
7. I only read when there is nothing else to do.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
8. When I go away on holidays, I will pack a book.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

9. I find it hard to put a good book down.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
10. I look forward to having time to read on weekends or holidays.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
11. I find reading to be boring.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
12. I enjoy borrowing books from a library and/or buying books from a bookstore.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Scoring:
For items 1-2, 4-6, 8-10, and 12 score a response of Strongly Disagree as 1, Disagree as 2, Neither Agree nor Disagree as 3, Agree as 4, and Strongly Agree as 5. Reverse-score items 3, 7, and 11 such that Strongly Disagree scores 5 and Strongly Agree scores 1. Sum these scores for the 12 items to produce a score between 12 and 60.

Appendix J

Comprehension

1. What was the object that caused the narrator's yacht to capsize?

_____

2. Where did the narrator encounter the snake?

_____

3. What did the narrator discover in the cave after his encounter with the bats?

_____

4. What sort of animal came to drink at the rocky pool?

_____

5. How long did it take for the narrator to be rescued?

_____

6. What did the narrator make from the bamboo?

_____

7. How many piglets were there?

_____

8. Who rescued the narrator?

_____

Appendix K

Event Sequence

Instructions:

Please place the word cards in the sequence in which you think that they occurred in the narrative. The box labeled “1” is for the earliest event while the box labeled “9” is for the last event that occurred.

1	2	3	4	5	6	7	8	9

Word cards (given in a random order):

Coconut	Ruins	Bamboo	Pigs	Pool	Cave	Reef	Fire	Cliff

Appendix L

Events	Score	Participant's Sequence
1-2		
2-3		
3-4		
4-5		
5-6		
6-7		
7-8		
8-9		
Total		

Event Sequence Scoring

Actual sequence in narrative	Locale	Score
Coconut – ruins	1. Coconut	
Ruins – bamboo	Ruins	
Bamboo – pigs	Bamboo	
Pigs – pool	2. Pigs	
Pool – cave	Pool	
Cave – reef	Cave	
Reef – fire	3. Reef	
Fire – cliff	Fire	
	Cliff	
	Total	

Appendix M

Instructions to Subjects

"I would like you to read through the information sheet, complete the consent form and fill out this reading enjoyment questionnaire."

For the practice Lexical Decision Task (LDT):

"Later in the session, you will be asked to respond to a series of trials in which two strings of letters will be presented. The first string will always be a word, but the second string will sometimes be a word and sometimes a nonsense word.

Your task is simply to press the response switch as quickly as possible if the second string is a word – but withhold any response if it is a nonsense word.

You should pay careful attention to the first word, because it signals the fact that the test string will be appearing very shortly. Your response should ONLY be based on the second (test) string.

At the end, the computer will display a feedback screen. You will be shown your average response time (in thousandths of a second) and the number of errors you have made in the preceding block of trials. You should try to make their responses faster and faster, while keeping errors down to only 2 or 3 in each block ideally.

Let me know if you have any questions regarding the task"

For the narrative:

"Please sit with your eyes closed and listen very carefully to the story. Call me as soon as the story ends."

For the actual LDT:

"The procedure is the same as the practice LDT, the only difference is that there are 8 blocks and the computer will pause to give you a short rest break between each block."

Following completion of the LDT:

"Thank you for completing the task, there are two more questionnaires to go. Please complete this comprehension questionnaire, followed by the event sequencing questionnaire. These two questionnaires are measures of your understanding of the narrative. After you have completed them, I will explain the experiment to you.